ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

ON

DANGOTE FERTILIZER PLANT

DRAFT REPORT

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Submitted to:

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
AFC	African Finance Corporation
AfDB	African Development Bank
AGO	Automotive Gas Oil
ALARP	As Low As Reasonably Practicable
API	American Petroleum Institute
AQMP	Air Quality Management Plan
ATK	Aviation Turbine Kerosene (Jet A1)
AVH	Ackermans & Van Haaren
BOD	Biochemical Oxygen Demand
BTEX	Benzen – Toluene – Ethylbenzene – Xylenes
C&S	Cherubim and Seraphim
CAGR	Combined Annual Growth Rate
CBD	Central Business District
CBM	Conventional Buoy Mooring
CBO	Community Based Organisation
CBS	Community Baseline Survey
CD	Chart Datum
CDA	Community Development Association
CFC	Chlorofluorocarbon
COLREG	Convention on the International Regulation for Preventing Collision at Sea
CPP	Clean Petroleum Products
CPR	Cardio-Pulmonary Resuscitation
CSW	Commercial Sex Workers
DCA	Distended Correspondence Analyses
DGPS	Differential Global Positioning System
DPK	Dual Purpose Kerosene
DPR	Department of Petroleum Resources
DWT	Deadweight tonnage
EAG	Environmental Assessment Guidelines
EAR	Environmental Audit Report
EBS	Environmental Baseline Survey

Abbreviation	Explanation
EGASPIN	Environmental Guidelines and Standards for the Petroleum Industry in Nigeria
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPC	Engineering, Procurement and Construction
EPFI	Equator Principles Financial Institutions
EPRP	Emergency Preparedness and Response Program
ERP	Emergency Response Plan
ES	Eastern Sector
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
EU	European Union
FAL	Convention on Facilitation of International Maritime Traffic
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FMEnv	Federal Ministry of Environment
FTZ	Free Trade Zone
GDP	Gross Domestic Product
GIIP	Good International Industry Practice
H&S	Health and Safety
HCFC	Hydrochlorofluorocarbon
HDPE	High-density Polyethylene
HDV	Heavy Duty Vehicle
HEMP	Hazards and Effects Management Process
HFC	Hydrofluorocarbon
HHK	House Hold Kerosene
HUB	Hydrocarbon Utilising Bacteria
HUF	Hydrocarbon Utilising Fungi
IFC	International Finance Corporation
IMDC	International Marine & Dredging Consultants
IPECA	International Petroleum Industry Environmental Conservation Association
ISGOTT	International Safety Guide for Oil Tankers and Terminals
ITCZ	Inter-Tropical Convergence Zone

Abbreviation	Explanation
ITD	Inter-Tropical Discontinuity
KP	Kilometre Point
LGA	Local Government Area
LRP	Livelihood Restoration Plan
MARPOL 73/78	International Convention for the Prevention of Pollution From Ships (Marine pollution)
MDG	Millennium Development Goals
MOU	Memorandum of understanding
ND	Not detected
NDDC	Niger Delta Development Commission
NEPZA	Nigeria Export Processing Zones Authority
NESREA	National Environmental Standards and Regulation Enforcement Agency
NGO	Non-Governmental Organisation
NM	Nautical Mile
NNPC	Nigeria National Petroleum Corporation
NOAA	National Oceanic and Atmospheric Administration
Nox	Nitrogen Oxides
NPA	Nigerian Ports Authority
NPC	National Population Commission
NWB	Nigeria West Belt
OCIMF	Oil Companies International Marine Forum
OKFTZ	Olokola Free Trade Zone
OSCP	Oil Spill Contingency Plan
OSR	Oil Spill Response
PAH	Polycyclic Aromatic Hydrocarbons
PAP	Project Affected Person
PDA	Project Development Area
PDCP	Public Disclosure and Consultation Plan
PLEM	Pipeline End Manifold
PM10	Particulate Matter smaller than 10 micrometres
PMS	Premium Motor Spirit (gasoline)
PPE	Personal Protective Equipment
PPM	Parts-Per-Million
PPP	Public-Private-Partnership
PRA	Participatory Rural Appraisal

Abbreviation	Explanation
PS	Performance Standard
PTW	Permit to work
QoL	Quality of Life
RAP	Resettlement Action Plan
RH	Relative Humidity
ROW	Right of Way
SIA	Social Impact Assessment
SLA	Sustainable Livelihood Assessment
SOLAS	International Convention for the Safety of Life at Sea 1974
SPC	Special Purpose Company
SPM	Single Point Mooring
STI	Sexually Transmitted Infections
TBA	Traditional Birth Attendant
TDS	Total Dissolved Solids
THB	Total Heterotrophic Bacteria
ToR	Terms of Reference
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
UK HSE	UK Health and Safety Executive
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States of America
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator (UTM) geographic coordinate system
VIP	Ventilated Improved Pit (Toilets)
VOC	Volatile Organic Compounds
WD	Water Depth
WGS	World Geodetic System 1984 (WGS 84)
WHO	World Health Organization
WS	Western Sector

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EXECUTIVE SUMMARY

0-1 INTRODUCTION

Dangote Group is one of the most diversified business conglomerates in Africa with a hard-earned reputation for excellent business practices and quality products with its operational headquarters in the bustling metropolis of Lagos, Nigeria in West Africa. The Group's activities encompass: Cement Manufacturing, Sugar Manufacturing, Salt Refining, Pasta Manufacturing, Noodles Manufacturing, Poly Products, Port Management and Real Estate. In a bid to enhance the nation's agricultural growth especially in the area of food security, Dangote Group is venturing into the manufacturing and marketing of fertilizers.

0-2 OVERVIEW OF THE PROJECT

The proposed Fertilizer complex consists of Ammonia and Urea plants with associated facilities and infrastructures. The complex envisages

- 2 x 2,200 MTPD Ammonia Plants based on HTAS technology;
- 2 x 3,850 MTPD Melt Urea Plants based on Snamprogetti technology;
- 2 x 3,850 MTPD Urea Granulation Plants based on Uhde Fertilizer Technology;
- A Captive Power plant comprising of three steam turbine generators of 40 MW capacity each, and
- 3 No. auxiliary boilers for 40 ata steam generation of 200 te capacity each.

In accordance with the Nigerian Environmental Impact Assessment Act 1992, the World Banks Operational Policy 4.01: Environmental Assessment (1999, revised April 2012) and the Equator Principles amongst others, an environmental and social impact assessment (ESIA) study is mandatory to these projects.

0-3 OBJECTIVES OF ESIA

The objectives of this ESIA are to:

- Acquire baseline data of the environment as well as the socio-economic and health conditions in a bid to characterize the project area;

- Determine and evaluate the potential impacts of the activities proposed in this project on the environment, on the level of the complete project.
- Establish the existing ecological and socio-economic conditions of the area;
- Establish the environmental/socio-economic and health sensitivities of the area to the new project;
- Identify, evaluate and predict the impacts of the project on the environment including socio-economic aspects with adequate interfacing and project interaction;
- Develop control strategies with a view to mitigating and ameliorating significant impacts which the project would have on the totality of measurable environmental characteristics;
- Recommend appropriate mitigation measures and monitoring activities, and
- Develop an Environmental and Social Management Plan (ESMP) that will ensure environmental sustainability throughout the project life span.

This ESIA takes into account the general framework laid down in the generic ESIA of the Lagos Free Zone, but focuses on the project area of the Dangote Fertilizer Plant.

0-4 THE PROJECT PROPONENT

Dangote Group, as a company was established in 1981 in Lagos to trade in cement and basic food in Nigeria. In 1999, Dangote Group started to substitute import and trading activities by local manufacturing in the model of emerging countries beginning with cement plants. Today, the Group is the largest manufacturing company in Africa with operations in 14 countries. Across all its activities, Dangote Group consolidates over $3 billion revenue per year and employs more than 25,000 employees.

0-5 TERMS OF REFERENCE

The major features in the Terms of Reference (ToR) of the Environmental and Social Impact Assessment (ESIA) for the Dangote Fertilizer Project as approved by the Federal Ministry of Environment (FMEnv) in line with the EIA Procedural Guidelines (FEPA, 1995) include:

- Qualitative and quantitative characterization of the baseline physical, chemical, biological and socio-environmental conditions of the project area prior to the commencement of the proposed project activities;
- Identification and assessment of potential impacts of the proposed project on the project area and adjacent locations;
- Recommendation of practical and cost effective mitigation plans to limit or completely eliminate any negative impact, and
- Recommendation of practical cost-effective post developmental EMP.
- Preparation and submission of a detailed EIA report which will form the basis for the issuance of an EIS and the final approval certificate by FMEnv.

0-6 PROJECT LOCATION

The proposed Dangote Fertilizer Plant is located on a site in the Lekki Free Zone. The Zone can be reached from a road that branched off from Lagos – Epe Expressway). It is situated on a parcel of land that is approximately 160 Ha in size and is located in the South East quadrant which lies in the South East portion of the LFZ. Lekki Free Zone (LFZ) is located in the Lekki Peninsula which is in the South Eastern part of Lagos State, the economic nerve centre of Nigeria. The Zone abuts the vast Atlantic Ocean in the south, and the quiet and graceful Lekki Lagoon in the north. Its geographical location is strategic as it is 60 km away from the centre of Lagos, 70 km away from Murtala Mohammed International Airport, about 8 km away from the proposed Lekki International Airport and 50 kilometres away from the Apapa Port, the largest port in West Africa.

0-7 ADMINISTRATIVE AND LEGAL FRAMEWORK

The legal and administrative framework, within which the ESIA for the Dangote Fertilizer Plant Project is executed, is entrenched in the broader framework of the National, State policies, laws and regulations. It also draws extensively from international standards and conventions. Some of the national and state environmental and social laws and regulations including international standards and conventions reviewed and adopted for this project include:

- The National Policy on Environment (1989, revised 1999)
- The National Guidelines and Standards for Environmental Pollution Control in Nigeria
- The National Effluent Limitation Regulation
- The Pollution Abatement in Industries Generating Wastes Regulation
- The Management of Hazardous and Solid Wastes Regulation
- The Environmental Impact Assessment Act No. 86 of 1992
- The Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN, 1991), revised 2002
- The Water Resources ACT, CAP W2, LFN 2004
- The Nigerian Free Zone Act (Act No. 63 of 1992)
- IFC Performance Standards for Environmental and Social Sustainability, 2012;
- The World Bank Operational Policy 4.01 – Environmental Assessment, 2011;
- The AfDB Integrated Environmental And Social Impact Assessment Guidelines, 2003;
- The Equator Principles, 2003/2006/2011.
- The Convention on Biological Diversity (1992)

0-8 PROJECT JUSTIFICATION

For well over four decades, Nigeria has run a mono-product economy. The country needed to envision and evolve a nation beyond oil else it could go into an economic oblivion. Nigeria, which earns more than 90 percent of the nation's export earnings and about 80 percent of government revenue from its oil industry, has seen decline in oil production and revenues in recent times. In the recent years, data released by Nigeria's Central Bank, has shown that oil production has been lower than the barrel per day (bpd) assumption used by the government for the purpose of revenue calculation in the annual budgets. In addition, the unfolding scenario of declining prices of crude oil globally and the challenges confronting local production has made it imperative to diversify the economy. Nigerian economy as currently structured is very vulnerable to external shocks. The country has allowed the easy money from oil to strangulate other cash cows like agriculture, solid minerals, tourism and many others

The backbone of any agricultural revolution is access of farmers to modern agricultural inputs, especially fertilizers and seeds. The decision by Dangote Group to establish an Ultra-Modern and large scale Fertilizer Plant in LFZ is apt and will go a long way at enhancing government policy of ensuring easy access to this product among farmers. The proposed Dangote Fertilizer project constitutes a bold attempt at meeting the following challenges confronting the fertilizer sector in Nigeria. They include:

- The need to improve farm income and contribute to GDP growth through increased and improved use of fertilizer by the farm population;
- The need to improve agricultural competitiveness through higher crop yield resulting from fertilizer use;
- The need to improve on nutrient use efficiency at farm level;
- The need to contribute to the protection of the environment;
- The need to utilize locally available raw materials for fertilizer production;
- The need for quality assurance in fertilizer marketing and use, and
- The need to contribute to employment

Other positive benefits of the Dangote Fertilizer project in Nigeria include the following:

- Consumption of the huge locally available natural gas which is the main plant input and which is hitherto being flared;
- The massive reduction of gas flaring in the country will lead to a reduction of the GHGs in the atmosphere;
- Increase in national production of fertilizers;
- Improvement of the captive communities through the application of the project's Corporate Social Responsibility (CSR) programme, and
- Making Nigeria to become a hub for West-Africa in fertilizer production.

In addition, findings from the EIA process that were conducted on the Dangote Fertilizer Plant indicate that there are no issues of major or moderate significance that could not be mitigated such that the proposed project was not acceptable from an environmental and/or socioeconomic perspective. The overall assessment of the potential and associated impacts of the Dangote Fertilizer Project indicated that it would impact positively on the economy of the stakeholders, host communities, Lagos State and Nigeria in general.

0-9 PROJECT DESCRIPTION

The product expected from Dangote Fertilizer Project is 7700 MT per day of Granulated Urea. The basic functional components of the complex include:

- The **Process Units** which consists of the following: Ammonia Plant Train 1: 2200 MTPD Ammonia; Ammonia Plant Train 2: 2200 MTPD Ammonia; Urea Plant Train 1: 3850 MTPD Urea; Urea Plant Train 2: 3850 MTPD Urea;Urea Granulation Plant Train 1: 3850 MTPD Granulated Urea andUrea Granulation Plant Train 2: 3850 MTPD Granulated Urea/

- **Utility Units** made up of the following: Water Treatment Plant, Steam and Power Generation,Cooling Water System, Natural Gas System, Nitrogen Production System, Instrument and Plant Air System, Potable Water System, Emergency and Power Diesel System, Effluent Treatment System and Fire Fighting System.

- **Offsite Units** with the following components: River Water Pre-treatment and Launching System, Ammonia Plants Flaring System, Ammonia Storage System 20000 MT and UFC Storage System

- **Bulk Urea** Handling Units with the following sub units: Urea Bulk Storage, Urea Handling System and Urea Bagging and Truck Loading System.

Basically, fertilizer Production involves ammonia, urea and granulator processing.

0-10 ENVIRONMENTAL BASELINE DESCRIPTION

In the process of studying the existing environmental conditions of the proposed project site, the baseline information on the area were obtained through field sampling and measurements, observations, as well, as physical, chemical and biological laboratory analysis of water and soil samples collected from the project area including literature research. The socio-economic and health conditions in the project community was also surveyed and documented. The approved one season data gathering campaign was carried out between 8th to 11th of July, 2014 (Wet Season). The study also reviewed literature and existing data from previous studies in the area and from similar ecosystem for benchmarking.

0-10-1 Study Approach

The baseline status of the project area was obtained through; consultations with the relevant stakeholders as well as from field studies covering the following:

- Initial review of existing data sets and literature on the proposed Project Area;
- Reconnaissance survey;
- Field studies including air, surface water, sediment, soil and vegetation sampling;
- Geophysical investigation and groundwater sampling;
- Field analysis and sample preservation;
- Laboratory analysis of samples
- ;Socio-economic and health studies;
- Data processing, analysis and interpretation; and
- Reporting

0-10-2 Consultation

Prior to field sampling, meetings were held with the relevant stakeholders like the community heads, heads of other community groups and all National, State and Local Government regulatory authorities' representatives to intimate them of the project and seek their consent to carry out the field data gathering. Consultation is an important element of socio-economic assessment and an integral component of the entire EIA process.

0-10-3 Field Sampling

A one-season (wet season) fieldwork was embarked upon for the baseline data gathering. The multi-disciplinary field study approach involved data acquisition on air quality and microclimate, soil quality, surface and groundwater quality, sediment and aquatic ecology, vegetation and wildlife, land use, geology/geophysics/ hydrogeology, socio-economics and health issues within the project influence zone. A team of experts and a Representative of the Federal Ministry of Environment (FMEnv), Abuja, participated in the field study.

0-11-4 Environmental Status of the Project Area

0-10-4-1 Biophysical Environment

Climate Conditions and Air Quality

Meteorological conditions at the study area are important as gaseous emissions from the processing plant and other facilities generating gaseous emissions may be dispersed from, or confined to, the local area depending on the weather conditions. Thus micro-meteorological conditions play an important role in assessing the air quality impacts of the proposed project.

Sampling and measurements of meteorological parameters and chemical constituents of atmospheric pollutants were carried out *in-situ* using mobile Meteorological Station and hand-held air quality monitoring equipment. Other parameters that were considered as critical to this study include: rainfall, air temperature, pressure, wind speed and direction, relative humidity, and radiation.

The measured daily averages of relative humidity, temperature and wind speed within the proposed project site during the field data gathering indicates that the average relative humidity ranged from 81 - 84% during the period of measurement while air temperature is observed to be between 22 - 24^{o}c during the same period. The average pressures of the atmosphere measured for the three day observation were between 756 mmHg and 759 mmHg. The maximum average daily wind speed was observed on 11th July with a magnitude of 2.71 m/s. Wind direction is dominated with Southwesterlies during the *in situ* observation period. However, in the earlier hours of the day wind direction are predominantly north westerlies.

Air Quality/Noise Level

The baseline ambient air quality of the project area investigated at selected locations during the fieldwork exercise shows that concentrations of ammonia (NH_3), nitrogen dioxide (NO_2), carbon monoxide (CO), volatile organic compounds (VOCs), sulphur dioxide (SO_2) and hydrogen sulphide measured in all the sampling stations and the control station were found to be below instruments detection limits. The concentration of total suspended particulates (TSP), however, varied spatially over the selected stations, ranging between 3.20 µg/m^3 and 8.49 µg/m^3 (Mean: 5.73 ± 1.88 µg/m^3). The control station also recorded value (5.47 – 6.18 µg/m^3) within the range observed for the project area. The mean concentration of SPM recorded in the current study was below Nigerian ambient air quality standards (NAAQS) of 250 µg/m^3 (daily average of hourly values) and 600 µg/m^3 (concentration not to be exceeded for more than once a year)

The baseline ambient noise levels measured during the field study exercise at selected sampling stations within the project zone of influence revealed that the noise levels within the project area during the field study were generally low with average minimum ranging from 37.40 – 44.70 dBA and average maximum value of 49.50 – 59.80 dBA. The values recorded at the control stations were slightly higher than what were recorded at the project zone of influence possibly due to their close proximity to the road. Generally, noise levels recorded at the monitoring stations were lower than the 90 dBA FMEnv limit.

Land Use

The proposed Dangote Fertilizer Plant site lies within the mangrove forest zone of Nigeria. It covers an area of 150 Hectares and is located closest to the Lekki Lagoon. The site is featured with flat topography and beautiful scenery. Fishing and farming constitute the major land use activities in the project area. The various land uses identified in the study area include Oil palm (Elaeisguineensis) plantation, citrus plantation, Raffia plantation, crop farming to cultivate plantain, banana, cassava(Mahihotesculentus), rice, pepper, tomatoes, maize and leafy vegetables. Other notable land uses include fishing for fishes, shrimps and crabs. Logging activities also dominates the entire forests. Changing economic consideration and massive industrial drive of the Lagos State Government in the recent times has occasioned a notable and spectacular change in the land use pattern of the area. The development of the area as Lekki Free Zone had attracted multinational companies to invest in the area and this trend is fast changing the land use pattern in the Lekki freshwater swamp forest from farm based activities to highly industrial one. Building of residential houses, hotels, office complex and factories are some of the apparent changes in land use pattern observed around the study area

Soil Quality

The results of soil physico-chemical analysis for for the topsoil (0 – 15 cm) and subsoil (15 – 30 cm) respectively for all the sample locations revealed the two soil depths within the study area and control site was predominantly fine-grained consolidated Loamy Sand soil. The sand, clay and silt contents of the topsoil ranged from 68.80 - 79.80%, 12.20 - 19.20% and 8.00 - 12.50% respectively, while the subsoil recorded values ranging from 69.2 - 80.10% sand, 11.2 - 18.30% silt and 8.00 - 14.90% clay. The soil reaction falls within acidic pH range of 4.04 - 5.51 (topsoil) and 4.04 - 5.40 (subsoil). The respective values for the control stations were 5.51 and 5.64 for top soils and 4.26 and 5.39 for subsoil. Spatial variations in measured values were also low (CV <12%) for both topsoil and subsoil The Organic matter content of the topsoil was high, ranging from 3.27 - 5.14% and for the subsoil. Total nitrogen (N) and ammonium (NH_4^+) ions contents of the soil ranged from 0.14 - 0.42% and 1.15 - 2.97 mg/kg respectively for topsoil, and 0.06 - 0.32% and 0.65 - 2.97 mg/kg) respectively for subsoil. The observed nitrogen levels in both soil depths fall within medium to high soil fertility rating.

Total phosphorus (P) contents of the topsoil and subsoil were within low to medium soil fertility classification. The values ranged from 3.97 - 12.34 mg/kg for topsoil and 4.12 - 12.56 mg/kg for subsoil. Low sulphate (SO_4^{2-}) and chloride (Cl^-) ions concentrations were recorded in the soil samples with values ranging from ranging from 3.65 – 7.11 mg/kg and 1.40 – 1.72 mg/kg respectively for topsoil, and 3.40 – 8.38 mg/kg and 1.35 – 1.96 mg/kg respectively for subsoil. Values recorded from the control stations were also within what was obtained for the proposed project influence zone. The exchangeable cations contents in both the topsoil and subsoil were high ranging from 0.34 - 0.69 cmol/kg (Na^{+}), 0.75 - 3.02 cmol/kg (K^{+}), 1.2 - 2.20 cmol/kg (Ca^{2+}) and 1.45 – 2.00 cmol/kg (Mg^{2+}). The exchangeable acidity ranged from 2.20 - 5.20 cmol/kg, while the cation exchange capacity (CEC) and base saturation ranged from 47.10 - 74.75% respectively. Values recorded for the topsoil for these cations were in most cases higher than those obtained for the subsoil. Values from the control stations were also within the range recorded for the project zone of influence.

The summary of results of oil and grease, total petroleum hydrocarbon, BTEX and polycyclic hydrocarbons concentrations measured in the soil samples across the project zone of influence and control stations indicated that oil and grease content of the soil ranged from 10.24 - 12.63 mg/kg (topsoil) and 10.62 - 12.88 mg/kg (subsoil), while total petroleum hydrocarbon (TPH) content ranged from 9.47 - 11.55 mg/kg (topsoil) and 9.45 - 11.72 mg/kg (subsoil). All the heavy metals analysed showed measurable concentrations except mercury (Hg) with concentration below instrument detection limit (<0.01 mg/kg). Iron (Fe) recorded the highest concentrations (354 – 458 mg/kg topsoil and 369 – 440 mg/kg subsoil).

Heterotrophic bacteria analysis revealed total viable count of 1.11 – 2.38 x 10^{5} cfu/g (topsoil) and 1.04 – 2.67 x 10^{5} cfu/g (subsoil), while hydrocarbon degraders constituted about 5.50% (topsoil) and 2.50% (subsoil). The most predominant organisms among the isolates are the Bacillus sp, Rhizobium sp, and Micrococcus sp. Fungi determination in the soils revealed total heterotrophic fungi ranging from 0.17 - 1.26 x 103 spore/g (topsoil) and 0.11 - 1.40 x 103 spore/g (subsoil).. The hydrocarbon utilizing fungi isolate only accounted for 4.12% and 2.55% f or the topsoil and subsoil respectively. Most predominant among the fungi isolates.

Geology, Geomorphology and Hydrogeology of Project Area

Two stratigraphic units constitute the major aquifer systems in the study area.

(i) **The Alluvial:** This unit occurs as lenses of sands within less permeable beds of silt and clays. Aquifers occurs at shallow depths, with very erratic lateral extent. Alluvial aquifers in this environment are very susceptible to pollution since they occur mostly at shallow depths and in many locations have direct contact with surface runoff and river waters. There is also the likelihood of saline intrusion into alluvial aquifer systems in the area due to the distance of the site to the shoreline.

(ii) **The Benin Formation:** This stratigraphic unit constitutes the main aquifer system in most parts of the Dahomey Basin. Benin Formation is significantly thick. Its lithologic composition is mostly sand and sandstone (about 90%) while clays and lignitic beds constitute about 10%. The Benin Formation constitutes a large continuous aquifer system with enormous storage capacity.

Topographically, Lagos state lies entirely within the coastal plain which is characterized by sand bars, lagoons and creeks. The land does not rise very much above sea level anywhere in the state. At the project area, the average elevation is about 7m. The rivers, creeks and lagoons in the state ramify and join each other in a rather intricate fashion.

Groundwater and surface water are fundamentally interconnected. It is often difficult to separate the two because they feed (complement) each other. The source of groundwater (recharge) is through precipitation or surface water that percolates downward. Hence, one can contaminate the other. The concept of aquifer vulnerability derives from the assumption that the physical geologic materials may provide some level of protection to groundwater, especially with regard to pollutants infiltrating from the surface. Consequently, the lithologic variations and the thickness of the unsaturated zone (vadose zone), constitute the focus in aquifer vulnerability assessment. In the study area, the depth to static water level (water table), an approximation of vadose zone thickness, ranges from 0.37 m in borehole 3 to 0.80 m in borehole 2. Based on index rating for depth to groundwater, the vadose zone thickness falls within the high vulnerability rating, thus suggesting that the near surface aquifers in the area are vulnerable to contaminants deriving from surface activities.

The aquifer systems in the area are poorly/weakly protected, consequently, the aquifer units in the area are vulnerable to polluting or contaminating fluids infiltrating from the surface.

Groundwater Quality

The result of the physico-chemical characteristics of groundwater within the Dangote Fertilizer proposed project area compared with the reference boreholes from the adjacent proposed Fertilizer site and control borehole revealed that the pH (11.14) showed high alkalinity value far higher than the Guideline values of 6.5 – 8.50 for drinking water. The pH value also reflects the intrusion of seawater to the water table due to close proximity to sea. The alkalinity showed the presence of carbonate and bicarbonate alkalinity, with carbonate ions and total alkalinity of 139.60 mg/L and 620 mg/L$CaCO_3$ respectively. Salinity as chloride (Cl^-) (243.5 mg/L) recorded in the groundwater sample was high confirming its saline condition of the water table, compared with what were recorded at the Refinery site. Sulphate (SO_4^{2-}) and nitrate (NO_3^-) levels recorded in the borehole water were 157.20 mg/L and 28.30 mg/L respectively. These values were, however, lower than WHO limits for drinking water. Phosphate (PO_4^{3-}) and sulphide (S^{2-}) ions were below instrument detection limit (<0.01 mg/L).

The groundwater samples recorded low biodegradable and oxidisable matters content as reflected in the BOD and COD values. The oil and grease (O&G) values measured was 2.24 mg/L, while the total petroleum hydrocarbon value was 1.95 mg/L which is higher than DPR Target and Intervention values for mineral oil in groundwater. BTEX content of the groundwater were below instrument detection limit, while measurable levels of polycyclic aromatic hydrocarbon were recorded in the groundwater sample.

Heavy metals determined in the groundwater samples showed varied concentrations with Cd, Hg and V having values below instrument detection limits (<0.001 mg/L). The concentration range of other metals are in the order of Fe> Mn> Ni > Zn> Cr > Pbr = Cu. Copper and zinc recorded concentrations lower than their maximum allowable limits in drinking water, while Cr, Fe, Mn, Ni and Pb were present at higher concentrations than the WHO guideline levels in water.

The summary of microbial characteristics of groundwater samples from the proposed fertilizer project area showed that the total heterotrophic bacteria and hydrocarbon degraders (HUB) determined were 0.68 x 10^5 cfu/ml and 1.41 x 10^3 cfu/ml respectively. The hydrocarbon degraders (HUB) constituted 2.07%. Coliform and fungi were not recorded in the sample, showing no growth. Most prevalent among the bacteria isolates are Bacillus sp. and *Micrococcus luteus.*

Surface Water

Surface water hydrology is required for an understanding of the movement of potential pollutant inputs and their relationship with the water body. The Lekki lagoon which constitutes the main inland river within the influence zone of the Fertilizer project. The river is perennial and navigable all the year round. It was observed that the flood levels vary between the dry season and the rainy season. Discharge into the river may have significant effect as pollutants input in the river will speedily arrive at the downstream target area.

The surface water temperature ranged from 28.80 - 29.20 ^{0}C with very low spatial variation (CV = 0.96%), which is attributable to the different period of sample collection and measurement. The colour of the surface water was amber with the high colour units ranging from 23.00 - 28.00 Pt/Co units and could be attributed to run-off into water bodies with high-entrained suspended particles and coloured substances, predominantly of organic origin and, decomposed vegetation in the water body. Colour values obtained from the control stations were also within the range recorded within the project influenced zone. The electrical conductivity values of the surface water were low ranging from 100 – 110 µS/cm, with low spatial variation (CV = 5.22%). Classification of potability based on electrical conductivity ascribes <325 µScm^{-1} for fresh and potable water, hence the surface water body is considered fresh.

Total suspended solid (TSS) in the surface water ranged from 116.0 mg/L to 140 mg/L The observed high value recorded could be as result of influx of runoff into the water body during the period of study (raining season). The pH of the surface water body was within the acidic range with values between 5.86 and 6.22. Total hardness of the surface water samples ranged from 84.6 - 88.3 mg/L$CaCO_3$ with a mean value of 86.27 mg/L$CaCO_3$. Values obtained from the control stations were also within the range. Classification of the water quality of the lagoon by hardness showed a moderately soft water body. Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD) levels in the surface water ranged from 5.67 - 6.41 mg/L, 1.20 - 2.25 mg/L and 12.60 - 16.20 mg/L respectively. Low salinity (measured as chloride), nitrate, sulphate and phosphate were measured in the lagoon water sample. The respective, chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-) and phosphate (PO_4^{3-}) concentrations in the water bodies were 61.70 – 102.80 mg/L, 13.50 - 29.00 mg/L and 1.09 - 1.90 mg/L, while sulphide (S^{2-}) ion was not detected in the water body.

Oil and grease values recorded in the water body ranged from 2.77 - 4.36 mg/L Oil and grease are made up of hydrocarbon oil of both petrogenic and biogenic origin; fats, oils and waxes of both plant and animal origin, all of which must have contributed to the measured oil and grease in this study. However, total hydrocarbons (THC) contents measured in the water bodies were very low, ranging from 2.04 - 3.97 mg/L. Correspondingly, low values of polycyclic aromatic hydrocarbons (PAHs) were recorded in the water bodies. Benzo(a) pyrene, naphhthalenee and Benzo(k) fluoranthene showed the highest concentrations of 0.065 µg/L, 0.035 µg/L and 0.030 µg/L respectively, while other measured PAHs showed concentrations less than 0.030 µg/L.

Heavy metal analysis in the surface water samples revealed low concentrations below the acceptable limits in drinking water. The order of concentrations in the water samples was Zn > Fe > Cr > Ni > Cu > Mn > Pb, while Cadmium (Cd) and mercury (Hg) were below instrument detection limit.

The heterotrophic bacterial counts ranged from 0.75×10^4 - 2.80×10^4 cfu/ml. Values obtained from the control points also fell within this range. The coliform and *E.coli* count ranged from 0.58×10^3 - 2.10×10^3 MPN/100ml and NG - 0.32×10^3 MPN/100ml respectively. The hydrocarbon degrading bacteria count ranged between 0.50×10^3 cfu/ml and 1.29×10^3 cfu/ml constituting 9.89%. The predominant bacterial species were, *Pseudomonas*, Bacillus sp. and Proteus sp. Total heterotrophic fungal counts in the water samples ranged from NG - 0.57 x 10^3 Spore/ml, with petroleum degrader (NG - 0.45 x 10^2 Spore/ml) constituting 5.0%. Predominant among the fungi isolates were *Aspergillus niger and Mucor mucedo.*

Sediment Study

The particle size of the sediment samples showed sand (49.8 - 54.80%)> clay (22.8 - 29.3%) > silt (16.0 – 24.0%). Low spatial variations (CV 3.31 – 14.37%) among sampling points within the study area as well as the control stations was recorded. The pH values of the sediment samples were in the acidic range of 5.07 – 5.25. Values from the control stations were also within the range recorded for the project influence zone. The low pH condition may affect metal speciation and enhance metals' solubility and possible leaching into the water column. The conductivity of the sediment solution ranged between 1.04 mS/cm and 1.30 mS/cm, showing high dissolved ions that may from time to time get leached into the water column. Some of the ions may be beneficial or otherwise to benthic organisms in the water body.

Total organic matter contents of 5.21 - 6.02% were recorded in the sediment samples, with the lowest value from sediment with high sand content. The nutrient content, nitrogen and phosphorus in the sediment samples ranged from 0.88 - 1.86% and 0.48 - 2.77 mg/kg respectively. While spatial variation of nitrogen levels (CV = 33.01%) along the course of the Lagoon was moderate, high spatial variation (CV = 64.53) was recorded for phosphorus distribution in sediment along the river course. The order of magnitude of exchangeable cations' concentrations in the sediment samples were: Ca^{2+} (3.10 - 5.30 cmol/kg) > K^+ (3.68 - 4.90 cmol/kg) > Na^+ (2.92 - 4.52 cmol/kg) > Mg^{2+} (3.10 - 4.20 cmol/kg). The exchangeable acidity and cation exchange capacity of the sediment sample ranged from 4.50 - 5.60 cmol/kg and 19.90 - 23.24 cmol/kg respectively.

Heavy metals analysed in the sediment were arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), iron (Fe), mercury (Hg), lead (Pb), nickel (Ni), vanadium (V) and zinc (Zn). All the metals showed measurable concentrations with Fe recording very high concentration (1317 – 1370 mg/kg). The order of concentrations of other heavy metals in the sediment were: Zn > Ni > Pb > Cr > Cu > As > V > Cd > Hg. The concentrations of these metals from the control stations were not significantly ($p>0.05$) different from that of the project influence zone. The levels of these metals in the sediment samples were below their Target values, thus showing that the rivers' sediment was not polluted with heavy metals during the period under review.

Oil and grease in the sediment, which constitute the hydrocarbon content, fats and waxes from both plant and animal origin ranged from 29.84 mg/kg to 34.40 mg/kg, while total hydrocarbon content ranged from 32.35 - 35.62 mg/kg. Distribution of these pollutants across the sampling stations and the control was more or else even across (CV < 4.0% respectively), showing that they are possibly from the same source of which biogenic origin is most probable, while anthropogenic input is also likely.

Benzene, toluene, ethylbenzene and xylenes (BTEX) concentrations were below instrument detection limit, thus, showing that the sediment was not polluted with petroleum products. The total petroleum hydrocarbon values obtained in this study were also lower than 50 mg/kg DPR Target value. The 16 PAHs analysed in the sediment samples showed measurable concentrations in all the sampling stations, with $PAHs_{Total}$ ranging between 32.52 µg/kg and 50.46 µg/kg with Benzo(a) pyrene and Phenanthrene showing highest concentrations.

The heterotrophic bacterial counts ranged from 1.73×10^5 - 2.99×10^5 cfu/g with values greater than what were obtained for the water column. Values from the control stations were also within the range recorded for the project area. The hydrocarbon degrading bacteria count ranged between 0.20×10^4 cfu/g and 2.49×10^4 cfu/ml constituting 8.67%. The predominant bacterial species were *Pseudomonas sp. and Bacillus sp.* The heterotrophic fungal counts in the sediment samples ranged from 0.68×10^3 - 1.42×10^3 Spore/g, with petroleum degrader ranging from 0.12×10^3 - 0.56×10^3 Spore/g, constituting 34.55%. Predominant among the fungi isolates were Penicillium sp.. Predominant among the fungi isolates were *Aspergillus sp.*, *Mucor mucedo,* and *Penicillium notatium.*

Hydrobiology

Planktons refer to the large class of microscopic organisms (2 -200 micrometer) that are carried around by the water current in any natural body of water. Biologists have divided plankton into two (2) classes; phytoplankton and zooplankton. The phytoplankton is free-floating organisms of the water body that undergo photosynthesis with the help of chlorophyll and thereby contribute to primary production in their endemic aquatic environment. The zooplankton on the other hand is animal component of the plankton spectrum.

The phytoplankton recorded 4 (four) group of species. They were the Diatoms (Division – Bacillariophyta), Blue-green algae (Division – Cyanophyta), Euglenoids (Division - Euglenopohyta) and Chlorophytes (Division – Chlorophyta). The dominant group of phytoplankton was the Diatoms, followed by the Blue-green algae and then the Chlorophytes and then the Euglenoids. Whereas the Diatoms, recorded 55% (Centrales – 22.5% - 9 species, Pennales – 32.5% - 13 species), Blue-green algae (22.5%, 9 species), Chlorophytes (12.5% - 5 species) and Euglenoids reported 10%, 4 species In all a total of forty (40) species were recorded at the 8 stations studied. Total number of species recorded per station ranged between 21 and 29.

The zooplankton recorded 3 (three) groups of species for the zooplankton (Holoplankton and Meroplankton forms). They were Phylum – Crustacea, Phylum - Rotifer and the Juvenile stages. The dominant group of zooplankton was the Phylum – Crustacea, followed by the Rotifers. Whereas the Crustaceans recorded 46.7% (Calanoid Copepods, 4 species 26.7% and Cyclopoids, 3 species – 20%), Rotifers (40% - 6 species) and Juvenile stages reported 13.3%, The juvenile stages were represented by one form namely: Rotiferan egg.

The macrobenthic fauna consisted of 5 taxa belonging mainly to three phyla, viz: phyla mollusca (3 taxa), chordata (1 taxa) and insect (1 taxa). The percentage distribution indicated that class insects dominate by 40%, followed closely by class bivalvia (30%), class gastropoda (29%) and the least piesces (1%). the dominant species include *Chironomus sp.* and *Melonoides tuberculata.*

Fisheries Studies

The entire lagoon creek system (Lagos – Lekki – Omu Creek – Mahin Lagoon) constitutes the major coastal feature of southwest Nigeria. Fishing is one of the major occupations of the people in the project area. Men, women and children alike are involved in this occupation. Artisanal or small scale fisheries using dugout canoes with or without motorized engines are the predominant fisheries of Lekki lagoon.

In this study, fisheries sampling was done between 10th and 11th of July, 2014.The types of fishing gears used in the area were examined, the fishermen operating in the area were approached and their catches were observed. The fish species were classified to family level using some available identification texts.

The fishing gears used by fisherfolks in this area were bamboo traps (Oparun), castnets (obiriki), gillnets (atafo), setnets (Atamu), pole and hooks (Poro), basket traps (Igun/ Ogun), long line (Ewoolokun), Manatee trap (Ipa), Net trap (Keteku) and liftnets (AwoSalapore).

From the assessment of the fishermen catch from the Lekki lagoon, *Chrysichthysnigrodigitatus* was the most abundant species followed by *Tilapia guineensis.* The catch ranged between 4 -7 kg/day/person. This is to say between 125 – 175 kg/month/person; although this catch varies from season to season. The fishermen also alleged that the low catch is primarily as a result of activities of the sand mining activities within the area, which have destroyed the nursery ground of the fishes. In term of the health status of the catch, that is the condition factor, which is the index of the fatness or wellbeing of a species, it can be said that the fishes were healthy.

The major fishing problems in Omu Creek and Lekki Lagoon are crab (*Callinectes amnicola*) attack on gillnets, theft of lead sinkers by other fishermen, net destruction by both inboard and outboard engines used for logging and transportation in the area and water hyacinth (*Echhornia crassipes*) infestation that destroy floating nets.

0-10-4-2 Terrestrial Ecology

Vegetation

A total of 78 plant species belonging to 33 families and comprising of trees, raffia palm, oil palm, ferns and herbs were encountered within the site of the proposed Dangote Refinery. The families with the highest frequency of species include *Rubaceae, Euphorbiaceae, Ulmaceae, Apocynaceae, loganiaceae, Guttiferae and Mimosoideae*. The most common species of the study area of Lekki freshwater swamp forest is the raffia palm (Raffia farinifera) which dominates the swamps. The better-drained area supports oil palm trees (Eleaisguinensis), coconut trees and vast array of valuable tree species which constitute the dominant layer of closed canopy with few and scattered emergent tree species. The ferns, few grasses and herbs constitute the understorey species and occupy the floor of the forest. Tree species that were occasionally encountered include *Macarangabateri, Capolobialutea, Lophiraalata, Picralimanitida, Anthocleistanobilis and Mitragynastipulosa,* while the rare species include *Fagaramicrophylla, Lophiraalata, Albiziazygia, Bambusa vulgaris, Uapacatogoensis, Strombosiapustulaca, Cassia nodusa and Baphianitida.* Herbs were predominantly abundant in the study area. They were represented by 48 species distributed among 21 families. The families Asteraceae was the most diverse with 5 species, followed by *Poaceae* and *Euphorbiaceae* with 4 species each.

Wildlife

Wildlife is important to the national economy both as a source of meat and as a basis for tourism and recreation. Wild animal meat is the main source of cheap protein in the majority of rural communities in Nigeria. The wildlife species associated with the study area are the invertebrates represented mainly by insects and the vertebrate animals represented by mammals, amphibians, reptiles and bird. The species of insects encountered in the study area include Mantis religiosa, Zonocerusvarigatus, Apismellifera, Acraeterpicore and others. Many species of animals in the mammalian category were associated with the study area of Lekki fresh water swamp forests. Some of the abundant species include Cercophitecusmona (Mona monkey), Thryonomysgregarianus (cane rat), Funiscinrus spp. Cephalophusmaxwelli (maxwells duiker), Choropsisliberiensis and others.

0-10-5 Socio-Economics Study

This study provides baseline information for assessing the cumulative positive and negative impacts of Dangote Fertilizer Plant project on the communities' social and economic livelihoods. In essence, the information provided by the study will to a large extent assist to reinforce strategies for maximizing the positive socio-economic impacts and simultaneously minimizing to the barest the negative effects of the proposed fertilizer plant in the Lekki Free Zone, Lagos state, Nigeria. The study was carried out using participatory assessment methodology, structured questionnaire, focus group discussions and interviews with key informants. This made it possible to assess the socio-economic status of the community, identify their needs and priorities for development. Based on the total number of housing units (3,920), 392 questionnaires were administered. This implies that 10% of the total number of housing units was surveyed. Thus, the questionnaires were administered based on the size of the communities. Considering the homogeneity of the population, this sample size is considered adequate. In administering the questionnaire, random sampling technique was adopted.

During field survey, the captive communities around DFL project that were enumerated are Idasho, Imobido, Olomowewe, Idotu, Okesegun, Ilege, Itoke, Magbonsegun, Okunraye, Okenata, Elekuru-Lasia and Okun Tiye. These communities are governed by traditional rulers otherwise called Baales. Each Baale rules his settlement with his Chiefs-in-Council. The council is responsible for all administrative, customary issues and conflict arbitration. Thus, in these communities, leadership structure is made up of the traditional rulers, religious leaders, youths and women leaders. In general, the project area is relatively peaceful as youth restiveness is hardly reported. Conflicts between and among communities are unusual. Wherever conflict occurs, the existing traditional norms and administration are sufficient to resolve them as evident by the few court cases ever reported in these communities.

In these communities, adult population (18–45 years) constitutes 50% of the total population. 10% are above 45 years while 40% are below 18 years. The implication of this is that the communities have able-bodied labour force that could participate actively in the various productive activities that will take place in Dangote Fertilizer Project. On the average, females constitute about 55% of the population in these communities.

The prominent forms of land ownership in the communities are family and personal land tenure. At the death of the family head, the family land is shared amongst the children. In these communities, males are mainly involved in fishing especially in the open sea, while the females are involved in fish processing and fishing in the immediate waters. Less than 20% of the population of people who have attained 18 years and above are gainfully employed, hence the unemployment rate is generally high in all the communities. Greater percentage of the youths in the communities claimed to be unemployed because those who are engaged in fishing and crop farming did not regard fishing and farming as their primary occupation.

Communities in the project area are grossly deficient with respect to social infrastructure. Most of the communities in the study area only have access to government owned primary while secondary school pupils in most of the communities travel distances of 3 – 4 to bigger communities to obtain secondary education. The manpower in virtually all the schools is inadequate with high teacher/student ratio of above 1:40. The schools also lack basic facilities like water supply and toilet. In addition, instruction materials are grossly inadequate. None of the communities in studied project area is linked with the national power grid line for electricity supply.

From the survey provision of electricity is given the highest priority in terms of community needs. Next is provision of portable water to reduce vulnerability to water borne diseases. In addition, construction and rehabilitation of the access roads was considered essential to facilitate intra mobility of goods and the people.

0-10-6 Health Study

The baseline public health assessment of Dangote Fertilizer project area reveals that the general health status of the area is grossly underdeveloped. The various health indices that were considered during the course of the study are at variance with WHO specifications on primary health care. In general, primary health care delivery system which is designed to meet various health challenges that are confronting people within the communities is appalling. Thus, basic health services such as antenatal care, immunization of children and adults, treatment of malaria fever and hypertension among others are generally lacking or poor in these communities.

The few existing health centres in the area are of poor quality both in terms of drugs, personnel and service rendered. Higher and quality health services could only be guaranteed at neighbouring but relatively distant communities that have general hospitals. This explains the high infant mortality rate and high rate of disease prevalence in these communities. Commonest diseases include Malaria Fever, Upper Respiratory Tract Infection, Typhoid Fever, Diarrhoea and vomiting and Hypertension. Others include Worm Infestation, Diabetes Mellitus, Lower Respiratory Tract Infection and Arthritis. In view of the lack of orthodox medical facilities, alternative medicine is often sought to confront these ailments. In addition, Traditional Birth Attendants (TBAs) are found in every community.

Access to safe water supply is precariously low in all communities. Most households rely on supplies from streams and rivers. Rain harvesting is practised and is one the major sources of drinking water. The few existing wells are usually uncovered. The scarcity of safe water is complicated by the intrusion of saline water from the Atlantic into the fresh water at certain times of the year. The dearth of safe water has further aggravated the prevalence of water borne diseases in the area.

Sanitation is unhygienic as open defecation is still in vogue in all communities. Waste management is rather too poor as wastes are disposed in open dumps, buried and burned indiscriminately.

Intervention in the health sector in these communities is critical for enhanced production. Most of the expected benefits accruing from government and development partners' interventions could easily be eroded if this sector is not adequately taken care of. It is therefore canvassed that governments (state and LGA) and development partners should consider this need as critical and therefore intervene without further delay.

0-11 IMPACT ANALYSIS, MITIGATION AND MANAGEMENT MEASURES

This ESIA has assessed the environmental and social impacts of the proposed project in line with the applicable standards. The study identified positive impacts as well as negative impacts. Livelihood and socio-economic development aspect of the project was a typical example of the positive impact. On the account of the recommended mitigation measures, the negative impacts were rated negligible, minor or moderate.

A summary of the qualitative impacts for the construction and operation phases and their residual significance having carefully considered the proposed mitigation and management measures is presented in Tables 0-1 and 0-2.

The proposed project site lies in the SE Quadrant of LFZ, located in mangrove forest swamps closest to Lekki Lagoon of Nigeria. In the area, there are currently no significant existing projects. Due to this, the potential impact of cumulative effects is insignificant. However, it was noted that the impacts of all the different future projects in the LFZ and the infrastructure development of the LFZ itself, are cumulative to each other.

All-encompassing environmental and social development plan had been developed for the proposed project. The plan characterizes envisaged impacts, highlights mitigation measures, chronicles monitoring indicators/parameters, frequency of monitoring and the party responsible for each action under the plan.

Based on the ESIA Team's site visits undertaken, only economic displacement will occur, due to the loss of fishing resources and the reduction of land resources especially for farming. Thus, a Livelihood Restoration Plan will be written to ensuring commensurate compensation to the host communities for loss of resources in line with IFC Performance Standards, in particular Performance Standard 5: Land Acquisition and Involuntary Resettlement (IFC, 2012a).

Table 0-1: Summary of Qualitative Impacts for the Construction Phase of the Proposed Project.

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Terrestrial Soils and Geology	Destabilisation of beach-dune system due to construction activities at the shore crossing	Moderate	• Demarcate work areas and minimise dune vegetation clearing • Use appropriate excavation, infill and trenching methods	Minor
Surface and Groundwater	Change in drainage patterns due to clearing and excavations	Moderate	• Proper placement of soil stockpiles • Design permanent drainage installations for heavy rainfall events. • Protect storm water channels from erosion	Minor
Surface and Groundwater	Impacts on water quality from spills and leaks and increased sedimentation	Moderate	• Bunding and containment measures • Use of Impervious concrete surfaces • Design and ensuring integrity of tanks to API standards • Installation of Cathodic corrosion protection • Trained personnel	Minor
Marine Water	Impacts on marine water quality and biodiversity as a result of routine and non-routine discharges	Minor	• Compliance with MARPOL requirements and other ballast management conventions.	Minor
Onshore Biodiversity	Loss and damage to terrestrial habitats and species	Moderate	• Wildlife surveys and implementation of recommended management measures • Minimise clearing • Demarcate work areas • Rehabilitate disturbed land	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Offshore Biodiversity	Loss and damage to marine habitats and species	Moderate	• Wildlife surveys and implementation of recommended management measures • Controlled movement of men and equipment during project phase • Minimise vessel movement	Minor
Noise and Vibration	Increased noise levels from onshore activities and equipment Effect of Noise from underwater infrastructure installation on Marine Ecology	Moderate	• Use of silencers and mufflers • Reduction of project traffic through community areas where possible • Adherence to speed limit • Development and implementation of grievance procedure • Development of noise monitoring and management procedure for managing noise generated.	Minor
Light Spill	Outdoor lighting of the facility site and truck parking on neighbouring communities Impact of light on wildlife within close habitats	Minor	• Control light spill to adjacent properties and identified sensitive areas	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Waste	Impacts related to poor management and disposal of waste	Minor	• Development and implementation of a solid waste management program • Identify Suitable disposal facility(s) • Monitoring of the disposal facility • Development of Waste Management Plan (WMP) • Internal and independent auditing of waste management contractors and waste disposal sites, in consultation with LFZDA	Minor
Traffic	Increased traffic and strain on road network	Moderate	• Development of Traffic Management Plan • No tanker trucks to park next to roads • Vetting of tanker trucks • Detailed traffic study • Liaise with the LFZDA and Local Government Authority regarding safe transport routes	Moderate

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Livelihoods and Microeconomics	Negative impacts to Livelihoods and Microeconomics	Moderate	• Minimization of land clearance • Replacement and re-planting of uprooted trees • Information to fishermen regarding underwater operations • Nautical charts with cautionary advice. • Notify other users of the sea and Lagoon of the presence of underwater facilities • Compensate economically displaced people in accordance to Livelihood Restoration Plan	Minor
Livelihoods and Microeconomics	Positive impacts to Livelihoods and Microeconomics	Major positive	• Preferential status to local community with regards to employment as site workers • Assist with construction of stalls for the village to sell goods to trucks • Organise basic skills training programme for locals	Major positive
Social Infrastructure	Impacts to social Infrastructure due to increased pressure on social amenities and road infrastructure	Moderate	• Information to local community about project operations and use or • Upgrade some local infrastructures • Provide health facilities for workers • Possibility of providing water to captive communities.	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Socio-Cultural Institutions and Cohesion	Disturbance of existing socio-cultural institutions and a disruption of current levels of community cohesion as a result of the presence of non-local workers	Moderate	• Ensure closed camp for workforce • Design and implement Employee Code of Conduct • Conduct community relations education programme • Create awareness about transmission of communicable diseases	Minor
Transport and Access	Blockage of transport routes and restricted access to beach	Moderate	• Design and implement Traffic Management Plan • Provide information on temporary road closures and alternative access routes • Improve signage and overall safety of roads with local authorities • Design and conduct traffic awareness training • Provide Information to fishermen about offshore activities	Moderate
Cultural Sites	Damage to cultural sites due to site clearing and grading activities	Minor	• Protection of cultural sites during construction • Design Grievance procedure • Design and enforce Employee Code of Conduct • Chance find procedure	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Community Health	Impacts to community health due to introduction of new communicable diseases, reduced domestic water quality and respiratory health impacts	Moderate	• Closed camp for workforce • Health awareness raising • Code of conduct for workers • Protect drinking water sources • Groundwater monitoring • Waste Management Plan • Dust suppression • Use of condoms	Minor
Occupational Health and Safety	Occupational Health and Safety risks to workers on site	Moderate	• Occupational Health and Safety Plan • Implement Health and Safety communication and training programmes • Emergency facilities and personal protection equipment • Job safety analysis and industrial hygiene surveys • Monitoring and record-keeping • Truck loading procedures • Emergency Preparedness and Response Plan	Minor
Public safety	Public safety impacts as related to soil, surface and groundwater contamination and traffic accidents	Moderate	• Driver training and strict enforcement • Investigate road accidents • Protect surface and groundwater • Emergency Preparedness and Response Plan	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Hydrocarbon Spills	Impacts on sea- and coastal birds, marine mammals, marine turtles, coastal habitats, fish stocks and fisheries	Moderate	• Spill prevention: ○ Spill prevention program design for construction phase ○ Provision of spill response training to all relevant construction workforce personnel. ○ Leakage test prior to start of operations • Spill response: ○ Oil Spill Contingency Plan (OSCP) with detailed procedures that will be followed in the event of a Tier 2 and 3 hydrocarbon spill ○ On site spill response equipment for Tier 1 and 2 spills ○ Adequate oil spill insurance cover to cover costs of clean up in the event of a large spill	Minor

Table 0-2: Summary of Qualitative Impacts for the Operations Phase of the Proposed Project.

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Terrestrial Soils and Geology	Possibility of Oil Spill from leaking pipelines	Major	• Spill prevention program design for operations phase (inspection + maintenance program) • Provision of spill response training to all relevant operations workforce personnel. • A designated area will be developed to allow for the bio-remediation of contaminated soils • Inspection + maintenance program	Minor
Surface and Groundwater	Possibility of aquifer and surface water contamination from spills and leaks and possibility of increased sedimentation	Moderate	• Oils, hydrocarbons and other hazardous materials will be stored in designated locations with specific measures to prevent leakage and release of their contents, including the sitting of the storage area away from surface water drains and on an impermeable base with impermeable containment that has no outflow and is of adequate capacity to contain 100% of the contents; • Plant and machinery will be kept away from surface waters and will have drip trays installed beneath oil tanks / engines / gearboxes / hydraulics which will be checked and emptied regularly; • Collection, retention and testing of any groundwater resulting from dewatering activities within potential contaminated sites; • Re-fuelling and delivery areas will be located away from surface water drains and natural water bodies and courses; • Provision of spill response equipment to contain and clean-up spills; Bunding and containment measures Impervious concrete surfaces Design and integrity of tanks to API standards Cathodic corrosion protection Inspection of equipment integrity Automatic spill prevention devices Overfill protection. Storm water channels with oil water separators Provision of training for operations personnel Spill control and response plans Effluent and groundwater monitoring	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Marine Water	Impacts on marine water quality and biodiversity as a result of routine and non-routine discharges	Moderate	• Compliance with MARPOL requirements and other ballast management conventions. • Zero discharge of food waste and sewage	Minor
Onshore Biodiversity	Loss and damage to terrestrial habitats and species	Minor	• Minimise clearing • Demarcate work areas • Rehabilitate disturbed land	Minor
Offshore Biodiversity	Loss and damage to marine habitats and species	Moderate	• Turtle surveys during nesting season • Controlled vessel movements	Minor
Noise and Vibration	Increased noise levels from onshore activities and equipment	Minor	• Construction limited to appropriate hours if possible • Noise monitoring during construction • Equipment with lower sound power levels • Silencers and mufflers • Reduce project traffic through community areas • Adherence to speed limit • Design and implementation of Grievance procedure	Minor
Light Spill	Outdoor lighting of the facility site and truck parking	Moderate	• Control light spill to adjacent properties	Minor
Waste	Impacts related to poor management and disposal of waste	Moderate	• Development and implementation of a solid waste management program • Identify Suitable disposal facility(s) • Monitoring of the disposal facility • Waste Management Plan (WMP) • Internal and independent auditing of waste management contractors and waste disposal sites	Moderate
Traffic	Increased traffic and strain on road network	Major	• No tanker trucks to park next to roads (DFL has a huge parking area foreseen, for short- and long-term parking) • Vetting of tanker trucks • Liaise with the LFZDA and local government authorities regarding safe transport routes	Moderate

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Livelihoods and Microeconomics	Negative impacts to Livelihoods and Microeconomics	Moderate	• Minimise land clearance • Replacement planting of coconut trees • Information to fishermen regarding offshore operations and exclusion zones • Notify other users of the sea of the presence of the exclusion and advisory areas • Nautical charts with cautionary advice	Minor
Livelihoods and Microeconomics	Positive impacts to Livelihoods and Micro-economics	Minor	• Preferential status to local community with regards to employment • Assist with construction of stalls for the village to sell goods to trucks • Basic skills training programme for locals	Moderate
Social Infrastructure	Impacts to social Infrastructure due to increased pressure on social amenities and road infrastructure	Minor	• Information to local community about project operations and use or upgrade of local infrastructure • Health facilities for workers • Possibility of providing water to affected communities	Minor
Socio-Cultural Institutions and Cohesion	Disturbance of existing socio-cultural institutions and a disruption of current levels of community cohesion as a result of the presence of non-local workers	Moderate	• Closed camp for workforce • Employee code of conduct • Community relations education programme • Awareness about transmission of communicable diseases	Minor
Transport and Access	Blockage of transport routes and restricted access to beach	Moderate	• Traffic Management Plan • Information on temporary road closures and alternative access routes • Improve signage and overall safety of roads with local authorities • Traffic awareness training • Information to fishermen about offshore activities	Minor
Cultural Sites	Damage to cultural sites due to site clearing and grading activities	Moderate	• Protection of cultural sites during construction • Grievance procedure • Employee code of conduct • Chance find procedure	Minor
Health	Impacts to community health due to introduction of new communicable diseases, reduced domestic water quality and respiratory health impacts	Moderate	• Closed camp for workforce • Health awareness raising • Code of conduct for workers • Protect drinking water sources • Groundwater monitoring • Waste Management Plan • Dust suppression	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Health	Occupational Health and Safety risks to workers on site	Moderate	• Occupational Health and Safety Plan • Implement Health and Safety communication and training programmes • Emergency facilities and personal protection equipment • Job safety analysis and industrial hygiene surveys • Monitoring and record-keeping • Traffic Management Plan • Truck loading procedures • Emergency Preparedness and Response Plan	Minor
Public safety	Public safety impacts as related to soil, surface and groundwater contamination and traffic accidents	Moderate	• Driver training and strict enforcement • Investigate road accidents • Protect surface and groundwater • Emergency Preparedness and Response Plan	Minor
Hydrocarbon Spills	Impacts on sea- and coastal birds, marine mammals, marine turtles, coastal habitats, fish stocks and fisheries	Moderate	• Spill prevention: • Mooring design • Operational terminal regulations and offloading / loading procedures • Pipeline protection • Spill response: • Oil Spill Contingency Plan (OSCP) with detailed procedures that will be followed in the event of a Tier 2 and 3 hydrocarbon spill • On site spill response equipment for Tier 1 and 2 spills • Adequate oil spill insurance cover to cover costs of clean up in the event of a large spill	Minor

0-12 CONCLUSION

The conduct of this ESIA for the proposed Dangote Fertilizer Plant at the Lekki Free Zone (LFZ) in Lagos State was carried out in strict compliance with acceptable National and International regulatory requirements. The process involved an extensive literature review, and wide-range consultation with the captive communities and other stakeholders, sampling and determination of the conditions of biophysical, social and health environmental components of the project area. The study sought the views and concerns of the host communities on essential aspects of the proposed project through interaction that were incorporated in the impact assessment process.

This ESIA has identified and assessed both positive and negative impacts of the proposed project and accordingly evaluated the associated and potential negative effects on the environment (biophysical), socio-economic and health characteristics of the project area in detail and mitigation measures have also been prescribed for significant negative impacts.

For effective implementation of the recommended mitigation measures, an Environmental and Social Management Plan (ESMP) has been developed to ensure environmental sustainability during the construction and operation phases of the proposed refinery project.

The Environmental and Social Impact Assessment of the Dangote Refinery Plant revealed that the project will have significant transformative impacts on the socio-economic life of the host communities and Lagos State in particular as well as the national economy in general. Nonetheless, some households will be economically displaced. Consequential to this, a Livelihood Restoration Plan will be developed in a bid to ensure commensurable compensation to the affected.

In general, the proposed fertilizer plant, with its ancillary connections would pose limited environmental and social risks, taken into account the proposed mitigation measures. However, the project will contribute immensely to the economy of Lagos State and the Nation at large by meeting a substantial proportion of the Nation's fertilizer needs. This effort would go a long way at improving farm income and GDP growth; conserve foreign exchange by reducing importation of fertilizer; generate more employment opportunities for the unemployed Nigerians; preserve the environment not only for the present generation but for the unborn generation; consume the huge locally available natural gas which is the main plant input and which is hitherto being flared thereby leading to a reduction in GHGs. The project will also make Nigeria to become a hub for West-Africa in fertilizer production.

The LFZ has designated SW Quadrant for the petro chemical related industries, which is generally suitable for the proposed Dangote Fertilizer Plant and all environmental and social risks can be minimized and managed through implementing preventative measures and sound environmental management systems.

It is recommended that environmental performance should be regularly monitored to ensure compliance and that corrective measures be taken if necessary. In addition, it is very necessary that this information should be made available to the host communities on a regular basis. Fire and spill prevention should be adequate, as specified in the report, and general Health and Safety Regulations should be adhered to in accordance with the requirements of International Health and Safety Standards. The Environmental and Social Management Plan should be used as an on-site reference document during all phases (Planning, Construction and Operation) of the proposed Dangote Fertilizer Plant.

Environmental auditing should be regularly undertaken, in order to determine compliance with the proposed ESMP, and parties responsible for the implementation of the ESMP should be held responsible for any inadequacy during the implementation process. Any polluted soil, groundwater, and surface water or on terrestrial or aquatic ecology encountered during the baseline survey and during the construction process must be reported to the relevant authorities and then disposed of in accordance with the acceptable standards.

In case of future expansion of the Dangote Fertilizer Plant, compliance with environmental, health and safety issues must again be checked and improved where necessary during an ESIA, with special attention to air quality, soil quality and ground water quality.

CHAPTER ONE

BACKGROUND AND INTRODUCTION

CHAPTER ONE

INTRODUCTION

1.1 DANGOTE FERTILIZER COMPLEX IN LEKKI FREE ZONE

Dangote Group is one of the most diversified business conglomerates in Africa with a hard-earned reputation for excellent business practices and quality products with its operational headquarters in the bustling metropolis of Lagos, Nigeria in West Africa. The Group's activities encompass: Cement Manufacturing, Sugar Manufacturing, Salt Refining, Pasta Manufacturing, Noodles Manufacturing, Poly Products, Port Management and Real Estate.

In a bid to enhance the nation agriculture growth especially in the area of food security, Dangote Group is venturing into the manufacturing and marketing of fertilizers. The proposed Fertilizer Plant Complex is to be located at the Lekki Free Zone (LFZ). The complex consists of both Ammonia and Urea plants with associated facilities and infrastructures.

In accordance with the Nigerian Environmental Impact Assessment Act 1992, the World Banks Operational Policy 4.01: Environmental Assessment (1999, revised April 2012) and the Equator Principles amongst others, an environmental and social impact assessment (ESIA) study is mandatory to this project.

1.2 THE LEKKI FREE ZONE PROJECT

Lekki Free Zone (LFZ) was launched following the execution of a Tripartite Agreement in early 2006 between China-Africa Lekki Investment Ltd, Lagos State Government and Lekki Worldwide Investments Ltd. Pursuant to the provisions of this Tripartite Agreement, Lekki Free Zone Development Company FZC (LFZDC) was incorporated and established in Nigeria in May 2006 as a China-Nigeria joint venture exclusively for investment, development, management and operation of LFZ.

Lagos Free Zone is a multi-use facility with specific zones for oil and gas; manufacturing; business; financial services, media and telecommunication; real estate services, recreation and tourism.

In general, LFZ has a preferential policy hi-tech industrial sector, targeted to create a minimum of 2 million jobs and high efficiency services in:

- Oil and Gas
- Petrochemicals
- Electronics
- Manufacturing - Light and Heavy equipment, machinery and automobiles
- Pharmaceuticals
- Textiles
- Shopping, Warehousing and Transportation
- Banking and Financial Centre including Insurance services

In addition, the Zone provides a high-grade residential Zone with first class environment due to the envisioned economic strength of LFZ, comprising of:

- High class residential apartment and villas for investors and employees;
- Shopping Malls and Plazas;
- Specialist Hospitals and Clinics;
- Schools, Research and Development Centres
- Hotels, Tourism and Recreational Centres including Sandy Beach Gardens and bathing, Golf Courses, Gyms and Water Sports sector, all in harmony with environment and nature's green.

In a reaction to meeting the needs of the nation especially in food security, Dangote Group intends to develop a state of the art Fertilizer Plant in this Zone. In line with the Nigerian environmental regulatory policy, this project must be subjected to ESIA.

Lekki Free Zone has a total land area of 165 square km with a favourable development environment. The most attractive decisional factor for the establishment of the Zone is the large market demand. Nigeria has a population of about 140 million while that of the surrounding West African Economic Community is about 500 million. Even though the local industries among these economies are developing, yet more than 90% of the products are imported. Therefore, it could be concluded that the market potential is considerable in this region. The second factor is the favourable export advantages. Nigeria is a signatory to the Lome Convention. This implies that the products made in Nigeria could be exported to Europe and the United States with no quota restrictions and low tariff. The third of all is the rich natural resources. Nigeria is very rich in oil, natural gas, wood, minerals and other natural resources. Foreign capital can utilize the local resources to process production or explore various kinds of resources through project development and commodity trade. LFZ has been licensed by the Nigeria Export Processing Zones Authority (NEPZA) with a tax free status under the Nigerian Export Processing Zone Act.

Lagos Free Zone offers a One-Stop Service in a bid to meeting the service requirements of investors and enterprises wishing to set up trading within the Zone. This includes coordinating Nigeria Government Department and Agencies such as NEPZA, Nigeria Customs Service, Nigeria Immigration, Department of Petroleum Resources (DPR) and Nigerian Police Force among others.

1.3 OBJECTIVES OF THIS ESIA

This ESIA is commissioned by Dangote Fertilizer Ltd, an enterprise that will build and operate the Dangote Fertilizer Plant in the LFZ. The objectives of this ESIA are to:

- Acquire baseline data of the environment as well as the socio-economic and health conditions in a bid to characterize the project area;
- Determine and evaluate the potential impacts of the activities proposed in this project on the environment, on the level of the complete project.
- Establish the existing ecological and socio-economic conditions of the area;
- Establish the environmental/socio-economic and health sensitivities of the area to the new project;
- Identify, evaluate and predict the impacts of the project on the environment including socio-economic aspects with adequate interfacing and project interaction;

- Develop control strategies with a view to mitigating and ameliorating significant impacts which the project would have on the totality of measurable environmental characteristics, and
- Recommend appropriate mitigation measures and monitoring activities
- Develop an Environmental and Social Management Plan (ESMP) that will ensure environmental sustainability throughout the project life span.

This ESIA takes into account the general framework laid down in the generic ESIA of the LFZ, but focuses on the project area of the Dangote Fertilizer Plant.

1.4 THE PROJECT PROPONENT

Dangote, as a company was established in 1981 in Lagos to trade in cement and basic food in Nigeria. In 1999, Dangote started to substitute import and trading activities by local manufacturing in the model of emerging countries beginning with cement plants. Today, Dangote is the largest manufacturing company in Africa with operations in 14 countries. Across all its activities, Dangote consolidates over $3 billion revenues per year and employs more than 25,000 employees.

Dangote Cement is the largest company listed in Nigeria representing 30% of the Nigerian Stock Exchange. Dangote sugar refinery is ranked second world largest. In the oil and gas and petrochemical sector, Dangote is until now mostly active on upstream side as reference local investor with interests in different blocks offshore Nigeria together with Anadarko, Chevron, ExxonMobil, Petrobras or Statoil. From its upstream activities and in context of depressing gas prices, Dangote realized the opportunity to monetize a part of the local natural gas production with a fertilizer facility. Actually Nigeria is importing all its needs for fertilizer with major consequences on the country balance sheet. Therefore, Dangote decided to build a world class fertilizer plant that should cover all the domestic consumption for ammonia and urea in Nigeria. This local production is expected to improve the overall performances of the agriculture sector which currently accounts for about 45% of the Nigeria GDP.

To achieve this goal, Dangote Fertilizer Ltd (DFL) was registered by the Corporate Affairs Commission in Nigeria and NEPZA to operate in the Lekki Free Zone. DFL shareholders include Greenview International, Dangote Industries Ltd and Aliko Dangote with 90%, 9.8% and 0.2% equities respectively.

At the end of 2011, DFL selected an Italian engineering company, Saipem to perform the Front End Engineering and Design (FEED). Currently Saipem is working on the Engineering, Procurement and Construction (EPC) of the $1.9 billion fertilizer plant. Furthermore, in her desire to ensure that the proposed Fertilizer Plant is built and operated with the highest world-class standards, DFL has decided to get the support of a third party as the project manager. In that wise, Tata Consulting Engineering Ltd Company, India was appointed to provide Project Management Consultancy (PMC) for the plant. According to the terms of the contract and in respect with its global experience in designing, building and operating large fertilizer plants, Tata shall support DFL in supervising the engineering, construction management, and in providing assistance for quality management, health and safety. DFL expects Tata to assist Saipem to complete the Dangote Fertilizer project on time for first production in 2014 and in conformity with the highest global standards.

1.5 THE ESIA TEAM

This study is led by Phidmund International Limited. The team is comprised of engineering, environmental and social sciences specialists with a combination of experience in undertaking ESIA's for oil and infrastructure developments and other projects in Nigeria. Phidmund International Limited is a Nigerian consultancy company specialised in Urban & Regional Planning, Architecture, Engineering and Environmental Management Consultancy. In addition to her corporate experience, series of studies have been undertaken by specialists in the company to address specific issues. For this study, analytical services were provided by the laboratory of Sustainable Agrotech Nigeria Ltd, Akure, Nigeria which is a DPR[1] and FMEnv[2] approved laboratory.

[1] Department of Petroleum Resources (Nigeria)

[2] Federal Ministry of Environment (Nigeria)

1.6 THE ESIA STUDY

1.6.1 Overview of the ESIA process

The ESIA study for Dangote Fertilizer Plant was concerned with identifying, predicting and evaluating foreseeable impacts, both beneficial and adverse, that are likely to emanate from all aspects of the project. Also inclusive were proffered mitigating measures to eliminate or minimize negative impacts while maximizing the positive impacts. This study is required purposely to provide information on the environmental, socio-economic and health effects of the Dangote Fertilizer project and to make sure that the proposed operations of the facilities are within acceptable limits set by the company, the Federal Ministry of Environment (FMEnv), the host State's Environmental Protection Agency and the international limits set out by IFC and other international bodies.

1.6.2 Baseline Data Collection

The ESIA report provides a description of the existing environmental and socio-economic conditions as a basis against which the impacts of the project can be assessed. The base line includes information on receptors and resources that were identified during scoping as having the potential to be significantly affected by the proposed project. The description of the baseline has the following main objectives:

a) To identify the key environmental and socio-economic resources and conditions in areas potentially affected by the project (such as atmosphere, geology and soil, groundwater, surface water, fauna and flora and the marine environment);
b) To describe and, where possible, quantify their characteristics i.e. their nature, condition, quality and extent;
c) To provide data to aid the prediction and evaluation of possible impacts, and
d) To provide informed judgments about the importance, value and sensitivity or vulnerability of resources and receptors.

For this EIA, base line data collection was obtained from existing sources including the following:

- Stakeholders including government agencies, community chiefs, elders, women and youths in the various communities and community based organisations (cooperative societies, development committees, etc.);
- Local experts and research and academic organizations;
- Existing and approved EIA reports, and
- Other published sources.

Additional primary baseline data process involved sampling and data gathering for information on socio-economics, terrestrial soils and geology, surface water, groundwater, air quality, noise, fauna and flora, traffic and waste surveys. The exercise also included water quality and sediment sampling and testing.

1.6.3 EIA Terms of Reference

The Terms of Reference (ToR) for this EIA are based on standard EIA requirements and stakeholder engagement (community representatives, FMEnv, LGA Representatives, NGOs and CBOs etc). Details of the TOR are attached as Appendix 1 in this report.

1.6.4 EIA Work Scope

As defined in the EIA Terms of Reference (ToR), the work scope for the proposed study includes the following:

- Review of national and international environmental regulations, standards, codes and conventions relevant to the proposed project activities;
- Review of existing literature on the study area in order to characterize the baseline conditions;
- Gap analysis, to identify areas where additional information would be required and the result used in planning and execution of field sampling/measurement aspects of the EIA project;
- Field sampling/testing at the proposed project area;
- Consultation with identified stakeholders and regulatory agencies;
- Impact identification, prediction, interpretation and evaluation;

- Development of cost effective mitigation/ameliorative and enhancement measures, monitoring programmes and Environmental Management Plan (EMP) covering the project life cycle; and
- Preparation of draft and final EIA reports that meet local and international requirements.

1.6.5 EIA Methodology

The EIA study pathway involved preliminary actions (i.e. initial planning and review activities), field data gathering campaign, data analysis/interpretation, reporting and experts/stakeholders review.

1.6.5.1 Preliminary Actions

The first step in the EIA study was the development and submission of the project proposal/EIA Terms of Reference (ToR) by DFL to the Federal Ministry of Environment (FMEnv). This is in line with the Nigerian EIA Procedural Guidelines. The project proposal contained synopsis of the proposed Fertilizer project while the ToR document outlined the general scope of the EIA study, the regulatory framework for conducting the study, objectives, baseline data requirements and assessment tools and methods for the EIA. Further, the ToR highlighted some key issues/activities of environmental concern in the proposed project planning and implementation.

Desktop study, which generally involved consulting relevant textbooks, research publications, articles, reports on previous environmental surveys of proximal/similar environment as well as technical presentations relevant to the study area was carried out. This was prior to field data gathering campaign in order to obtain relevant background information on the biophysical and social environment of the study area. The results from desktop study were used to identify information gaps on the baseline status of the study area and hence the definition of the extent of field investigation/data collection. Further research was also conducted at the end of the field data gathering exercise in order to compare literature information with generated field data and for additional information on the study area.

1.6.5.2 Field Data Gathering, Analysis and Interpretation

Information gathered from desktop study was used to categorize the major aquatic and terrestrial habitats in the area and thus define their respective sampling requirements. This enabled the effective collection of qualitative and quantitative data on the flora and fauna of the project area. The fieldwork covered all relevant elements of the ecological environment to complement information obtained from literature. Field data gathering covered meteorology/ambient air, groundwater, surface water and sediments, vegetation, wildlife and socio-economic/health characteristics of the study area. Sampling/characterization of the floral and faunal composition of the surface water and sediment was also carried out. Field samples were subsequently transferred to the laboratory, analyzed and interpreted and used to describe the existing environment as documented in chapter four of this report.

1.6.5.3 Consultation with Regulators, Stakeholders and Experts

Consultation is an integral part of every phase in the EIA implementation. This involved information dissemination and interactions/dialogues with the various stakeholders in the proposed project area including professionals in relevant fields of engineering, science, health, and environmental issues. This was used to intimate them of the proposed project and associated activities, solicit/articulate their views, concerns and expectations on pertinent issues of environmental, social and health concern for integration into the impact prediction, assessment, evaluation and mitigation. Stakeholders (including regulators) consulted include the Federal Ministry of Environment (FMEnv), Lagos State Environmental Protection Agency (LASEPA), the affected local government authority (Ibeju-Lekki LGA), community chiefs and elders, women and youths in the various communities, local fishermen and hunters, community based organizations (cooperatives, development committees, etc.).

1.6.5.4 Impact Identification and Evaluation

At this stage of the EIA study, the potential adverse or beneficial impacts of the proposed project activities on the existing environment were identified by considering the interactions of the environmental aspects with the existing environment at the pre-construction/mobilization, construction, operation and decommissioning phases of the project. The FMEnv EIA Sectoral Sectoral Guidelines for Manufacturing Industries (FEPA, 1995), Sectoral Guidelines for Oil and Gas Industry projects (FEPA, 1995), Sectoral Guidelines for Agriculture (FEPA, 1995), IFC's Sustainability Framework (2012 edition) and the conceptual project description among other source references, were used in the process. Evaluation of the identified impacts were carried out using such criteria as legal/regulatory requirements in respect of planned activities, magnitude of impact, risk posed by impact, public perception and importance of affected environmental component.

1.6.5.5 Impact Mitigation

In proffering mitigation measures designed to prevent, reduce or control the adverse impacts of the environmental aspects of the proposed project, professional judgment (based on scientific deductions), project experience, knowledge of the ecosystem in which the proposed project would be located and consensus of opinions among experts were used as tools. Other resource materials also consulted include the FMEnv EIA Sectoral Sectoral Guidelines for Manufacturing Industries (FEPA, 1995), Sectoral Guidelines for Oil and Gas Industry projects (FEPA, 1995), Sectoral Guidelines for Agriculture (FEPA, 1995), IFC's Sustainability Framework, etc. Also, enhancement measures were proffered to ensure optimization of the beneficial impacts of the proposed project.

1.7.5.6 Reporting and Review

The findings of the proposed project EIA study were subsequently documented as contained in this draft report. The final version of this report shall be issued at the end of regulators/stakeholders review meetings. This shall incorporate all pertinent issues and comments arising from the review meetings as shall be directed by the Federal Ministry of Environment. Also, in order to allow for on-going improvement of operational practices if those initially established prove inadequate, post auditing or monitoring have been designed into the EMP developed for the proposed project. The EMP shall also enable a rapid rescue/response if an unforeseen environmental impact occurs.

1.7 LEGAL AND POLICY FRAMEWORK IN NIGERIA

1.7.1 General Institutional Framework

Nigeria is a Federal Republic comprising of 36 states, and a Federal Capital territory in Abuja. Nigeria functions under a Presidential system of government, with an elected President, serving as both Head of State and Head of Government. The President wields executive power through the Federal Executive Council, which is also composed of the Vice President and 30-member cabinet.

Legislative power is vested in the bicameral National Assembly of Nigeria, whose members are popularly elected for four-year terms. The upper house (Senate) comprises 109 members while the lower house (House of Representatives) has 360 members. The senate and House of Representatives have concurrent legislative functions. Bills are not deemed to be validly passed if they have not received the joint assent of both houses.

The executive powers of state are vested in the governor, who exercises these powers directly or through the deputy governor, commissioners or other designated state officials. The legislative powers of a state are vested in the House of Assembly. The House of Assembly has power to make laws for the peace, order and good government of the state.
Existing statutes on environmental protection in Nigeria contain specific provisions designed to prohibit or control environmental pollution/degradation and also to prescribe sanctions or damages to be enforced against persons or corporate entities who contravene the provisions.

The principal bodies responsible for environmental matters and saddled with enforcing existing statutes and regulations in Nigeria are the Federal Ministry of Environment (FMEnv), and the Department of Petroleum Resources (DPR) for petroleum related projects. Besides them, the States' Ministries of Environment and States Environmental Protection Agencies have some responsibilities. Thus, this ESIA study has been undertaken in line with statutory requirements for environmental management in Nigeria. These are the National Environmental Policy, the EIA Act No. 86 of 1992, the FMEnv EIA Sectoral

Sectoral Guidelines for Manufacturing Industries (FEPA, 1995), Sectoral Guidelines for Oil and Gas Industry projects (FEPA, 1995), Sectoral Guidelines for Agriculture (FEPA, 1995).

The following subsections outline the guiding policies and regulations enforced by the FMEnv which are relevant to the proposed Fertilizer project. Also presented are other national statutes and conventions on environmental protection.

1.7.2 Lagos State Environmental Protection Agency (LASEPA)

The Lagos State Environmental Protection Agency is responsible for the oversight of the environment in Lagos State. The Agency registers and monitors development projects throughout the state, and also manages matters relating to waste generated within the State. The Agency is the key in the development of governmental policies for environmental sustainability, and regulation and enforcement of Federal and State policies/regulations. Specific functions of LASEPA include:

- Advising the State Government on all environmental management policies;
- Giving direction to the affairs of the Agency on all environmental matters;
- Preparing periodic Master plan to enhance capacity building of the agency and for the development and natural resources management;
- Carrying out public enlightenment and educating the general public on sound methods of environmental sanitation and management;
- Carrying out appropriate test on insecticides, herbicides and other agricultural chemicals;
- Monitoring and controlling disposal of solids, gaseous and liquid wastes generated by both government operations;
- Setting, monitoring and enforcing standards and guidelines on vehicular emission;
- Surveying ad monitoring surface underground and potable water, air land and soil environments in the state to determine pollution level in them and collect baseline data;

- Promoting co- operation in environmental science and technologies with similar bodies in other countries international bodies connected with the protection of the environment; and
- Cooperating with the federal, state and local Governments, statutory Bodies and Research Agencies on matters and facilities relating to environmental protection.

1.7.3 Lagos State Ministry of Environment

The Lagos State Ministry of the Environment was established in 1979 by the first elected Governor of Lagos State, Alhaji Lateef Jakande when it was carved out of the then Ministry of Works and Transport. It was later merged with Ministry of Physical Planning and became Ministry of Environment and Physical Planning. In 2003, the administration of the immediate past Governor of Lagos State, Asiwaju Bola Ahmed Tinubu separated the office of the Environment from Physical Planning and upgraded the present Office of the Environment to a full-fledged Ministry. The mandate of the Ministry was primarily to secure a clean, healthier and sustainable Environment which will be conducive for tourism, economic growth and well being of its citizenry.

- In the year 2005, two offices were created under the Ministry namely: Office of Environmental Services (OES) and Office of Drainage Services (ODS) with the following responsibilities:

- Waste Management;
- Environmental Sanitation and Protection Services;
- Pollution Control;
- Ecological and Conservation matters;
- Control and regulation of Outdoor Advertisement;
- Drainage services;
- De-flooding;
- Sewage Management;
- Coastal and Hinterland Erosion control;
- Evaluation of Environmental Impact Assessment (EIA), and
- Environmental Audit Report (EAR)

Parastatals under this Ministry include:

- Lagos State Waste Management Authority (LAWMA)
- Lagos State Environmental Protection Agency (LASEPA)
- Lagos State Signage and Advertisement Agency (LASAA)
- Lagos State Waste Water Management Office (LSWMO)
- Lagos State Parks and Garden Agency (LASPARK)

One key function defined for the Ministry as highlighted above is to monitor the implementation of EIA guidelines and procedures on all development policies and projects within the State. In this regard EIA is a regulatory requirement in the State.

1.7.4 The Federal Ministry of Environment

The Federal Environmental Protection Agency (FEPA) [presently subsumed into the Federal Ministry of Environment (FMEnv)] was inaugurated in 1988 by Act No. 58 of 1988 and subsequently amended through Act No. 59 of 1992. The body is charged / empowered with the overall responsibility of environmental matters in Nigeria. It has developed instruments of intervention to halt environmental degradation in the form of policies, standard, guidelines and regulations and programmes. With the initiation of these instruments, enforcement by FMEnv has become the most effective tool to bring industries and developers into compliance through compliance promotions. The relevant policies, guidelines and regulations of the ministry are outlined below.

National Policy on Environment (1989, revised 1999)

This document describes guidelines and strategies for achieving the policy goal of sustainable development by:

- Securing for all Nigerians a quality of environment adequate for their health and well-being;
- Conserving and using the natural resources for the benefit of present and future generations;
- Restoring, maintaining and enhancing the ecosystem and ecological processes essential for the preservation of biological diversity;

- Raising public awareness and promoting understanding of the essential linkages between the environment, resources and development; and
- Collaboration with other countries, international organisations and agencies to achieve optimal use of trans-boundary co-operation in order to prevent environmental recourses.

National Guidelines and Standards for Environmental Pollution Control in Nigeria

This guideline and standard was initiated in March 1991 sequel to the promulgation of the National Environmental Policy in 1989. This document is a basic instrument for monitoring and controlling industrial and urban pollution. The guidelines and standards relates to six (6) areas of concern, thus:

- Effluent limitations;
- Water quality or industrial water uses at point of intake;
- Industrial emission limitations;
- Noise exposure limitations;
- Management of solid and hazardous wastes; and
- Pollution abatement in industries.

National Effluent Limitation Regulation

The National Effluent Limitation Regulation, S.I.8 of 1991 (No. 42, Vol. 78, August, 1991), makes it mandatory for industries as waste generating facilities (including research institutes, clinics, hotels etc.) to install anti-pollution and pollution abatement equipment on site. The regulation is specific for each category of waste generating facility with respect to limitations of solid and liquid discharges or gaseous emissions into the ecosystem. Appropriate penalties for contravention are specified also in the regulation.

Pollution Abatement in Industries Generating Wastes Regulation

The pollution abatement regulation, S.I.9 of 1991 (No. 42, Vol. 78, August, 1991) imposes restrictions on the release of toxic substances and stipulates requirements for pollution monitoring units, machinery for combating pollution and contingency plan by industries; submission of lists and details of chemicals used by industries to FMEnv; requirement of permit by industries for the storage and transportation of harmful or toxic waste; the generator's liability; strategies for waste reduction; permissible limits of discharge into public drains; protection of workers and safety requirements; for environmental audit (or environmental impact assessment for new industries) and penalty for contravention.

Management of Hazardous and Solid Wastes Regulation

The management of hazardous and solid waste regulation, S.I.15 of 1991 (No. 102, Vol. 78, August, 1991) defines the requirements for groundwater protection, surface impoundment, land treatment, waste piles, landfills, incinerators etc. It also describes the hazardous substances tracking programme with a comprehensive list of acutely hazardous chemical products and dangerous waste constituent. It also states the requirements and procedure for inspection, enforcement and penalty.

Environmental Impact Assessment Act

The Act No. 86 of 1992 makes EIA mandatory for all new major public and private projects in Nigeria. The EIA Act sets out to:

- Consider the likely impacts, and the extent of these impacts on the environment before embarking on any project or activity;
- Promote the implementation of appropriate policy in all federal lands consistent with all laws and decision-making processes through which the goal of this act may be realised; and
- Encourage the development of procedures for information exchange, notification and consultation between organisations and persons when the proposed activities are likely to have significant environmental effects on boundary or trans-state or on the environment of bordering towns and villages.

The Act gives specific powers to the FMEnv to facilitate environmental assessment of projects. The FMEnv EIA Sectoral Sectoral Guidelines for Manufacturing Industries, Sectoral Guidelines for Oil and Gas Industry projects and Sectoral Guidelines for Agriculture (published by FEPA in September 1995) provide assistance in the proper and detailed execution of EIA study of the proposed project in consonance with EIA Act of 1992.

1.7.5 National Environmental Standards and Regulations Agency (NESREA)

Prior to the dumping of toxic waste in Koko village, in Delta State, in 1987, Nigeria was ill-equipped to manage serious environmental crisis, as there were no institutional arrangements or mechanisms for environmental protection and enforcement of environmental laws and regulations in the country. Arising from the Koko toxic waste episode, the Federal Government promulgated the Harmful Waste Decree 42 of 1988, which facilitated the establishment of the Federal Environmental Protection Agency (FEPA) through Decree 58 of 1988 and 59 (amended) of 1992. FEPA was then charged with the overall responsibility for environmental management and protection.

In the wisdom of the Government, FEPA and other relevant Departments in other Ministries were merged to form the Federal Ministry of Environment in 1999, but without an appropriate enabling law on enforcement issues. To address this lapse, the Federal Government in line with section 20 of the 1999 Constitution of the Federal Republic of Nigeria, established the National Environmental Standards and Regulations Enforcement Agency (NESREA), a parastatal of the Federal Ministry of Environment through National Environmental Standards and Regulations Enforcement Agency (Establishment) Act No. 25, 2007.

The Act saddles NESREA with the responsibility for the protection and development of the environment, biodiversity conservation and sustainable development of Nigeria's natural resources and environmental technology including coordination, and liaison with, relevant stakeholders within and outside Nigeria on matters of enforcement of environmental standards, regulations, rules, laws, policies and guidelines.

Specific functions of the Agency, amongst others include to:

- enforce compliance with laws, guidelines, policies and standards on environmental matters;
- coordinate and liaise with, stakeholders, within and outside Nigeria on matters of environmental standards, regulations and enforcement;
- enforce compliance with the provisions of international agreements, protocols, conventions and treaties on the environment including climate change, biodiversity conservation, desertification, forestry, oil and gas, chemicals,

hazardous wastes, ozone depletion, marine and wild life, pollution, sanitation and such other environmental agreements as may from time to time come into force;

- enforce compliance with policies, standards, , legislation and guidelines on water quality, Environmental Health and Sanitation, including pollution abatement;
- enforce compliance with guidelines, and legislation on sustainable management of the ecosystem, biodiversity conservation and the development of Nigeria's natural resources;
- enforce compliance with any legislation on sound chemical management, safe use of pesticides and disposal of spent packages thereof;
- enforce compliance with regulations on the importation, exportation, production, distribution, storage, sale, use, handling and disposal of hazardous chemicals and waste, other than in the oil and gas sector;
- enforce through compliance monitoring, the environmental regulations and standards on noise, air, land, seas, oceans and other water bodies other than in the oil and gas sector;
- ensure that environmental projects funded by donor organizations and external support agencies adhere to regulations in environmental safety and protection;
- enforce environmental control measures through registration, licensing and permitting Systems other than in the oil and gas sector;
- conduct environmental audit and establish data bank on regulatory and enforcement mechanisms of environmental standards other than in the oil and gas sector;
- create public awareness and provide environmental education on sustainable environmental management, promote private sector compliance with environmental regulations other than in the oil and gas sector and publish general scientific or other data resulting from the performance of its functions; and
- carry out such activities as are necessary or expedient for the performance of its functions.

1.7.6 The Nigerian Urban and Regional Planning Act, 1992

Decree 88 of 1992 established a Development Control Department (DCD) charged with the responsibility for matters relating to development control and implementation of physical development plans at Federal, State and Local Government Levels within their respective jurisdictions. Specifically, the Act is to ensure that:

- Approval of the relevant DCD shall be required for all developments;
- A developer shall submit a development plan for the approval of DCD of Local Government, State or Federal Government;
- A developer (whether private or government) shall apply for a development permit in such manner using such forms and providing such information including plans, designs, drawings and any other information as may be prescribed;
- A developer shall at the time of submitting his application for development submit to an appropriate Control Department a detailed Environmental Impact Statement (EIS) for an application for:
    a) A residential land in excess of 2 hectares, or
    b) Permission to build or expand a factory or for the construction of an office building in excess of 4 floors or 5000 square metres of a lettable space, or
    c) Permission for a major recreational development.

1.7.7 Federal and State Ministries of Health

The Federal and State Ministries of Health require employers/employees to comply with the Factories Act, CAP 126, 1990 Laws of the Federation, which stipulates in Part II through V, provisions and regulations for health, safety and welfare in the workplace.

Part II – Health (cleanliness; overcrowding; ventilation; lighting; drainage of floors; and sanitary conveniences).

Part III – Safety (prime movers; transmission machinery; powered machinery; other machinery; unfenced machinery; construction and maintenance of fencing; construction and disposal of new machinery; vessels containing dangerous liquids; self-acting machines;

training and supervision of inexperienced personnel; chains, ropes and lifting tackle; safe means of access and safe place of employment; precautions in places where dangerous fumes are likely to be present; precautions with respect to explosive or inflammable dust, gas, vapour or substance; air receivers; prevention of fire; and safety provisions in case of fire).

Part IV – Welfare (supply of drinking water; washing facilities; accommodation for clothing; first aid; and exemption if ambulance room is provided).

Parts V – Special Provisions and Regulations - (removal of dust or fumes; meals in certain dangerous trades; protective clothing and appliances; protection of eyes in certain processes; power to make regulations for health, safety and welfare; and power to take samples).

1.7.8 Other National Regulations

Other national regulations on environmental protection relevant to the proposed project are:

Land Use Act, 1978

The Land Use Act of 1978 states that "… it is public interest that the rights of all Nigerians to use and enjoy land in Nigeria and the natural fruits thereof in sufficient quality to enable them to provide for the sustenance of themselves and their families be assured, protected and preserved".

Forestry Act, 1958

This Act of 1958 provides for the preservation of forests and the setting up of forest reserves. It is an offence, punishable with up to 6 months imprisonment, to cut down trees over 2ft in girth or to set fire to the forest except under special circumstances. The policy on forest resources management and sustainable is aimed at achieving self-sufficiency in all aspects of forest production through the use of sound forest management techniques as well as the mobilization of human and material resources. The overall objectives of forest policy are to prevent further deforestation and to recreate forest cover, either for productive or for protective purposes, on already deforested fragile land. Specifically, the National Agricultural Policy of 1988 in which the Forestry Policy is subsumed, provides for:

- consolidation and expansion of the forest estate in Nigeria and its management for sustained yield;
- regeneration of the forests at rates higher than exploitation;
- conservation and protection of the environment viz: forest, soil, water, flora, fauna and the protection of the forest resources from fires, cattle grazers and illegal encroachment;
- development of Forestry industry through the harvesting and utilisation of timber, its derivatives and the reduction of wastes; and
- wildlife conservation, management and development through the creation and effective management of national parks, game reserves, tourist and recreational facilities, etc.

Endangered Species Act

The Endangered Species Act (Control of International Trade and Traffic) Cap.108 Law of Nigeria, 1990 prohibits the hunting, capture and trade of endangered species.

Criminal Code

The Nigerian Criminal Code makes it an offence punishable with up to 6 months imprisonment for any person who:

- violates the atmosphere in any place so as to make it noxious to the health of persons in general dwelling or carry on business in the neighbourhood, or passing along a public way; or
- does any act which is, and which he knows or has reason to believe to be, likely to spread the infection of any disease dangerous to life, whether human or animal.

Inland Fisheries ACT, CAP I10, LFN 2004

Focused on the protection of the water habitat and its species, the following sections are instructive:

Section 1 prohibits unlicensed operations of motor fishing boats within the inland waters of Nigeria.

Section 6 prohibits the taking or destruction of fish by harmful means. This offence is punishable with a fine of N3, 000 or an imprisonment term of 2 years or both.

Water Resources ACT, CAP W2, LFN 2004

The Water Resources Act is targeted at developing and improving the quantity and quality of water resources. The following sections are pertinent:

Section 5 and 6 provides authority to make pollution prevention plans and regulations for the protection of fisheries, flora and fauna.

Section 18 makes offenders liable, under this Act, to be punished with a fine not exceeding N2000 or an imprisonment term of six months. He would also pay an additional fine of N100 for everyday the offence continues.

Labour Act, 1999

Nigeria has ratified all eight core International Labour Organisation Conventions. The Labour Act (1990) is the primary law protecting the employment rights of individual workers. The Act covers protection of wages; contracts; employment terms and conditions; recruitment; and classifies workers and special worker types.

Trade Union Amendment Act, 1995

Union membership is governed by the Trade Union Amendment Act (1995). A 1999 constitution includes stipulation of equal pay for equal work without discrimination on account of sex, or any other ground whatsoever.

Land Rights Act No. 6, 1978

The Land Use Act No. 6 was enacted in 1978. The Act vests all land in the urban areas of each state under the control and management of the governor of the state. The governor of the state holds the land in trust for the people of the state and is solely responsible for the allocation of land in all urban areas to individuals who reside in the state and to organizations for residential, agricultural and commercial purposes. All other land in the state subject to conditions under the Land Use Act is under the control and management of the local government. The Act divests traditional owners of land and vests such land in the state governor for the benefit and use of all Nigerians. It provides the processes through which land maybe acquired by the federal government.

Nigerian Free Trade Zone Act No. 63, 1992

In 1992, the Nigerian Free Zone Act (Act No. 63 of 1992) was passed establishing the Nigerian Export Processing Zone Authority (NEPZA). As proposed, free trade zones (FTZ), are expanses of land with improved ports and/or transportation, ware housing facilities, uninterrupted electricity and water supplies, advanced telecommunications services and other amenities to accommodate business operations. Under the FTZ system, enterprises are exempt from customs duties, local taxes, and foreign exchange restrictions, and qualify for incentives—tax holidays, rent-free land, no strikes or lockouts, no quotas in European Union (EU) and United Stated (US) markets, as long as end products are exported (although some portion can be sold in the domestic market). The NEPZA is responsible for the regulation of FTZ operations. Its tasks involve policy formulation, licensing and monitoring. The zones are governed by the FTZ Act which stipulates that an extensive EIA must be carried out before the commencement of any major projects.

Sea Fisheries Act No. 71, 1992

The Sea Fisheries Act (Act No. 71 of 1992) repeals the Seas Fisheries Act and makes provision for the control, regulation and protection of sea fisheries in the territorial waters of Nigeria. The first part of the Act concerns the licensing of motor fishing boats. Section for specifies criteria for issue of a licence. The second part of this Act concerns enforcement, the prohibition of certain fishing methods and offences and penalties.

Sea Fisheries ACT, CAP S4, LFN 2004

The Sea Fisheries Act makes it illegal to take or harm fishes within Nigerian waters by use of explosives, poisonous or noxious substances. Relevant sections include the following:

- Section 1 prohibits any unlicensed operation of motor fishing boats within Nigerian waters.
- Section 10 makes destruction of fishes punishable with a fine of N50,000 or an imprisonment term of 2 years.
- Section 14 (2) provides authority to make for the protection and conservation of sea fishes.

National Inland Waterways Authority (NIWA) Act 1997

This is an Act of the Federal Ministry of Transport on the use of and navigation in inland waterways and permit by NIWA for dredging.

Nigeria Maritime Administration and Safety Agency

The Nigerian Maritime Administration and Safety Agency (NIMASA) is an Agency of the Federal Ministry of Transport with a mandate to protecting the coastal territorial waters and the Exclusive Economic Zone (EEZ) of Nigeria from pollutants like oil and others.

There are also other regulations including:

- Wild Animals Preservation Act Cap 132 LFN 1990;
- River Basins Development Authority Act, 1987; and
- Natural Resources Conservation Act Cap 286 LFN 1990.

1.8 INTERNATIONAL GUIDELINES AND CONVENTIONS

In addition to the national laws/regulations, Nigeria is signatory or party to several international conventions and treaties that support the use of ESIA as the key tool for achieving environmentally sustainable development. The ESIA shall be guided by the international environmental and social regulations from IFC/World Bank where applicable. All other relevant international guidelines and conventions, and industry best management practices shall also apply, including the international financing community.

Examples of such statutes to guide this study include:

- IFC General Environmental, Health and Safety Guidelines, 2007;
- IFC Performance Standards for Environmental and Social Sustainability, 2012;
- IFC Handbook for Preparing a Resettlement Action Plan, 2002;
- World Bank Operational Policy 4.01 – Environmental Assessment, 2011;
- AfDB Integrated Environmental And Social Impact Assessment Guidelines, 2003;
- AfDB Policy on the Environment, 2004;
- AfDB Environmental Review Procedures for Private Sector Operations, 2000;
- AfDB Gender Policy, 2001;
- AfDB Policy on Poverty Reduction, 2004;
- AfDB Policy on Involuntary Resettlement, 2003;AfDB Environmental and Social Assessment Procedures for African Development Bank's Public Sector Operations, 2001, and
- The Equator Principles, 2003/2006/2011.

In the next paragraphs, firstly the most important IFC Standards and Guidelines will be highlighted and secondly, attempt will be made to have a closer look at some of the other international conventions/guidelines and agreements.

1.8.1 IFC's Sustainability Framework – 2012 Edition

The Sustainability Framework consists of:

- The Policy on Environmental and Social Sustainability, which defines IFC's commitments to environmental and social sustainability and responsibility in supporting project performance in partnership with clients.
- The Access to Information Policy, which articulates IFC's commitment to transparency.
- The Performance Standards, which define clients' responsibilities for managing their environmental and social risks and include requirements for IFC support.
- Environmental, Health and Safety (EHS) Guidelines. This is a technical guidance on environmental, health and safety issues, such as ambient air quality, chemical hazards, and disease prevention.

1.8.2 IFC's Performance Standards on Social and Environmental Sustainability

The 2012 edition of IFC's Sustainability Framework applies to all investment and advisory clients whose projects go through IFC's initial credit review process after January 1, 2012. IFC's Performance Standards define client roles and responsibilities for managing projects and requirements for IFC support. The standards include requirements to disclose information. The Guidance Notes are companion documents to the Performance Standards, providing guidance to clients (and IFC staff) in meeting the Performance Standards.

The standards are divided into the following issue-specific sections:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labour and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 7: Indigenous Peoples
- Performance Standard 8: Cultural Heritage

Together, these eight Performance Standards establish standards that the client is to meet throughout the life of an investment by IFC:

IFC PS 1 (Assessment and Management of Environmental and Social Risks and Impacts): PS 1 defines the importance of implementing a robust and effective Environmental and Social Management System on the business activity drawing on the assessment findings of social and environmental impacts from the project to then implement systems to avoid, reduce or remove the impacts identified through mitigation. Particular reference is made towards affected communities, grievance mechanisms and community consultation.

IFC PS 2 (Labour and Working Standards): PS 2 recognizes that the pursuit of economic development through job creation and income generation should be accompanied by the protection of the workers human rights. Safe and healthy working conditions can be a catalyst for tangible benefits for the project.

IFC PS 3 (Resource Efficiency and Pollution Prevention): PS 3 specifically addresses managing resource efficiency and pollution prevention within project life cycles. It encourages the project to actively utilize current internationally disseminated technologies and good practice.

IFC PS 4 (Community Health, Safety and Security): PS 4 specifies requirements for mitigating any potential for community exposure to risks and impacts arising from equipment accidents, structural failures and releases of hazardous materials. In addition, PS 4 realizes that communities may be affected by impacts on their natural resources, exposure to diseases and the use of security personnel.

IFC PS 5 (Land Acquisition and Involuntary Resettlement): This Standard outlines a policy to avoid or minimize involuntary physical resettlement as a consequence to the project. Where it is unavoidable, it requires suitable measures to mitigate adverse impacts on affected stakeholders, including appropriate compensation for any economic displacement such as loss of subsistence or commercial livelihood.

IFC PS 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resource): PS 6 sets out an approach to protect and conserve biodiversity including habitats, species, genes and genomes, all of which have potential social, economic, cultural and scientific importance, as well as means to ensure no net loss/no net reduction and biodiversity offset. This PS is guided by the Convention on Biological Diversity.

IFC PS 7 (Indigenous Peoples): This PS recognizes that indigenous people can be marginalized and vulnerable (for example, if their lands and resources are encroached upon by or significantly degraded by a project). Their languages, culture, religions, spiritual beliefs and institutions may also be under threat. This PS sets out how to avoid this and include the people in the project.

IFC PS 8 (Cultural Heritage): The PS aims to protect irreplaceable cultural heritage and to provide guidance for protecting cultural heritage throughout a project life cycle.

1.8.3 IFC's Environmental, Health and Safety (EHS) Guidelines (2007)

The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP), as defined in IFC's Performance Standard 3 on Pollution Prevention and Abatement[3]. Reference to the EHS Guidelines by IFC clients is required under Performance Standard 3. IFC uses the EHS Guidelines as a technical source of information during project appraisal activities, as described in IFC's Environmental and Social Review Procedure.

The EHS Guidelines contain the performance levels and measures that are normally acceptable to IFC and are generally considered to be achievable in new facilities at reasonable costs by existing technology. For IFC-financed projects, application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets with an appropriate timetable for achieving them. The environmental assessment process may recommend alternative (higher or lower) levels or measures, which, if acceptable to IFC, become project- or site-specific requirements.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

[3] GIIP is defined as the exercise of professionals be expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally or regionally. The outcome of such exercise should be that the project employs the most appropriate technologies in the project-specific circumstances.

1.8.4 General EHS Guidelines

The General EHS Guidelines contain information on cross-cutting environmental, health, and safety issues potentially applicable to all industry sectors. It is designed and should be used together with the relevant industry sector guideline(s). It sets our specific minimum standards in regards to environmental protection, occupational health and safety, and community health and safety throughout the project life cycle impacts.

The General EHS Guidelines are organized in 4 main chapters:

- Environmental
- Occupational Health and Safety
- Community Health and Safety
- Construction and Decommissioning

1.8.5 Industry Sector Guidelines

The Industry Sector Guidelines are organized in 8 main groups. The Guidelines with special concern to the proposed fertilizer project are briefly summarized:

- Forestry
- Agribusiness/Food Production
- Chemicals
- General Manufacturing
- Power

1.8.6 IFC Sector Guidelines – Nitrogenous Fertilizer Production

This guideline provides a description of industry specific impacts and management including identification of air emissions including greenhouse gases (GHGs), wastewater, hazardous materials, wastes and noise, definition of detailed compliance requirements (emission/discharge limits, noise etc), abatement measures to ensure compliance, suggested performance indicators and monitoring requirements. It also provides advice on Occupational Health and Safety (e.g. management, storage and shipping of hazardous products, disposal of wastes among others).

1.8.7 Other international conventions/guidelines and agreements

World Bank Operational Directive

The World Bank Operational Directive 4.01: ''Environmental Assessment'' of 1991 (revised April 2012), classifies projects according to the nature and extent of their environmental impacts.

OECD Common Approaches on Environment and Officially Supported Export Credits

In December 2003, the Organization for Economic Co-operation and Development (OECD) Council adopted the Recommendations on Common Approaches on Environment and Officially Supported Export Credits (the Recommendation). The Recommendation is designed to, among other things, promote good environmental practice and consistent approaches for projects benefiting from officially supported export credits, and to encourage the prevention and the mitigation of the adverse environmental impacts of projects, including involuntary resettlement. The Recommendation prescribes that a benefiting project's Environmental Impact Assessment Report should indicate the need for a resettlement plan, prepared in accordance to host government standards and the World Bank' Group's Performance Standards.

Equator Principles (EP)

It is a financial industry benchmark for determining, assessing and managing social and environmental risk in project financing.

Principle 2: Social and Environmental Assessment

For each project assessed as being either Category A or Category B, the borrower has conducted a Social and Environmental Assessment ("Assessment") process to address, as appropriate and to the Equator Principles Financial Institutions (EPFI) satisfaction, the relevant social and environmental impacts and risks of the proposed project (which may include, if relevant, the illustrative list of issues as found in Exhibit II of the EP). The Assessment should also propose mitigation and management measures relevant and appropriate to the nature and scale of the proposed project.

These Principles are intended to serve as a common baseline and framework for the implementation by each EPFI of its own internal social and environmental policies, procedures and standards elated to its project financing activities. EPFI will not provide loans to projects where the borrower will not or is unable to comply with her respective social and environmental policies and procedures that implement the Equator Principles.

Environmental and Social safeguards policies (African Development Bank)

The African Development Bank issued its Environmental Assessment Guidelines (EAG) in 1992, but since then, many changes have occurred in the Bank' structure and operations. The revised **Environmental and Social Assessment Procedures** (ESAP) have therefore been updated to reflect the more integrated approach addressing all crosscutting themes as well as the new organizational structure. The main purpose of the Environmental and Social Assessment Procedures (ESAP) is to improve decision-making and project results in order to ensure that Bank-financed projects[4], plans and programs are environmentally and socially sustainable as well as in line with Bank's policies and guidelines.

Other relevant AfDB policies are: AfDB Policy on the Environment (2004), AfDB Environmental Review Procedures for Private Sector Operations (2000), AfDB Gender Policy (2001), AfDB Policy on Poverty Reduction (2004) and AfDB Policy on Involuntary Resettlement (2003).

Convention Concerning the Protection of the World Cultural and National Heritage (World Heritage Convention), 1972

The World Heritage Convention (1978), seeks to set aside areas of cultural and natural heritage, the latter defined as areas with outstanding universal value from the aesthetic, scientific and conservation points of view.

[4] The ESAP apply to the Bank's public sector operations. Similar procedures were developed and approved for the Bank's private sector operations: AfDB Environmental Review Procedures for Private Sector Operations (2000).

United Nations Guiding Principles on the Human Environment

The United Nations (UN), concerned about negative environmental trends since its formation, published two major concept documents: Guiding Principles on the Human Environment, 1972 and the Rio Declaration on Environment and Development. Ten of the Guiding Principles were defined as formal declarations that express the basis on which an environmental policy can be built and which provide a foundation for action. The principles most relevant to the proposed project are summarized below.

Principle Two

The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate.

Principle Four

Man has a special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat, which are now gravely imperilled by a combination of adverse factors. Nature conservation, including wildlife, must therefore receive importance in planning for economic development.

Principle Six

The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon the ecosystems. The just struggle of the peoples of all countries against pollution should be supported.

The Rio Declaration on Environment and Development

The UN Conference on Environment and Development (Rio de Janeiro, 1992), reaffirmed the 1972 declaration on the Human Environment, and sought to build upon it. This is with the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people. It is also to aid work towards international agreements, which respect the interests of all, protect the integrity of the global environmental developmental system, and recognize the integral and interdependent nature of the earth. The UN thus added additional principles to the originals, the more relevant being:

Principle One

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle Ten

Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle Seventeen

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Convention on the Conservation of Migratory Species of Wild Animals or Bonn Convention (1979)

The Bonn Convention's mode of action is conservation and management of migratory species (including waterfowl and other wetland species) and promotion of measures for their conservation, including habitat conservation. Conservation of these habitats is one of the principal actions taken for endangered species or groups of species, which are subject of Agreements under the Bonn Convention. This was adopted in 1979.

Convention on Biological Diversity (1992)

The objectives of this Convention, which was opened for signature at the 1992 Rio Earth Summit, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1987)

The Basel Convention addresses the risks posed by the generation and disposal of hazardous wastes. This Convention defines the wastes to be regulated and controls the trans-boundary movement of hazardous wastes and other wastes to protect human health and the environment against their adverse effects.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, (1972)

The Convention stipulated that contracting parties shall individually and collectively protect and preserve the marine environment from all sources of pollution and take effective measures, according to their scientific, technical and economic capabilities, to prevent, reduce and where practicable eliminate pollution caused by dumping or incineration at sea of wastes or other matter. They shall harmonize their policies in this regard as appropriate.

African Convention on the Conservation of Nature and Natural Resources, 1968

African countries shall take all necessary measures to ensure that conservation and management of natural resources are treated as an integral part of development planning at all

Convention on International Trade on Endangered Species of Fauna and Flora (CITES), 1973

Each country party to the Convention is to conserve to the extent practicable the various species of fish, wildlife and plants. They are of aesthetic, ecological, educational, historical, recreational and scientific value to a nation and its people.

Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1981

These countries are to take all necessary measures to prevent, reduce, combat and control pollution of the Continental area with particular emphasis on pollution by ship, aircraft, land-based sources, activities relating to exploration and production of the seabed and atmospheric pollution. The countries are also expected to prevent, reduce, combat and control coastal erosion, protect and preserve rare or fragile ecosystem; cooperate in dealing with pollution emergencies in the Convention area; establish rules and procedures for the determination of liability and the payment of adequate and prompt compensation for pollution damage of the area.

UN Convention on the Law of the Sea, 1982

It sets up a comprehensive legal regime for the seas and oceans and established material rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment.

Vienna Convention for the Protection of the Ozone Layer, including the Montreal Protocol and the London Amendment (1994)

This convention is aimed at protecting human health and the environment against adverse effects resulting or likely to result from human activities, which could modify the ozone layer.

United Nations Framework Convention on Climate Change (UNFCC), 1992 and Kyoto Protocol on Climate Change, 1997

Green Houses Gases (GHG) emissions, particularly of carbon dioxide (CO_2) are implicated in global warming of the atmosphere causing global change/increase in the earth's atmospheric temperature and the latter is responsible for series of adverse climatic/meteorological changes such as sea level rise, excessive heat, flooding, desertification, reduced agricultural productivity, human ill health and death of grazing mammals, among others. The Convention and its Protocol called for the protection of climate system for the benefit of present and future generations of humankind, reduction or prevention of anthropogenic emissions of GHG in energy, transport, industry, agriculture, forestry and waste management sector.

Ramsar Convention on Wetlands, 2002

Wetlands are areas of submerged or water saturated or water dominated lands. The Treaty is for conservation and management of wetlands because they are important habitats for specialized plants and animals.

Protocol Concerning Cooperation in Combating Pollution in Cases of Emergency in the West and Central African Region, 1981

The Abidjan Convention obligates the Contracting Parties to take all appropriate measures to prevent, reduce, combat, and control pollution and to ensure the sound environmental management of natural resources in the Convention area. To meet their obligations, the Contracting Parties are called upon to cooperate with relevant international, regional, and sub-regional organizations to establish and adopt recommended practices, procedures, and measures designed to fight pollution. These initiatives should be supported by the national laws. The Abidjan Convention focuses on: pollution from normal or accidental discharge from ships; pollution caused by dumping from ships and aircraft; pollution caused by discharge from rivers, estuaries, coastal establishments, and outfalls, or emanating from any other sources on the Contracting Parties' territories; pollution from activities relating to the exploration and exploitation of the sea-bed; pollution from or through the atmosphere; and coastal erosion caused by human activity, such as land reclamation and coastal engineering. In addition, the Contracting Parties are called upon to work towards establishing protected areas for fragile ecosystems and endangered species and controlling activities likely to have adverse effects on endangered species, ecosystems, or biological processes.

1.9 REPORT STRUCTURE

This report starts with a table of contents, a list of tables, a list of figures and a table with all the relevant abbreviations. The details of the Environmental and Social Impact Assessment of the proposed Dangote Fertilizer Plant are reported as follows:

Chapter Zero: Executive summary

A non-technical summary (executive summary) of the content of all the chapters in the report.

Chapter One: Introduction

An introduction with background information on the proponent, the methodology and a review of the legal and administrative framework as applicable to the proposed project.

Chapter Two: Project Justification

This chapter discusses the project justification, the need/value and the envisaged sustainability of the project.

Chapter Three: Project and Process Description

This chapter discusses the technical details of the proposed project.

Chapter Four: Description of the Existing Environment

A description of the ecological and socio-economic baseline condition of the area.

Chapter Five: Associated and Potential Impacts

A discussion of the impact assessment approach and a presentation of the associated and potential impacts of the projects.

Chapter Six: Mitigation Measures

In this chapter, mitigation measures for the significant impacts of the project are proffered.

Chapter Seven: Environmental and Social Management Plan (ESMP)

This is a tool to properly manage the environmental concerns mentioned in the ESIA; by integrating it into the EIA we ensure future compliance with legislation, good environmental performance and integration of environmental concerns into the decision making.

Chapter Eight: Decommissioning

Dangote Fertilizer project is a part of LFZ, an industrial/commercial site that will be built for the future centuries, with continuous maintenance. Demolition and recovery of the land in original state is not an issue in this project. Due to this reason, this chapter is restricted to some notices regarding decommissioning and abandonment of the project.

Chapter Nine: Conclusions

In this chapter, the key findings of the study are highlighted.

References and Appendices

The report is closed with references and appendices. These appendices are:

Appendix 1. Terms of Reference (ToR)

Appendix 2. Environmental Baseline Data

Appendix 3. Waste Management Plan (WMP)

Appendix 4. Health Safety and Environment (HSE) Plan

Appendix 5. Memorandum of Understanding

Appendix 6. Field Sampling Map

1.10 DECLARATION

In compliance with all relevant National, State, Local Governments laws and regulation, including International agreements/conventions, DFL declares that it has prepared this Environmental and Social Impact Assessment (ESIA) using the best available expertise in personnel, equipment and universally acceptable methods.

CHAPTER TWO

PROJECT JUSTIFICATION

CHAPTER TWO

PROJECT JUSTIFICATION

2.1 INTRODUCTION

This chapter provides information on the project in terms of the need for the project and the benefits. It also presents a number of project alternatives that were considered during the project design.

2.2 NEED FOR THE PROJECT

For well over four decades, Nigeria has run a mono-product economy. The country needed to envision and evolve a nation beyond oil else it could go into an economic oblivion. Nigeria, which earns more than 90 percent of the nation's export earnings and about 80 percent of government revenue from its oil industry, has seen decline in oil production and revenues in recent times. In the recent years, data released by Nigeria's Central Bank, has shown that oil production has been lower than the barrel per day (bpd) assumption used by the government for the purpose of revenue calculation in the annual budgets. In addition, the unfolding scenario of declining prices of crude oil globally and the challenges confronting local production has made it imperative to diversify the economy. Nigerian economy as currently structured is very vulnerable to external shocks. The country has allowed the easy money from oil to strangulate other cash cows like agriculture, solid minerals, tourism and many others.

It had been established that the agricultural sector has the largest potential to diversify the economy, create jobs, secure food supply, lower inflation and expand foreign exchange earnings for the country. It has been pointed out that if a fully integrated approach is adopted across the value chain of various agricultural commodities for which the nation possesses comparative advantage, Nigeria would rapidly emerge from its current state of dependence on a single source of revenue. Therefore, transforming the agriculture sector at the present time is compelling giving the increasing wave of uncertainty in the international and domestic oil and gas market.

The backbone of any agricultural revolution is access of farmers to modern agricultural inputs, especially fertilizers and seeds. For decades, successive governments in Nigeria procured and distributed fertilizers. Unfortunately, the government system was corrupt and undermined the private sector. It did not deliver fertilizers to genuine farmers. Instead, rich and powerful political farmers hijacked the subsidized fertilizers. As a result, no more than 11% of all the farmers in the country got the fertilizers distributed by the government. In a bid to proffer a sustainable solution to this teething problem, at the inception of the current administration of President Jonathan Goodluck, the old system of government buying and selling fertilizers was scrapped, and all fertilizer companies were required to sell directly to farmers, not to government warehouses. The decision by Dangote Group to establish an Ultra Modern and large scale Fertilizer Plant in LFZ is apt and will go a long way at enhancing government policy of ensuring easy access to this product among farmers. The proposed Dangote Fertilizer project constitutes a bold attempt at meeting the following challenges confronting the fertilizer sector in Nigeria. They include:

- The need to improve farm income and contribute to GDP growth through increased and improved use of fertilizer by the farm population;
- The need to improve agricultural competitiveness through higher crop yield resulting from fertilizer use;
- The need to improve on nutrient use efficiency at farm level;
- The need to contribute to the protection of the environment;
- The need to utilize locally available raw materials for fertilizer production;
- The need for quality assurance in fertilizer marketing and use, and
- The need to contribute to employment

The fertilizer market in Nigeria is the largest in West Africa region representing an average of 45 percent of total fertilizer consumption (in nutrients base) in the Economic Community of West African States (ECOWAS). Yet, the average nutrient fertilizer consumption for the country was estimated at around 2.0 kg/ha in 2009 (FAOSTAT, 2011), which is below the regional average of 4.0 kg/ha and compared to other developing regions of the world. Thus, Nigeria offers a good market for fertilizer production as the nation has a huge agronomic potential for fertilizer consumption. No doubt, fertilizer products from the proposed Dangote Fertilizer will be massively patronized both in Nigeria and other neighboring West African countries.

Dangote Fertilizer Ltd would also aim at generating income from operating the facility with greater efficiency and to reduce cost of procurement of fertilizer by the third party and the farmers in general. In addition, the outputs will be available to all companies wishing to import, store and distribute the products in Nigeria.

2.3 VALUE OF THE PROJECT

The cost of establishing the proposed project is USD1.5 billion. This amount is to be sourced from equities from Green View International, Dangote Industry Limited and Aliko Dangote (40%) and loans from financial institutions (60%). This is a good monetary injection into the economy. The activities involved include the following: site acquisition, civil and mechanical works, basic and detailed engineering, operations, etc.

It is estimated that over 95% of the amount appropriated to civil works will be local, and the monetary injection into the economy will help improve the standards of living for the people through employment and technology transfer. It is anticipated that the project will need a considerable number of labourers, who will be sourced locally. Specifically, about 9,000 construction staff will be needed for this purpose and other infrastructural development work at this stage.

2.4 ECONOMIC BENEFITS

On completion, the proposed Fertilizer Plant will limit dependence on unstable fertilizer imports in Nigeria. Thus, the project is expected to meet the strong demand for urea fertilizer not only in Nigeria but also in the international market. Presently, there is a global fertilizer imbalance creating opportunities for exports. Dangote Fertilizer project will therefore help to boost and diversify Nigeria's foreign exchange earnings.

Again, relative to the current situation, the project would create a means for lowering the cost of fertilizer products in the country as the products which hitherto were imported will now be available locally. In addition, the project is expected to generate direct employment. Specifically, the project shall employ over 750 workers.

Naturally, fertilizer helps in improving the soil fertility. Its application, therefore, implies a boost in agricultural productivity. Since this sector contributes 30% to Nigeria's GDP and the largest employer of labour, the ripple effects on enhanced income and standards of living are enormous.

2.5 OTHER POSITIVE BENEFITS

Other positive benefits of the Dangote Fertilizer project in Nigeria would include the following:

- Consumption of the huge locally available natural gas which is the main plant input and which is hitherto being flared;
- The massive reduction of gas flaring in the country will lead to a reduction of the GHGs in the atmosphere;
- Increase in national production of fertilizers;
- Improvement of the captive communities through the application of the project's Corporate Social Responsibility (CSR) programme, and
- Develop a strategic role for Nigeria to become a hub for West-Africa in fertilizer production, generating additional volume, revenue and jobs to the country.

2.6 PROJECT'S SUSTAINABILITY

2.6.1 Environmental Sustainability of the project

The Project's activities are guided by national and international environmental regulatory and design standards. The incorporation of the findings and recommendations of this ESIA at various stages of the project shall be strictly ensured so as to guarantee that the project is environmentally sustainable. DFL shall also ensure strict adherence to the Environmental and Social Management Plan (ESMP) of this ESIA in order to help safeguard the environment at the various phases of the project's activities. In general, the environmental sustainability of the project is premised on the followings:

- DFL shall ensure that all the fertilizer operational activities and processes are designed in a manner that will keep all the potential adverse effects to the environment to the minimum and within the acceptable regulatory levels; and
- DFL shall ensure that Dangote Fertilizer Project waste management programme shall be aimed at environmental preservation and shall strictly be in line with nationally and internationally acceptable standards.

2.6.2 Technical Sustainability of the Project

The design and construction of the facility shall follow the internationally acclaimed best practices, while tested and proven technology shall be employed to ensure the technical sustainability of the project. Materials of internationally acceptable standards shall be procured for use in the construction of the facility.

2.6.3 Economic Sustainability of the Project

The Nigerian economy largely depends on revenue from crude oil. With the current drive towards economic diversification using agriculture as a launch pad, there is an assured ready market for the proposed facility. In view of the widespread unemployment all over the nation, labour supply is not envisaged to be difficult. Furthermore, most of the required raw materials needed by the proposed development would be sourced locally. For these reasons, the economic sustainability of the proposed project is greatly envisaged.

2.6.4 Social Sustainability of the Project

The proponent will ensure periodic engagement throughout project life span so as to maintain cordial relationship with all stakeholders and host communities. The company employment policy shall give preference to qualified indigenes of the host communities in a bid to ensure harmonious relationship.

2.7 PROJECT ALTERNATIVES

In accordance with the requirements of Nigeria's ESIA procedures together with international best practice, including the IFC Performance Standards, a number of alternatives have been considered during the formulation of the proposed Project design. Alternatives considered are outlined below.

2.7.1 Location Alternatives

Important factors influencing site selection for a fertilizer plant are:

- Availability of feedstock;
- Availability of water;
- Availability of deep sea port;
- Length of a conveyor belt required to transport the fertilizer to shipping vessels;
- Product off-take points;
- Availability of skilled manpower;
- Qualified contractors;
- Access to maintenance services; and
- Infrastructure for meeting the plant personnel's housing and communal needs.

Lagos Free Zone was identified as the preferred location taking into consideration the above location alternative factors and on the basis of the following evaluation factors:

Feedstock Availability

The Zone is located in close proximity to the new oil and gas deposit discoveries in Nigeria. Thus, the site offers a great potential with respect to feedstock from these vast oil and gas fields. Dangote Refinery Ltd (DRL) is also proposing to establish an ultra modern refinery in the Zone. Specifically, the proposed refinery is sharing boundary with the fertilizer plant. The fertilizer plant shall be fed from the DRL. However, in the nearest future, it is expected that gas pipeline shall run between the nearby oil and gas fields to the proposed site at which point supply would switch to this.

Deep Sea Port

The master plan of the Lagos Free Zone includes a state of the art deep sea port which will be constructed in several phases up to -18 m water depth. The offshore area located adjacent to this port quickly reaches depths in excess of 15m allowing access by appropriate vessels for export of the finished product.

Land Availability

The management of the Lagos Free Zone has allocated the land for the project including potential future expansion. This portion in the master plan was earmarked for industrial development.

Existing Port Facilities

There is an all-weather, operating port at Apapa, Lagos which can meet the requirement for bringing most of the project cargo during construction and later during operation. At the interim, DFL in collaboration with DRL has concluded arrangement to construct a jetty that could meet the needs of these two projects pending the completion of the LFZ Deep Sea Port when a suitable a suitable Roll-On–Roll Off facility would be created at the Project site.

Local Industries

In accordance to LFZ master plan, several small and medium sized companies including a refinery will be established in the Zone. In addition, a number of maintenance and fabrication workshops will also be set that could meet the requirements of the industry. It is also expected that oil companies engaged in the exploration of oil and gas fields will be established in the Zone. All these facilities will complement the proposed fertilizer plant.

Local Transport

The road network between LFZ, Lagos Metropolis and Apapa Port is adequate for mass transit and the delivery of land based machinery and parts for the plant at present. It is anticipated with the growth of the LFZ, critical transport infrastructure including rail would be improved in and around the area to support the increase in capacity load. Air transport will also be facilitated following the completion of Lekki International Airport which is about 8 kilometers from the site.

Proximity to the Sea

The distance of the conveyor to the loading jetty is a key factor for site selection. Urea is highly hydroscopic in nature and the chances of moisture pick up in the product increase with the length of the conveying system. As the site is located in an equatorial climate, humidity levels are always high. It is thus preferable to have the shortest possible length of product conveying system. The proposed site should also have adequate draft (depth) available within a short distance from the shore to reduce the cost of jetty construction. The coastal system around the project site meets these requirements.

Possibility for Roll-On Roll-Off for Heavy Equipment

Construction of the plant will require delivery of heavy plant e.g. cranes, and some Over Dimension Consignments (ODC) e.g. CO2 Absorber Column, Flash Column, Synthesis Convertor and Urea Reactor. Such ODC could easily be delivered to site on amphibious transporters through the sea and the Lagoon.

Proximity to the Main Road

As the majority of the equipment will be unloaded at a jetty to be developed along the coast and delivered by road to the site, the preferred site has been selected on the basis of being as close to the main trunk road as possible.

Proximity to Oil and Gas Fields

The project site lies in close proximity to the rich Oil and Gas (O&G) fields. Thus, a gas pipeline that will link up the site with this gas field is envisaged.

Site Elevation

The proposed site is located close to the sea shore at one side and bounded with the lagoon on the other side. Thus, it has an average existing grid level of 1.8 m above mean sea level (MSL). The maximum high tide level reported is about 2.0 m. It is thus proposed to increase the finished grade level of the site to 3.5 m above MSL to avoid any disruptions in plant operations during the worst case high tide levels. The quantity of refilling earth required to raise the site is estimated to be approximately 1 million m^3. This quantity of material is not available from the land site near to LFZ. The sites which are closer to the sea are preferred as it is envisaged that dredged marine sand will be used for raising the site grade level.

Environmental Considerations

The development is not within any officially designated protected Area. Some patches of mangroves are observed in close proximity to the proposed site. However, they are in a degraded state.

Risk of River Bank Erosion

Provision has been made for sufficient set-back to the Lagoon where erosion risks are considered to be greatest. Such provision will definitely reduce these envisaged risks.

Availability of Skilled Manpower

Urban centers are usually associated with pools of skilled manpower. Lagos metropolis perhaps offers the best of such manpower in Nigeria. In addition, the city possesses several higher institutions that offer courses that are needed in the production of fertilizer.

Availability of Infrastructure and Peaceful Environment

The Fertilizer Plant is being located in a Free Trade Zone that assures massive infrastructure including transportation infrastructure (road, rail and air), energy infrastructure, water infrastructure, waste infrastructure, waste water infrastructure and other municipal infrastructure. Apart from developing her own infrastructure network, Dangote Fertilizer Limited shall also leverage on these general infrastructure for enhanced product delivery.

The prevailing environment is peaceful as there is no recorded case of rift among the host communities and Dangote Group. In additional, no inter-communal crises was ever reported among the host communities. Interaction with community members showed a high desire for the establishment of the Fertilizer Plant as they are convinced that the project will enhance their socio-economic status through provision of jobs and infrastructure improvement.

Resettlement

There are no dwellings and commercial enterprises within the boundary or in the vicinity of the project site. Thus, there would be no resettlement. The proposed site has therefore reduced development cost and community agitation usually associated with a development of this nature. However, economic loss in terms of land and crops is envisaged. All the affected shall be adequately compensated.

2.7.2 Plant Alternatives

Production Processes

In addition to the selection of the proposed project location, there are a number of possible alternatives in relation to the production processes and the design of the proposed Fertilizer Plant. In general, there are three main process licensors for ammonia synthesis. They include:

- Kellogg, Brown and Root (KBR);
- Uhde GmbH (Thyssen Krupp group); and
- Haldor Topsoe A/S (HTAS).

These three processes have licensed more than 92% of the ammonia plants worldwide, both operating and under construction.

The method to be implemented to form the basis of the fertilizer plant process will depend on the process license own by the Engineering, Procurement and Construction (EPC) contractor selected for the construction of the plant. This is because different potential EPC contractors hold different process licenses.

Best Alternative Technology (BAT)

Through the use of BAT assessment on construction methods and operational compliance, the project will not only meet but will exceed industry accepted standards for fertilizer plants. The project shall therefore adopt the most efficient and state-of-the-art technologies or processes that will strive to reduce environmental impacts from the plant to the barest minimum.

2.7.4 Go/No-go

The desirability of the project is based on the benefits derivable from economic diversification with a focus on agriculture. One of the basic challenges confronting agriculture in Nigeria is inadequate inputs especially fertilizer. The current volume of production is inadequate while its distribution is inefficient. Retail prices to the end users are high since fertilizers are largely imported to the country.

The proposed fertilizer plant is needed to enhance agricultural production in the country at a reduced cost. It is also expected that if put in place, it will offer employment opportunities to Nigerians thereby increasing their standards of living. These prospects will elude Nigerians if the project is not developed.

Again, LFZ has planned and zoned the block on which the Fertilizer Plant is being proposed for oil and gas related industries. Should the proposed Fertilizer Plant Project not go ahead, it is likely that another industrial developer linked to the oil and gas sector will be granted the permission to develop these plots within the block.

CHAPTER THREE

PROJECT DESCRIPTION

CHAPTER THREE

PROJECT DESCRIPTION

3.1 INTRODUCTION

This chapter provides a description of the proposed production process, the project location, project schedule and details of the plant's products. Details are then given on the main project activities, site preparation, construction and installation and operation. Finally, it provides information on the various discharges, waste and emissions likely to arise from the project and personnel requirements is provided as well as Emergency Response and Health and Safety requirements.

3.2 PROJECT LOCATION

The proposed Dangote Fertilizer Plant is located on a site in the Lekki Free Zone (LFZ). LFZ is in Lagos State, one of the South Western States, Nigeria (Figure 3-1). The Zone is located in the Lekki Peninsula which is in the South Eastern part of Lagos State, the economic nerve centre of Nigeria (Figure 3-2). The Zone can be reached from other part of the country through a road that branched off from Lagos – Epe Expressway (Figures 3-2 and 3-3). The Zone abuts the vast Atlantic Ocean in the south, and the quiet and graceful Lekki Lagoon in the north (Figure 3-2). Its geographical location is strategic as it is 60 km away from the centre of Lagos, 70 km away from Murtala Mohammed International Airport, about 8 km away from the proposed Lekki International Airport and 50 kilometres away from the Apapa Port, the largest port in West Africa (Figure 3-2).

Dangote Fertilizer Plant is situated on a parcel of land that is approximately 500 Ha in size in the South East Quadrant (SE) of Lekki Free Zone which lies in the South East portion of the LFZ (Figure 3-4). Essentially, the master plan for the LFZ subdivides the area into four main quadrants each having its own land use and consequently its own theme. The quadrants include:

South West Quadrant (SW) - General mixed industries, including light and medium engineering with a large part dedicated for logistics and distribution, potentially serving both the international and national markets. In addition a new special residential area is proposed to the north of the industrial zone, with both low and high-density housing, largely intended for as a leisure and residential resort with tourist facilities.

South East Quadrant (SE) - Petro chemical related industries including methanol plant and port facilities. This quadrant is to accommodate the proposed Dangote Refinery and Dangote Fertilizer Plant.

North West Quadrant (NW) - General mixed industrial area, including medium and light industrial uses as well as heavy uses. Housing for the workers in the Free Zone area will be provided within this quadrant where residential areas of different densities and house types would be provided to the north and south of the main industrial zones.

North East Quadrant (NE) – The quadrant offers a mixed-use urban area as a new waterside town providing a range of employment, commercial, residential, community and recreational uses. It will complement the role of the other three quadrants and act as the city administrative, business and residential centre for the whole of the LFZ.

The Zone is located in close proximity to the new oil and gas deposit discoveries in Nigeria (Figure 3-5). Thus, the site offers a great potential with respect to feedstock from these vast oil and gas fields. Dangote Refinery Ltd (DRL) is also proposing to establish an ultra modern refinery in the Zone. Specifically, the proposed refinery is sharing boundary with the fertilizer plant. The fertilizer plant shall be partly fed from the DRL.

The location also typifies the coastal shorelines of the Atlantic Ocean in Nigeria with partially waterlogged areas, firm grounds and coastal mangrove forest. The project area is climatically stable characterized by all year round rainfall, high humidity, high temperature and mild wind speed. The location lies within the low tide zone of the Ocean and remain secured despite influence of the Atlantic Ocean tides and rainfalls of the Lekki peninsula on adjacent Lagoon water level. The host communities have demonstrated high level of preparedness to strongly give unalloyed support and cooperation for the project. The project is further covered by the existing Memorandum of Understanding (MoU) signed by the LFZ management and the representatives of the host communities. Dangote Fertilizer

Limited has signed a long-term lease with the LFZ Enterprise for the land on which the proposed facility site will be sited. A Certificate of Occupancy has already been issued by the Lagos State Government in respect of this lease arrangement.

The coordinates of the LFZ boundary are given in

Table **3-1**.

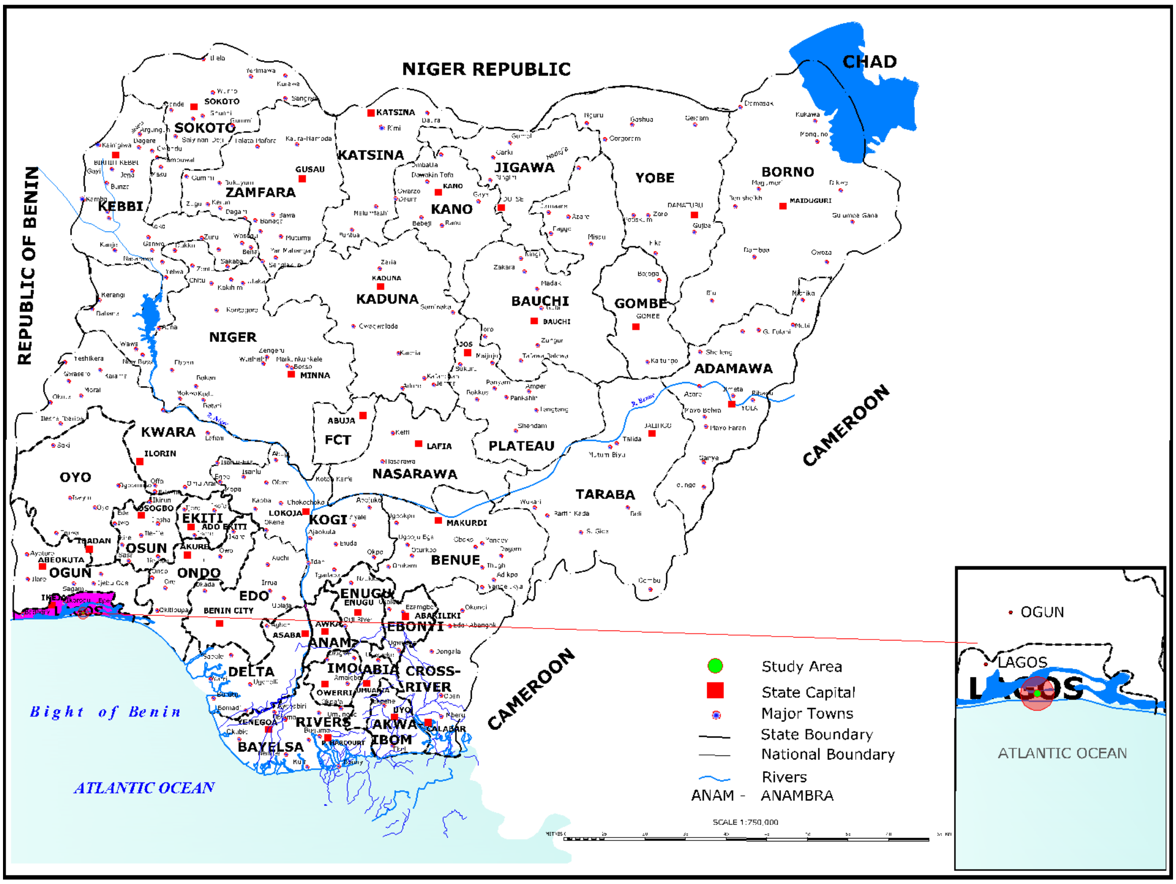


Figure 3-1: Lagos State within Nigeria

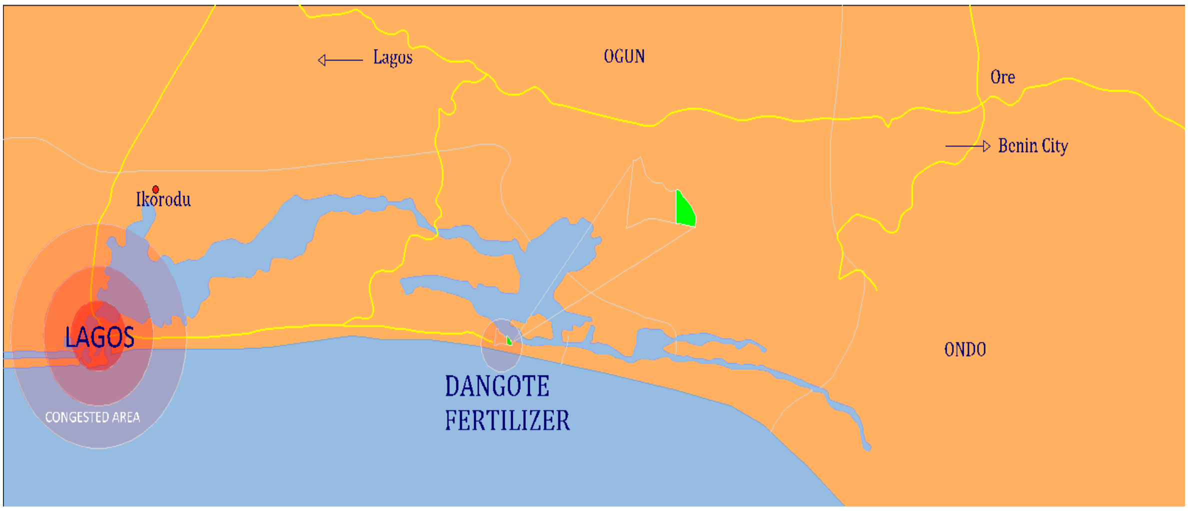


Figure 3-2: Proposed Dangote Fertilizer Plant within regional setting. The plant can be accessed from Lagos through an existing road network that branched off from Lagos – Epe Expressway

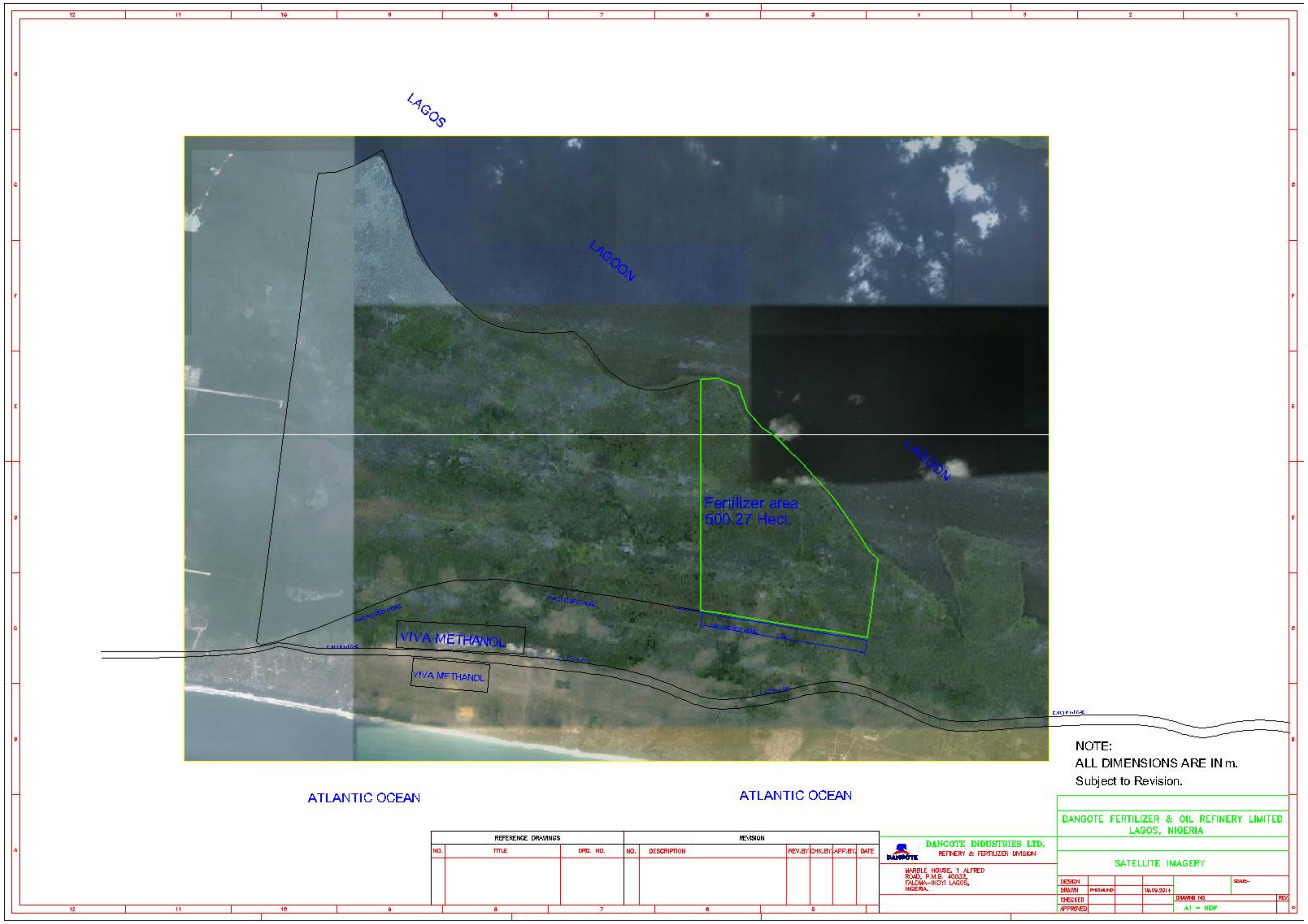


Figure 3-3: Location of Dangote Fertilizer Plant as derived from Satellite Imagery

Table 3-4: Lekki Master Plan showing Lekki Free Zone

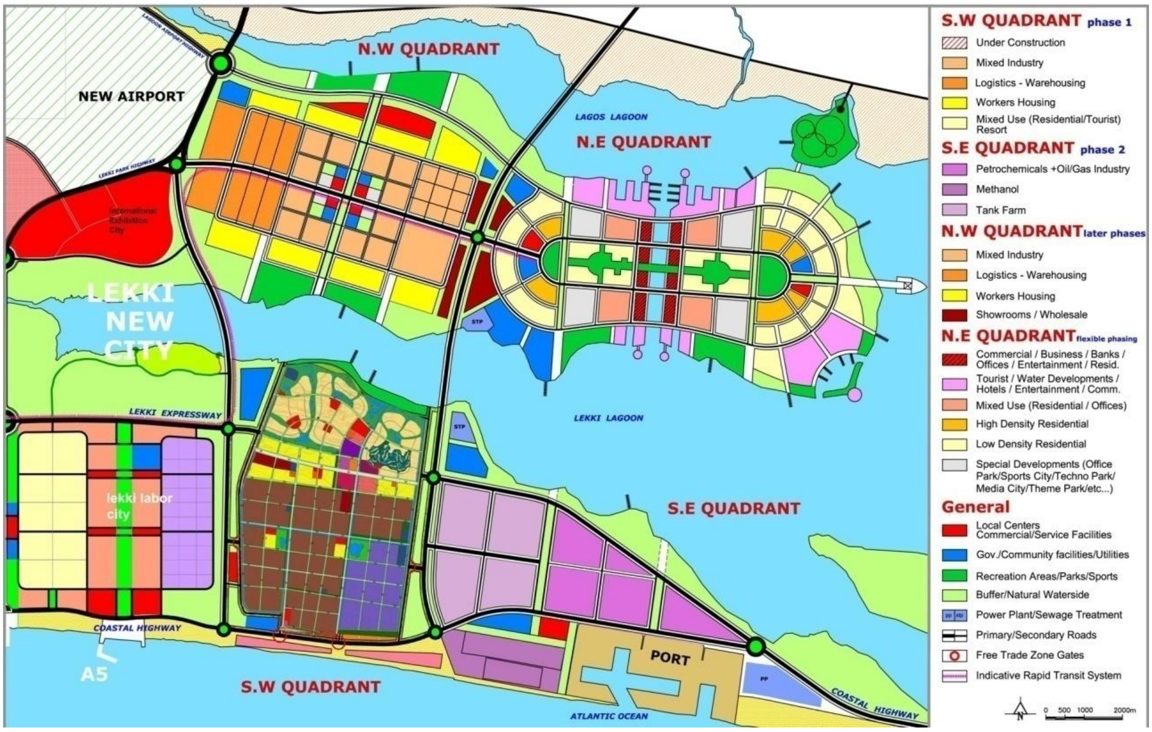


Figure 3-5: Lekki Free Zone Master Plan

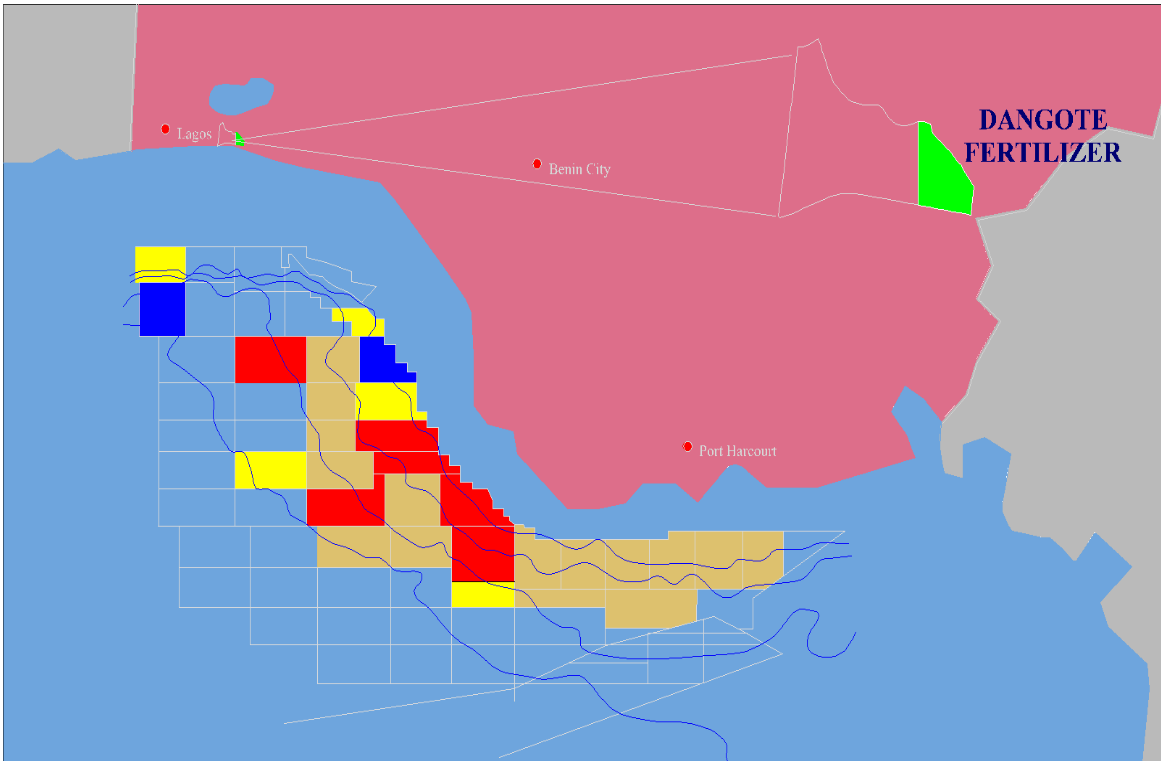


Figure 3-6: Oil Blocks in Nigeria

Table 3-1: Proposed Dangote Fertilizer Plant boundary coordinates

Boundary Nr.	EASTING	NORTHING
1(M)	614732E	71163N
2(N)	616849E	711287N
3(O)	616996E	712411N
4(01)	6168254E	712601N
5(P)	614732E	712601N
6(R)	615229E	712601N
7(S)	615229E	711559N

3.3 PROJECT SCHEDULE

The actual activity from commencement of site preparation to decommissioning is expected to last approximately forty two (42) months (Figure 3-7). Execution of both trains 1 and 2 shall be taken simultaneously with two months in commissioning between the two trains.

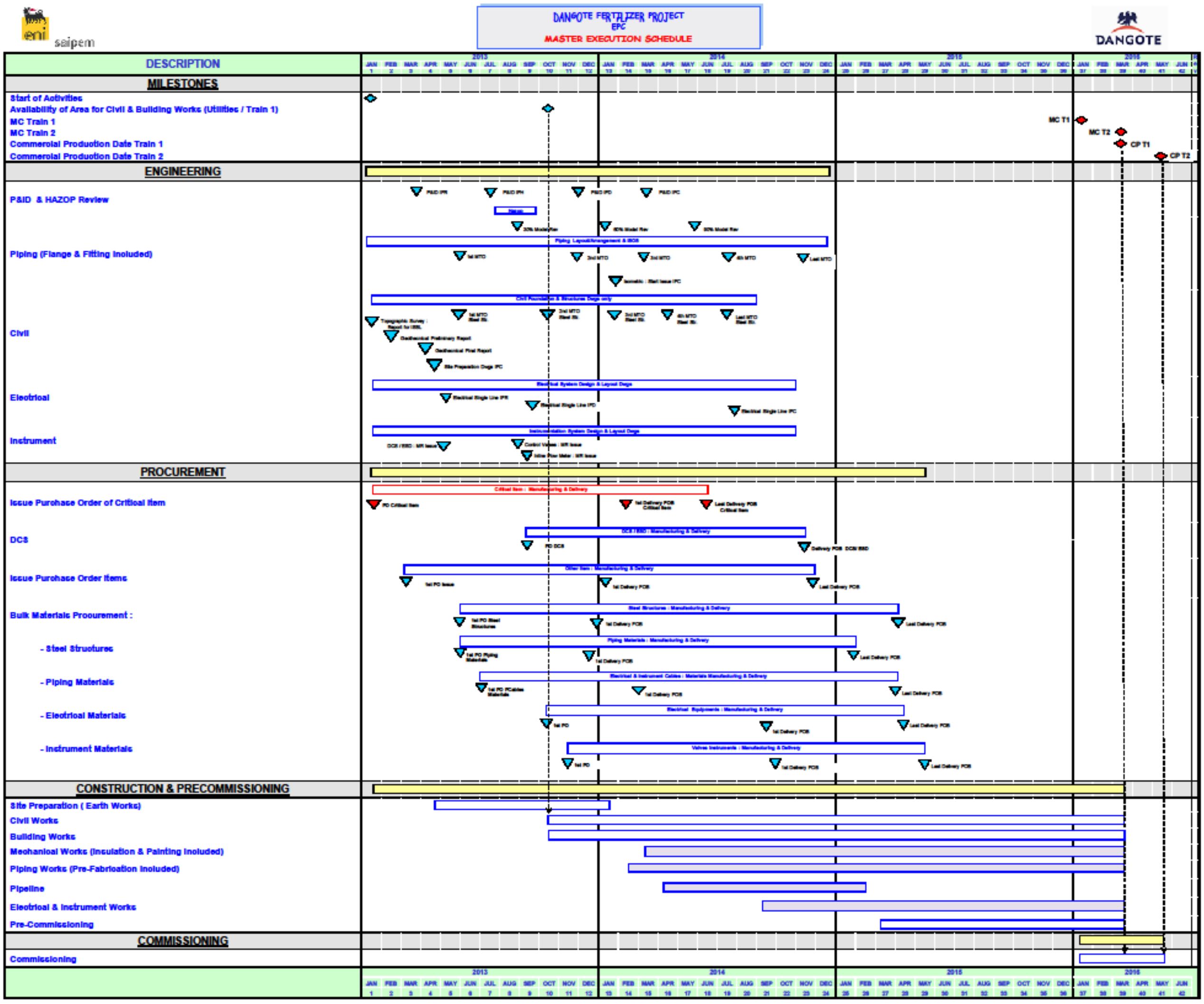


Figure 3-7: Work Schedule for the proposed Dangote Fertilizer Plant

3.4 PRODUCTS EXPECTED FROM PROJECT

The product from Dangote Fertilizer Project is 7700 MT per day of Granulated Urea.

Product Characteristics of Granular Urea:-

- Particle shape –Granules
- Unit Nitrogen content -46.0 % by wt. min.

- Biuret content- 0.9 % by wt. max.
- Water content- 0.35 % by wt. max.
- Formaldehyde content- 0.45 – 0.5 max % by wt.
- Free Ammonia content- 50 – 100 max ppm.
- Appearance –White
- Temperature- 39 – 50 max °C
- Crushing Strength- 2.5 kgf min. on 2.8 mm medium size.
- Particle Size -2-4 mm Min. 90% wt & <2 mm Max. 5% wt

3.5 DESCRIPTION OF PLANT FACILITIES

3.5.1 Introduction

The Complex is identified by the following functional blocks (Figures 3-7 and 3-8): They include

1. **Process Units:**
    - Ammonia Plant Train 1: 2200 MTPD Ammonia
    - Ammonia Plant Train 2: 2200 MTPD Ammonia
    - Urea Plant Train 1: 3850 MTPD Urea
    - Urea Plant Train 2: 3850 MTPD Urea
    - Urea Granulation Plant Train 1: 3850 MTPD Granulated Urea
    - Urea Granulation Plant Train 2: 3850 MTPD Granulated Urea

2. **Utility Units:**
    - Water Treatment Plant
    - Steam and Power Generation
    - Cooling Water System
    - Natural Gas System
    - Nitrogen Production System
    - Instrument and Plant Air System
    - Potable Water System
    - Emergency and Power Diesel System

- Effluent Treatment System
- Fire Fighting System

3. Offsite Units:

- Lagoon Water Pre-treatment and Launching System
- Ammonia Plants Flaring System
- Ammonia Storage System 20000 MT
- UFC Storage System

4. Bulk Urea Handling Units: Unit Identification Capacity

- Urea Bulk Storage
- Urea Handling System
- Urea Bagging and Truck Loading System

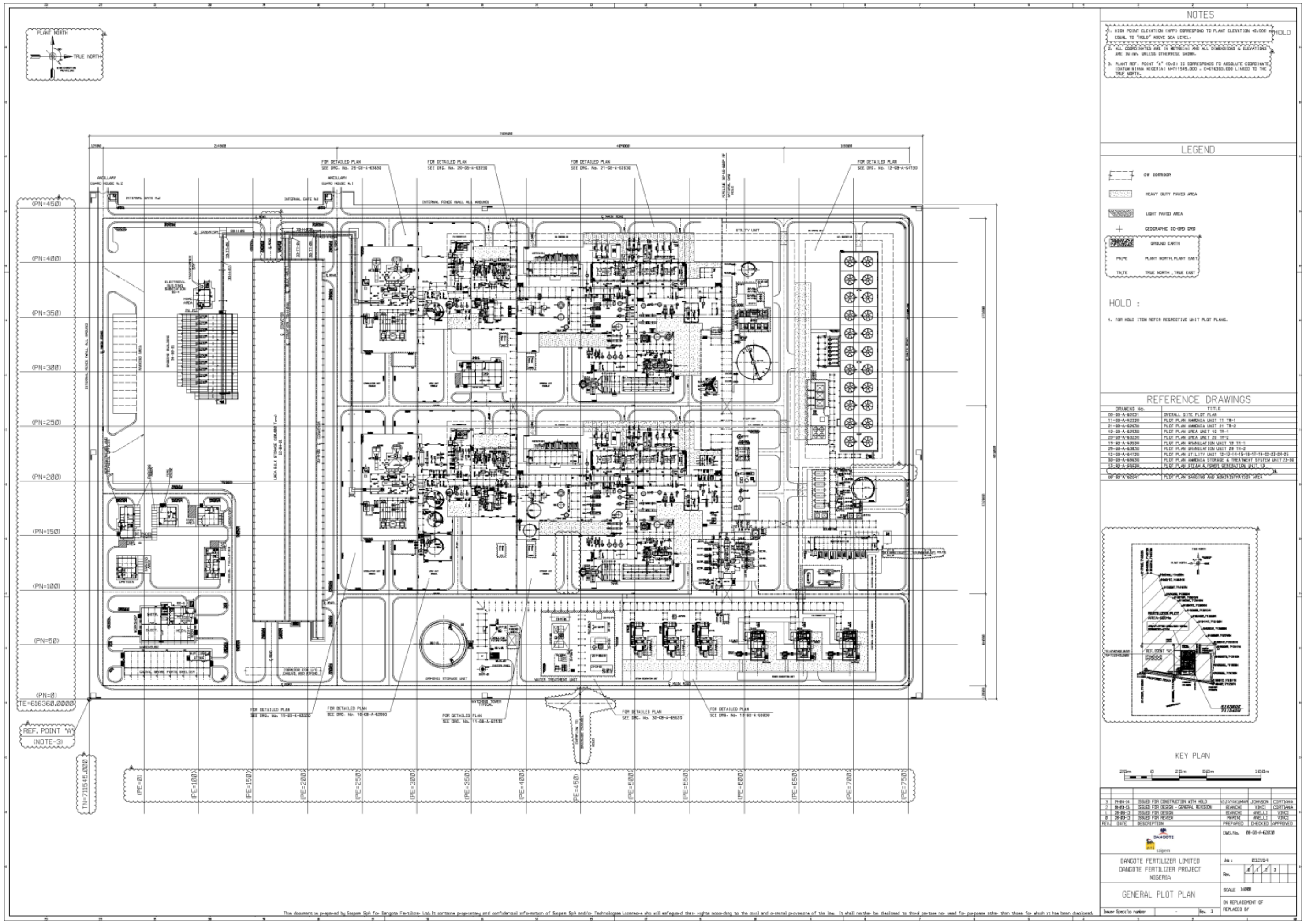


Figure 3-8: Dangote Fertilizer Plant Detailed Site Plan

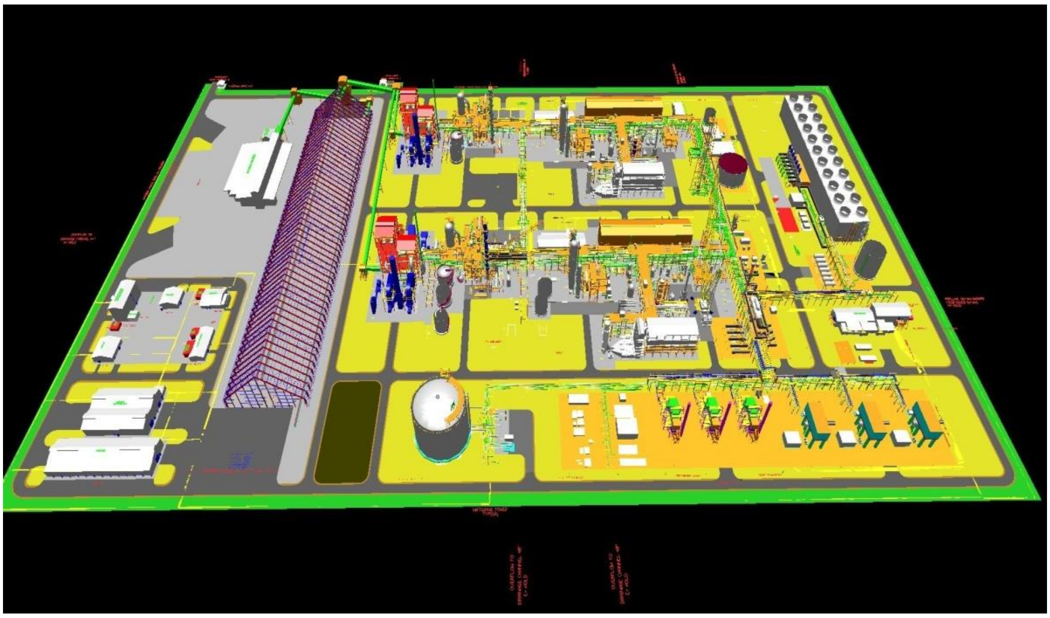


Figure 3-9: Dangote Fertilizer Plant Model

3.5.2 Process Description

a) Ammonia Plant Process Description

This process involves:

- Desulphurization;
- Reforming;
- Shift Conversion;
- CO_2 removal;
- Methanation;
- Ammonia Synthesis;
- Ammonia Refrigeration, and
- Process condensate stripping

In the ammonia plant, ammonia is produced from synthesis gas containing hydrogen and nitrogen in the ratio of approximately 3:1. Besides these components, the synthesis gas contains inert gases such as argon and methane to a limited extent. The source of hydrogen is the hydrocarbons in the natural gas. The source of Nitrogen is the atmospheric air. Product ammonia and carbon-dioxide is sent to urea plant.

The process steps necessary for production of ammonia from the above-mentioned raw materials are as follows:-

- The hydrocarbon feed is desulphurized to the ppb level in the desulphurization section;
- The desulphurized hydrocarbon feed is reformed with steam and air into raw synthesis gas (process gas). The gas contains mainly hydrogen, nitrogen, carbon monoxide, carbon dioxide and steam;
- In the gas purification section, the CO is first converted into CO_2. Then the CO_2 is removed from the process gas in the CO_2 removal section;
- The CO and CO_2 residues in the gas outlet of the CO_2 removal unit are converted into methane by reaction with H_2 (methanation) before the synthesis gas is sent to the ammonia synthesis loop;
- The purified synthesis gas is compressed and then routed to the ammonia synthesis loop, where it is converted into ammonia. In order to limit the accumulation of argon and methane in the loop, a purge stream is taken out. The liquid ammonia product is depressurized during which the dissolved gases, let-down gas and inert gas, are flared off.

b) Urea Plant Process Description

Snamprogetti ammonia stripping process is characterized by a urea synthesis loop operating at about 160 kg/cm^2(g) with ammonia to carbon dioxide molar ratio at urea reactor inlet of 3.3 ÷ 3.6.This allows a CO_2 conversion into urea of 60÷63% in the reactor itself. However, the perforated trays in the system prevent back-flow and favour gas absorption by the liquid.

There are two kinds of chemical reactions occurring at the same time in the urea reactor:

$2NH_3 + CO_2 = NH_2\text{-}COO\text{-}NH_4$ + 136230 kJ/kmol of carbamate (at 1.03 kg/cm^2; 25°C);

$NH_2\text{-}COO\text{-}NH_4 = NH_2\text{-}CO\text{-}NH_2 + H_2O$ - 17575 kJ/kmol of urea (at 1.03 kg/cm^2; 25°C)

First reaction is strongly exothermic and the second one is weakly endothermic and occurs in the liquid phase at low speed. Downstream the urea synthesis the decomposition (and relevant recovery) of unconverted chemical reagents is carried out in three subsequent steps: High Pressure Decomposition in H.P.stripper; Medium Pressure Decomposition in M.P. Decomposer and, finally, Low Pressure Decomposition in L. P. Decomposer.

The decomposition reaction is the reverse reaction of the first one above shown, viz.: NH_2-COO-NH_4 =2NH_3 + CO_2 (- Heat) and, as can be inferred from the equation, it is promoted by reducing pressure and/or adding heat. The urea reactor effluent solution enters the stripper, under slightly lower pressure than the urea reactor, where a fair part of the unconverted carbamate is decomposed, thanks also to the stripping action of NH_3 excess, so that the overall yield of the H.P. synthesis loop referred to CO_2 is as high as 80÷85% (on molar basis). Ammonia and carbon dioxide vapours from the stripper top, after mixing with the carbamate recycle solution from M.P. section, are condensed at the same pressure level of the stripper itself, in the H.P. carbamate condenser; thus producing the LS steam which is used in downstream sections. After separating the inert gases which are passed to M.P. section, the carbamate solution is finally recycled to the reactor bottom by means of a liquid/liquid ejector, which exploits H.P. ammonia feed to reactors as motive fluid. This ejector and the kettle-type carbamate condenser above mentioned, allow a horizontal layout, which is one of the main features of Snamprogetti process. Downstream of the stripper residual carbamate and ammonia are recovered in two recycle stages operating at about 17.5 kg/cm^2 (g) (M.P. section) and 3.7 kg/cm2 (g) (L.P. section) respectively. Ammonia and carbon dioxide vapours coming from carbamate decomposition are condensed and recycled to H.P. section. The solution leaving the L.P. section arrives to the concentration section where process condensate is removed in order to reach a concentration of about 96 – 97% which is required to feed granulator.

Urea Sections are characterized by the following main process steps:

- Urea synthesis and NH_3, CO_2 recovery at high pressure;
- Urea purification and NH_3, CO_2 recovery at medium and low pressures;

- Urea concentration, and
- Waste water treatment.

Urea solution production unit is also provided with the following:

- Auxiliary installation, and
- Steam networks.

c) Granulator Plant Process Description

The urea solution at a concentration of 97% wt. is delivered to the granulation unit battery limits at a pressure of 6.1 kg/cm^2(g) and at a temperature of 135°C by pumps P-08 A/B (in urea unit). Urea-formaldehyde solution is added to the urea solution, at a rate of 4.0-5.5 kg formaldehyde per ton of end product. The formaldehyde addition guarantees a free flowing product without further treatment. Standard formaldehyde solution may be used or, when locally available, liquid urea/formaldehyde pre-condensate is favoured. This latter product of higher formaldehyde concentration can be stored for several months in steel tanks without degradation or polymerization, and gives the same outstanding results in a granulation plant.

In the granulator L-50, solution is sprayed onto granules suspended in a fluidized layer. This fluidized bed is generated by the granulator fluidization air fan U-51. In case of cold or damp ambient air or fine tuning of bed temperature, use can be made of the granulator fluidization air heaters E-50 A/B/C/D. The solution injectors located in the fluid bed require low pressure atomization air (approximately0.5 kg/cm^2(g)) supplied by the atomization air blower K-51 and heated up to 135 - 145 °C in the granulator atomization air heater E-51.

Ambient air is used for fluidization. Atomization air and fluidization air are extracted from the top of the granulator. This air contains entrained urea dust and traces of ammonia. Therefore it is washed in the wet granulator scrubber C-50. The cleaned air is then discharged to atmosphere by granulator scrubber exhaust fan U-50 through the stack L-55. Urea dust entrained with air in the granulator scrubber C-50 amounts, for the whole plant, to 3.5% of unit production and is recovered as a 45% wt. solution which is recycled back to the urea unit concentration section.

The washing is carried out by means of process condensate from the urea unit. The granulated product extracted from the granulator L-50 by the vibrating granulator extractors.H-50 A/B flows, through the safety screens S-50 A/B, to the first fluid bed cooler L-51.The safety screens are provided in order to remove any lumps or agglomerates which are eventually discharged in the urea solution recycle tank T-53.In case too large quantities of solids are accumulated within short time, heat for dissolution as well as agitation is provided by the immersed steam ejectors X-53 A/B. To prevent crystallization in the tank T-53, the temperature must be capable of reaching 80°C (depending on the concentration of the solution). The temperature is controlled by regulating the LS steam to T-53.The first fluid bed cooler L-51 is a standard fluid bed cooler using ambient air supplied by the first cooler fluidization air fan U-52 as cooling medium. Air exhausted from the cooler contains some dust, it is washed in the cooler scrubber C-51 and vented through the stack together with the off gas from the granulator scrubber C-50.Dust emission from this source is very low. In the event ambient air is particularly cold or damp, use can be made of the first cooler air pre-heater E-52.Urea granules cooled down to an intermediate temperature (65°C) are lifted by the bucket elevators H-51 A/B to the vibrating screens S-51A/B/C/D where they are classified in three fractions: oversize, undersize and on-size. Undersize granules are recycled directly to the granulator whereas oversize granules are first crushed in roll crushers Z-50 A/B and then fed back to the granulator to be used as a seed material to initiate granulation. The on-size fraction is further cooled down in the final fluid bed cooler L-59 and sent to storage via the final conveyor belt at a temperature of approximately 39°C.The final cooling in L-59 is necessitated by the fact that the product is less prone to caking when cold than hot. However provisions have been made to by-pass the final cooler, e.g. for repair of fan U-56 as a temporary measure to avoid plant shut-down. In the final cooler, product is cooled by means of conditioned air supplied by the final cooler fluidization air fan U-56. The ambient air is first dried by condensation of a portion of its moisture in the final cooler air chiller E-53 and then slightly preheated by the final cooler air preheater E-54. The moisture in the air is condensed in the air chiller to droplets which are separated from the cooled air in the moisture separator V-56 of the air chilling unit and subsequently discharged to T-55, granulation steam condensate recovery tank. The re-heating of the air is carried out to prevent moisture pick-up by the granules in the final fluid bed cooler. The final cooler air chiller is driven by ammonia from the refrigeration system in ammonia unit. Exhaust air from L-59 is also scrubbed in cooler scrubber C-51 before venting to the atmosphere. A start-up bin T-54 is provided for start up and shut down operations. A urea solution recycle tank T-53 is installed beneath the granulator and collects the possible overflows, for example from the screens, to dissolve them by dilute scrubbing solution.

3.5.3 Utilities

a) Water Treatment Plant

The raw water available at Fertilizer Complex battery limit will be used for the following water production:

- Cooling water make-up
- Service water
- Fire fighting water
- Potable water
- Demineralized water

The unit includes the following functional sections:

- Filtration of incoming raw water by Dual Media Filtration Package including Chemicals dosing packages;
- Demineralized Water Production and Storage, and
- Condensate Polishing System.

The purpose of the Water Treatment Plant is to provide adequate treatment of the Lagoon Water. A dedicated Water Intake system shall be provided to send water to the Treatment Plant.

The Water Treatment Plant shall be designed to provide treated water to both Fertilizer Complex and Refinery Complex. Required treated water flow rates are:

- 2300 m^3/h (Fertilizer Complex)
- 3750 m3/h (Refinery Complex)

The water treatment plant is designed based on a multi train modular concept to guarantee flexibility and availability of the system. In particular: Two trains (1500 m^3/h of inlet water each) shall be dedicated to Fertilizer Complex, for a total of 3000 m^3/h of inlet water and Three trains (1500 m^3/h of inlet water each) shall be dedicated to Refinery Complex, for a total of 4500 m^3/h of inlet water

b) Steam and Power Generation

i. Steam Generation System

This Unit covers all necessary equipments and facilities to feed, at required water quality, both the Auxiliary Boilers and the steam generation process exchangers in Ammonia Unit (Waste Heat Boiler [W.H.B].) in order to produce very high pressure steam and high pressure steam for motive and heating uses. The resulting steam condensate will be collected and recovered.

This unit includes the following functional sections:

- Boiler Feed Water preparation, storage and feed to the process W.H.B. and to the Auxiliary Boilers;
- Chemicals dosing packages as required for the BFW preparation (13-PK-01, 13- PK-02 and 13-PK-03);
- Steam Production by means of the Auxiliary Boilers (13-B-01, 13-B-02 and 13- B-03);
- Boiler Blow Down System, and
- Condensate Recovery System.

ii. Power Generation System

The total power requirement of the complex shall be met by three (3) Steam Turbine Generators (13-G-01/02/03) of 40 MW capacity each. The capacities of Steam Turbine Generators (STGs) will cover the power requirement of Ammonia and Urea plants and Utility facilities with an export of 12 MW under normal operating condition.

c) Cooling Water System

This Unit covers the necessary equipment and facilities to feed fresh CW to the process Units. It is provided mainly for Ammonia, Urea and Utilities process cooling requirements, based on evaporative cooling water cells of conditioned water routed to the users and then returned to the cooling towers for restoring the proper temperature before being recycled to the users. To cover water losses due to evaporation, drifting and blow down, basin is equipped with level measurement and control for make-up water.

The unit includes the following functional sections:

- Common Cooling Water System for Ammonia and Urea train 1, Ammonia and Urea train 2 and for Utilities (including cooling towers, water basin and pumping station);
- Chemicals dosing packages (corrosion inhibitor& anti-scalant, hypochlorite), and
- Side Stream Filtration package

d) Natural Gas System

This Unit covers the equipment and facilities necessary to treat the natural gas from Plant battery limit and to reduce the gas pressure according to Fuel Gas Plant requirements.

The unit includes the following functional sections:

- Filtration of natural gas from battery limits through Natural Gas Filter (15-S-01);
- Split of Natural Gas into two different pressure levels;
- High pressure level for process feed of Ammonia train 1 and train 2;
- Low pressure level for LP Fuel Gas, feed of Ammonia train 1 and train 2 (reformers), Ammonia Storage Flare, Front-end/Back-end flares and Auxiliary Boilers, and
- Gas heating, required for low pressure users through the Fuel Gas Heater (15- E-01).

e) Nitrogen Production System

This Unit covers the necessary equipment and facilities to produce nitrogen with purity of 99.9%, to meet the purging requirement of equipment, for machinery seals, for utility stations, for flare headers and sub headers purging and for process units during start-up/shutdown in order to cover the nitrogen for continuous and intermittent demand of the entire Complex. Nitrogen is used as Inert Gas. The unit includes the following functional sections:

1. Nitrogen Generation Package (16-PK-01), a cryogenic air separator fed by Plant air System.
2. Nitrogen Storage and Vaporization Package (16-PK-02) consisting in a combined installation of a storage device (liquid nitrogen storage) with vaporizer sized to satisfy Plant nitrogen demand during every operating case.

f) Instrument and Plant Air System

This Unit covers the necessary equipment and facilities to produce compressed air for plant and instrumentation requirements. The main air compressed suppliers are the Air Compressors of Ammonia Plant (11-K-421 and 21-K-421). The unit includes the following functional sections:

1. Back-up Instrument Air Compressor (17-K-01), used only in case of Ammonia Plant not in operation,
2. Black Start Air Compressor (17-K-02) for black start;
3. Instrument Air Dryers (17-PK-01 A/B) for instrument air production;
4. Black Start Air Dryer (17-PK-02) dedicated to Black Start Air Compressor, and
5. Instrument Air Receiver (17-V-01).

g) Potable Water System

This potable water unit covers the equipment and the facilities required to ensure the following services:

1. Water for domestic use;
2. Water for safety shower and eye-wash station.

The unit includes the following functional sections:

1. Water Filtration designed to have a solids content with maximum 5 µm of particle size (18-S-01 A/B);
2. Potable Water Storage (18-T-01) and distribution ring fed by Potable Water Pumps (18-P-01 A/B);
3. Chemical dosing package (sodium hypochlorite) (18-PK-01).

h) Emergency & Power Diesel System

This Unit covers the equipment and the facilities required to bring the Complex to safe shut down in case of failure of normal power. The Unit is also used during start-up. A Diesel Oil Storage Vessel (22-V-01) is provided to supply the Emergency and Power Generators (22-G-01 and 22-G-02). Diesel oil to storage will be supplied via road tankers.

i) Effluent Treatment System

This Unit covers the equipment and facilities for collecting and treating waste waters, to allow the final discharge outside of Fertilizer Plant battery limit within the tolerated pollutant concentration limits. This unit includes the following functional sections:

1. Rain waters accidentally oil contaminated collecting and treatment system for oil/water separation.
2. Effluent Treatment System.

Water from following sources shall reach equalization basin:

- Waste water from UFC storage tank kerbed area
- Sanitary waste water from sanitary waste water basins
- De-oiled water from oil/solids separation package
- De-oiled water from Reverse weir basins
- Laboratory effluent pit
- Neutralization Basin - Treated effluent from mixed bed regeneration
- Neutralization Basin - Treated effluent from Ionic beds regeneration

Outlet from Equalization basin goes to Biological Treatment Package which is also provided with chlorination system. Outlet from Biological Treatment Package is divided into two streams. First stream goes to sludge drier package which also has following three inputs:-

- Backwash water from side stream filter package
- Backwash water from dual media filtration system
- Input from blow down pit

Outlet from Sludge drier package is Dried Sludge which is disposed of as per the prevalent Environment Norms. Second stream from Biological treatment goes to Outfall Basin. This is the final discharge point of treated effluent by gravity flow to Observation Rain Basin. A provision exists in the system to recycle back off-spec effluent from outfall basin to Equalization basin for re-treatment.

j) Fire Fighting System

Selection of extinguishing agents

Following fire extinguishing agents will be used:

1. Water (raw water) shall be used to control/fight fires in general plant area;
2. Aqueous Film Forming Foam (AFFF) shall deployed to fight fires originated by liquid hydrocarbons in the plant area;
3. Dry chemical powder shall be used to control and extinguish small fire in plant areas and inside the buildings;
4. CO_2 (carbon dioxide) shall be used to control and extinguish electrical fires (class” C” fire) at electrical areas and inside the buildings, and
5. Clean Agent System (Inert gas type) shall be used to provide fire extinguishing of selected enclosures (false floor) inside building.

Fire Fighting Equipment /System Selection

The above extinguishing agents shall be applied to fire source by means of fixed and portable facilities as indicated below:

1. Fire water system consisting of the fire water storage tank (in common with utility service), fire water pumps and fire water main network;
2. Fire hydrants, fire water/foam monitor, hose reel and hose storage box shall be provided around the all plant;

3. Fixed water spray systems (water deluge system) for protection of dedicated equipment;
4. Automatic clean agent system for protection of buildings;
5. Appropriate number of portable facilities including: fire extinguishers and mobile fire extinguishers;
6. Appropriate number of emergency showers and eyewash unit, and
7. Fire Station facilities including one (1) Fire Truck.

Fire water pumping and storage system

Fire Water Pumping System

The fire water pumps shall be designed to supply 568m3/h. The pumping system will consist of two (2) fire water pumps, each rated to discharge 568m3/h equal to 2x100% of the maximum fire water demand. The configuration will be as follow:

- one (1) – horizontal centrifugal pump 24-P-02 –electric motor driven - rated for 568 m3/h at 8.4 barg discharge pressure serving as main fire pump unit;
- one (1) – horizontal centrifugal pump 24-P-03 –diesel engine driven - rated for 568 m3/h at 8.4 barg discharge pressure serving as fire pump stand-by unit;

These pumps can be operated either automatically or manually. For this purpose, each pump shall be provided with a dedicated local controller. Each controller will have its own pressure sensing line. Diesel engine shall be provided with a diesel oil fuel tank having a capacity calculated as per NFPA20 requirements.

Fire water pumps will be designed in compliance with NFPA20. The fire water network shall be maintained under pressure by means of suitable jockey pumps (duty and spare), the configuration will be two (2) horizontal centrifugal pumps 24-P-01 A/B – electric motor driven – each one rated for 30 m3/h at 8.4 barg discharged pressure. Each jockey pump will have own pressure sensing line and will run in discontinuous way. These pumps can be operated either automatically or manually. For this purpose, it shall be provided with a dedicated local controller. Jockey pumps will be powered by emergency power. Fire water pump system will be skid mounted and self-contained including pumps, drivers, controllers and fuel tank as required.

Fire Water storage tank capacity

Fire water shall be stored in an above ground tank (12-T-01), in common with the water services of the plants. This tank provides the utility water and the firewater. The net stored capacity to firewater service shall be 2000 m^3 which shall be able to provide 100% of maximum demand for 4 hours. This storage tank shall be sized adequately to allow the replenishment of the fire water capacity in a time sufficiently short to limit disruption after usage of the fire water for fire-fighting. As a general rule, the fire water capacity shall be filled up in compliance with NFPA22 requirements.

3.5.4 Offsite Units

a) Ammonia Plants Flaring System

This unit is designed to dispose the Blow Down gases safely from the Front End and Back End Section of both the Ammonia Plants (Trains 1 & 2).

This system consists of 2 separate flaring systems here below described:

1. **Ammonia Back End Flare:** This system has been designed for the collection and combustion of process, ammonia rich gas. Elevated Flare System, which is to be supplied as a package (25-PK-01) and installed inside the fertilizer Complex.
2. **Ammonia Front End Flare:-**This system has been designed for the collection and combustion of process, hydrogen rich gas. Elevated Flare System, which is to be supplied as a package (25-PK-02) and installed inside the fertilizer Complex.

b) Ammonia Storage System 20000 MT

This Unit outlines the process requirements of the Ammonia Storage System mainly covers the requirements of Liquid Ammonia Storage, transfer of Liquid Ammonia from the Ammonia Plants to Urea Plants, transfer of vapor Ammonia to Ammonia Plants, Storage Refrigeration and Flaring of Ammonia Vapors during emergency conditions. The unit includes the following functional sections:

1. Ammonia Storage Tank (30-T-01)
2. Transfer of Liquid Ammonia from Ammonia plants to Urea plants by Ammonia process transfer pump (30-P-01)

3. Transfer of Ammonia Vapor to Ammonia Plants by Ammonia Vapor Displacement Blower (30-U-01)
4. Ammonia Stand-by Refrigeration Package (30-PK-02)
5. Ammonia Storage Flare (30-PK-01)

c) UFC Storage System

This Unit covers the necessary equipment and facilities to store liquid Urea Formaldehyde 85% Concentrated (UFC) and to transfer it by dedicated dosing pump system to the Urea Granulation Trains 1 and 2. This unit includes the following functional sections:

1. UFC Storage Tank (31-T-01) filled by trucks by means of UFC Unloading Pump (31-P-01);
2. UFC Transferring System (31-P-02A for train 1 and 31-P-02B for train 2 plus 31- P-02C as common spare pump).

d) Bulk Urea Handling Units

These comprise the following:

- Urea Bulk Storage;
- Urea Handling System, and
- Urea Bagging and Truck Loading System

Urea Handling System (33-PK-01) consists of a belt conveyors system for storing urea produced at Urea Granulation Train 1 and Urea Granulation Train 2 inside Urea Bulk Storage (32-BH-01) and for transferring granulated urea from Urea Bulk Storage (32-BH-01) to bagging silos located inside Bagging Building 34-BB-01.

Urea Handling System (33-PK-01) includes the following facilities:

- A belt conveyor system to transfer bulk urea coming from Urea Granulation Train 1 to Urea Bulk Storage 32-BH-01;
- A belt conveyor system to transfer bulk urea coming from Urea Granulation Train 2 to Urea Bulk Storage 32-BH-01;

- Reclaiming facilities (by others) to reclaim bulk urea stored inside Urea Bulk Storage 32- BH-01 (100,000 metric tons net capacity);
- A belt conveyor system to transfer bulk urea reclaimed from Urea Bulk Storage 32-BH-01 to bagging silos located inside Bagging Building 34-BB-01;
- Bagging and Truck loading facilities located inside Bagging Building 34-BB-01.

Bagging and Truck loading facility will consist of following:-

- 5 No. Automatic bagging lines for 50 kg bags for design capacity of 1200 bags/hour(60 TPH each line);
- 6 No. Manual bagging lines for 50 kg bags for design capacity of 1200 bags/hour(60 TPH each line);
- 1 No. Manual bagging line for 1000 kg bags for design capacity of 65 bags/hour(65 TPH each line), and
- 1 No. Bulk Loading line for design capacity of 60 TPH.

3.6 DETAILED ENGINEERING DESIGNS

The Basic Engineering Design Data are intended to provide the Process and Engineering Departments with the technical information required to carry out and complete the Engineering Design for the Project. Following are the major heads under which the exercise shall be carried out:

1. **General Information**
    - Scope of facilities
    - System of measurement units
    - Standard specifications, codes and standards
    - Environmental requirements
    - Safety requirements
    - Availability requirements
2. **Site Information**
    - Site location
    - Site condition

- Access facilities to site
- Reference elevation
- Climatic data
- Special environmental conditions

3. Utility Information

- Electrical power
- Utility costs

4. Equipment Information

- Heaters
- Vessels
- Shell and Tube exchangers
- Air cooled Heat exchangers
- Machinery
- Package definition
- Boilers
- Atmospheric storage tanks
- Corrosion Allowance
- Minimum design metal temperature

5. Instruments and Control Systems

- General information
- Control room and Instrument panel
- Distributed Control System (DCS)
- Supervision and Protection System
- Instrument Supply
- Instrument Characteristics
- Instruments Installation

6. Electrical

- Distribution System
- Maximum voltage drops in cables
- Wiring system
- Electric control monitoring system

- Power factor Improvement
- Recommended Luminance levels
- Aeronautical Obstruction Marking
- Other mandatory Requirements
- Electrical Equipment

7. Plant Layout and Piping Design

- Plant layout
- Underground Systems
- Structures
- Lines and Piping Components
- Above Ground Design
- Insulation and Painting
- Corrosion Allowance

8. Civil

- Fencing
- Roads
- Buildings
- Design
- Miscellaneous

9. Miscellaneous Information

- Telecommunication
- Process Requirements
- Utility Measurement at Battery Limit
- Welding of Pipelines and Non-destructive Testing

3.7 SITE CLEARANCE PROCESS

The facility site covers an area of approximately 500 ha. The site is generally flat. In preparation for site clearance, enumeration of socio-economic and agricultural activities on-going on the acquired site had been carried out. Consultation with the host communities has been done and adequate compensation as agreed with community members during enumeration effected. Site preparation and earthworks at the facility site will include:

- Vegetation clearing activities and removal of organic material;
- Removal of unsuitable material and top soil; and
- Levelling and compaction, including cut to fill operation on site and borrowing to fill from an approved source if required.

Before levelling (cut or fill) operations can start, vegetation and organic material, as well as unsuitable material and top soil, will be cleared. The clear and grub operation will be followed by the removal of topsoil and unsuitable material. Material will be transported to a spoil site identified by Dangote Fertilizer where it will be spread and levelled. Once vegetation and top soil and unsuitable material in the terrain has been cleared, cut or fill operations can start. The terrain will be levelled to the agreed elevation, which will include cutting the high areas and filling the lower areas. The shortfall in fill will be imported from creeks. Fill material will be compacted to the required density in layers, which will continue until the final elevation has been achieved. The depth of topsoil to be stripped is 500 mm.

3.8 DREDGING AND BACKFILLING PROCESS

Dredging is 'building within nature'. This means that understanding the integration with the environment and incorporating working methods to mitigate adverse effects are an integrated part of every dredging project. Sand for filling this swampy area and raising level of the ground shall be sourced from the lagoon. In view of this, dredging and backfilling process decision in respect of source of sand, volume of sand required and level to be sand filled will be taken based on final ground level computed by EIL as dictated by the topography of the project site.

3.9 CONSTRUCTION AND INSTALLATION PROCESSES

3.9.1 Construction

Based on the Licenses, Design and Engineering Design, material will be either procured by M/s Saipem OR by M/s Dangote Fertilizer Limited.

Construction will be carried out in 3 phases. They include:

- Construction at Vendors' Works.
- Construction at Site.
- Part construction at Vendor's works (Modules) and part at site.

Construction at Vendor's Works

There will be a Vendors List agreed between M/s Saipem and M/s Dangote Fertilizers Limited. M/s Saipem will carry out the design of all the equipment / machinery required for the Plant. The company will issue all the necessary specifications and drawings for the Construction of Equipment with Purchase Order. After Order, Vendor will submit Design Calculations, all the Fabrication and Quality Control Procedures, detailed Fabrication Drawing / Assembly Drawing to M/s Saipem, M/s Tata Consulting Engineers and M/s Dangote Fertilizer Limited. After approval of drawings and calculations, the Vendor will construct the equipment.

During construction, M/s Saipem will delegate their Inspectors to carry out Inspection. Every Inspection procedure will be properly documented. All Machinery will be tested for satisfactory performance at Vendors' works. Structural Items will be pre-fabricated at Vendors' works and delivered to site. This will also be as per the Specifications issued by M/s Saipem under her Inspection.

After accepting all these items at Vendor's works, the equipment will be shipped to Site.

Construction at Site

Items such as Storage Tanks e.g. Ammonia Storage, Filtered Water storage, etc. will be constructed at site. All piping spools will be pre-fabricated, welded, inspected and painted (Part of Construction) at site before Installation. The pre-fabrication of the spools will be executed as follow:

- Piping Specifications for the complete plant shall be prepared by M/s Saipem.

- In accordance with the Piping Specifications, Welding Procedure Specifications (WPS) will be prepared by M/s Onshore Construction Company (a sub-contractor to Dangote Fertilizer Ltd) and submitted to M/s Saipem for approval.
- On receipt of approval, these procedures will be qualified and a report will be generated, called Procedure Qualification Record (PQR). There will be one set of WPS / PQR for a range of Thicknesses but for a single grade of material. Combination of WPS and PQR will be followed throughout the piping execution.
- Piping Isometric will be generated by M/s Saipem and issued to M/s Onshore. Using state of the art software, list of piping isometrics, for which work can commence, will be generated.
- All the joints will be marked on the hard copy of the drawing as “Shop Joint” OR “Field Joint”.
- All items required for the Isometrics will be listed out as Bill of Material (BOM). This material will be issued to M/s Onshore.
- First, all these items will be shot blasted and primer painted as per the Specifications issued by M/s Saipem.
- Then Pre-fabrication will be carried out in a workshop away from the plant. Only those joints, which are marked as “Shop Joint”, will be executed for Pre-fabrications.
- Welding will be carried out in accordance with the WPS.
- There will be strict adherence to the Piping Specifications, Isometrics, WPS and PQR and QA/QC aspects.
- All the quality checks like Fitup, Weld visual, Radiography Tests, Ultrasonic Tests, etc. will be executed by the Contractor and witnessed by M/s Saipem and M/s Tata Consulting Engineers (TCE).
- A proper document will be generated to record each and every such activity.
- On completion of Pre-fabrication, these piping spools will be properly tagged and kept on the lay down area.

Package Units will be transported in broken down condition to site, and will be installed at site.

Part Construction at Vendor's Works (Modules) and Part at Site

- The proposed plant is characterised of many large sized packages. These will be partly constructed at Vendor's works while the rest activities will be carried out at site. These Packages include Reformer, Compressor Packages, Urea bagging / handling packages, water treatment packages, Boiler Packages, Power Plants, Cooling Towers, etc.
- All equipment forming packages will be constructed at vendors' works. The construction will be carried out as per 3.9.1.1. Then the final assembly and completion of construction will be carried out at site as described in 3.9.1.2.

3.9.2 Installation Process

Installation will be done by M/s Onshore Construction Company. Construction Management will be carried out by M/s Saipem. M/s Tata Consulting Engineers will act on behalf of M/s Dangote Fertilizers Limited as Project Management Consultants. In addition to the items in the scope of M/s Saipem, M/s Dangote Fertilizer will also procure items such as Insulation material, paints, maintenance tools, Inspection tools, etc.

On receipt of items at site, they will be inspected to ensure that the same is received without any transit damage. These items will be stored in designated and well bounded lay down area. Items, which needs covered storage will be kept in a store, specially built for such items. Perishable items and complex electronic instruments will be kept in Air Conditioned storage. Installation Processes will be different for different categories of Equipment / Packages.

Installation of Equipment and Machinery

These items will be constructed 100% at vendor's works. Thus, they will be ready for installation, as received. The steps that will be involved in the installation process will include:

- Prepare Installation Scheme;
- Check Foundations orientation;

- Level foundation by chipping;
- Place Packing Plates;
- Mark up North direction;
- Place item on foundation maintaining nozzle orientation;
- Level and align them using shims;
- Grout Foundation Bolts/Equipment base frame;
- Finally align by tightening foundation bolts;
- Install platforms and ladders, wherever applicable, and
- Prepare Protocol readings indicating co-ordinates and elevation.

Consequently, all other internals of these equipment, like trays, packings, catalysts, alumina balls, lube oils, chemicals, etc. will be filled, so that it is ready for commissioning.

Piping work

Available front for the erection of the piping spools will be identified. Pre-fabricated spools identified shall be shifted to the site. They will be erected on structures, equipment and underground, as the routing may be. Welding will be carried out following the same steps as Piping Constructed in Workshop. The records will be further updated, taking into account, the Field Joints.

All types of support inline instruments, valves, Safety Valves, etc. will be installed. All the terminal points will be hooked up either with other piping or with equipment, as the case may be. There will be a complete check to ensure that the piping work is executed as per the Piping and Instrumentation Diagram.

Line will be hydraulically tested as per the piping design conditions and applicable piping codes. On successful completion of hydro test, piping will be released for further activities like painting and insulation, flushing, drying out, and will be released for commissioning.

Package Units

Package units are a combination of Equipment, Machinery and Piping. Equipment will be installed as described in 3.9.2.1. Piping will be installed as in 3.9.2.2. There will be a complete check to ensure that the piping work is executed as per the Piping and Instrumentation Diagram for each package unit. Finally, the unit will be released for commissioning.

Site Fabricated Tanks

Except for Ammonia Tank, all the material required for the construction of the Storage Tanks will be brought to site in pre-fabricated and rolled condition. M/s Onshore will construct these tanks, as per the drawings under the strict supervision of Ms Saipem, M/s TCE and M/s Dangote. Construction of the tank and quality checks will be in accordance with the applicable API codes.

For ammonia Storage Tanks, all materials like plates, pipes, flanges, structures, fittings, etc. will be brought to the site. After fabrication and rolling of the plates, all construction activity will be same as the rest of the tanks.

Inspection will be carried out in strict compliance with the Applicable codes. Each and every Quality check will be recorded and a proper Quality Dossier will be generated. After ensuring complete compliance with the Design and Drawings, these tanks will be released for Hydraulic Test. On successful completion of hydro test, piping will be subjected to further activities like painting and insulation, flushing, drying out among others. On completion of these processes, the tanks will be released for commissioning.

Structural Work

Complete structures will be in pre-fabricated condition. Each component will be tagged as per the Fabrication Drawing. Erection will be carried out as per the Structural Assembly Drawings. First, the main columns will be bolted with the foundation. Then, main beams will be erected by bolting. After alignment/levelling, they will be grouted. Subsequently, secondary/tertiary columns and beams will be erected. All joints will be properly bolted. Finally, gratings, hand rails, toe bar, knee bar, platforms and ladders, safety latched, etc. will be erected.

After final dimensional checking, these structures will be released for erection of equipment and piping. Final touch up coat painting will be applied. Wherever applicable, fire proof mortar will be applied.

Miscellaneous Work

Miscellaneous works in the plant include the following:

- Application of Hot and Cold Insulation
- Painting work
- Fire proofing of structures, wherever applicable.

3.10 OPERATION PROCESS

3.10.1 Ammonia Plant

Process Description

In the plant, ammonia is produced from synthesis gas containing hydrogen and nitrogen in the ratio of approximately 3:1. Besides these components, the synthesis gas contains inert gases such as argon and methane to a limited extent. The source of H_2 is the hydrocarbons in the natural gas. The source of N_2 is the atmospheric air. The source of CO_2 is the hydrocarbons in the natural gas feed. Product ammonia and CO_2 is sent to urea plant. As indicated in Figure 3-9, the following processes take place in the ammonia plant. They include:

a) Desulphurization
b) Reforming
c) Shift Conversion
d) CO_2 removal
e) Methanation
f) Ammonia Synthesis
g) Ammonia Refrigeration

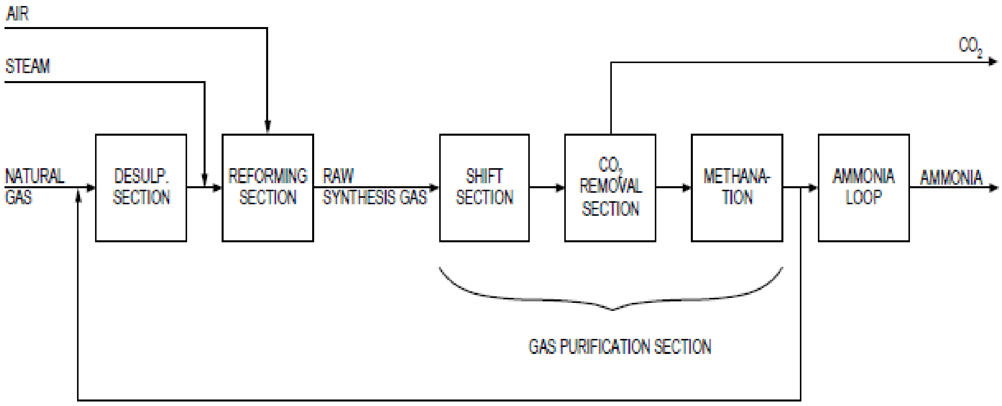


Figure 3-10: Main Process Steps

a) Desulphurization

The natural gas feedstock coming from battery limit contains minor quantities of sulphur compounds which have to be removed in order to avoid poisoning of the reforming catalyst in the primary reformer, 11-F-201, and the low temperature shift catalyst in the CO converter, 11-R-205. Particularly the low temperature shift converter, 11-R-205, is sensitive to deactivation by sulphur and sulphur-bearing compounds. Prior to hydrogenation, the feed gas is mixed with Hydrogen rich recycle stream which is coming from synthesis gas compressor 2nd stage discharge. Then the Feed gas is heated in 11-E-204-1 and 11-E-204-2 in the reformer flue gas section. Since the gas contains organic sulphur compounds, the desulphurization takes place in two stages. The organic sulphur compounds are converted to H_2S by the hydrogenation catalyst TK261, and the H_2S absorption takes place in the sulphur absorption catalyst HTZ-51. After desulphurization, the content of sulphur is less than 0.1 vol. ppm.

Figure 3-11: A Model of a Typical Ammonia Plant

- Hydrogenation

The preheated natural gas is fed to the Hydrogenator (11-R-201). The vessel contains HTAS Hydrogenation Catalyst TK-261, which is a cobalt-molybdenum based catalyst. TK-261 catalyzes the following reactions: $RSH + H_2 = RH + H_2S$, $R_1SSR_2 + 3H_2 = R_1H + R_2H + 2H_2S$, $R_1SR_2 + 2H_2 = R_1H + R_2H + H_2S$ (CH), $4S + 4H_2 = C_4H_10 + H_2S$,$COS + H_2 = CO + H_2S$ where R is hydrocarbon radical.

The hydrogenation catalyst must not get into contact with hydrocarbons without the presence of hydrogen. The result would be poor conversion of the organic sulphur compounds causing an increased sulphur slip to the reforming section. The temperature also plays an important role with regard to catalyst activity; at low temperatures the hydrogenation reactions progress very slowly and conversion is not optimal while at high temperatures undesirable cracking reactions may occur with deactivation of catalyst due to carbon lay-down on the catalyst itself. The optimum temperature range is between 350 and 400°C.

- H_2S Absorption

The hydrogenated natural gas is fed to the sulphur absorbers (11-R-202 A/B). The two sulphur absorbers, located in series, are identical. 11-R-202 B acts as a guard in case of sulphur breakthrough from 11-R-202 A or in case 11-R-202A is taken out of service for catalyst replacement. Each vessel has one catalyst bed which contains HTZ-51 catalyst. This zinc oxide catalyst is in the form of 4 mm extrudates. The normal operating temperature is approximately 355°C. The zinc oxide reacts with the hydrogen sulphide and carbonyl sulphide in the following equilibrium reactions: $ZnO + H_2S = ZnS + H_2O$, $ZnO + COS = ZnS + CO_2$.

b) Reforming

In the reforming section, the desulphurized gas is converted into synthesis gas by catalytic reforming of the hydrocarbon mixture with steam and the addition of air. The steam reforming process can be described by the following reactions:

(1) $CnH_2n+2 + 2H_2O = Cn\text{-}1H_2n + CO_2 + 3H_2$ - heat

(2) $CH_4 + 2H_2O = CO_2 + 4H_2$ - heat (39.4 kcal/mol)

(3) CO2 + H2 = CO + H2O - heat (9.84 kcal/mol).

Reaction (1) describes the mechanism of reforming the higher hydrocarbons, which are reformed in stages to lower and lower hydrocarbons, finally resulting in methane, which is reformed as shown in reaction (2). The heat input required for the reverse shift reaction (3) is very small compared to the heat input required for reaction (1) and (2). The reactions take place in two steps, primary reforming and secondary reforming. Thus, the reforming unit consists of a primary reformer with a waste heat section and a secondary reformer.

- Primary Reformer, 11-F-201

The first step of the steam reforming process takes place in the Primary reformer, 11-F-201. The desulfurized hydrocarbon and steam mixture is preheated to 520°C in the Feed gas/steam preheater, 11-E-201, before entering the Primary reformer, 11-F-201. The process gas passes downwards through vertical tubes containing the nickel- based catalyst. The required heat is transferred by radiation from a number of wall burners to the catalyst tubes. In order to ensure complete combustion of the fuel gas, the burners are operated with an excess air ratio of about 10%, which corresponds to about 2 vol % (dry) of oxygen in the flue gas. The hydrocarbons in the feed to the Primary reformer are converted into hydrogen and carbon oxides, and the gas from the Primary reformer contains approximately 11.6 mole% (dry) of methane with a Primary reformer outlet temperature of about 821°C. The Primary reformer has a total of 300 reformer tubes installed in two chambers. The chambers are placed side by side in a duplex row arrangement and function as one unit. The two furnace chambers have a common flue gas duct and flue gas heat recovery section. Each furnace chamber contains a number of vertically mounted, high alloy Cr-Ni steel tubes filled with Topsøe' s reforming catalyst. The tubes are mounted in a single row along the centre line of the chamber. The process gas is flowing downwards with the gas being distributed to the top of the tubes from a header through "hairpins" at a temperature of about 520°C. The gas leaves the tubes through bottom "hairpins" and enters a refractory lined collector through high alloy hot collectors. The tubes are heated by a number of burners located in each side wall of the furnace chambers and arranged in horizontal rows at several elevations to provide easy control of the uniform temperature profile along the length of the catalyst tubes. In this manner, the optimal utilization of the expensive high alloy tubes is obtained. Flue gas flow is upwards with outlet near the top of the radiant chamber. The flue gas outlet system comprises a common flue gas collector mounted between the two radiation chambers. The flue gas temperature is about 1085°C. The upper part of the reformer tubes is loaded with catalyst RK-211-7H, while the middle part of the reformer tubes is loaded with catalyst RK-201-7H and the bottom part with R-67-7H.

- <u>Flue gas heat recovery section</u>

  The flue gas passes via the flue gas duct to the flue gas heat recovery section, in which the sensible heat of the flue gas is utilized for the following duties:

  - ✓ Preheating of the hydrocarbon/steam mixture going to primary reformer, 11-E-201.
  - ✓ Final preheating of the process air for the Secondary reformer, 11-E-202-1.
  - ✓ Final superheating of high pressure steam, 11-E-203-1.
  - ✓ Final preheating of natural gas going to the desulphurization, 11-E-204-1.
  - ✓ Superheating of high pressure steam, 11-E-203-2.

- ✓ Preheating of process air for the Secondary reformer, 11-E-202-2.
- ✓ Preheating of natural gas, 11-E-204-2.
- ✓ Boiler feed water preheating, 11-E-205.

At the outlet the flue gas temperature is reduced to approx. 189°C. A Flue gas blower, 11-U-201, takes the flue gas to the Flue gas stack.

- Secondary reformer, 11-R-203

The gas from the Primary reformer is passed on to the Secondary reformer, 11-R- 203, through a refractory lined transfer line. The gas is admitted to the vessel through a top dome mixing chamber, where it is mixed with the process air which has been compressed to 39 kg/cm^2g by the Process air compressor, 11-K-421, and preheated to 550°C in the flue gas heat recovery section. The Secondary reformer is a refractory lined vessel. The burner mixer is mounted at the top of the vessel. Partial combustion takes place in the top of 11-R-203 and causes a considerable increase in the temperature. From the combustion zone, the gas passes down through a catalyst bed, where the last part of the reforming takes place as the gas cools. The temperature of the process gas leaving the Secondary reformer is about 1000°C, and the methane concentration is 0.40 mole% (dry). The Secondary reformer outlet gas contains about 14.34 mole% CO and 7.4 mole% CO_2. Cooling of the process gas takes place in the Waste heat boiler No.1, 11-E-208. The Secondary reformer is to be charged with the following Topsøe catalysts: a top layer of RKS-2, a main layer of RKS-2-7H. The catalyst bed rests on two layers of alumina balls with different sizes, and alumina tiles are placed on top of the catalyst bed to hold down the catalyst and to protect the catalyst from direct flame contact. Combustion of the process gas with air produces a gas temperature of 1100- 1200°C in the upper section of the Secondary reformer. Because the reforming reaction of methane absorbs heat, the temperature decreases down through the catalyst. The balance between reforming done in the Primary and Secondary reformers depends on preheat temperatures and the methane leakage. In practice the firing in the Primary reformer is adjusted so that the desired outlet conditions from the Secondary reformer are obtained with the amount of process air required to give a hydrogen/nitrogen ratio of approximately 3 to 1 in the synthesis gas to the loop. The process gas leaves the reforming section at about 1000°C. It is cooled to about 360°C in the Waste heat boiler, 11-E-208, where 120 kg/cm^{2}g saturated steam is produced. After cooling, the gas flows to the HTCO-converter, 11-R-204.

c) Shift Section

The carbon monoxide in the process gas leaving the reforming section is converted into carbon dioxide and hydrogen according to the shift reaction: $CO + H_2O = CO_2 + H_2$ + heat (9.84 kcal/mol). The shift reaction equilibrium is moved towards higher conversion of CO by lower temperature and more water vapor, however, the reaction rate increases with higher temperature. The optimum temperature for the shift reaction depends on the activity of the catalyst and the composition of the gas. The shift reaction takes place in the two adiabatic CO converters (11-R-204 and 11- R-205), with process gas cooling after each converter. After reforming, about 14.3% CO is present in the gas (dry basis). In the High temperature CO converter, 11-R-204, the CO content is reduced to approximately 3.5 vol%, and the temperature increases from 360°C to 436°C. It is then cooled to 205°C and passed on to the Low temperature CO converter, 11-R-205, in which the CO content is reduced to approx. 0.3 vol%, while the temperature increases to 229°C. The heat content of the effluent from the high temperature CO converter, 11- R-204, is recovered in the Methanator trim heater, 11-E-211, in the Waste heat boiler No.2, 11-E-210, and in the BFW preheater No.1, 11-E-212.

d) CO_2 Removal Section

The CO2 removal system is based on the two-stage activated MDEA process by BASF. The solvent used for CO_2 absorption is aMDEA. The main process system consists of two-stage CO_2 absorption in a flash-regenerated semilean solution and in a strip-regenerated lean solution. The aMDEA solution contains about 40 wt% aMDEA; an activator increases the mass transfer rate of CO_2 from the gas phase to the liquid phase. The rest of the solution is water. The overall reactions occurring during the CO_2 absorption process are described by the following equations: $R_3N + H_2O + CO_2 = R_3NH+ + HCO_3$; $2R_2NH + CO_2 = R_2NH_2+ + R_2N\text{-}COO$ The first reaction describes the reaction for a tertiary amine (e.g. MDEA). The second reaction describes the reaction for a secondary amine (activator).

- Process description

The gas leaving the CO conversion section has a CO_2 content of 18.79 mole% (dry). Due to its content of steam, the gas also contains a considerable amount of recoverable heat, mainly latent heat of condensation. This heat is recovered by BFW preheater No. 2, 11-E-213, the Stripper reboiler, 11-E-302, and DMW preheater No.2, 11-E-305. After the process condensate is separated from the gas in the Process gas separator, 11-V-304, the gas enters the CO_2 absorber, 11-C- 302, at a temperature of about 65°C.

In the CO_2 absorber, 11-C-302, the CO_2 is removed from the gas by countercurrent absorption in two stages. In the lower part of the absorber, a flash-regenerated semilean solution is used for bulk CO_2 removal. In the upper part, a strip- regenerated lean solution is used for scrubbing. At the absorber outlet, the CO_2 content in the gas is reduced to less than 500 ppm (dry). The solutions which enter the absorber at 50°C (lean solution) and 75°C (semilean solution) are heated to about 83°C by the exothermic absorption reactions. High interfacial areas between gas and liquid are provided by IMTP 50 rings in the bulk absorber and by IMTP 25 in the lean absorber respectively. To prevent loss of scrubbing solution and activator by entrainment in the purified gas, the top of the column is provided with three washing trays fed with about 1410 kg/h of water. Flash regeneration of the rich solution is performed in two stages to obtain the desired high purity of the CO_2 product. In the HP flash drum, 11-V-302, most of the dissolved inert components are released at a pressure of 6.3 kg/cm^{2}g. The flash gas from the HP flash drum is sent to the reformer fuel header. The rich solution continues to the LP flash drum, 11-V-301, where most of the CO_2 is released from the solution at a pressure of 0.64 kg/cm^{2}g. Both flash drums are loaded with pall rings. The CO_2 released in the LP flash drum is saturated with water at a temperature of approximately 71°C. This mixture is cooled to 40°C in the CO_2 product cooler, 11-E- 306, and the overhead condensate is separated from the CO_2 product in the CO_2 product separator, 11-V-303. The CO_2 product leaving 11-V-303 is exported to the urea plant at a pressure of 0.5 kg/cm2g. The flashed solution from the bottom of the LP flash drum is divided into two streams. Most of the solution is pumped into the lower part of the absorber by the Semilean solution pump, 11-P-301 A/B/C; the rest is transferred to the CO_2 stripper, 11-C-301, for final removal of the CO_2 via the Split stream pump, 11-P-303 A/B. Before entering the top of the stripper, the semilean solution is heated in the Solution heat exchanger, 11-E-301, by the lean solution coming from the bottom of the stripper. In the CO_2 stripper, the CO_2 is stripped off by indirect heat. The heat required for stripping is produced in the Stripper reboiler, 11-E-302. The CO_2 stripper is loaded with pall rings. The CO_2 leaving the top of the CO_2 stripper at approximately 96°C is saturated with water vapor. Condensation of this water increases the temperature in the LP flash drum, resulting in better LP flash performance. The lean solution from the bottom of the CO_2 stripper column is cooled to 50°C through the Solution heat exchanger, 11-E-301, and the Lean solution cooler, 11-E- 303, before being pumped to the top of the absorber by the Lean solution pump, 11- P-302 A/B.As described above, most of the CO_2 is removed from the process gas by absorption in the semilean solution. During normal operation, the semilean solution flow is about 3200 t/h. The Semilean solution pumps, 11-P 301 A/B/C, are driven as follows: 11-P-301 A Electric motor, 11-MP-301 A 11-P-301 B Electric motor, 11-MP-301 B 11-P-301 C Electric motor, 11-MP-301 C All three Semilean solution pumps are connected in parallel. During normal operation the A and B pumps will be running.

e) Methanation

The final gas preparation step is the methanation, a process in which the residual carbon oxides are converted into methane. The methane acts as an inert gas in the ammonia synthesis loop, whereas oxygen-containing compounds such as carbon oxides (CO and CO_2) are severe poisons to the ammonia synthesis catalyst. The methanation process takes place in the Methanator, 11-R-301, and the reactions involved are the reverse of the reforming reactions: $CO + 3H_2 = CH4 + H_2O$ + heat (49.2 kcal/mol) $CO_2 + 4H_2 = CH4 + 2H_2O$ + heat (39.4 kcal/mol).

- <u>Process description</u>

The inlet temperature to the Methanator, 11-R-301, is designed to be 300°C at start of run. The process gas from the CO_2 absorber, 11-C-302, is heated to this temperature as it passes through the Gas-gas exchanger, 11-E-311, and the Methanator trim heater 11-E-211.After the CO_2 removal, the gas contains 0.05% CO_2 and 0.40% CO (dry basis). These compounds are converted to CH4 by reaction with H_2. The content of CO + CO_2 is reduced to less than 5 ppm. During normal operation, the temperature increase across the catalyst bed should be approximately 24°C, which corresponds to an outlet temperature of approximately 328°C. The Gas-gas exchanger, 11-E-311, then cools the purified gas to approximately 77°C. The gas is then routed to the Final cooler, 11-E-312, and the Final gas separator, 11-V-311, where the condensate is separated from the gas at 40°C. The purified gas contains N_2, H_2 and approximately 1.2 mole% (dry) of inert as Ar and CH4. The H_2:N_2 ratio in the synthesis gas is approximately 3:1.

f) Ammonia Synthesis Section

The ammonia synthesis process takes place in the ammonia synthesis converter (11-R-501) according to the following reaction scheme: $3H_2 + N_2 = 2NH_3$ + heat (22 kcal/mol)

The reaction is reversible and only part of the hydrogen and nitrogen is converted into ammonia when the gas passes through the catalyst bed. High pressures and low temperatures favour a high equilibrium concentration of ammonia. In 11-R-501, about 30% of the nitrogen and hydrogen is converted into ammonia. The unconverted remainder is recycled to the converter after separation of the liquid ammonia product.The ammonia synthesis loop has been designed for a maximum pressure of 217 kg/cm^{2}g. The normal operating pressure will be 195 kg/cm^{2}g at the inlet to the ammonia converter, depending on load and catalyst activity. At reduced load, the loop pressure will decrease. Normal operating temperatures will be in the range of 370-510°C for the first bed, 425-480°C for the second bed, and 420-460°C for the third bed in 11-R-501. After the synthesis gas has passed through 11-R-501, the effluent gas is to be cooled down to a temperature at which most of the ammonia condenses. A considerable amount of the heat released by the reaction is utilised to produce high pressure steam in the waste heat boiler (11-E-501) and to preheat the high pressure boiler feed water in 11-E-502. The purified synthesis gas contains a small amount of impurities, mainly the inerts, Ar and CH4. A continuous purge from the synthesis loop is necessary to avoid accumulation of the inerts.

The converter effluent gas is cooled stepwise, first in the waste heat boiler (11-E-501) from approximately 455°C to 340°C. Next, the gas is cooled to about 260-270°C in the

BFW preheater (11-E-502) and then in the hot heat exchanger (11-E-503), where the effluent synthesis gas cools to about 60°C by preheating the converter feed gas. The synthesis gas is then cooled to 38°C in the water cooler (11-E-504) and further to 24°C in the cold exchanger (11-E-505), which is used to preheat the converter feed gas. Final cooling of the synthesis gas to 0°C takes place in the 1st (11-E-506) and 2nd (11-E-508) ammonia chiller. The condensed ammonia is separated from the circulating synthesis gas in the ammonia separator (11-V-501). From the separator, the gas is recirculated through the cold and hot heat exchangers to the synthesis converter by the circulator, which is an integrated part of the synthesis gas compressor (11-K-431). The synthesis gas is compressed from 31 to 188 kg/cm2g in the centrifugal type two-casing synthesis gas compressor, 11-K-431. Part of the last casing of 11-K- 431 forms the recirculation compressor in the synthesis loop. The make-up synthesis gas is introduced into the loop between the 1st (11-E-506) and the 2nd ammonia chiller (11-E-508).

g) Refrigeration Circuit

The purpose of the refrigeration circuit is to perform the various cooling tasks in the ammonia synthesis loop. Its primary task is to condense the ammonia which is produced in the converter. Other tasks are cooling of make-up gas, purge gas and inert gas and cooling in the Urea Granulation Unit. Refrigeration circuit (of unit 11 only) is able to manage small discontinuous flow of ammonia vapour from ammonia storage tank (unit 30).The refrigeration circuit includes the following main equipment: -

- Four chillers operating at two different pressures
- The ammonia compressor
- The ammonia condenser
- The ammonia accumulator
- Two K.O. drums to protect the refrigeration compressor from droplets of ammonia
- A flash vessel from which the make-up ammonia is taken and to which the ammonia is returned from the refrigeration circuit.

The unit is designed to operate in two modes depending on whether the ammonia is sent to storage as cold product or to the downstream urea plant as hot product. Liquid ammonia flows from the accumulator, 11-V-504, through the product heater, 11-E-512, to the first synthesis loop chiller, 11-E-506, where it is expanded to 4.7 kg/cm2g corresponding to a temperature of 7.2^oC. Liquid ammonia from 11-E-506 is transferred to the second synthesis loop chiller, 11-E- 508, and the purge gas chiller, 11-E-514, where it is further expanded to 2.7 kg/cm^{2}g corresponding to a temperature of -4^oC. Evaporated ammonia from the chillers and from the flash vessel, 11-V-503, is compressed by the ammonia compressor, 11-K-441. The suction pressures correspond to the pressures in the flash vessel and the chillers. After compression, the ammonia from 11-K-441 is condensed in the ammonia condenser, 11-E-510A/B, and collected in the accumulator, 11-V-504. Inert gases accumulating in the refrigeration system are vented from the ammonia accumulator, 11-V-504. Ammonia is condensed in the inert vent gas chiller, 11-E-511, and separated in the inert vent gas separator, 11-V-505. The gas, which still contains some ammonia, is sent to the ammonia recovery unit. Evaporated ammonia from 11-E-511 is sent to the ammonia compressor, 11-K-441. During the ammonia to storage case, the ammonia is sent to flash vessel, 11-V- 503 from letdown vessel 11-V-502. In the flash vessel ammonia is flashed to 0.05 kg/cm^{2}g which help in cooling of ammonia suitable to storage temperatures. Then the -33^oC ammonia is pumped to storage using 11-P- 501 pumps. The flashed vapours in flash vessel as mentioned above are recovered by the ammonia refrigeration compressor, 11-K-441 in plant itself.

3.10.2 Urea Process

Snamprogetti ammonia stripping process is characterized by a urea synthesis loop operating at about 160 kg/cm^2(g) with ammonia to carbon dioxide molar ratio at urea reactor inlet of 3.3 - 3.6. This allows a CO_2 conversion into urea of 60 - 63% in the reactor itself, as a result of the perforated trays which prevent back-flow and favor gas absorption by the liquid. There are two kinds of chemical reactions at the same time in the urea reactor:

a) $2NH_3 + CO_2 = NH_2\text{-}COO\text{-}NH_4$ + 136230 kJ/kmol of carbamate (at 1.03 kg/cm^2; 25°C)

b) $NH_2\text{-}COO\text{-}NH_4 = NH_2\text{-}CO\text{-}NH_2 + H_2O$ - 17575 kJ/kmol of urea (at 1.03 kg/cm^2; 25°C)

The first reaction is strongly exothermic and the second one is weakly endothermic and occurs in the liquid phase at low speed. Downstream the urea synthesis the decomposition (and relevant recovery) of unconverted chemical reagents is carried out in three subsequent steps: High Pressure Decomposition in H.P. stripper; Medium Pressure Decomposition in M.P. Decomposer and, finally, Low Pressure Decomposition in L.P. Decomposer. The decomposition reaction is the reverse reaction of the first one above showed, viz.:

$NH_2 – COO - NH_4 = 2NH_3 + CO_2$ (- Heat)

and, as can be inferred from the equation, it is promoted by reducing pressure and adding heat. The urea reactor effluent solution enters the stripper, under slightly lower pressure than the urea reactor, where a fair part of the unconverted carbamate is decomposed, due to the stripping action of excess NH_3, so that the overall yield of the H.P. synthesis loop referred to CO_2 is as high as 80-85% (on molar basis). Ammonia and carbon dioxide vapors from the stripper top, after mixing with the carbamate recycle solution from M.P. section, are condensed at the same pressure level of the stripper, in the H.P. carbamate condenser; thus producing the LS steam which is used in downstream sections. After separating the inert gases which are passed to M.P. section, the carbamate solution is finally recycled to the reactor bottom by means of a liquid/liquid ejector, which exploits H.P. ammonia feed to reactor as motive fluid. This ejector and the kettle-type carbamate condenser above mentioned, allow a horizontal layout, which is one of the main features of Snamprogetti process. Downstream of the stripper residual carbamate and ammonia are recovered in two recycle stages operating at about 17.5 kg/cm2 (g) (M.P. section) and 3.7 kg/cm2 (g) (L.P. section) respectively. Ammonia and carbon dioxide vapors coming from carbamate decomposition are condensed and recycled to H.P. section. The solution leaving the L.P. section arrives to the concentration section where process condensate is removed in order to reach a concentration of about 96 – 97% which is required to feed the granulator (Figures 3-11 and 3-12).

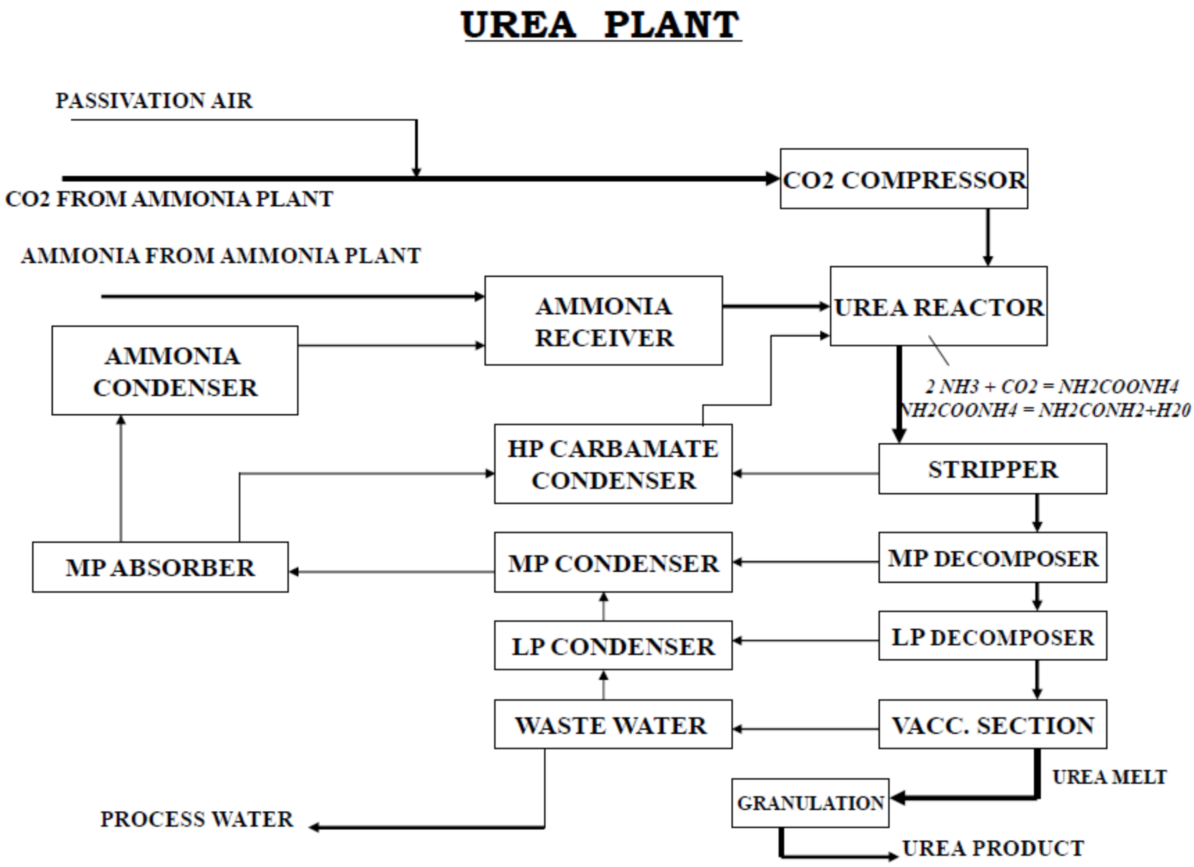


Figure 3-12: Process Description of Urea Production

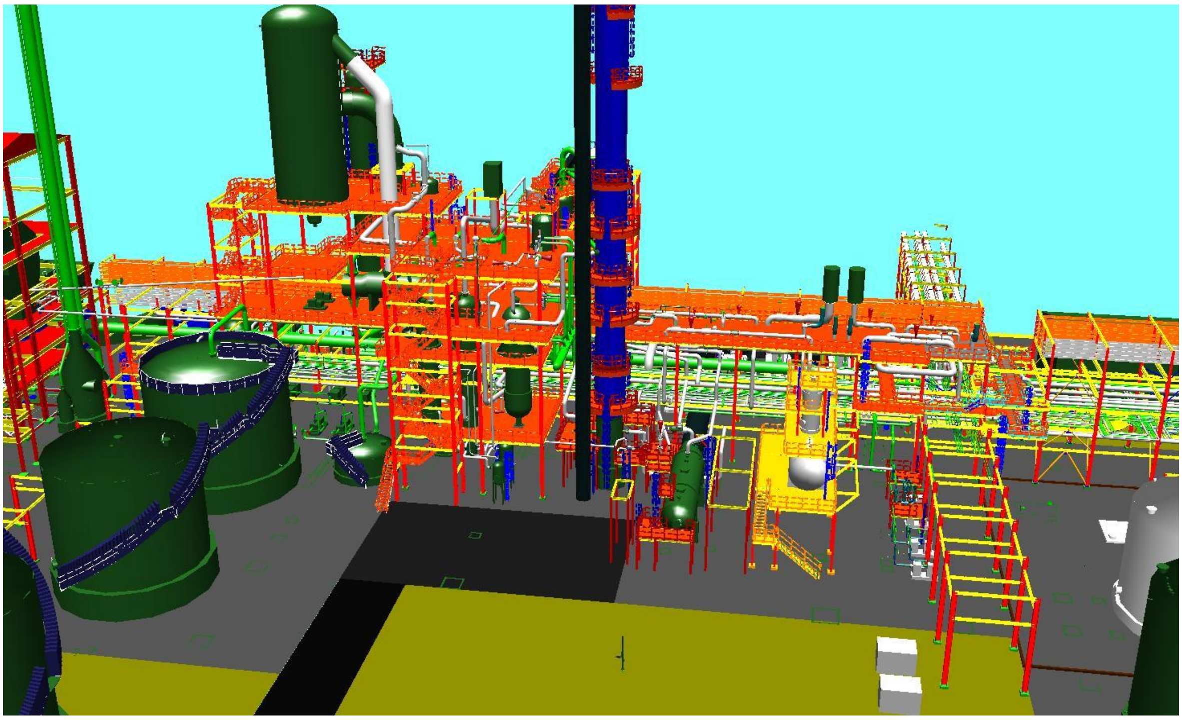


Figure 3-13: A Model of a DFL Urea Plant

Urea Sections are characterized by the following main process steps:

a) Urea synthesis and NH_3, CO_2 recovery at high pressure;
b) Urea purification and NH3, and carbamate recovery at medium and low pressures;
c) Urea concentration;
d) Waste water treatment;
e) Auxiliary installation;
f) Steam networks, and
g) Condensate Recovery & Flushing networks.

a) Urea Synthesis and NH3, CO2 Recovery at High Pressure

Urea is produced by synthesis from liquid ammonia and gaseous carbon dioxide. In the urea reactor 10-R-01, the ammonia and carbon dioxide react to form ammonium carbamate, a portion of which dehydrates to urea and water. The reactions are as follows:

$$2NH_3 + CO_2 = NH_2COONH_4$$

$$NH_2COONH_4 = NH_2CONH_2 + H_2O$$

In synthesis conditions (T = 188-190°C, P = 160 kg/cm^2(g)), the first reaction occurs rapidly and is complete, the second reaction occurs slowly and determines the reactor volume. The fraction of ammonium carbamate that dehydrates is determined by the ratios of the various reagents, the operating temperature, pressure and the residence time in the reactor. The mole ratio of ammonia to carbon dioxide is around 3.3 - 3.6.The mole ratio of water to carbon dioxide is around 0.5 - 0.7. The liquid ammonia feed to Urea Unit, coming from Ammonia Unit, is filtered through NH_3 filters 10-S-04 A/B, then enters into NH_3 recovery tower 10-C- 05, and is collected in the ammonia receiver 10-V-05. From 10-V-05, it is drawn and pumped to about 23.6 kg/cm2 (g) pressure by means of ammonia booster centrifugal pump 10-P-05 A/B. Part of this ammonia is sent to medium pressure absorber 10-C-01, the remaining part enters the high pressure synthesis loop. The ammonia to the synthesis loop is pumped by H.P. ammonia centrifugal pump 10-P-01 A/B, at a pressure of about 224 kg/cm^2(g). Before entering the reactor, the ammonia is used as propelling fluid in the carbamate ejector 10-X-01. The liquid mixture of NH^3 and carbamate from 10-X-01 enters the urea reactor bottom where it reacts with the carbon dioxide compressed feed. The carbon dioxide feed drawn to the Urea Unit battery limits, from the Ammonia Units, at about 0.5 kg/cm^2(g) and 40 °C temperature, enters the CO_2 compressor 10-K-01, and leaves it at a pressure of about 160 kg/cm^2(g). A small quantity of air is added to the carbon dioxide feed at the 10-K-01 suction in order to passivate the stainless steel surfaces of H.P. loop items, thus protecting them from corrosion due both to the reagents and reaction products. Another small quantity of air is added to the bottom of stripper 10-E-01, by 10-K-02 A/B compressor, in order to passivate it. The reaction products leaving the reactor flow to the upper part of stripper 10-E-01, which operates at about 150 kg/cm2 (g).The gaseous stream, leaving the top of the stripper, after mixing with the recovered solution from the bottom of medium pressure absorber 10-C-01, enters the carbamate condenser, 10-E-05. Except for incondensable gases, vapours are condensed and recycled to the urea reactor 10-R-01, by means of carbamate ejector 10-X-01. Condensing vapours at high pressure and temperature allows the production of saturated steam at 3.5 kg/cm^2(g) in the carbamate condenser 10-E-05. Incondensable gases, consisting of inert gases (passivation air plus inerts with CO_2 from B.L.) and containing a little quantity of NH_3 and CO_2, come out from the top of the carbamate separator 10-V-01 and flow directly into the bottom of the medium pressure decomposer 10-L-02.

b) Urea Purification and NH_3 & CO_2 Recovery at Medium and Low Pressure

Urea purification and overhead vapours recovery take place in two stages at decreasing pressure, as follows: 1st stage at 17.5 kg/cm^2(g) pressure and 2nd stage at 3.7 kg/cm^2(g) pressure.

<u>1st purification and recovery stage at 17.5 kg/cm^2(g) pressure</u>: The solution, with a low residual CO_2 content, leaving the bottom of the stripper, E-01, is expanded to the pressure of 17.5 kg/cm^2(g) and enters the upper part of medium pressure decomposer. This item is mainly divided into the following three sections:

- ✓ Top separator, 10-V-02, where the released flash gases are removed before the solution enters the tube bundle.
- ✓ In tube falling film type decomposer, 10-E-02A (upper part) and 10-E-02B (lower part), where the carbonate is decomposed and the required heat is supplied by

means of condensing steam at 5.3 kg/cm^2(g) (in the upper part of the shell, 10-E-02A) and cooling steam condensate, coming from the stripper 10-E-01 (in the lower part of the shell, 10-E-02B).

- ✓ Urea solution holder, 10-L-02, where the 1st stage's purified urea solution at 60 - 63 % wt. is collected.

The NH3 and CO^2 rich gases, leaving the top separator 10-V-02, are mixed with the carbonate solution coming from the recovery section at 3.7 kg/cm^2(g) and sent to medium pressure condenser 10-E-06, where CO^2 is almost totally absorbed and condensation / reaction heat is removed by cooling water coming from ammonia condenser 10-E-09.The mixed phase effluent from 10-E-06 flows into the medium pressure absorber 10-C-01 bottom, where the gaseous phase enters the rectification section. This is of bell-cap trays type and performs CO^2 absorption and NH_3 rectification. In the column a reflux of liquid ammonia allows balancing the energy entering the column, and removing residual CO_2 and H_2O contained in the rising stream of gaseous ammonia and inerts. This reflux is drawn from the ammonia receiver 10-V-05, and sent to the column by means of ammonia booster pump 10-P-05 A/B. A gaseous stream of saturated ammonia and inerts, with a few ppm of CO_2 (20 -100 p.p.m.) residue, comes out of the top of the rectification section and it is partially condensed in the ammonia condenser 10-E-09. From here two phases are sent to the ammonia receiver 10-V-05. The uncondensed stream, saturated with ammonia, leaving the 10-V-05, rises the ammonia recovery tower 10-C-05, where an additional amount of ammonia is condensed by means of the descending liquid ammonia stream coming from the B.L. The gaseous stream leaving the 10-C-05 top rises the medium pressure falling film absorber 10-E-11, where its residual ammonia content is drastically reduced by means of countercurrent stream of an ammonia water diluted flow which absorbs gaseous ammonia. The absorption of ammonia generates heat which increases the temperature of descending liquid, thereby tending to prevent further ammonia absorption. To maintain the temperature at a favorable level a cooling water flow is provided in the shell side of 10-E-11. The M.P. inerts washing tower 10-C-03, connected to the upper part of 10-E- 11, consists of three valve trays where the inert gases are submitted to a last washing step with clean condensate. The inerts, leaving column, are connected to granulator dust scrubber or alternatively to continuous vent stack 10-V-12. From the bottom of 10-E-11 the NH_3/H_2O solution is recycled back to the medium pressure absorber, 10-C-01, by means of the centrifugal pumps 10- P-07 A/B. The 10-C-01 bottom effluent is recycled, by means of H.P. carbamate centrifugal pump 10-P-02 A/B, to the synthesis recovery section.

2nd purification and recovery stage at 3.7 kg/cm2 (g): The solution, with a very low residual CO_2 content, leaving the bottom of the M.P. decomposer is expanded to the pressure of 3.7 kg/cm^2(g) and enters the upper part of low pressure decomposer. This item is mainly divided into the following three sections:

- ✓ Top separator 10-V-03, where the released flash gases are removed before the solution enters the tube bundle;
- ✓ In tube falling film type decomposer 10-E-03, where the carbonate is decomposed and the required heat is supplied by means of condensing saturated steam at 3.5 kg/cm2 (g), and
- ✓ Urea solution holder 10-L-03, where purified urea solution at 69 - 71 % wt. is collected.

The gases leaving the 10-V-03 are firstly mixed with the liquid coming from reflux accumulator 10-V-17 of the distillation tower 10-C-02, and subsequently sent to L.P. condenser 10-E-08, where the remaining NH3 and CO2 vapours are totally condensed. Condensation heat is removed by cooling water flowing in the tube side. The carbonate solution at the outlet of 10-E-08 is recovered into carbonate solution accumulator 10-V-06. From here the carbonate solution is recycled back to the M.P. absorber bottom 10-C-01 by means of centrifugal pump 10-P-03 A/B, passing through the shell side of M.P. condenser 10-E-06. The 10-V-06 is assembled with a low pressure washing tower C-04, in order to help the pressure control of L.P. recovery stage. L.P. section vent is connected to discontinuous vent stack 10-V-13.

c) Urea Concentration

As it is necessary, for granulation unit, to concentrate the urea solution up to 97% by wt., one vacuum concentration stage is provided. The urea solution leaving the low pressure decomposer bottom with about 70% wt. urea, is sent to the bottom of vacuum concentrator 10-E-14 which operates at the a pressure of 0.3 kg/cm2 (abs). Before entering 10-E-14, the solution is mixed with the urea solution recycle coming from granulation unit and with urea solution recycle from 10-P-09 on discontinuous basis. Saturated steam at 3.5 kg/cm^2(g) is supplied to the 10- E-14 shell side to concentrate the urea solution flowing in the tube side. The mixed phase, coming out from the process side of 10-E-14, enters the gas-liquid vacuum separator 10-V-14, from where vapours are extracted by the vacuum system 10-PK-01, while the urea solution (97 % by wt.), is sent to granulation unit by means of 10-P-08 A/B, after mixing with UF85 additive

d) Waste Water Treatment

This section, unit 27, is common to urea units, 10 and 20. The process condensate containing NH_3-CO_2 and urea coming out from vacuum system of both urea units, 10 and 20 is treated in this section to make free of contaminants before sent to utility unit. The contaminated water of each urea unit is collected in the process condensate tank 10-T-02. From this tank the process condensate is pumped, by means of 10-P-14 A/B, to a common buffer off spec tank, 27-T-05, then the mixed solution is sent to the upper part of distillation tower 27-C-02. The Tank 10-T-02 also receives the drain solutions accumulated into underground carbonate close drain tank 10-T-04, and fed to process condensate tank by means of pump 10-P-16 A/B. Before entering the distillation column, the process condensate picks up heat from the purified condensate leaving the bottom of the column itself, by means of preheater 27-E-16. The column 27-C-02 is provided with trays and is divided in two main sections by a chimney tray. Column process conditions are:

- Pressure (top): 2.5 kg/cm2 (g)
- Temperature (top): 118°C

The condensate from the chimney tray is drawn and pumped, by centrifugal pump 27-P-15 A/B/C, to urea hydrolyzer 27-R-02, where process conditions are suitable to decompose urea into CO_2 and NH_3.The necessary decomposition heat is provided by adding steam at 44 kg/cm^2(g) and 380°C. Hydrolyzer process conditions are:

- Pressure: 34 kg/cm2 (g)
- Temperature: 235 °C.

The out coming vapours from the hydrolyzer as well as the vapours from the top of the distillation tower are mixed and condensed in the overhead condenser, 27-E-17, then collected in the reflux accumulator, 27-V-17 and split to LP section of urea unit 10 & 20 by reflux pumps, 27-P-17A/B. The recycle stream is mixed upstream of 10-E-08 with the LP Decomposer overhead vapors. The hydrolyzed condensate leaving the bottom of the 27-R-02, after having decreased its temperature passing through hydrolyzer preheater, 27-E-18, enters the distillation tower immediately under the chimney tray where the final NH_3 and CO_2 stripping takes place. Saturated steam at 5.3 kg/cm^2(g), injected directly at the column bottom, provides the necessary stripping force. The purified process condensate leaves the column bottom at 143°C and it is cooled at 45°C by means of:

- Distillation tower feed preheating by means of 27-E-16
- Process condensate cooler 27-E-23

3.10.3 Granulation Process

In the fluid bed process, granular urea is produced by spraying liquid urea solution onto seed material in the fluidized state. The basic characteristics of this process are:

- The liquid urea is a concentrated solution and not a pure melt;
- The spraying occurs in the core of a fluidized layer by means of a large number of spray heads;
- The particle size enlargement is achieved by accretion, and
- Urea-Formaldehyde solution (UF85) is added to the urea solution before spraying, as a process aid and anti-caking agent.

In the granulation plant the 97% wt. urea solution with a temperature of about 135°C from the Urea evaporation section is pumped by granulator feed pumps, 10-P-08 A/B, to the granulator, 19-L-50 A/B. UF85 is added to the urea stream as an additive upstream of the granulator feed pumps, 10-P-08 A/B. In the granulator a fluidized bed of the product is generated by granulator fluidization air fan 19-U-51. Into this fluidized bed, consisting of the recycled fine granules and crushed oversize granules, urea solution is sprayed and atomized by atomization air compressor, 19-K-51, to fine droplets, which are colliding with the urea particles in the fluidization bed. By this the diameter of the particle is growing. In the last part of the granulator the product is cooled by fluidization air to a temperature of 95°C. At the outlet of the granulator, safety screens, 19-S-50 A/B, are installed to remove agglomerates and particles bigger than 10 mm from the product stream. The removed agglomerates are collected in the recycle tank, 19-T-53, where they are dissolved together with lumps from vibrating screens, 19-S-51 A/B/C/D, finally the concentrated urea solution is recycled to the urea evaporation section to be processed again. After passing the safety screens the product is cooled down in the first fluid bed cooler by means of air from the first fluid bed cooler fluidization air fan, 19-U-52, to a temperature of about 65°C and from there transferred by bucket elevators,19-H-51 A/B, to the vibrating screens, 19-S-51 A/B/C/D. These screens divide the product into three main fractions: oversize, on-size and undersize fraction. The on-size product is transferred to the final fluid bed cooler, 19-L-59, where it is cooled down to a temperature of 39°C, by means of cooled fluidization air, and finally transferred to the bulk storage. The undersize fraction is directly recycled back to the granulator, while the oversize fraction is transferred to the roll crushers, 19-Z-50 A/B/C/D where it is crushed into fine particles and finally are also recycled to granulator. The air streams from the fluidized bed coolers and granulator containing urea dust are washed in the coolers scrubber, 19-C-51, and granulator dust scrubber, 19-C-50, to remove the entrained urea dust. The MP vent gas coming from Urea Unit has been re-routed to the granulator scrubber 19-C-50, where it is treated together with the main exhaust air stream coming from the granulator itself.

a) Granulator Section and Solids Circuit

The granulator lower part, 19-L-50 B, receives the feedstock urea solution from the granulator feed pumps, 10-P-08 A/B, located in the Urea Unit. The urea/formaldehyde UF85, drawn from the UFC storage tank 31-T-01, is metered by UFC transfer pumps 31-P-02 A/B/C and added to the urea solution at suction of 10-P-08 A/B to ensure efficient mixing of both fluids. The urea solution, at 97%wt concentration, which contains formaldehyde is dispensed to the injection headers and sprayed by atomization air in the granulator. The atomization air is delivered by the atomization air compressor, 19-K-51. Ambient air is used for atomization of the urea melt. Downstream the compressor the atomization air is heated to 135°C in the heater 19-E-51. This heater is operated with MS steam. The granulator fluidization air is compressed by the granulator fluidization air fan, 19-U-51, and sent to the granulator. In order to control the granulator fluidization air temperature the fluidization air system is fitted with the following equipment: - the fluidization air which is sent in the first four granulator chambers can be heated by the granulator fluidization air heaters, 19-E-50 A/B/C/D. The rest of the air that is sent to the cooling chambers n ° 5, 6 and 7 and it does not require heating or cooling. The heat exchangers 19-E-50 A/B/C/D are operated with LS steam or with MS steam (during start-up).

When ambient air is particularly cold and/or damp or when plant is operated at reduced capacity and/or during plant start-up, heaters 19-E-50 A/B/C/D must be put in operation with LS steam; MS steam is only used under start-up conditions. Granular urea extracted by the granulator extractors, 19-H-50 A/B, flows through the safety screens, 19-S-50 A/B, and fall into the first fluid bed cooler 19-L-51. The safety screens remove any lumps or agglomerates bigger than 10 mm. The lump fraction is collected into the recycle tank 19-T-53. The first fluid bed cooler 19-L-51 is a standard fluidized bed cooler. Ambient air supplied by the first cooler fluidization fan, 19-U-52, is used as cooling medium. If the ambient air is particularly damp, cold or when the plant operates at low capacity, the first fluid bed cooler air pre-heater,19-E-52 can be used. The fluidization air from the first fluid bed cooler 19-L-51 is cleaned in the fluid bed coolers scrubber 19-C-51 before it is discharged to the atmosphere through the vent stack 19-L-55. The air flow through the coolers scrubber is maintained by the coolers scrubber exhaust fan, 19-U-53. Urea granules inside first fluid bed cooler 19-L-51 are cooled down to the required temperature of around 65°C and then lifted by the bucket elevators, 19- H-51 A/B to the screening section 19-S-51 A/B/C/D where they are classified into three fractions: oversize, undersize and on-size. The on-size fraction is sent to the final fluid bed cooler 19-L-59. The undersize fraction is recycled directly to the granulator upper casing 19-L-50 A. The oversize fraction is firstly crushed in the roll crusher 19-Z-50 A/B/C/D, before being sent back to the granulator as seed material. The ratio between the oversize and undersize flow rates and the on-size flow rate is defined as the solid recycle ratio and it is approximately equal to 0.5. The final fluid bed cooler 19-L-59 is a standard fluidized bed cooler. Conditioned air, supplied by the final fluid bed cooler fluidization air fan, 19-U-56, is used as cooling medium. The air is treated to prevent moisture pick-up of the product during cooling. Ambient air is first chilled to 6°C to remove excess humidity in air chiller 19-E-53, by evaporating liquid ammonia at 1°C. The resulting water droplets are removed from the air stream by the moisture separator 19-V-56. Finally the air is slightly pre-heated in the pre-heater 19-E-54 to about 7°C to avoid moisture pick-up by urea granules. At the discharge of 19-U-56 the air temperature is about 10°C. The fluidization air of the final fluid bed cooler is also cleaned in coolers scrubber 19-C-51 before it is discharged to atmosphere through the vent stack 19-L-55. The air flow is maintained by the coolers scrubber exhaust fan 19-U-53. The cooled urea granules are sent to storage via belt conveyors.

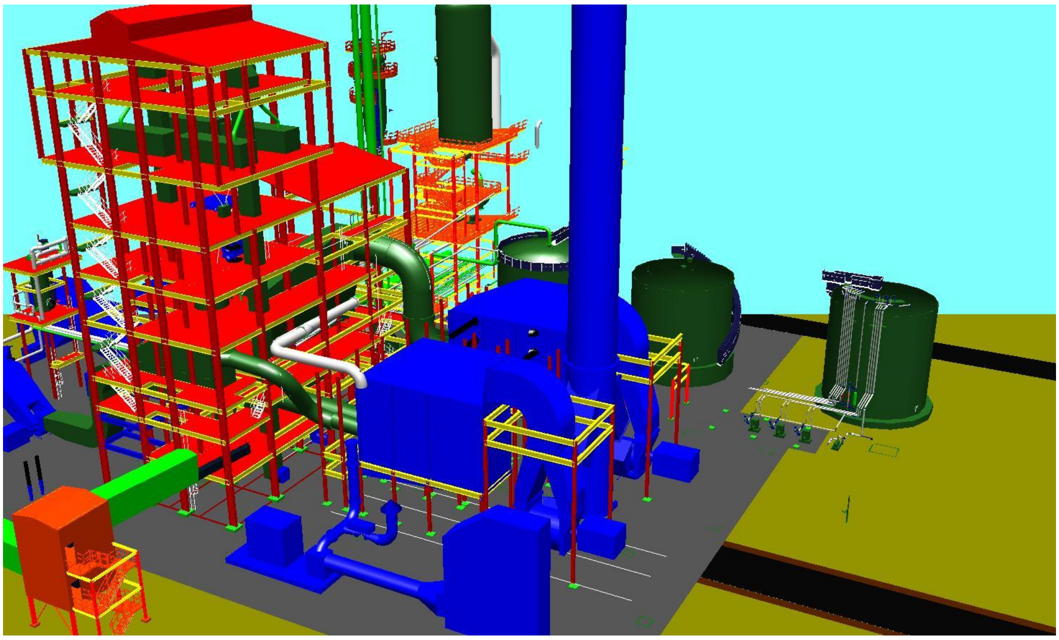


Figure 3-13: A Model of DFL Granulation Plant

3.11 INFRASTRUCTURE

1. Workers Camps

Workers camps shall be established at site with all facilities such as potable water, power, recreational facilities, sewage, sanitation facilities etc. The development of workers camp is critical as about 3000 workers shall be engaged for project works during construction phase.

2. Water-Intake

Lagoon water shall be the only intake source for Water Treatment Plant for water to be used for process plants. Borewell water shall be used for providing potable and drinking water to workers and others during construction phase.

3. Marine Outfall for Disposal of Treated Effluents

All treated effluents shall be discharged into the deep sea through a distributor to be designed at the engineering stage. This design shall be standardized to ensure proper mixing and dilution. The pipeline from the plant area to the sea that will transport treated effluents shall be routed on the same corridor to be engineered to route crude intake lines for refinery project. The engineering design and other details shall be in conformity with the prevailing regulatory framework.

4. Construction Site including Sheds, Welding Bays etc

Following facilities shall be set up for Construction works. They include:

- Pre-fabrication workshop with Automatic welding machines, shot blasting machine , EOT cranes etc
- Painting shop
- Civil yard
- Batching plant
- Piling works yard

5. Other buildings and structures on site

Other buildings that will be erected on the site include:

- Administration buildings
- Stores
- Canteens
- Control and technical building
- Electrical Substations
- Workshop
- Laboratory
- Guard house

All necessary Urban and Regional Planning Regulations including setbacks, airspace, lighting among others are observed and met in the planning of the this buildings (Figure 3-7)

6. Road Network Design

The design provides for both the main arterial road and access road with sufficient Right of Way (ROA). Specifically, the main arterial road has a ROA of 24m while that of access road is 18m. Each road is well furnished with drainage system, walkways among others. Adequate provision has been made for access and exit into the complex. In an attempt to minimize traffic snarls within the complex, the design ensures that there are few cross junctions (Figure 3-7). On completion, efforts shall be made to landscape these roads tastefully.

7. Loading Rack

The distribution facilities would be equipped with 13 loading bays. These include 5 Automatic Lines (50 Kg bags – 100 kg bags per hour per line); 6 Manual Lines (50 kg Bags – 800 bags per hour per line); 1 Big Bag Line (100 kg bags – 15 bags per hour per) and 1 Bulk Loading Line (30 tonnes per hour). Each loading station will have two 4-inch loading arms for loading trucks from above and a loading platform skid way. A skid is a steel frame on/in which equipment necessary for loading and measuring of the product is installed. This includes filters, measuring devices and valves. The loading rack total throughput is approximated at 2.8 million metric tonnes per annum.

8. Truck Parking

Truck parking will be required to accommodate the trucks waiting to be loaded with product. A total of 13 truck parking spaces will be provided within the plant. The distribution area, truck parking area and roads on site will be covered with reinforced concrete and/or interlocking concrete paver blocks.

9. Truck Loading and Transportation

Truck fill and transport of product to local markets will be via the truck loading rack. The trucks will access the site at the entrances close to the distribution facilities, and proceed to the office for their loading order prior to loading. Trucks will then be directed to the truck loading bays for loading with product. Trucks may be required to stop within the truck parking areas on site, while waiting for product loading. A long-term parking has been foreseen for all trucks, while the short-term parking is open for trucks foreseen to be loaded in the next 24 hours.

10. Drainage Design

The drains are designed using open-channel flow systems, consequently by partially filled drainage systems. The runoff design flow to be discharged shall be ensured throughout the drainage system, in compliance with the upstream and downstream elevation constraints of the drainage system. The water elevation assumed upstream shall be adequate to the level of the surrounding ground, while the downstream hydraulic section shall permit the discharge of the total runoff quantity, in compliance with the effluent constraints. The drainage system shall be fully consistent with the grading plan design.

- **Drainage Systems for Uncontaminated Paved Areas and Parking**

  The parking (asphalted or paved) can be gravity drained through both rectangular channels with traffic-bearing covers and a system of catch basins and piping. Uncontaminated paved areas of the plant (areas where there are not sources of contamination) are mainly drained through catch basins connected by a piping system. The catch basins are connected in series (preferably up to a maximum of two) by secondary pipes up to the confluence point, fitted with a manhole, with the main drainage line. Contrary to other systems (e.g. potentially contaminated waters drainage systems) it is not necessary to arrange siphoning on the catch basins because there is not fire propagation through piping. In plant areas the ideal unit surface area for drainage of each catch basin is approximately 40m² (20m x 20m squares), while in the parking, where immediate drainage of rainwater is not critical, the unit surface area can increased to 1200 - 1600m² (maximum 40m x 40m squares). The slope of the runoff surfaces shall be from 1 to 2%.

- **Drainage Systems for Roads**

For roads up to 3.00 - 4.00 m in width, with one or two watersheds, water can be drained off directly into the adjacent areas (which are usually gravelled) without providing a dedicated sewer. For larger roads, main plant roads with a width of 8.00 - 10.00 m and secondary roads with a width of 5.00 - 6.00 m, drainage can be realized using roadside channels. In the drainage system by roadside channels, channels can have a trapezoidal or rectangular shape, as a rule without any cover, with the exception of road intersections which shall be covered with reinforced concrete slabs. Alternatively, road crossings can be made using siphoned pipes connected by end pits.

11. Security and Access Control

The adopted CCTV and Security systems shall be based on the use of an integrated management platform. Thus, they shall be implemented as one (1) fully integrated overall system

- **CCTV System**

The system shall provide the Plant operators with live and/or time-delayed visual indication of:

- ✓ Normal operation of specific process-related Plant functions;
- ✓ Appropriate work activity of personnel;
- ✓ Theft or malicious activity;
- ✓ Unauthorized personnel access to Plant areas;
- ✓ Emergency response activities, and
- ✓ Historical events of interest.

The system shall be an open standard integrated system with IP network centrifunctional and management architecture, including video recording facility. It shall enable monitoring of key areas and equipment from nine (9) operator control units. A quantity of industrial cameras shall be installed in the process/utility units, at the Plant gates and along the perimeter fences. All cameras installed in the process/utility units shall be equipped with PTZ lens, while all cameras installed at the Plant gates and along the perimeter fences shall be fixed and thermal type. All the video/control signals from the cameras shall be conveyed over Single Mode (SM) fibre optic cable to the nearest building where it shall be terminated to a local CCTV cabinet. The cable above shall be composite type, including also copper conductors for camera AC power supply. All the local CCTV cabinets shall be connected back to a main CCTV central equipment

- **Access Control System**

The system shall be provided to control and monitor personnel and vehicles/trucks access across the facility. The system shall be based on badge with proximity badge-reader and intercom station. Badge readers and door control mechanisms shall be installed at every building entrance as well as at some indoor rooms. Intercom stations shall be also installed at every building entrance. Exit from these locations shall be by push-button on the secure side of the door. All external building doors, including emergency exits and the automatic/manual (a/m) indoor rooms, shall have magnetic contact alarms to indicate when a door has been left open or opened without authority. At each Plant vehicle/truck entry/exit location, automatic vehicular cross-bars with stanchion-mounted proximity badge-readers together with intercom stations shall be provided to control movement of traffic flow and enabling personnel to announce their presence, respectively. At each Plant pedestrian access location, high-security turnstiles shall be provided to permit access to authorized personnel. Each turnstile shall be equipped with proximity badge-reader and intercom station too.

- **Intrusion Detection System**

The system shall be provided to identify attempts by unauthorized personnel to obtain access to the Plant. It shall be based upon the use of Plant perimeter wall fence-mounted fiber optic sensor cables to protect the entire perimeter fence, including all vehicle and personnel gates; fence over climbing in any way shall result in detection and alarm. Passage point shall be covered with remotely controlled infrared (IR) barriers,

12. Services and Safety Systems

- **Water Supply and Sanitation**

Water Supply

The purpose of the Water Treatment Plant is to provide adequate treatment of the Lagoon Water. A dedicated Water Intake system shall be provided to send water to the Treatment Plant. The Water Treatment Plant shall be designed to provide treated water to both Fertilizer Complex and Refinery Complex. Required treated water flow rates are:

- ✓ 2300 m^3/h for the Fertilizer Complex
- ✓ 3750 m^3/h for the Refinery Complex

Based on the required process treatments, the expected raw water to be treated is around 6800 m^3/h. Considering a design margin of 10%, 7500 m^3/h has been selected as Water Treatment Plant Inlet Duty. The water treatment plant is designed based on a multi train modular concept to guarantee flexibility and availability of the system. Two trains (1500 m^3/h of inlet water each) shall be dedicated to Fertilizer Complex, for a total of 3000 m^3/h of inlet water .Three trains (1500 m^3/h of inlet water each) shall be dedicated to Refinery Complex, for a total of 4500 m^3/h of inlet water

Sanitation

The package units shall be designed and constructed in order to guarantee the maximum operating reliability and operating flexibility without any effect on the package characteristics and capacity.

The main scope of Sanitary Waste Water Packages includes:

1) To collect sanitary waste water from the following manned areas:

- ✓ Administration Building Area
- ✓ Ancillary Guard House nr 1
- ✓ Ancillary Guard House nr 2
- ✓ Control and Technical Building
- ✓ Electrical Substation SS-1
- ✓ Electrical Substation SS-2
- ✓ Handling and Bagging Electrical Building
- ✓ Substation SS-3

2) To send sanitary waste water to the Biological Treatment Package, via Equalization Basin, where it is processed prior to discharge. Treated water will be discharged offshore. The Effluent and Waste Water system is designed to match the FMEnv Effluent limitation Guidelines. For this reason, sanitary waste water coming from each Sanitary Lift Station Package will be collected and sent to a biological treatment

- **Storm water system**

The drains are designed using open-channel flow systems, consequently by partially filled drainage systems. The runoff design flow to be discharged shall be ensured throughout the drainage system, in compliance with the upstream and downstream elevation constraints of the drainage system: the water elevation assumed upstream shall be adequate to the level of the surrounding ground, while the downstream hydraulic section shall permit the discharge of the total runoff quantity, in compliance with the effluent constraints. The drainage system shall be fully consistent with the grading plan design.

<u>Drainage systems for uncontaminated paved areas and parking</u>

The parking (asphalted or paved) can be gravity drained through both rectangular channels with traffic-bearing covers and a system of catch basins and piping. Uncontaminated paved areas of the plant (areas where there are not sources of contamination) are mainly drained through catch basins connected by a piping system. The catch basins are connected in series (preferably up to a maximum of two) by secondary pipes up to the confluence point, fitted with a manhole, with the main drainage line. Contrary to other systems (e.g. potentially contaminated waters drainage systems) it is not necessary to arrange siphoning on the catch basins because there is not fire propagation through piping. In plant areas the ideal unit surface area for drainage of each catch basin is approximately 400 m^2 (20m x 20m squares), while in the parking, where immediate drainage of rainwater is not critical, the unit surface area can increased to 1200 - 1600 m^2 (maximum 40 m x 40 m squares). The slope of the runoff surfaces shall be from 1 to 2%.For roads up to 3.00 - 4.00 m in width, with one or two watersheds, water can be drained off directly into the adjacent areas (which are usually graveled) without providing a dedicated sewer. For larger roads, main plant roads with a width of 8.00 - 10.00 m and secondary roads with a width of 5.00 - 6.00 m, drainage can be realized using roadside channels. In the drainage system by roadside channels, channels can have a trapezoidal or rectangular shape, as a rule without any cover, with the exception of road intersections which shall be covered with reinforced concrete slabs. Alternatively, road crossings can be made using siphoned pipes connected by end pits.

- **Electricity Generation**

  The total power requirement of the complex shall be produced by three (3) Steam Turbine Generators (13-G-01/02/03). The capacities of STGs will cover the power requirement of Ammonia and Urea plants plus Utility facilities with an export of 12 MW under normal operating condition.

- **System Automation and Emergency Shutdown**

  State of the art Integrated Control and Safety System (ICSS) is being installed for Monitoring, Control and Protection of Man, Machines and Environment in the entire Dangote Fertilizer Complex. ICSS system comprises of Distributed Control System (DCS) and Programmable Logic Controllers (PLCs), Emergency Shutdown

Systems (ESDS) and Fire and Gas (F&G) system. The entire Fertilizer Complex has been provided with Four Layer of Protection consisting of DCS and PLC systems as 1st layer of Protection for Monitoring; Alert, and Control Functions, Independent Redundant ESDS as 2nd layer of Protection for Emergency Shutdowns; Independent Redundant F&G system as 3rd layer of Protection for Fire and Gas leak conditions and Mechanical Devices (directly mounted on the process/equipment and automatically activate at pre-set conditions) as 4th and Last layer of defense in the event of failure of Electronic Control and Safe Guarding Systems. DCS, PLCs, ESD, F&G systems are based on latest technology of multi-tasking Processors for Monitoring, Control and Safe Guarding System. ICSS system is supplied by World renowned manufacturer M/S Yokogawa Electric Works, Japan which consists of DCS Viz. Centum VP system and ESDS and F&G system viz. Prosafe System.

Various Physical, Chemical properties such as Pressure, Temperature, Level, Flow, Vibration, Axial-Displacement, pH, Conductivity, SO_X, NO_X, CO_2 etc. of the Process and Equipment are measured with specialized microprocessor based Sensors + Transmitters which are used in DCS/ESDS for monitoring, controlling and protection of the Process and Equipment for Safe and Optimized Operations. A group of on-line dedicated analyzers are used for continuous monitoring and controlling of the liquid and gaseous effluents of various plants.

System Automation**:**

Proven, Modern and Sate-of-the-Art Distributed Control System (DCS) and Dedicated Redundant PLCs are being provided for Monitoring and Control applications. These systems provide the 1st line of Plant Protection. The DCS shall be primarily responsible for process monitoring, alarm functions and shall perform all continuous regulatory control and batch control for major Process Units thereby keeping all the parameters within the specified limits of the Process. PLC based monitoring, control systems are being used for auxiliary / utility units and high speed rotating machines**.** These entire PLC based systems are interfaced to DCS for Centralized Monitoring and Controls. DCS is the main interfaces of Operator with Process, Equipment / Machinery and Operator can take corrective action through DCS HMI (Human Machine Interface) Control Desks. The entire Fertilizer Complex is being centrally monitored, controlled, and safe guarded from the Central Control Room which is manned by experienced and trained Engineers and Operators.

Distributed Control System receives inputs from field sensors / transmitters via dedicated cables or field bus cable at the DCS system Input modules. DCS Central Processing Unit (CPU) fetches this data and processes this input as per application control algorithm and provides output at the DCS system Output module. The output signal from output module is sent to the final control element via dedicated cables or field bus cables. The final control element regulates the process inlet or outlet to keep the process parameters close to the set point/value. The set point/value is set by the Operator through HMI of DCS or it is auto set by the Control algorithm of the process.

Similar to DCS system PLC also receives inputs from field sensors / transmitters via dedicated cables at the PLC system Input modules. PLC Central Processing Unit (CPU) fetches this data and processes this input as per application control algorithm and provides output at the PLC system Output module. The output signal from output module is sent to the final control element via dedicated cables. The final control element regulates the process inlet or outlet to keep the process parameters close to the set point/value. The set point/value is set by the Operator through HMI of PLC/DCS or it is auto set by the Control algorithm of the process.

For ease of Operations the Fertilizer Complex is divided into 5 Major Units for control purposes which are Ammonia # 1, Ammonia # 2, Urea # 1, Urea # 2 and Utilities plus bagging. Each unit is having dedicated Control Systems and dedicated Control Desks. Each Control Desk has multiple HMIs for operators to monitor and control multiple parameters / units simultaneously. The DCS and PLC system provides extremely accurate and sensitive composite system to keep thousands of operating parameters within the operating envelope. Also these systems provide Alert and Alarm functions by way of display, colour change and audio sounds to draw attention of the Operator during plant disturbances and upsets. Alert function helps the Operators in deciding the corrective actions. These systems provide visual over view of each unit and their sub-groups and real time trend and operator guide messages for optimized and smooth control and trend of the plant parameters. There is provision of historizing the trends and alarms for fault diagnosis and process optimization. This also helps in root cause analysis of any failure pertaining to Process, Equipment, and Machine.

Redundancies for Processors, Input-Output (I/O) modules, Communication Networks, Power Supply modules, HMI stations have been provided to meet unexpected failure of components. The system capabilities allow on-line replacement of failed components. Uninterrupted Power System with battery back-up and redundancies provided for continuous availability of these systems.
These systems are connected to Engineering Work Stations and minor on-line modifications are allowed during plant operations. Also these systems provide on-line strong system diagnostic and rectification features. DCS/PLC systems have been selected considering their proven continuous operating record at various continuous process industries and based on superior MTBF, MTTR factors.

Emergency Shutdown

Emergency Shutdown comprises of Emergency Shutdown Systems (ESDS) and F&G Systems and act as 2nd & 3rd line of Protections respectively. Both the systems are Safety Integrity Level (SIL) Certified Programmable Logic Controllers (according to IEC61508 and IEC61511) and are being used for Critical Emergency Shutdowns and Protections. Redundancies for Processors, Input-Output (I/O) modules, Communication Networks, Power Supply modules, HMI stations have been provided to meet unexpected failure of components. The system capabilities allow on-line replacement of failed components. Redundant

Uninterrupted Power System with battery back-up provided for continuous availability of Emergency Shutdown Systems.

ESDS/F&G Systems receive inputs from field sensors / transmitters via dedicated cables at the Input modules. ESDS/ F&G Central Processing Units (CPU) fetch this data and processes this input as per application interlock logic algorithm and provide output at the Output module. The output signal from output module is sent to the final control element via dedicated cables. The final control element operates as per the ESDS/F&G output to bring the process to safe condition (Safe condition is achieved by Stoppage of the process/Machine and/or Isolating-Venting the Machine/Process) or Tripping of the Plant as required.

Dedicated Machine Monitoring System (sub-system of ESDS) has been provided for condition monitoring and safe guarding the rotating equipment by shutting down the equipment in case the equipment goes out of the safe operating envelope.

For ease of Operation and maintenance the Fertilizer Complex is divided into 5 Units (as detailed above) and each unit has dedicated ESDS and F&G system. Two out of Three (2 of 3) trip logics with three independent sensors have been applied for process and equipment for improved Reliability and Protection. 2of 3 trip logic eliminates spurious trips which generates environmental issues as well as reduces the equipment life in addition to economical and production losses. The ESDS trip logics have undergone Process/Equipment HAZOP analysis. The entire Fertilizer complex has been designed as Fail Safe for power fail / instrument air-fail conditions.

ESDS system provides Pre-Trip and Trip Alarms on operator HMIs. Based on the Pre-Trip alert the operator can take suitable corrective action to bring back the plant to normal condition. The Sequence of Event Recording features of these systems help in fault diagnosis, fault rectification and root cause analysis of the plant.

The Fire and Gas detection system is a SIL certified system which automatically initiates Automatic Protection Systems in case of Fire and Gas leak detection and brings the Plant to a safe condition. There are field sensor to detect fire and gas leak in the Process areas and heat and smoke detectors in various buildings. These signals are used in F&G system to activate automatic protection systems and also alerts in the form of alarm displays, alarm messages, audio alert system for Control Desk operator and fire and safety department. The automatic F&G system reduces the possibility of Fire and Gas leak which has major environmental impacts. Besides this CCTV system is being installed for plant surveillance in case of leakage of gasses or fire.

These systems are connected to Engineering Work Stations and minor on-line modifications are allowed during plant operations. Also these systems provide on-line strong system diagnostic and rectification features.

ESDS/F&G systems have been selected considering their proven continuous operating record at various continuous process industries and based on superior Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR factors).

All System Automation and Emergency Shutdown System Equipment are housed in Safe Areas with air-conditioning and F&G sensors and Clean Agent System to safe guard the system components.

- **Fire Fighting Protection**

Selection of extinguishing agents

Following fire extinguishing agents will be used. They include:

a) Water (raw water) shall be used to control/fight fires in general plant area;
b) Aqueous Film Forming Foam (AFFF) shall be deplored to fight fires originated by liquid hydrocarbons in the plant area;
c) Dry chemical powder shall be used to control and extinguish small fire in plant areas and inside the buildings;

d) CO_2 (carbon dioxide) shall be used to control and extinguish electrical fires (class" C" fire) at electrical areas and inside the buildings, and

e) Clean Agent System (Inert gas type) shall be used to provide fire extinguishing of selected enclosures (false floor) inside building.

Fire Fighting Equipment /System Selection

The above extinguishing agents shall be applied to fire source by means of fixed and portable facilities as below indicate:

a) Fire water system consisting of the fire water storage tank (in common with utility service), fire water pumps and fire water main network;

b) Fire hydrants, fire water/foam monitor, hose reel and hose storage box shall be provided around the plant;

c) Fixed water spray systems (water deluge system) shall be deployed for protection of dedicated equipment;

d) Automatic clean agent system shall be adopted for protection of buildings;

e) Appropriate number of portable facilities including fire extinguishers and mobile fire extinguishers shall be acquired;

f) Appropriate number of emergency showers and eyewash unit shall also be acquired, and

g) Fire Station facilities including one (1) Fire Truck shall be procured.

Fire Water Pumping And Storage System

- Fire Water Pumping System

The fire water pumps shall be designed to supply 568m^3/h. The pumping system will consist of two (2) fire water pumps, each rated to discharge 568m^3/h equal to 2x100% of the maximum fire water demand. The configuration will be as follow:

- 1 No. horizontal centrifugal pump 24-P-02 – electric motor driven - rated for 568 m3/h at 8.4 barg discharge pressure serving as main fire pump unit.
- 1No. horizontal centrifugal pump 24-P-03 – diesel engine driven - rated for 568 m3/h at 8.4 barg discharge pressure serving as fire pump stand-by unit.

These pumps can be operated either automatically or manually. For this purpose, it shall be provided with a dedicated local controller. Each controller will have own pressure sensing line. Diesel engine shall be provided with a diesel oil fuel tank having a capacity calculated as per NFPA20 requirements. Fire water pumps will be designed in compliance with NFPA20. The fire water network shall be maintained under pressure by means of suitable jockey pumps (duty and spare). The configuration will be: - two (2) horizontal centrifugal pumps 24-P-01 A/B – electric motor driven – each one rated for 30 m3/h at 8.4 barge discharge pressure. Each jockey pump will have own pressure sensing line and will run in discontinuous way. These pumps can be operated either automatically or manually, to this purpose it shall be provided with a dedicated local controller. Jockey pumps will be powered by emergency power. Fire water pump system will be skid mounted and self-contained including pumps, drivers, controllers and fuel tank as required.

Fire Water Storage Tank Capacity

Fire water shall be stored in an above ground tank (12-T-01), in common with the water services of the plants. This tank provides the utility water and the firewater. The net stored capacity to firewater service shall be 2000m^3 which shall be unable to provide 100% of maximum demand for 4 hours.

This storage tank shall be sized adequately to allow the replenishment of the fire water capacity in a time sufficiently short to limit disruption after usage of the fire water for fire-fighting. As a general rule, the fire water capacity shall be filled up in compliance with NFPA22 requirements.

13. Waste Management Plan (WMP)

The main purpose of the WMP is to provide effective guidance on collection, handling, transportation, storage, and disposal or recovery of wastes generated on site during Construction, Pre-Commissioning and Commissioning phases.

The WMP involves:

- Identification of the waste legislation;
- Definition of waste classification criteria;
- Inventory of all wastes produced during site activities;
- Control of the amount of waste generated following good operating practices and respecting waste reduction principles;
- Assisting Contractor and Subcontractors in managing their wastes in compliance with requirements of established Dangote policies and applicable waste regulations;
- Guidance for the collection, segregation, handling, temporary storage, transport and disposal of wastes in order to protect human health and to minimize the impact on the environment;
- Guidance for waste reduction according to the hierarchical application of the practices of reuse, recycling, recovery, treatment and final disposal in approved disposal sites.
- Disposing of all waste in a safe manner and at approved disposal sites;
- Cooperating with Dangote and governmental agencies to manage correctly wastes produced on site, and
- Providing a basis for training activities.

Laws and Regulation

Following applicable Nigerian laws and regulation shall be complied with:

a) ISO 14001:2004 Environmental Management System
b) Guidelines and Standards for Environmental Pollution Control in Nigeria (FEPA, 1991)
c) The National Environmental Protection (Effluent Limitation) Regulations, 1991
d) The Federal Environmental Protection Agency (FEPA) Act 1990
e) Labour Act, 1971
f) Factories Act, 1987
g) Trade Union Act, 1973
h) Electricity Supply Regulations, 1979
i) Wiring Regulations, 1979
j) Earthing, Code of Practice, 1976
k) Nigeria Nuclear Regulatory Agency for NDT

Classification of waste

Emphasis shall be given to practice waste segregation at project operation prior to disposal of any waste material. Waste segregation shall be practiced in accordance with hazard classification, physical and chemical properties, potential for reuse / recycle and ultimate disposal at all operational sites. Segregation at source also facilitates easy collection, saves time, money and effort spent on sorting out waste materials at later stages. Work sites and camp used by the Contractor shall be maintained in a clean and sanitary condition. Types of Wastes generated during Project activities shall include:

a) Batteries
b) Oily waste / empty oil drums
c) Paint waste
d) Chemical drums
e) Medical Waste (soiled dressings, used needles and syringes. expired drugs, blood and blood products)
f) NDT chemical waste
g) Contaminated soil
h) Hydro test water
i) Sewage
j) Concrete waste
k) Scrap metal
l) Glass waste
m) Wood scrap / packaging materials
n) Paper
o) Food Waste
p) Plastic Waste
q) Office papers / Toner and printer cartridges
r) Tires
s) Dredged spoils.

Hazardous Waste

Hazardous substances include but not limited to any element, compound, mixture, solution which because of its quality and/or concentration, or physical, chemical or infectious characteristics, may:

- ✓ Cause or significantly contribute to an increase in mortality or an increase or incorporating reversible illness, or;
- ✓ Pose substantial hazards to human health or the environment when improperly treated, stored, transported, or disposed off, or otherwise managed, and
- ✓ Hazardous substances shall satisfy characteristics of ignitability, corrosivity, reactivity and toxicity.

For the purpose of these procedures the following categories of waste are considered to be hazardous waste:

a) Oily waste / empty oil drums
b) Paint waste / chemical drums
c) Medical waste (infectious dangerous waste)
d) NDT Chemical waste
e) Contaminated soil
f) Hydro test water (only if it contained inhibitors shall be considered as hazardous waste)
g) Batteries
h) Sewage

All hazardous wastes generated in camp or returned from the working strip shall be stored in a secured and clearly identified area for subsequent disposal by an accredited waste disposal sub-contractor. Hazardous wastes shall be clearly labeled and identified with incompatible materials segregated from each other. Safe Handling of Chemicals (SHOC) or Materials Safety Data Sheet (MSDS) shall be readily available at the storage areas to inform the personnel regarding the precautions to be taken when handling, transporting and disposing these hazardous waste materials. Hazardous waste shall be securely packed, bounded and labeled in accordance with legislative requirements to ensure that the waste can be transported safely by an accredited waste disposal contractor for subsequent disposal to the approved disposal site without risk to those handling the waste or the environment. It is the responsibility of the Environmental Officer/Environmental Engineer to ensure that all hazardous wastes are properly packaged and labeled.

Non – Hazardous Waste

Domestic/Office waste includes paper, aluminum cans, glass, cartons, kitchen waste etc. Domestic waste may also include some recyclable material such as paper, plastics, glass, and printer toner cartridges. For the purpose of this plan the following categories of waste are considered to be non-hazardous waste:

a) Scrap metal
b) Glass waste
c) Wood scrap / pallets / packaging material
d) Food waste (non putrescible)
e) Plastic waste
f) Office papers / toner and printer cartridge
g) Tires
h) Concrete Waste
i) Dredged Spoils

Table 3-2: Estimated Waste Volumes

Waste type	Estimated Volume	Disposal
Construction		
General Domestic waste including food wastes (construction camp)	104,100 m^3	Temporarily stored on site and disposed of at licensed disposal facility.
Organic material including uncontaminated dredged spoil	370,000m^3 (Top soil removal only. Does not include dredged material for lagoon water intake basing	Loaded onto dumper trucks and removed to spoil within Dangote Fertilizer plant
Contaminated soil	10 m^3	Loaded onto dumper trucks and removed to spoil within Dangote Fertilizer plant
Batteries, chemical drums, medical waste, paint waste, NDT chemical wastes, hydro test water, oil waste/empty oil drums.	115,000 m^3 (including all items specified)	Temporarily stored on site and disposed of at licensed disposal facility.
Building rubble (wood, scrap metals, steel, card board, PVC, glass wastes, masonry including packaging materials etc.)	350 m^3	General building wastes that cannot be reused will be removed from the site periodically to a licensed facility.
Concrete rubble	16,500 m^3	To be reused as rubble fill on low lying areas of the site if possible. Alternatively to be removed from site and spoiled in an appropriate area.
Steel waste	300 tons	Temporarily stored on site and removed to local scrap dealer for recycling once every two months.
Commissioning		
Mill scale, weld platter, rust and limited debris.	Small quantities not confirmed.	Collect at test location and subsequent disposal at a licensed waste disposal facility.
Operation		
Plastic (packaging and off cuts synthetic rope)	4 m^3 / month	Removal at site for recycling
Cardboard	5 m^3 / month	Removal at site for recycling
Glass for recycling	0.5 m^3 / month	Removal at site for recycling
Crankcase oil from servicing of generators	Not confirmed	Depends on laboratory analysis and Final Vendor Manual.

Waste type	Estimated Volume	Disposal
General solid wastes, including recyclables (domestic-type, office wastes including papers, toners, printer cartridges, tires, biodegradable non-hazardous wastes)	Small quantities not confirmed	Temporary stored on site on disposed of at licensed disposal facility.
Oily liquids/sludges and oil/water mixtures (hazardous wastes)	Small quantities not confirmed	Recovery through oil water separator system. Sludge will be treated with high temperature incineration for heavily contaminated combustible materials and controlled landfill.
Oil contaminated solid waters (hazardous wastes)	Small quantities not confirmed.	Incineration of heavily contaminated combustible materials and controlled landfill.
Small quantities of healthcare waste.	Small quantities not confirmed	These require incineration (preferred) or autoclaving and controlled landfill.

3.12 AIR EMISSIONS

Varying amounts of greenhouse gasses such as CO_2 and CH_4 and other pollutants such as carbon monoxide (CO), oxides of nitrogen (NO_x) and sulphur (SO_x), volatile organic compounds (VOCs) and particulate matter (PM) will be generated during the construction and operational phases from construction vehicles, generators, tanker trucks and support vessels engines. The primary air emissions associated to fertilizer products production, storage and distribution facilities are NOX, NH3 and Urea Dust. These releases are associated with primary reformers, granulation towers, vent stack separators and auxiliary boilers. These emission rates have been calculated for each of these facilities as depicted in Table 3-3.

Table 3-3: Emissions from Dangote Fertilizer Operation at Full Capacity

EMISSION AT FULL CAPACITY FOR DANGOTE FERTILIZER										
S/NO	SOURCE	FLUE GAS FLOW RATE (NM3/HR)	EXIT TEMP (DEG.C)	STACK HEIGHT (M)	STACK DIA(M)	EXIT VELOCITY (M/S)	POLLUTANT EMISSION RATE(g/s)			
							NOX	NH3	UREA DUST	SOX
1	Primary Reformers 11-L-201 /21-L-201	410288	199	30	4.3	14.88	34.19	-	-	3.42
2	Granulation Towers 19-L-55/29-L-55	1037531.7	43	44	4.8	19.83	-	30.26	8.65	-
3	Vent Stack Separators 10-V-12/20-V-12	88	50	60	1.19	0.03	-	0.47	-	-
4	Auxiliary Boilers 13-B-01/13-B-02/13-B-03	125607	150.6	35	2.1	18.67	8.37	-	-	1.05
Note:-Flue gas flow and emission concentration values are referred to a temperature of 273K , a pressure of 101 Kpa and 3% O_2 on a dry basis for the Primary Reformer and for the Auxiliary Boilers and real O_2 percentage for Granulation Towers and Vent Stacks.										

3.13 EMERGENCY RESPONSE PLAN (ERP)

The objective of the ERP is to ensure that any emergency affecting the place of operational activities is dealt with in an efficient and professional manner so that the safety of personnel is not comprised in any way, the environmental pollution risks are prevented or minimized and that all other losses which may arise from emergencies are prevented or minimized. The ERP addresses emergency response procedures for the Contractor, Subcontractors and all personnel working for the Project.

It is the responsibility of management to familiarize themselves with the emergency procedures, which apply to the project.

The ERP will include as a minimum the following:

a) Emergency Communication Procedures: These include a description of the communication procedure and command hierarchy to define who is responsible for directing the activities of the various respondents, and the means of maintaining communication between the facility operators, Emergency Response Contractor, Company and Local Emergency Services.
b) Identification of potential scenarios (fire, severe injury, road traffic accident, Incident, spills etc.) and action plans.
c) Site Specific ERP Orientation: Training for site personnel and visitors.
d) Emergency Events Log: The Contractor is required to log all emergency events and report them to the Company and appropriate regulatory authorities.
e) Emergency Contact List: listing of Contractor personnel, Emergency Response Contractor(s), and Emergency Services to contact with primary and secondary contact information.
f) Emergency Equipment List and Alarms.
g) Emergency Response Team: description of the roles of Contractor and Subcontractor field and support personnel during an emergency.
h) Emergency Support Services: Description of emergency conditions requiring procedures for implementing additional help from Company and Contractor.

Work shall be conducted in accordance with ERP requirements. Field HSE Manager shall ascertain the effectiveness of Emergency Response plan by conducting audits and organizing exercises/drills to the work force regularly. All personnel involved in the emergency response group shall also be familiarized with their roles and responsibilities by regular exercises/drills.

Field HSE Manager will issue the performance report of each exercise/drill conducted at site to the Project Management team (PMT) containing the information on recommendations to be taken for improvement. Following are potential foreseen types of emergency expected but not limited to:

- Fire and explosion
- Oil, Chemical spills and release
- Medical Evacuation (MEDEVAC)
- Vehicle accidents
- Work at height

3.14 HEALTH SAFETY AND ENVIRONMENT (HSE) PLAN

The purpose of HSE Plan is to define the HSE Policy and Management Commitment and to describe briefly how these issues will be implemented during the execution of the Dangote Fertilizer Project. This Plan will remain in force throughout the entire project and will be updated as project conditions change, in order to ensure that it always addresses them appropriately.

The Project HSE Plan is of primary importance in ensuring that HSE issues are comprehensively addressed to all interested parties involved in the Project, during all the stages of the Project development, and that all Project choices and decisions are justified with respect to their implication for HSE issues during design, construction and commissioning. The HSE Plans is a “living document” and will remain in force throughout the life of the Project. The HSE Plan shall continuously be reviewed to ensure that appropriate update is made as dictated by circumstances during the Project activities. This plan shall be considered as a general guideline for the management of the Project

HSE issues and shall be made available also to Vendors and construction Contractors and give the baselines for the preparation of their HSE plans.

HSE Policy

The Project will fully comply with Policy statement on HSE. The policy shall reflect the commitment of Top Management to the protection of the environment, and the health and safety of its personnel and all people that could be affected by its operations. The HSE Policy is the base upon which the Project HSE objectives are set.

Management Commitment

The implementation of the integrated HSE Management System, in accordance with the HSE Policy statement, is integrated into business objectives. Where conflict may exist between HSE and other business objectives, Management will promote resolution of such conflicts so that the outcome is consistent with the HSE Policy. Management leadership and commitment are the drivers upon which the HSE Management System is implemented in order to ensure that continuous improvement is achieved.

Management shall communicate to all Contractor's and Subcontractor's employees a sound commitment towards the achievement of the highest HSE standards. Through active consultation and involvement, employees shall be encouraged to contribute to success in meeting this commitment. Effective motivation and communication tools to manage and communicate HSE issues shall be realized within the organization, where the HSE Management System is implemented at all levels and HSE responsibilities are clearly defined and assigned.

Management shall be routinely involved in reviewing the actual application of the HSE Management System and its performance, so as to provide the necessary corrective actions to ensure the continuous improvement of the whole system.

In addition, the Project Management shall accept the ultimate responsibility for the proper implementation of all Project HSE Plans and will demonstrate commitment to the continuous improvement of the HSE culture within the project by leadership and example.

Project Management will also provide full support to Project HSE Staff, and ensure that managers, leaders, and supervisors accept their moral and legal duties regarding HSE, and that they are held accountable for them.

Project HSE Objectives

The specific objectives of the HSE Management System applied to the Project are summarised as follows:

- to ensure that all relevant design decisions are duly taken considering HSE aspects;
- to ensure that significant HSE impacts related to the execution of the Project are properly identified and prevented while control and mitigation measures are developed to eliminate or minimise harm to people, damage to equipment, and adverse environmental effects;
- to maintain a safe working environment to minimize the possibility of accidents and damage during all phases of the Project;
- to provide adequate guidance on all HSE issues, and
- to encourage the adoption of a positive, proactive, and committed HSE culture.

The above objectives are in accordance with the principles stated in the HSE Policy statement which aims at achieving the target of:

- ZERO injury
- ZERO fatalities
- ZERO occupational illnesses
- Minimize adverse environmental impacts
- Maintain compliance with ISO 14001 AND OHSAS 18001

Project HSE Organization and Responsibilities

The Company strives at appointing a dedicated HSE Team for the Project which will be capable of meeting the Project Health, Safety and Environmental objectives through implementation of procedures and technical activities.

This Team will interface with all relevant departments to guarantee that all documents produced and activities performed during the Front End Engineering Design (FEED) and execution of the Project complies with the HSE Plan, HSE Requirements and objectives.

Project HSE Activity

This application of the HSE Management System to the Project is based on four fundamental points:

- Organization
- Assessment and Planning
- Implementation and Operation
- Checking and Corrective Actions

Management intends to ensure the correct implementation of its integrated HSE Management System as well as verify compliance with applicable HSE requirements by means of different activities:

- HSE Reporting;
- HSE Reviews, and
- HSE Audits and Inspections.

In particular, regular reporting of the following indicators will be carried out:

- Safety Indicators;
- Proactive Indicators;
- HSE Training Indicators;
- Environmental Indicators, and
- HSE Accidents.

HSE Audits shall be carried out throughout project life-cycle. Scope of this activity is to verify, during the whole project life-cycle, the correct implementation of the HSE Management System and to evaluate the overall Project HSE performance. The audits will be carried out by qualified HSE auditors, not directly involved in the activities to be audited. The HSE Manager will assist the auditors in their activities and help manage possible recommendations in order to properly address them. Audit results will be documented in dedicated Audit reports and shall include good points, corrective action requests and recommendations, and shall be reported in a timely manner. Corrective actions shall be implemented and their effectiveness verified.

3.15 PERSONNEL REQUIREMENTS

In addition to over 3000 workers that will be needed during the construction stage, the project intends to engage about 750 permanent staff on completion. The employment policy shall take into cognizance of the local content requirements as specified by the Federal Government of Nigeria. Specifically, during site clearance, dredging and backfilling, 98% of the workers to be engaged shall be Nigerians while during construction, 60% of the workers shall be Nigerians. Due to the high level of skill required during production only 50% of the workers that will be engaged shall be Nigerians.

3.16 DISMANTLING

The Fertilizer Plant has been designed to have a life of at least 50 years, and is part of an industrial site being built for the future centuries, with continuous maintenance. Taking into account this consideration, dismantling and recovery of the land in original state is a scenario that's highly unlikely to occur in this project

CHAPTER FOUR

ENVIRONMENTAL BASELINE DESCRIPTION

CHAPTER FOUR

ENVIRONMENTAL BASELINE DESCRIPTION

4.1 INTRODUCTION

The proposed Dangote Fertilizer Plant project located in Ibeju Lekki, Lagos State, requires an Environmental Impact Assessment (EIA) to manage the project environment as stipulated by National and International Standards, Regulations and Conventions. Thus, the major aim of any well-planned EIA study is the characterization of the study environment prior to the commencement of the project activities. A pre-requisite to this is the acquisition of baseline data on the immediate environment of the proposed project site and the zone of influence.

Baseline data provide information on the present status of the environmental conditions and establish the conditions of the various components that have the potential to be affected by the various activities of the proposed project. Such data, therefore, form the basis for potential impact identification and appropriate mitigation measures associated with the development of the project.

This chapter of the report presents the field sampling procedure and laboratory methodology with which the baseline of the study area was characterized. It is a documentation of various aspects of the biophysical, social and health components of the environment, which may be affected by the proposed project activities. The baseline study has not been confined only to an inventory of the main components within the environment, but also revealed some understanding of the important functional relationships, which exist between these components.

The baseline data gathering exercise involves acquisition of information on the existing physical, chemical, biological, socio-economic and health conditions of the project influence zone. The approved one season data gathering campaign was carried out between 8th to 11th of July, 2014 (Wet Season),. The study also reviewed literature and existing data from previous studies in the area and from similar ecosystem for benchmarking.

4.2 AN OVERVIEW OF THE STUDY AREA

The proposed Dangote Fertilizer Plant Project area falls within the Ibeju Lekki Free Trade Zone of Lagos States. It covers an area of 500 Hectares expanse of land. It falls within the western Nigeria coastal zone that consists largely of coastal creeks and lagoon development by barrier beaches that extends to the outer sand bar (Webb and Hill, 1958 and Jeje, 1978). The area is drained by Lekki lagoon other minor creeks. The terrain is typical of coastal area – relatively flat and swampy in places. The topographic elevation is near sea level close to the coastline and rising to up to between 3-5m above sea level (a.s.l) in the hinterland. The area can be categorized into three ecological zones namely: Coastal Barrier Island, freshwater swamp forests and lowland rainforest. The most significant river that drains this zone is the Lekki Lagoon

4.3 STUDY APPROACH

The baseline status of the project area was obtained through; consultations with the relevant stakeholders as well as from field studies covering the following:

- Initial review of existing data sets and literature on the proposed Project Area;
- Reconnaissance survey;
- Field studies including air, surface water, sediment, soil and vegetation sampling;
- Geophysical investigation and groundwater sampling;
- Field analysis and sample preservation;
- Laboratory analysis of samples
- ;Socio-economic and health studies;
- Data processing, analysis and interpretation; and
- Reporting

4.3.1 Consultation

Prior to field sampling, meetings were held with the relevant stakeholders to intimate them of the project and seek their consent to carry out the field data gathering.

Consultation is an important element of socio-economic assessment and an integral component of the entire EIA process. This is because appropriate and adequate consultations will ensure smooth project implementation and guarantee economic and commercial sustainability of the proposed project. It involves information dissemination and interaction/dialogues with the host communities and other stakeholders on the EIA of the proposed project.

The key objectives of consultation on the EIA for the proposed Dangote Fertilizer Project are to:

- ensure that the communities and all stakeholders are given early and adequate information on the EIA and the proposed Dangote Fertilizer Project activities;
- provide a framework for improving the understanding of the potential impacts of the proposed project on the socio-economics and biophysical environment;
- include stakeholders' views and concerns as part of the EIA execution especially as it concerns the potential impacts;
- identify contentious issues in the proposed project execution;
- establish transparent procedures for carrying out the proposed projects; and
- create accountability and a sense of local ownership during project implementation, thus minimising communities conflicts and project delays that may result thereof.

4.3.2 Field Sampling

A one-season (wet season) fieldwork was embarked upon for the baseline data gathering. The multi-disciplinary field study approach involved data acquisition on air quality and microclimate, soil quality, surface and groundwater quality, sediment and aquatic ecology, vegetation and wildlife, land use, geology/geophysics/ hydrogeology, socio-economics and health issues within the project influence zone. A team of experts and a Representative of the Federal Ministry of Environment (FMEnv), Abuja, participated in the field study (**Plate 4-1**).

Plate 4-1: Team of Experts with FMEnv Representative and some staff of Dangote group ready for the field work

The various environmental components and the methods used in collecting the samples are as shown in **Table 4-1**. During the sampling campaign, samples from the various biophysical components of the environment were taken. They are: eight (8) surface water and sediment samples (including 2 controls), 16 soil samples (Topsoil and subsoil) from 6 sampling stations and 2 controls, 1 groundwater sample, while leveraging on three other monitoring boreholes from adjacent Dangote Fertizer site and a control at Magbon town. Also sampled were six (6) air quality/meteorological stations. *In situ* analysis of vegetation and wildlife diversity and fisheries study were carried out. Control stations were established away from the project area while socio-economic and health studies were conducted in communities within the project influence zone. All sampling stations were geo-referenced using GPS Garmin 12 Model and are relocated on the sampling map (**Figure 4-1**). The details of field work procedures, sampling protocols and laboratory analysis for the various environmental components are briefly presented in 4.3.3.

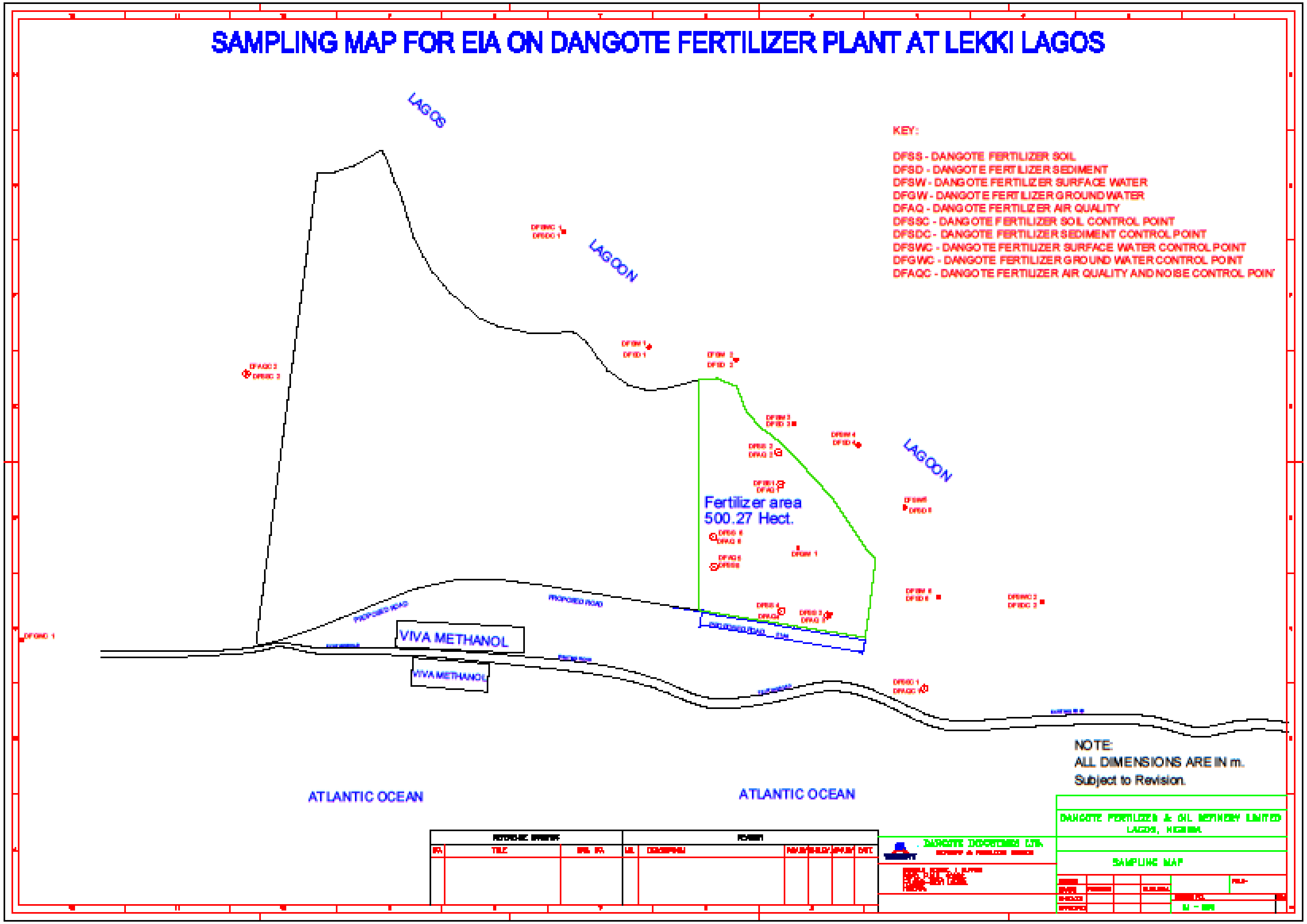


Figure 4-1: Sampling Map

Table 4-1: Environmental component and method of sample collection

Environmental Component	Method of collection
Meteorology	Literature Survey, Wind speed and direction display unit (Met 2000), Hanna portable thermo-hygrometer, thermocron i-button, EI-USB-2 RH/Temp Data Logger
Air Quality and Noise	Electronic gas monitors, Particulate matter counter/ monitor. Telegan photoionisation Gas analyzer (Viper), Noise meter
Soil/Land use	Dutch stainless steel hand auger, digger and spade for profile pit study, Core samplers, Interviews, and Direct observation
Geophysics/Geology/Hydrogeology	VES, Percussion drilling of boreholes and groundwater sampling
Surface Water	Water Samplers
Sediment	Sediment Grab sampler (Van ven grab)
Surface water Hydrobiology/ benthos	Collection with Van ven Grab, Collection with Plankton Net and sieves.
Fisheries	Direct observation and interview
Vegetation	Transects, key Informant Interviews, Use of Binoculars, Direct Observation and sample collection
Wildlife	Direct Observation, Key Informant Interviews and indirect count method
Socio-economics / health	Interviews, questionnaires, focus group discussions, publications

4.3.3 Detailed Methods of Sample Collection

4.3.3.1 Air Quality/Meteorology

Ambient air sampling was conducted in accordance with ASTM D5111-99. Twelve stations were selected for sampling and measurement. At each station, sampling and measurements of meteorological parameters and chemical constituents of atmospheric pollutants were carried out *in-situ* using mobile Meteorological Station (**Plate 4-2**) and hand-held air quality monitoring equipment described below:

(a) Suspended Particular Matter (SPM) using Particulate Matter Counter .

(b) Nitrogen dioxide (NO_2) using portable Crowcon Dosimeter.

(c) Sulphur dioxide (SO_2) using portable Crowcon Dosimeter.

(d) Hydrogen Sulphide (H_2S) and Volatile Organic Carbons (VOCs) using Telegan photoionisation Gas Analyzer (Viper).

(e) Carbon monoxide (CO) using portable Crowcon Dosimeter

f) Wind speed and Direction using mobile meteorological station

(g) Humidity and Ambient temperature using Hanna portable thermo-hygrometer.

Plate 4-2: *In situ* measurement of metereological and air quality parameters at fertilizer site

4.3.3.2 Noise Level Measurement

The noise levels at the twelve air quality measurement sites within the study area and control stations were determined sing a pre-calibrated BK precision 732 Sound Level Meter

4.3.3.3 Soil Samples

Composite soil samples were collected at two depths: 0-15cm (Topsoil) and 15 – 30cm (subsoil) with the aid of Dutch stainless steel hand auger from the six sampling locations within the proposed project area and two control sites outside the project area (**Plate 4-3**). A total number of sixteen (16) soil samples were collected. The soil samples were collected in duplicate; those for physical and chemical analysis were packed in black polythene bags, and those for microbial and oil and grease/hydrocarbon analysis wrapped in aluminum foil. The samples were properly labelled, preserved and taken to the laboratory for analysis. All *in-situ* observations were recorded in a field notebook.

Plate 4-3a: Taking soil sample with auger at one of the sampling points in Dangote Fertilizer site

Plate 4-3b: Soil bulk density measurement at site

4.3.3.4 Geophysical and Hydrogeological Investigation

The geophysical investigation involved the electrical resistivity method (**Plate 4-4**). A low frequency electric current (I) was passed into the ground through a pair of current electrodes while the resulting potential difference (ΔV) was measured across another pair of potential electrodes located within the current electrode pair. The vertical electrical sounding (VES) technique involving the Schlumberger array was employed. The inter-electrode spacing (AB/2) was varied from 1 m to 150 m with a maximum total spread length of 300 m. Three (3) Vertical Electrical Sounding stations were covered.

Plate 4-4: Geophysicists taking VES at one of the sampling stations with FMEnv Official witnessing

One (1) monitoring borehole was drilled using the rotary drilling technique within the site (**Plate 4.5**). The boreholes was drilled to depths of about 15 m and lithologically logged at 1 m interval. The borehole was cased using 4” PVC pipes and gravel packed. Static water level of the borehole were obtained using an electronic dip meter. The borehole was flushed for 30 minuites and sampled. Three other monitoring boreholes from Dangote Refinery site, which share a common boundary with the Fertilizer site, were also sampled. The pH, DO, salinity, conductivity, TDS and Temperature values of the groundwater were measured *in-situ* using portable meters and kit. Samples for other physicochemical and microbiological parameters were preserved in an ice chest according to the prescribed methods of APHA (1998) and the samples taken to the laboratory for analysis.

Plate 4-5: Borehole drilling at the fertilizer site

4.3.3.5 Surface Water Sampling

Sampling of surface water covered the environmental components specified below:

- Physico-chemistry and microbiology of surface water
- Phytoplankton
- Zooplankton

Sampling for Physico-chemistry and Microbiology

The main surface water body within the influence zone of the project area is the Lekki Lagon. Six sampling stations and two controls along the course of the lagoon were sampled. At each sampling station, grag samples were collected below the surface at three different time interval of 5 mins and mixed to form a composite sample (**Plate 4-6)**. Samples for laboratory analysis were taken and preserved as follows:

- General physico-chemical parameters: Samples were collected into 1 litre polyethylene bottles. The bottles were previously washed and rinsed with distilled water and with some portion of the surface water prior to sampling.
- Heavy metals- Samples were collected into 1 litre pre-cleaned polythene bottles and preserved by the addition of 2 ml Analar grade concentrated nitric acid.

- Oil and grease and THC- Samples were collected into 1 litre pre-cleaned glass bottles and preserved by the addition of 2 ml concentrated sulphuric acid.
- COD - Samples were collected into pre-cleaned 500 ml glass bottle and fixed with analar grade H_2SO_4
- Microbiology- Samples were collected into 25 ml sterilized McCartney bottles.
- BOD_5 - Samples were collected into 300 ml amber-colored BOD bottles.
- BTEX – 100 ml of the surface water samples were collected in vacumtainers.

Samples collected were stored at 4 ±2 °C ice chest on the field before transportation to the laboratory for further storage at 4 ±2 °C.

Water temperature was measured *in situ* using a portable thermometer. Hydrogen-ion concentration (pH), electrical conductivity, total dissolved solids (TDS) and turbidity were measured *in situ* using Hanna portable digital meters. Samples for dissolved oxygen (DO) were determined on site with Hanna dissolved oxygen meter and double checked with dissolved test kit.

Plate 4-6: Aquatic study team in survey boat during sampling of Lekki lagoon

Phytoplankton and Zooplankton

Planktons (zooplanktons and phytoplankton) samples were collected by towing standard plankton net, at 0.5 knot for 10 minutes. During towing, the plankton net sieves the water retaining the plankton inside the net. This allows the planktons to be collected in a 120 ml plastic container bottom of plankton net (**Plate 4-7**). The content of the plastic container beneath the plankton net is transferred into labelled plankton samples container and preserved in 4 % formalin. This activity was repeated in all sampling stations.

4.3.3.6 Bottom Sediment

Sediment samples were taken from the bottom of surface water using a 0.1sq m Van-ven grab. A total of eight (8) sediment samples (including control) were collected for physico-chemistry and kept in polythene bags; samples for hydrocarbon and microbiology analyses were kept separately in aluminium foil preserved in ice chest and transported to the laboratory for analysis.

Benthic Macrofauna

The Eckman grab was used in taking composite samples of profundal benthic fauna. Grabbed sediment samples were washed with water through a 0.55 µm mesh size sieve (**Plate 4-8)**. The sieved contents were preserved in 4% formalin in labelled jars for further analysis in the laboratory

Plate 4-7: Hydrobiologist taken phytoplankton sample with phytoplankton net

Plate 4-8: Collection of benthic sample.

4.3.3.7 Fisheries Study

Fisheries studies investigated fish species composition, diversity, harvest methodology, fishing activities and fish sales. These were carried out through inspection of catches by local fisher folks both in the field and in fishing camps, administration of questionnaires, interviews of fisher folks in camps regarding catch composition and methodology, survey of the fishes on sale within the area, and interview with middlemen about the source of their fishes and landing.

4.3.3.8 Vegetation and Wildlife Biodiversity

Vegetation Study

The vegetation biodiversity survey/inventory of the project area was conducted by dividing the area into transects. Random opportunistic survey covering the different habitats visited was used. The plants collected were identified according to the Angiosperm Phylogeny Group (APG) system of classification. Rare plants were photographed and/or pressed for herbarium collection. A habitat map was inspected during the onset of the survey and ground-trued during the survey proper. A species list of common plant found at each sampling area was produced, and for each plant species identified, aspects on the economic uses followed the inventory, format and designation as outlined in Bosch *et al.* (2002). Apart from the plants the survey-team sighted directly, the people were asked the names of the existing plants in their areas that are of economic importance to the local people, used either as sawn-wood, house-construction, poles, firewood, edible-fruits or for medicinal uses. The plant names mentioned in local or vernacular names were recorded and samples were collected for identification using the Nigerian Plants Identification Manual on getting back to the base.

Wildlife

Interviews

Field based interviews were conducted to collect wildlife biodiversity data by discussing with local hunters farmers and community leaders. They provided names of birds, reptiles, amphibians and mammals in their local vernacular. In order to facilitate the wildlife survey, books with coloured pictures of West-African mammals, birds and snakes were taken along and shown to the respondents, while asking if they have seen any of the animals in the picture before in the area, where, the sighting frequency and when last did they sight any of the animal? This approach made it easy for the survey team to communicate with the people and get the right answer from them.

Transect surveys (Observations)

In each transect of about 50 meters apart, the survey team walked through recording animals sighted. The presence of animals was also inferred from indices like dung, burrows, footprints, claw marks, tracks, nests and feathers where available.

Calls

On each plot, the survey team stood quiet for some minutes, listened and recorded bird and animal calls. The identification was aided by local knowledge.

4.3.3.9 Socio-Economics Study

Introduction

The study was purported to furnish an all-inclusive description of the prevailing socio-economic situations in Dangote Fertilizer Project area prior to the physical development of the Plant. The specific objectives of the study are therefore to:

- identify all neighbouring communities around the project area;
- establish and document the prevailing socio-economic characteristics of the inhabitants of these communities, and
- elicit empirical information on infrastructural facilities/economic activities of the communities.

The study therefore provides baseline information for assessing the cumulative positive and negative impacts of Dangote Fertilizer project on the communities' social and economic livelihoods. In essence, the information provided by the study will to a large extent assist to reinforce strategies for maximizing the positive socio-economic impacts and simultaneously minimizing to the barest the negative effects of the proposed Fertilizer Plant in the Lekki Free Zone, Lagos State, Nigeria.

Approach and Methodology

In order to attain the objectives of the study the following approach was adopted:

- **Pre-Engagement Talk with Community Leaders** This took place prior the commencement of the study to discuss implementation modalities and clear any grey area that relates to the work.
- **Desk Review:** This involved a thorough study of all available documents (both published and unpublished) that are related to the project. These include existing EIA Reports on projects in the Zone, maps of the area and documents on relevant socio – economic and demographic information about the people including their real life experiences.
- **Preparation of Data Collection Framework:** In view of the activities to be carried out, effective strategy to obtain field data was developed. Having come up with the

data collection method plan, the following instruments for data collection were developed:

a) Observation Guide
b) In-depth Interview Guide
c) Focus Group Discussion Guide
d) Ranking Checklist
e) Validated Questionnaire
f) Photo characterization

To accomplish the study tasks, both formal and informal methods were used in investigating the socio-economic components of the area. The *formal* method includes administration of pre-tested and validated instrument of data collection (Questionnaire) on respondents. This is with a view of obtaining quantitative data that will provide empirical basis for the study output especially socio–economic, demographic variables, household activities, community capacity analysis and infrastructural issues among others.

Based on the total number of housing units (2,087), 209 questionnaires were administered. This implies that 10% of the total number of housing units was surveyed. Thus, the questionnaires were administered based on the size of the communities. Considering the homogeneity of the population, this sample size is considered adequate. In administering the questionnaire, random sampling technique was adopted. All the 209 questionnaires were retrieved from the respondents.

Simple descriptive statistics such as percentages and graphs were used to analyze the field data. This ensured that the most outstanding factors of socio-economic relevance in the various communities were clearly identified. All questionnaires retrieved were cross-checked and examined for errors and inconsistency.

The *informal method* involved the use of Participatory Approach using Participatory Rural Appraisal (PRA) technique specifically. The relevant PRA tools that were used in the study include:

- **Direct Observation:** This includes observation of objects, events, processes, people's behaviour and other relevant indicators that were developed for the study. Project team members with the aid of relevant tools captured real time record of the processes to be observed. Some of these include household activities, social and physical infrastructure, agricultural production and marketing, social organization activities, local development strategies among others.
- **Semi Structure Interview (SSI) Checklist:** This includes the following:
    - ***a) Semi structure Interview with Key Informants (KII)***: Interviews with individuals in the communities who have deep (local) knowledge of the areas of the study interest and who can give an objective view from their experience and expertise was carried out. These include in-depth interviews with youth leaders, women leaders, Chairmen of Community Development Associations, resident teachers, health officials and community leaders (Plate 4-13).
    - ***b) Group Interviews and Discussions:*** This is a process of interacting with relevant groups of stakeholders to facilitate access to the knowledge of several people at once. The group consisted of 15 – 20 people and each member was encouraged to speak and keep discussion to the point. Members of each group were made up of all strata in the community such as Adults (Male and Female), Youths, Physically challenged, and specifically selected relevant social groups.
- ***Focus Group Discussion***: This involved interview with carefully selected group of people (5 -10) with adequate knowledge in the specific area of discussion (Plate 4-14). The areas include; demographic issues, Infrastructures, social services, economic issues, environmental issues and development activities among others. This method helped to clarify specific issues discussed by a larger group. The focus group discussions were also used as a way of involving target segments of the communities (youths, women and opinion leaders) and mainstreaming their responses with those acquired from the structured questionnaire administered. At least two (2) key informants knowledgeable in the history and culture of the various communities were interviewed on a one-on-one basis.
- ***Ranking and Scoring***: Tools under this approach were developed and designed to generate quantitative data on individual, group preferences. It also helps to clarify a reflection of the people's knowledge, criteria and estimation of comments, issues,

events and behaviour most especially in the area of agricultural activities, livelihood activities and constraints to economic activities. Ranking also helped provide facts that are relatively quantifiable.

In general, income, housing, level of education, occupation and employment were used as indices to assess the Quality of Life (QoL) of the inhabitants of the selected communities. Major facilities and infrastructure such as water facilities, school buildings, town halls, markets, electricity projects, healthcare facility, and other informal economic sectors were physically inspected by the EIA team to ascertain their functionality. For the study, all the communities (12) within Dangote Fertilizerinfluence zone were surveyed.

Plate 4-9: Key Informant Interview (KII) with a community leader that has a deep local knowledge of the study area and background information on LFZ community relationship issues
Source: Dangote Fertilizer EIA Field Work July 2014

Plate 4.10: Focal Group Discussion with a female group in one of the communities

Source: Dangote Fertilizer EIA Field Work July 2014

Plate 4.11: Phidmund Team Lead explaining some issues to Stakeholders at a meeting in one of the communities

Source: Dangote Fertilizer EIA Field Work July 2014

Plate 4-12: A group photograph taken after the conclusion of a stakeholders meeting in one of the communities

Source: Dangote Fertilizer EIA Field Work July 2014

4.3.3.10 Health Study

Introduction

Health Impact Assessment (HIA) is a retrospective study of an impact of a natural environment on the public health of people living within a defined area and prospective study of possible impacts of a new project on the general health of the communities where the new project is situated with a view to recommend mitigations against such impacts. This process will also form plans and procedures for effective Health Management Plan for the plant. Thus, the objectives of this study include, to:

a) Capture all existing health information in the study area, including
   - Existing health conditions of the people;
   - Health statistics in the area, state and epidemiological units;
   - Health records from existing health facilities;

- Census data, and
- Information on disease outbreak and trends in the project area.

b) Carry out Baseline Health Survey, including

- Demography /vital statistics;
- Immunization status;
- Nutritional status;
- Prevalence of common diseases in the communities;
- Health facilities and services;
- Identification of other sources of healthcare (Traditional Birth Attendants, etc);
- Other factors that could influence health (social-economics, housing, infrastructure, education etc);
- Knowledge, attitudes, beliefs and practices as regards STD/ HIV/ AIDS
- Sanitation/waste management practices, and
- Water quality/quantity including sources of water.

c) Determine Health Seeking Behaviours

Approach and Methodology

To achieve these objectives, the following methodology was adopted:

- **Stakeholder Identification and consultation**

Prior the survey, pre-engagement talks were held with identified stakeholders in the communities including Medical Director of Okondo General Hospital, Community Health Workers and Community' Heads. This was to sensitize the people ahead of the study in a bid to have their maximum co-operation.

- **Literature review**

The parameters for the literature review were specific to the health impacts of the site clearing, dredging and filling, plant construction, plant operation and closure and decommissioning. The literature search looked at the relationships between various phases and health, with specific health effects on the direct communities', workers on site, pollution, stress and mental health. The literature review also includes review of the existing health data from Lagos State Ministry of Health.

- **Fieldwork**

Data gathering techniques deployed for the study include:

- ✓ Oral Interviews;
- ✓ Administration of questionnaires;
- ✓ Physical observation;
- ✓ Community dialogue, and
- ✓ Surveys.

In general, information for the health survey was obtained through Key Informant Interviews (KIIs); Focus Group Discussion (FGD); On the spot assessment/Walk-through survey carried out using a checklist of environmental health issues; secondary data; questionnaire administered to a selected portion of the community and existing health related information obtained from Government and Private Clinics within the zone.

Plate 4-13: The Public Health Lead during his interaction with one of the communities. Listening with rapt attention were Dangote Group Head (HSE) and FMEnv Representative

Source: Dangote Fertilizer EIA Field Work July 2014

4.3.4 Laboratory Sample Analysis

All samples for physico-chemical (except *in-situ* measured data) and microbial analysis were carried out at Sustainable Agrotech Nig. Ltd Environmental laboratory, Akure, Nigeria, an FMEnv, DPR and IPAN accredited laboratory.

4.3.4.1 Water Analysis

Samples were analysed for physico-chemical parameters using methods prescribed by U.S Geological Survey (1987; 1989) APHA (1998). Parameters determined include total suspended solids, alkalinities, hardness, chloride, nitrate, phosphate, sulphate, ammonia, sulphide, chemical oxygen demand (COD), biological oxygen demand (BOD_5), oil and grease, total petroleum hydrocarbon, polycyclic aromatic hydrocarbon, BTEX and heavy metals. Microbiology parameters determined in the water samples were total heterotrophic bacterial and fungi, hydrocarbon utilising bacteria and fungi, and *E.coli*. Other water quality parameters were analysed *in situ* during the field data gathering. **Table 4-2** presents

Table 4-2: Test Methods for Water Physico-Chemistry

Parameter	Method/Instrument
Temperature (^oC)	Hanna portable digital meter
pH	Hanna portable digital meter
Conductivity (µS/cm)	Hanna portable digital meter
TDS (mg/L)	Hanna portable digital meter
TSS (mg/L)	Gravimetry
Turbidity (NTU)	Turbidity meter
DO (mg/L)	Hanna DO Meter and Test Kit
BOD_5 (mg/L)	DO measurement after 5 days
COD (mg/L)	Dichromate/titrimetry
Alkalinity (mg$CaCO_3$/L)	Titrimetry
Salinity as chloride (mg/L)	Titrimetry
Total hardness (mg$CaCO_3$/L)	Titrimetry using EDTA
Sulphate (mg/L)	Turbidimetry
Phosphate (mg/L)	Spectrophotometry
Nitrate (mg/L)	Spectrophotometry

Parameter	Method/Instrument
Ammonia (mg/L)	Nesslerisation
Hydrogen sulphide (mg/L)	Titrimetry
Oil and grease (mg/L)	Extraction / Spectrophotometry
Total hydrocarbon (mg/L)	Extraction / Gas chromatography
Calcium (mg/L)	Titrimetry using EDTA
Magnesium (mg/L)	Titrimetry using EDTA
Cadmium (mg/L)	Atomic Absorption Spectrophotometer (AAS)
Chromium (mg/L)	AAS
Copper (mg/L)	AAS
iron (mg/L)	AAS
Lead (mg/L)	AAS
Manganese (mg/L)	AAS
Nickel (mg/L)	AAS
Vanadium (mg/L)	AAS
Zinc (mg/L)	AAS

4.3.4.2 Plankton Analysis

Five (5) drops (using a dropper) of the concentrated sample (10 ml) was investigated at different magnifications (50X, 100X and 400X) using a Wild II binocular microscope with calibrated eye piece and the average recorded. The drop count microscope analysis method as described by Onyema (2007) was used to estimate the plankton flora and fauna. Since each sample drop from the dropper accounts to 0.1 ml, the results on abundance / occurrence were multiplied accordingly to give the values as numbers of organisms per ml, which is the standard unit of measurement. To create a suitable plankton sample mount, a dropper was used to take in at least 1.5ml of the sample after shaking properly. This was then allowed to stand for at least 3 minutes. After which one or two drops of concentrated sample from the dropper was then gently dropped on a glass-slide (7.5 cm by 2.5 cm) while placed on a flat laboratory table and covered with a glass-slide (2cm by 2cm). The mount was then placed on the microscope stage, fitted in and all transects thoroughly observed for phytoplankton (cells, filaments, colonies) and zooplankton species (e.g. adults and juvenile stages alike). Final data were presented as number of organisms (cells, filaments, colonies and whole organism) per ml. Standard methods were used to aid identification of the species.

Community Structure Analysis

The following diversity indices were used for biological data analysis and the results of these indices are presented in two (2) decimal places.

Species Richness Index (d)

The Species richness index (d) according to Margalef (1951) is a measure of diversity and was used to evaluate the community structure. Species Richness is a measure of the number of different kinds of organisms present in a particular area. This index is also referred to as Margalef index. The equation below was applied.

$$d = \frac{S - 1}{\ln N}$$

Where:

d = Species richness index

S = Number of species in a population

N = Total number of individuals in S species.

Menhinick's Index (D) (Ogbeibu, 2005).

The Menhinick's Index (D) is one of several diversity indices used to quantify diversity and hence measure diversity in categorical data. It represents a biological association with a number which give a measure of its community structure. The equation below was applied.

$$D = \frac{S}{\sqrt{N}}$$

S = Number of species in a population

N = Total number of individuals in S species.

Shannon and Weiner diversity index (H)

The Shannon and Weiner diversity index (Hs) is one of several diversity indices used to measure diversity in categorical data. It is simply the Information entropy of the distribution, treating species as symbols and their relative population sizes as the probability (Ogbeibu, 2005). Shannon and Wiener (1963) diversity index is also called Shannon index. The equation below was applied.

$$Hs = \frac{N\log N - \sum P_i \log P_i}{N}$$

Where HS = shannon and wiener diversity index

i = Counts denoting the ith species ranging from 1 – n

Pi = *Proportion that the ith species represents in terms of numbers of individuals with respect to the total number of individuals in the sampling space as whole.*

Species Equitability or Evenness index (j)

The Species Equitability or Evenness index (j) is one of several diversity indices used to measure diversity in categorical data. Evenness is a measure of the relative abundance of the different species making up the richness of an area (Ogbeibu, 2005). The equation below was applied.

$$j = \frac{Hs}{\log_2 S}$$

Where , j = Equitability index

Hs = Shannon and Weiner index

S = Number of species in a population

4.3.4.3 Soil / Sediment Analysis

Samples for physico-chemical parameters (except for hydrocarbons, microbiology and bulk density) were air dried in the laboratory for 2 weeks. They were ground into fine particles in a mortal, sieved through a 2 mm sieve and about 200 g of the sieved samples were sub-sampled by quartering for analysis. 5 g of sample were dried at 105^{o}C in an oven to a constant weight to determine the percentage dry matter content. All soil and sediment samples were analysed for physico-chemical parameters using standard methods (Margesin and Schinner, 2005). Parameter determined included: bulk density, particle size, pH, conductivity, organic matter, total nitrogen, phosphorus, exchangeable cations, heavy metals, oil and grease, total petroleum hydrocarbon (TPH), polycyclic aromatic hydrocarbons (PAHs) and BTEX. Samples for microbiology were analysed for total heterotrophic bacteria and fungi, and hydrocarbon utilizing bacteria and fungi.

4.3.4.4 Sediment Macrobenthic Analysis

In the laboratory, the preserved benthos samples collected from the different stations were washed with tap water through a 0.5 mm sieve to remove the preservative and any remaining fine sediments, The animals were sorted and identifications was made to species level where possible. The biota were identified using the following identification materials Campbell (1977), Edmunds (1978), Barnes (1980), FAO (1992) and Yankson and Kendall (2001). Statistical analysis involving diversity indices were used as described for planktons analysis.

4.3.5 Statistical Analysis

All data generated in this study were subjected to statistical analysis to test for spatial variation and significance difference between data within proposed project area and control stations using Excel and SPSS 15.0 packages as applicable. The statistical calculations reported included descriptive statistics (range, mean, standard deviation, coefficient of variation, frequency and percentages) and student t-Test. One level of significance ($p < 0.05$) was considered in the results interpretation. In addition, bar chart, pie chart and line graph were used in comparing results. The analytical results were also compared with local and international standards where applicable and with data from previous studies within the zonee.

4.3.6 Quality Assurance/Quality Control

Standard methods and procedures were strictly adhered to in the course of this study. The quality assurance programme covers all aspects of the study, including sample collection, handling, laboratory analysis, data coding, statistical analysis, presenting and communicating results. Chain of custody procedures including sample handling, transportation, logging and cross-checking in the laboratory were also implemented. Trip blanks were used to assess the quality assurance/quality control of sample preservation, packaging, shipping and storage.

The following precautions were also observed:

- Samples were collected in bottles that have been thoroughly washed with detergent (nutrient free) and rinsed thoroughly;
- All sampling equipment were properly protected and maintained in accordance with manufacturers' manuals;
- Sampling bottles were adequately labeled with masking tapes and indelible markers to avoid mistaken identity;
- Only analytical grade (Analar) chemicals were used and where applicable redistilled;
- Automated equipment were calibrated prior to field sampling;

Where samples were sent to another laboratory for analysis, a duplicate copy of the samples' information was sent along with the sample to the laboratory, independent of the sample. All movements of the samples were included on the sample record. Basic information was recorded together with results of analysis, in a sample register. With proper, sustained calibration of the instrument and the use of standardised observational procedures, equipment errors were brought to acceptable minimum.

4.4 ENVIRONMENTAL STATUS OF THE PROJECT AREA

4.4.1 Regional Climate and Meteorology

The regional climate in the Gulf of Guinea representative of the study area is influenced by two air masses, one over the Sahara desert (tropical continental) and the other over the Atlantic Ocean (maritime). These two air masses meet at the Inter-Tropical Convergence Zone (ITCZ) and the characteristics of weather and climate in the region are influenced by the seasonal migration of the ITC. During the dry months of November-December –January- February the tropical continental air from the northern anticyclone over the Sahara brings in northeasterly trade winds, which are dry and have a high dust load (on occasion these penetrate over the Atlantic as far south as 2°N in January). These winds bring a period of dry weather over the region of study. The northward migration of the ITCZ results in warm humid maritime air reaching further inland over the region. In March, the ITCZ is located between 9°N and 12°N and by May-June, it is located approximately between 15°N and 16°N. During these periods, the region generally experiences the rainy seasons. The most northerly limit of the ITCZ is approximately 18-24°N and occurs between July and August.

In general, two seasons are characteristic of the climate in the region, namely the dry and wet seasons. The occurrence of these seasons corresponds with periods when the tropical continental and maritime air masses, and their associated winds, influence the coast of Lagos. The peak of the rainy season occurs from May to July and again between September and November. The maximum northern location of the ITCZ between July and August creates an irregular dry season over the region, whereby rainfall and temperatures decline. Meso-scale disturbances, which also influence weather patterns in the region, include thermal convections, resulting in showery weather over large areas and line squalls (storms) which usually move from east to west or northeast to south-west.

4.4.1.1 Regional Wind Pattern

Figure 4-2 shows the generalize wind flow across the coast of West Africa during the months of April, June, August and October. Also included is the position of the Intercontinental Tropical Discontinuity (ITD) (marked in blue) during the period of analysis. The winds of the tropical Atlantic are known to have strong fluctuations on periods of a few days. These West African Waves result from instabilities in the tropical winds crossing Northwest Africa and in some cases develop into the tropical storms and hurricanes of the western Atlantic [*Yanai* and *Mukarami,* 1970; *Viltard et al*., 1997; *Diedhiou et al.,* 1998]. The wind oscillation changes wind speed and direction that, in turn, shifts the area of intense convection in zonal direction. West Africa is seen to be greatly covered with North Easterlies which pushes the ITD down below 14^{O}N in the month of April. In the month of June and August, the wind pattern is observed to have shifted to south westerly which dominates the Atlantic coast throughout the rainy season.

4.4.1.2 Analysis of Wind Regime in the Study Area

The wind climatology of the Dangote Fertizer Plant, Lekki Free Trade Zone (Lat $6^0$35'9''N and Long. $3^0$52'38''E) is described using Era-interim Reanalysis dataset from the European Centre of Medium and Long Range Weather Forecast (ECMWF) with a spatial resolution of 0.125^0 by 0.125^0 for the period of 1984-2013 (30 years) and validated by ground base observation from the Nigeria Meteorological Agency (NIMET).

Figure 4-3 shows the time series plot of the Zonal and Meridional wind components for the study area from 1984-2013. The minimum Zonal wind component is 2.35 m/s and maximum of 3.01 m/s at the Fertizer Plant. The component of a wind along a particular meridian otherwise called the meridional wind also has a minimum of 1.81 m/s and maximum of 2.49 m/s during the period of analysis.

The zonal wind flow is when the upper level winds will flow almost in a straight line from west to east. Meridional flow is when there are troughs of low pressure and ridges of high pressure that will result in a wave like (moving up and down) pattern like a roller coaster pattern. Also indicated is the trend line showing that the zonal wind component is increasing while the meridional is reducing over the years.

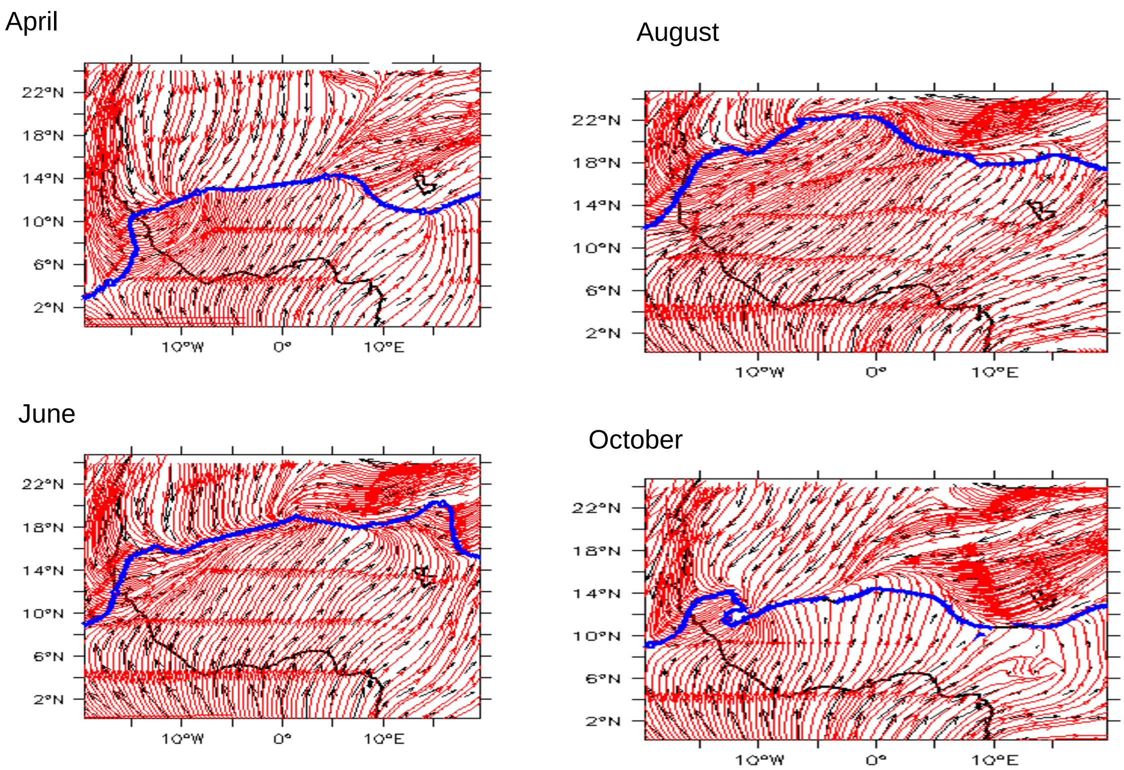


Figure 4-2 Wind flow across the coast of West Africa in April, June, August, and October ***Source: Lekki Free Trade Zone Project-NCEP/NCAR, ERA-40 data.***

Figure 4-4 shows the seasonal variability in the Zonal (u) and Meridional (v) wind component in the Fertizer Plant zone of influence during the 30-years climatological period under consideration. When the upper level winds are parallel or nearly parallel to the lines of latitude the wind pattern is termed zonal. When the winds cross the latitude lines at a sharp angle, the wind pattern is termed meridional.

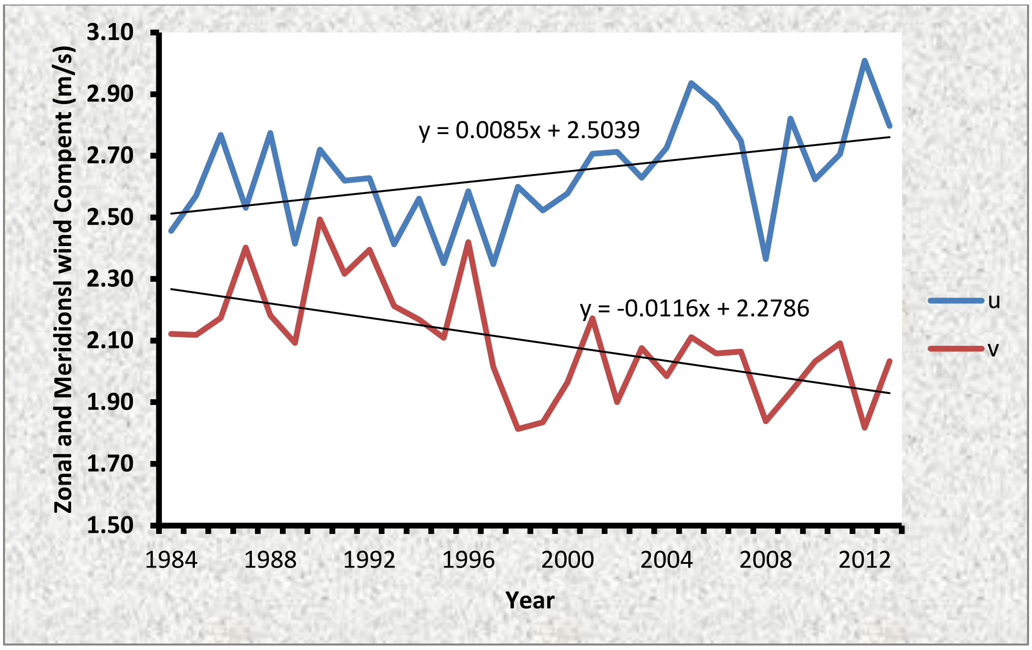


Figure 4-3: Inter-annual Variation of the Zonal and Meridional Wind Component
Source: Climatological data, NIMET, ERA-40; ERA interim data]

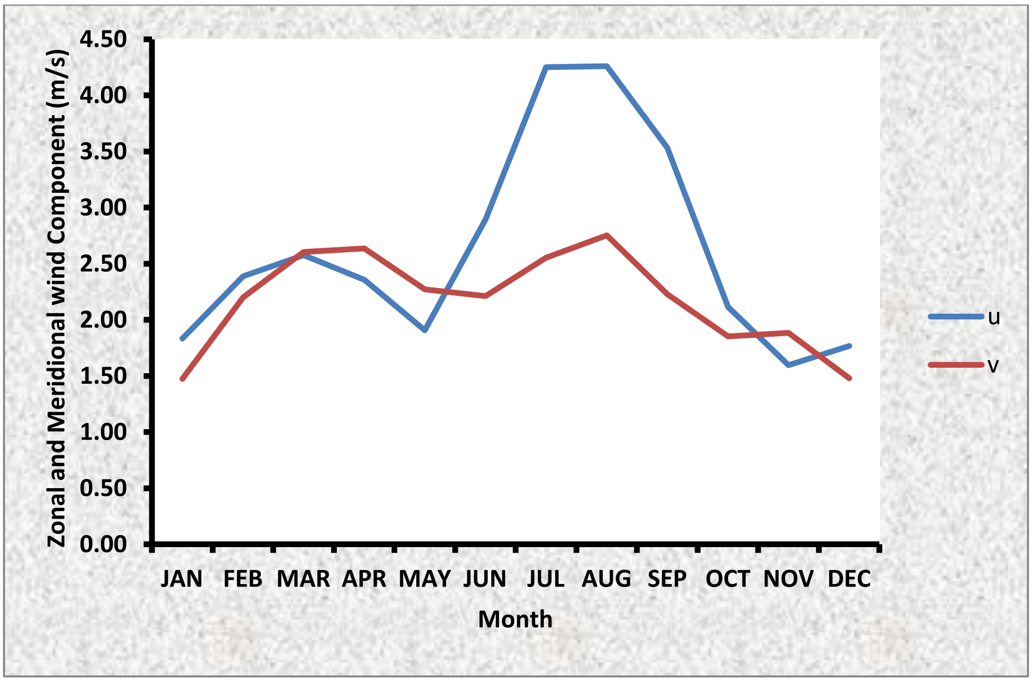


Fig 4-4: Inter-seasonal Variation of the Zonal and Meridional Wind Component
Source: Climatological data, NIMET, ERA-40; ERA interim data

The highest zonal and meridional components of wind-speed occurred in August with a magnitude of 4.26 m/s and 2.75 m/s respectively. The average zonal and meridional wind speed in the study site were 2.62±0.89 and 2.18 ±0.41 m/s respectively. It is further noted that the meridional wind speed is always less than the zonal wind component during the wet seasons. A highly meridional flow can cause atmospheric blocking and spells of much below and much above normal temperatures. A meridional pattern, which its highly curved flow, generates more vorticity than that associated with a zonal flow.

Figure 4-5 presents the time series of the resolved wind speed in the study area. The plot indicated that using 30 years climatological data for the study area the minimum wind speed is 3.46 m/s while the maximum is 4.02 m/s. A marginal decreasing trend was noted during the period of measurement. **Figure 4-6** presents the seasonal wind speed in the study area. The maximum wind was observed in August while the lowest is in November/December. The average wind speed in the zone is 3.78±0.76 m/s.

Figures 4-7a, b and **c** illustrate the monthly wind rose for the study site from January to December. Also very evident from the plots is that most of the wind pattern in the study region falls in the predominant South Westerly and West-south-West wind direction from January-April.

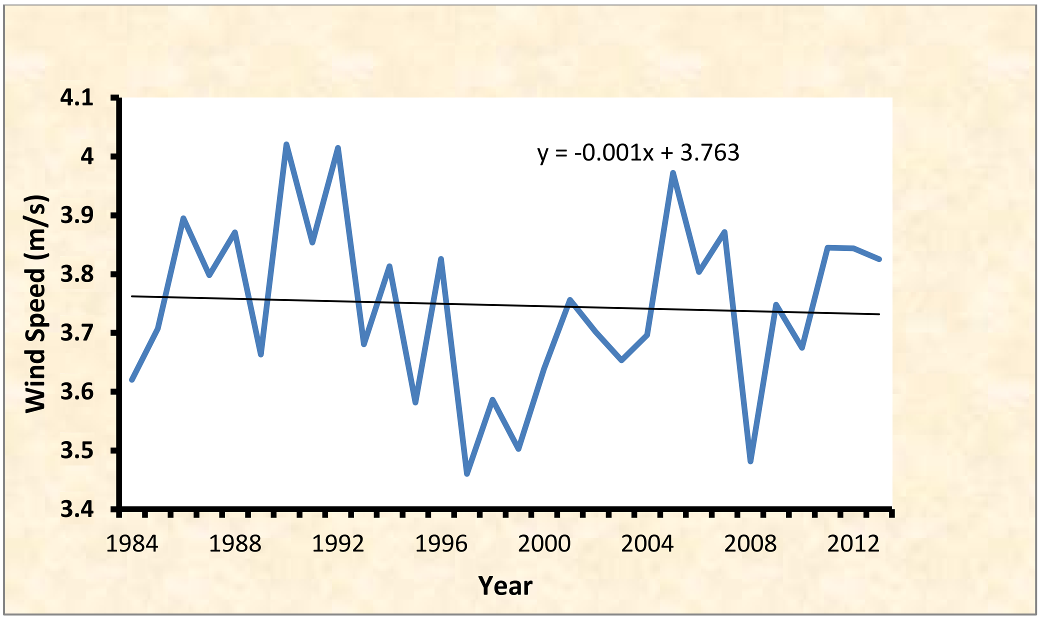


Fig. 4-5: Inter-annual variation of Wind Speed
Source: Climatological data, NIMET, ERA-40; ERA interim data]

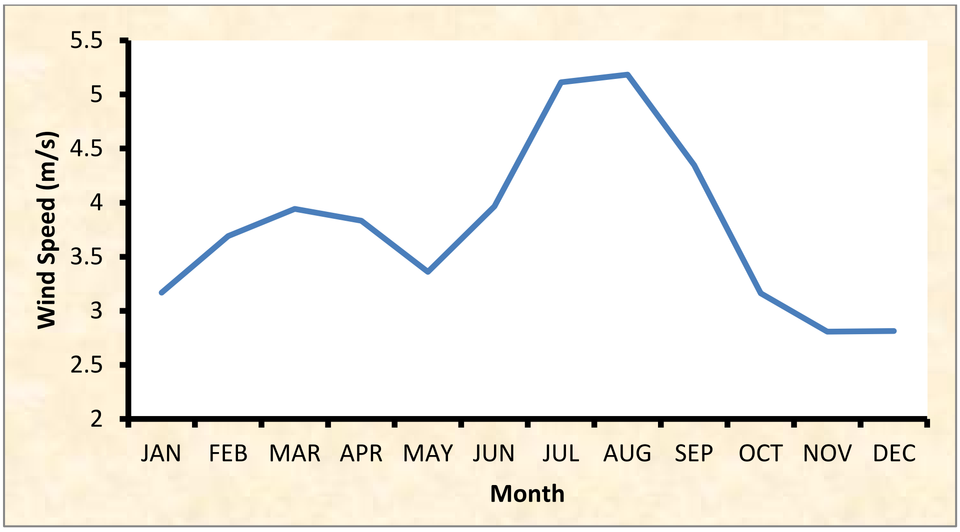


Fig. 4-6: Inter-seasonal variation of Wind Speed
Source: Climatological data, NIMET, ERA-40; ERA interim data]

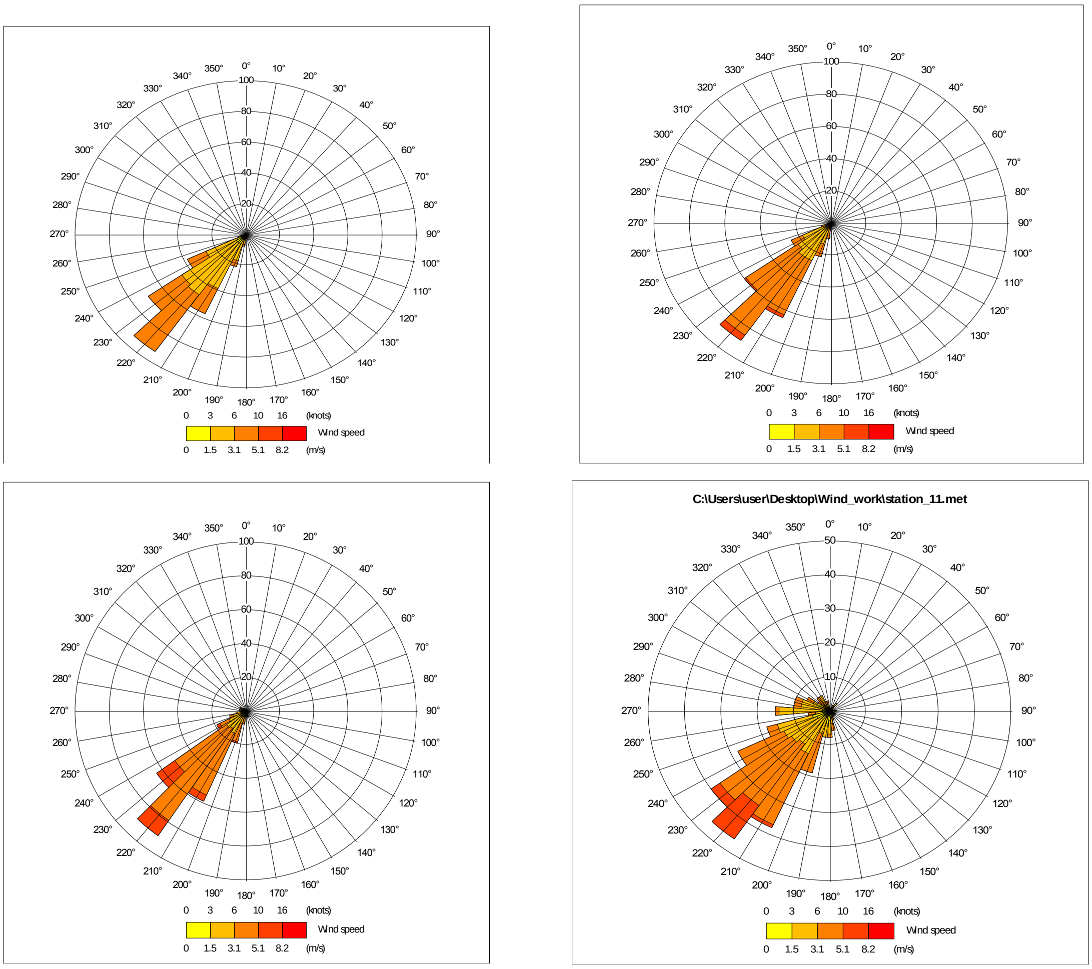


Fig 4-7a: Monthly wind rose in the study region for January, February, March and April
Source: Climatological data, NIMET, ERA-40; ERA interim data]

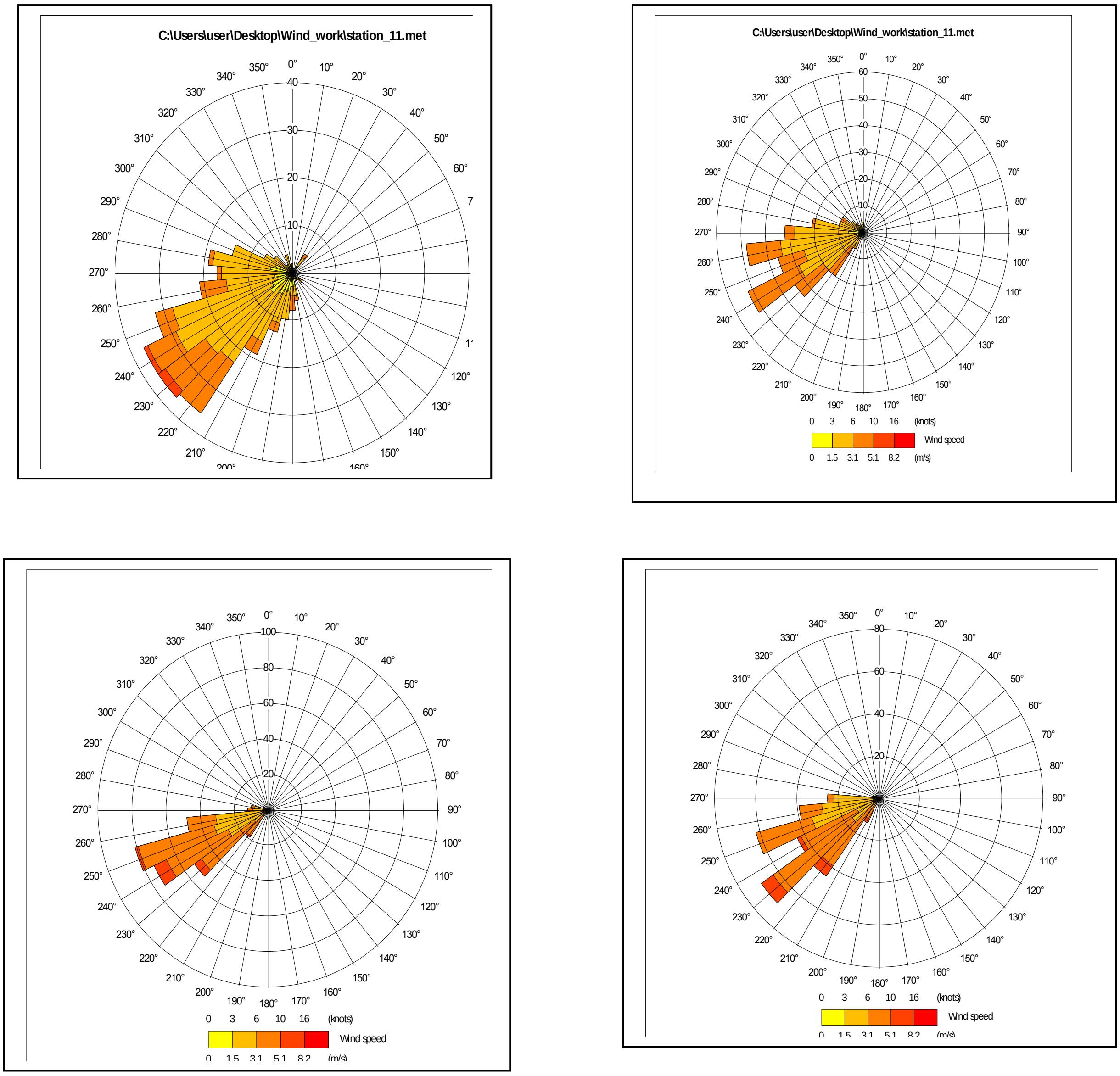


Fig 4.7b: Monthly wind rose in the study region for May, June, July and August

Source: Climatological data, NIMET, ERA-40; ERA interim data

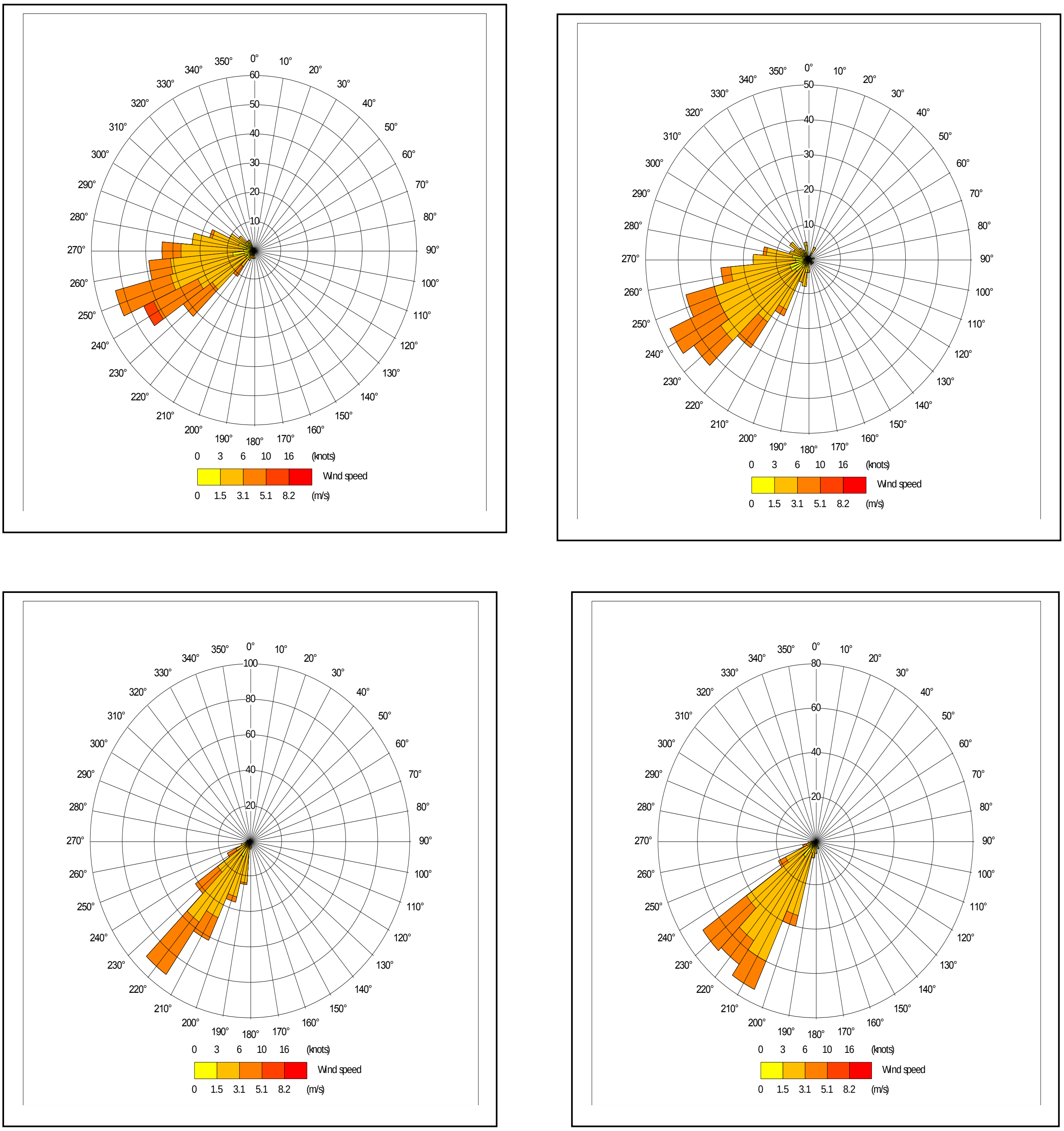


Fig 4.7c: Monthly wind rose in the study region for September. October, November and December *Source: - Climatological data, NIMET, ERA-40; ERA interim data*

Also observed from **Figures 4-7** is some north easterlies wind, which occurred in the study site occasionally during the dry harmattan seasons. The wind pattern over the study area shows that the wind flow pattern is southwesterly in more than 50% of the time as the ITD never moves over the coast. Other wind direction includes the West-South-Westerlies, and the South –South-Westerlies. The Tropical Maritime Air mass (MT) is responsible for rainy season in the study area. This wind (the Tropical Maritime Air mass) moves inwards from the Atlantic Ocean from February in the southern part of Nigeria, while it takes longer for the wind to fully cover the whole of the country, reaching the northern part of Nigeria in June. Its invasion is as a result of the northward retreat, of the tropical continental air mass (CT) known as the harmattan. The northward retreat of the tropical continental air mass (CT), is caused by the sun's northward shift from the tropic of Capricorn in the southern hemisphere to the tropic of Cancer in the northern hemisphere. This shift begins from February and ends in June, when the sun is fully overhead, at the tropic of cancer in the northern hemisphere.

4.4.1.3 Temperature Pattern

The inter-annual variation of temperature in the study area is shown in **Figure 4-8**. Temperature is seen to vary from 26.44^{0}c to 27.51^{0}c during the study period. Trend analysis indicated that temperature at the Dangote Fertizer Plant, Lekki free trade zone is rising at 0.016 ^{0}c /yr which indicated the effect of climate change in the area though at a very minimum level. **Figure 4-9** presents the seasonal variation of temperature from January to December. The lowest temperature recorded in the station is observed in August. The mean temperature observed was 26.80 ± 1.15^{0}c. It is observed that there were even and uniform distribution of temperature between 24.89 ^{o}C and 28.26^{o}C, which is very important to Engineering design and materials to be used within this point location.

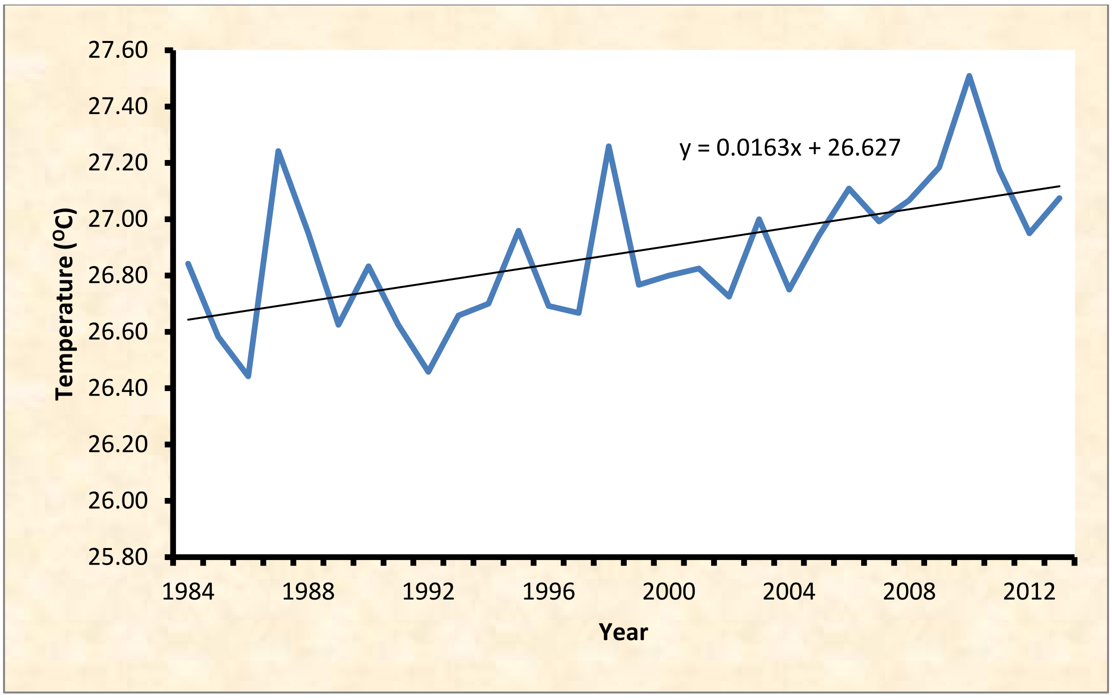


Fig 4-8: Inter-annual variation of Temperature

Source: Climatological data, NIMET, ERA-40; ERA interim data

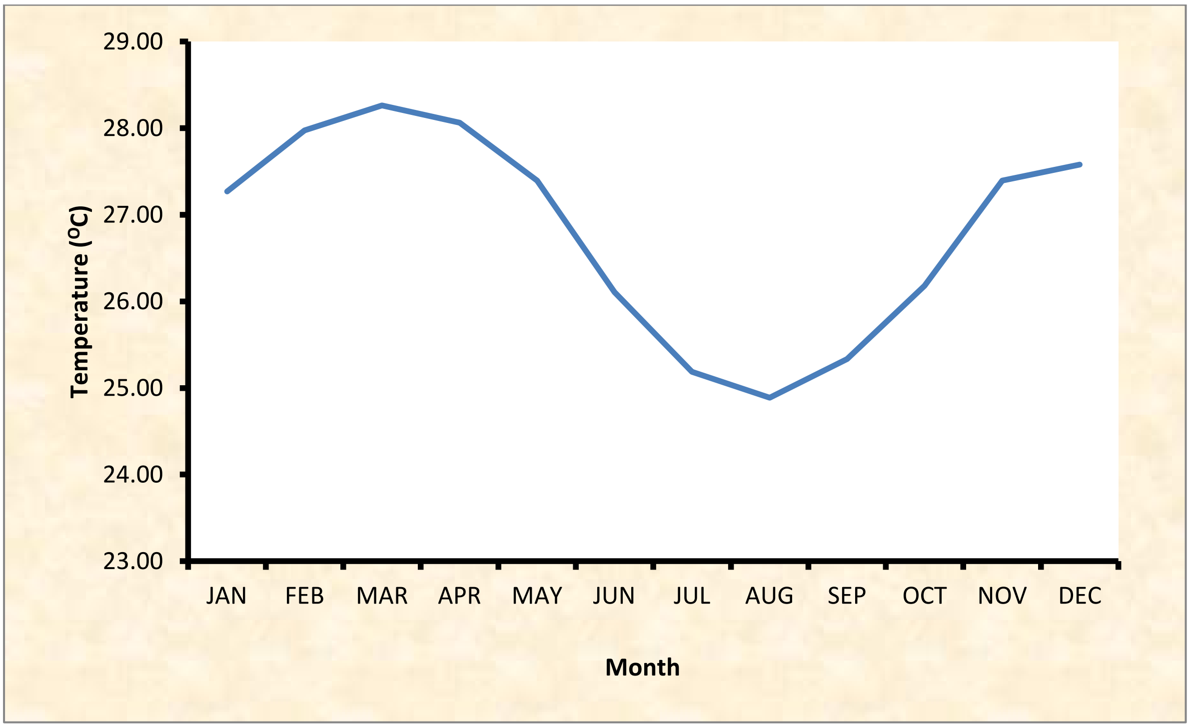


Fig 4-9: Inter-seasonal variation of Temperature

Source: Climatological data, NIMET, ERA-40; ERA interim data]

4.4.1.4 Rainfall Pattern

Rainfall distribution in the region is shown in **Figures 4-10** and **4-11**. Rainfall varies from 95 mm to 166 mm during the 30-year period with mean value of 131±19 mm. The onset of rainfall in the study area is March and increased to highest value in June as shown in **Figure 4-11.** A secondary peak of rainfall is also noted in September and rainfall decreases to minimum. Rainfall is observed to be increasing at 0.49 mm/year in the study area. During the dry months of November-December –January- February the tropical continental air from the northern anticyclone over the Sahara brings in north-easterly trade winds which are dry and have a high dust load (on occasion these penetrate over the Atlantic as far south as 2°N in January). These winds bring a period of dry weather over the region of study. August creates an irregular dry season over the region, whereby rainfall and temperatures decline.

Figure 4-12 presents the monthly averages for rainfall and temperature over the study site. The plot indicated the august break in which temperature reduces to the least value. Rainfall is observed to increase from march to peak value in June – July, while temperature is observed to reduce to minimum in August. However, temperature is observed to increase from September reaching maximum in December.

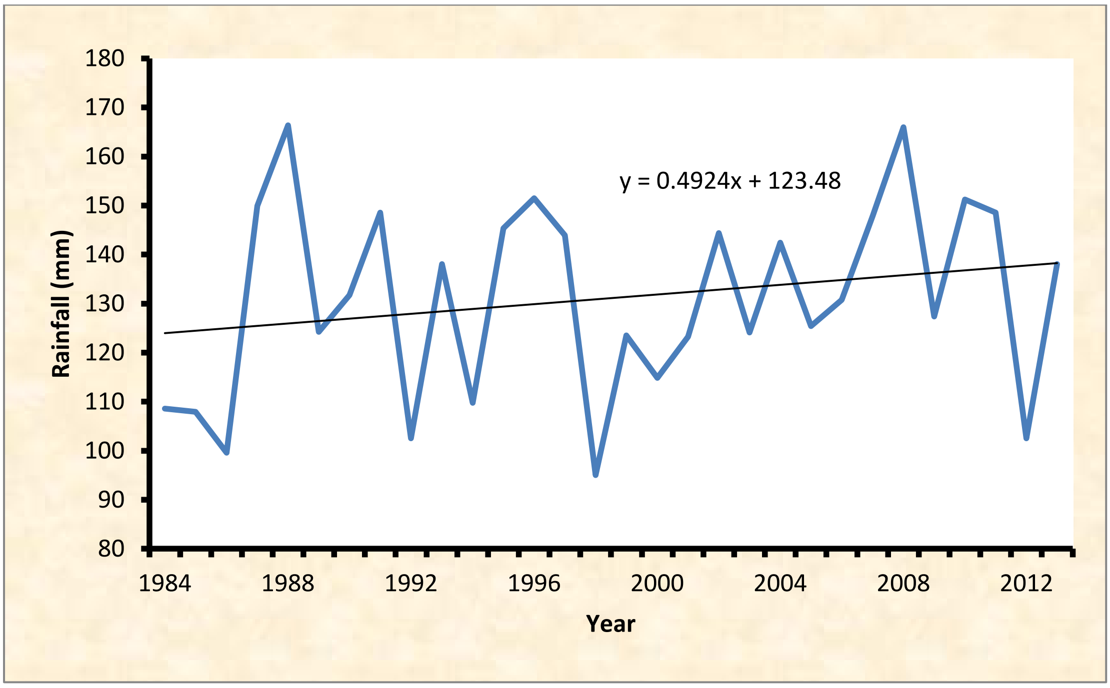


Fig 4.10: Inter-annual variation of Rainfall
Source: Climatological data, NIMET, ERA-40; ERA interim data

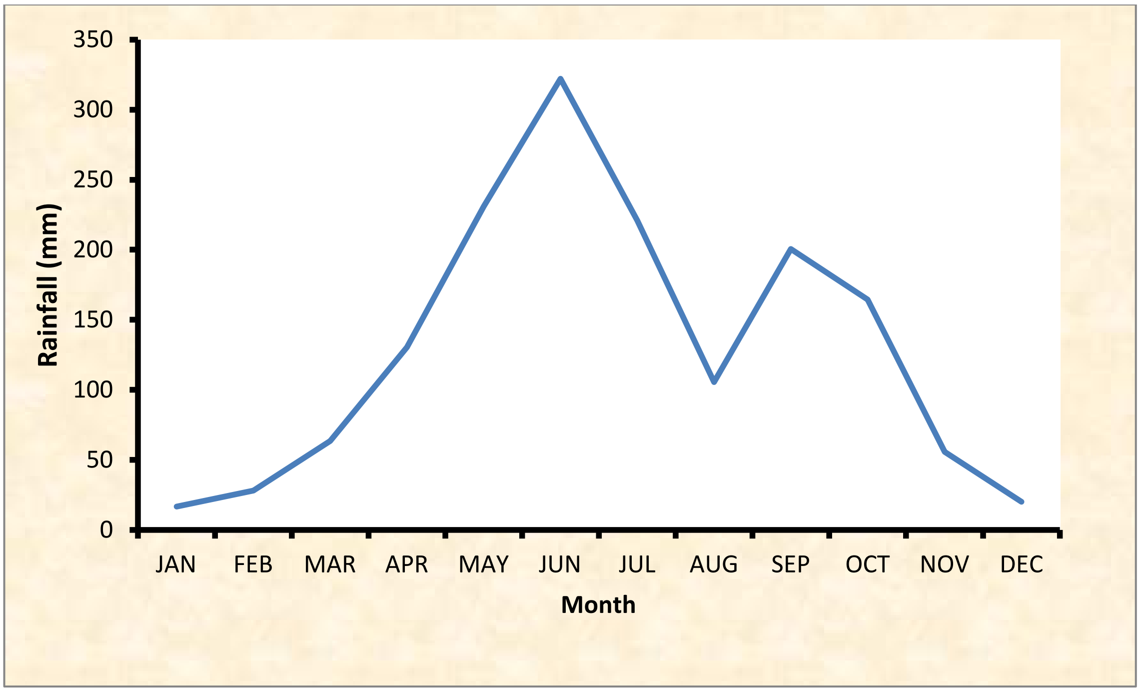


Fig 4-11: Inter-seasonal variation of Rainfall

Source: Climatological data, NIMET, ERA-40; ERA interim data

4.4.1.5 Solar Radiation

Figures 4-13 and **4-14** present the time series plot and the seasonal net radiation respectively within the zone. Net radiation is observed to vary from 49.951 and 55.766 KJm/s^2 during 30 years of analysis. Average solar radiation is in the magnitude of 52.26 KJm/s^2. Solar radiation is observed to reach peak values during the harmattan dry seasons and then reduces to minimum in June - July. A primary peak is noted in February and observed to decreases to minimum in June - July. From the time series plot, net radiation is observed to be slightly increasing at the rate of 0.018 KJm/s^2/year.

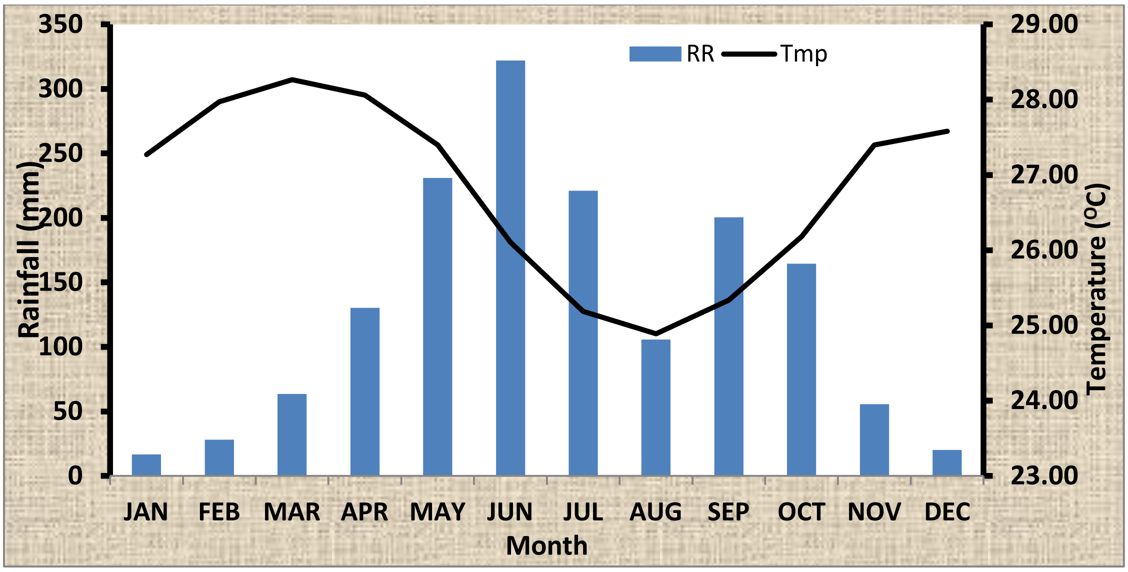


Fig 4-12: Plot of seasonal variation of rainfall and temperature at the study site for 30 years climatological data

Source: Climatological data, NIMET, ERA-40; ERA interim data

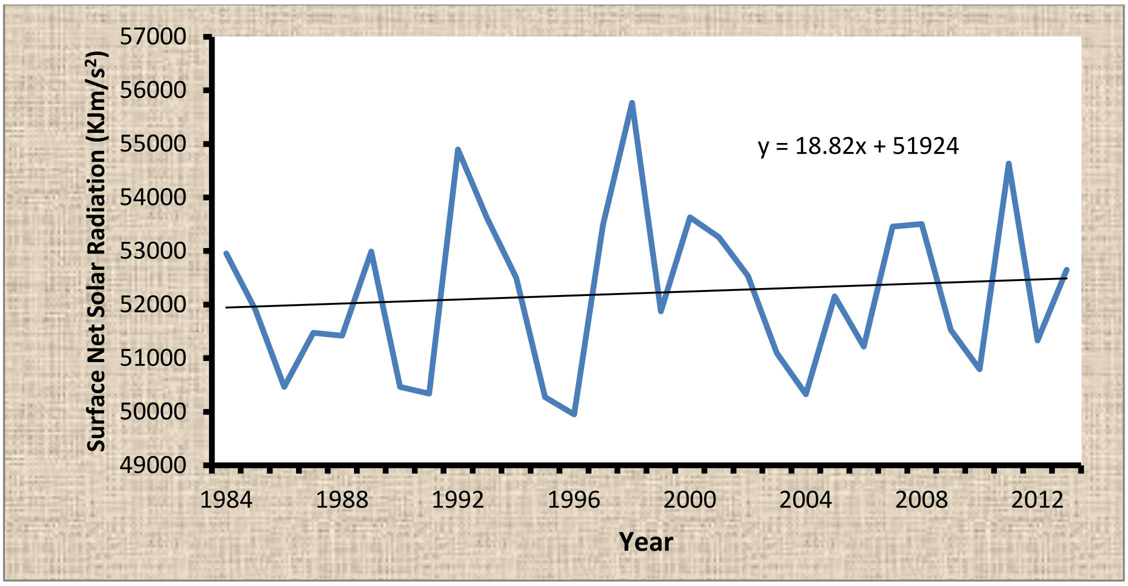


Fig 4-13. Inter-annual variation of Surface Net Solar Radiation

Source: Climatological data, NIMET, ERA-40; ERA interim data

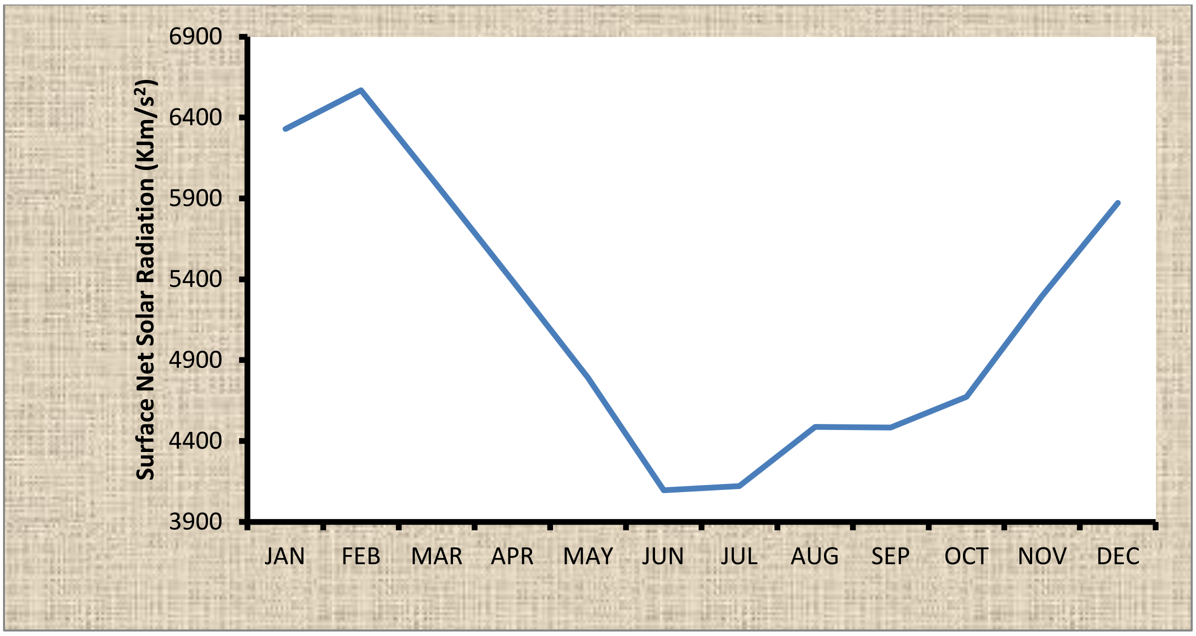


Fig 4.14: Inter-seasonal variation of Surface Net Solar Radiation

Source: Climatological data, NIMET, ERA-40; ERA interim data

4.4.2 Site-Specific Micro Climate

The measured daily averages of relative humidity, temperature and wind speed within the proposed project site during the field data gathering of 9th -11th July 2014 are presented in **Table 4-3.**

Table 4-3: Daily averages of relative humidity, temperature, and wind speed at the Fertizer plant site

	RH (%)	Temperature (^{0}C)	Pressure (mmHg)	Av. Windspeed (m/s)	Max speed (m/s)
Day 1	81.41±5.70	22.97±0.24	759 ± 1.5	2.46±1.19	4.54±1.69
Day 2	81.37±8.17	23.32±0.21	756 ± 1.8	2.08±1.40	4.19±2.31
Day 3	84.88±8.01	23.86±0.48	758 ± 1.2	2.71±1.05	5.11±1.70

The table indicates that the average relative humidity ranged from 81 - 84 % during the period of measurement while air temperature is observed to be between 22 - 24^{o}c during the same period. The average pressure of the atmosphere measured for the three day observation were between 756 mmHg and 759 mmHg. The maximum average daily wind speed was observed on 11th July with a magnitude of 2.71 m/s. The table further revealed that the maximum wind speed recorded were 4.54, 4.19 and 5.11 m/s for 9th, 10th and 11th July respectively.

Figure 4-15 shows the wind direction at the Dangote Fertizer Plant proposed site during 9th- 11th July 2014. Wind direction is dominated with Southwesterlies during the *in situ* observation period. However, in the earlier hours of the day wind direction is predominantly north westerlies, while **Figure 4-16** shows the wind rose for the site during the period of measurement.

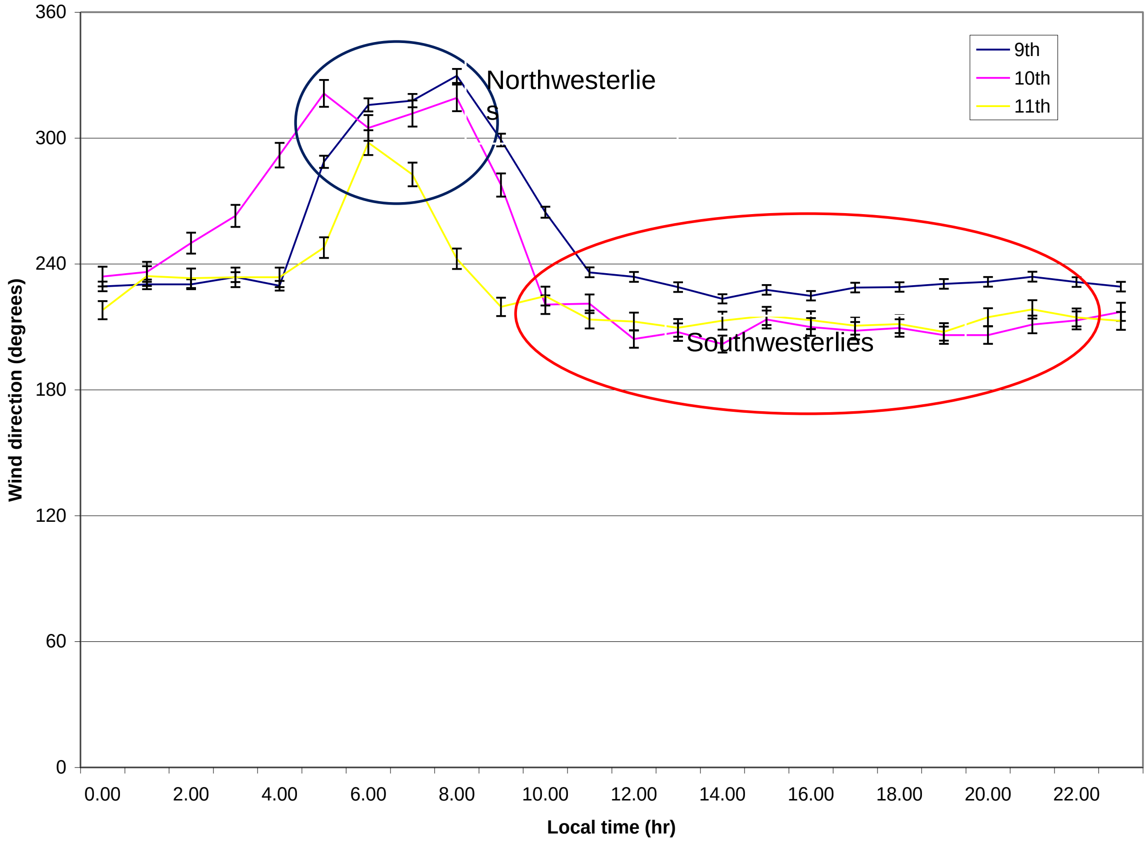


Fig. 4-15: Wind direction at the study site during the measurement campaign of 9th - 11th July 2014.

Source: Dangote Fertizer Plant project EIA July, 2014

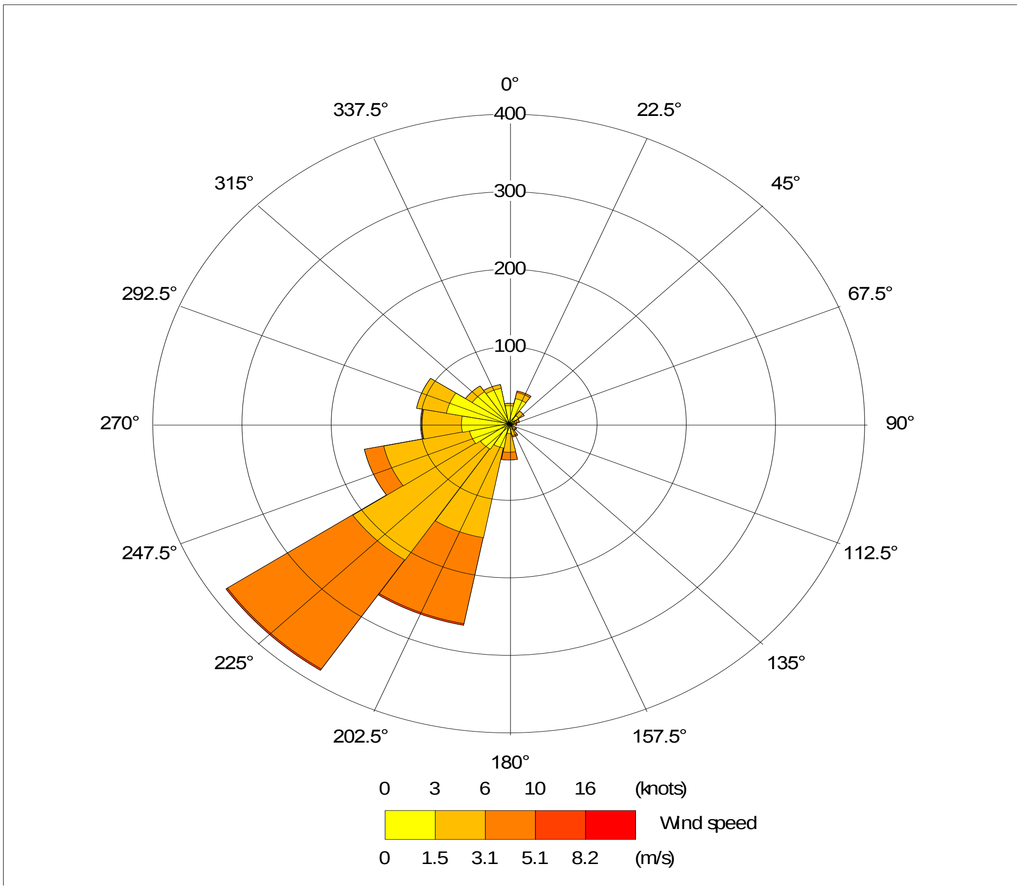


Fig. 4-16: Wind rose in the study region.

Source: Dangote Fertizer Plant project EIA July, 2014

4.4.3. Air Quality

The baseline ambient air quality of the project area investigated at selected locations **(Appendix 2-1**) during the fieldwork exercise is presented in **Table 4-4**.

The concentrations of ammonia (NH_3), nitrogen dioxide (NO_2), carbon monoxide (CO), volatile organic compounds (VOCs), sulphur dioxide (SO_2) and hydrogen sulphide measured in all the sampling stations and the control station were found to be below instruments detection limits. The concentration of total suspended particulates (TSP), however, varied spatially over the selected stations, ranging between 3.20 µg/m^3 and 8.49 µg/m^3 (Mean: 5.73 ± 1.88 µg/m^3). The control station also recorded value (5.47 – 6.18 µg/m^3) within the range observed for the project area. The observed low TSP values during this period (wet season) within the area may be due to washout of suspended particulates by rainwater. It has been observed that washout (wet deposition) is one the major mechanisms by which pollutants are removed from air (Harrison, 1996). The mean concentration of SPM recorded in the current study was below Nigerian ambient air quality standards (NAAQS) of 250 µg/m^3 (daily average of hourly values) and 600 µg/m^3 (concentration not to be exceeded for more than once a year) (FEPA - now FMEnv, 1991). This implies that there was no indication of SPM pollution in the project area, which is expected since there have not been any on-going industrial activities in the area. Industrial and other anthropogenic activities have been implicated in the elevation of airborne particulate matter concentrations with attendant health risks (Harrison, 1996; Ayres, 1998; WHO, 2000).

Table 4-4: Air quality characteristics within Dangote Fertizer project site

Sample Station	NH_3 (ppm)	NO_2 (ppm)	CO (ppm)	VOCs (ppm)	SO_2 (ppm)	H_2S (ppm)	SPM (µg/m^3)
DFAQ1	BDL	BDL	BDL	BDL	BDL	BDL	5.22
DFAQ2	BDL	BDL	BDL	BDL	BDL	BDL	4.36
DFAQ3	BDL	BDL	BDL	BDL	BDL	BDL	8.49
DFAQ4	BDL	BDL	BDL	BDL	BDL	BDL	6.25
DFAQ5	BDL	BDL	BDL	BDL	BDL	BDL	6.84
DFAQ6	BDL	BDL	BDL	BDL	BDL	BDL	3.20
$DFAQC_1$	BDL	BDL	BDL	BDL	BDL	BDL	5.47
$DFAQC_2$	BDL	BDL	BDL	BDL	BDL	BDL	6.18

BDL = Below Instrument Detection Limit (<0.01)

Source: Dangote Fertizer EIA Field Work July 2014

Figure 4-17 shows the comparison of mean concentrations of different fractions of the suspended particulate matters measured in the study area, with the Respirable fraction ($PM_{2.5}$) showing more than 70% of the total mean concentration of measured suspended particulate matter.

Generally, the data gathered from the field showed that the existing air quality within and around the project area is within the relevant ambient air quality criteria stipulated by the

FMEnv (FEPA, 1991) and WHO (2000) for the monitored pollutants (**Tables 4-5 and 4-6**). This implies that the air within the proposed project site and influence zone is at its present condition uncontaminated by air pollutants.

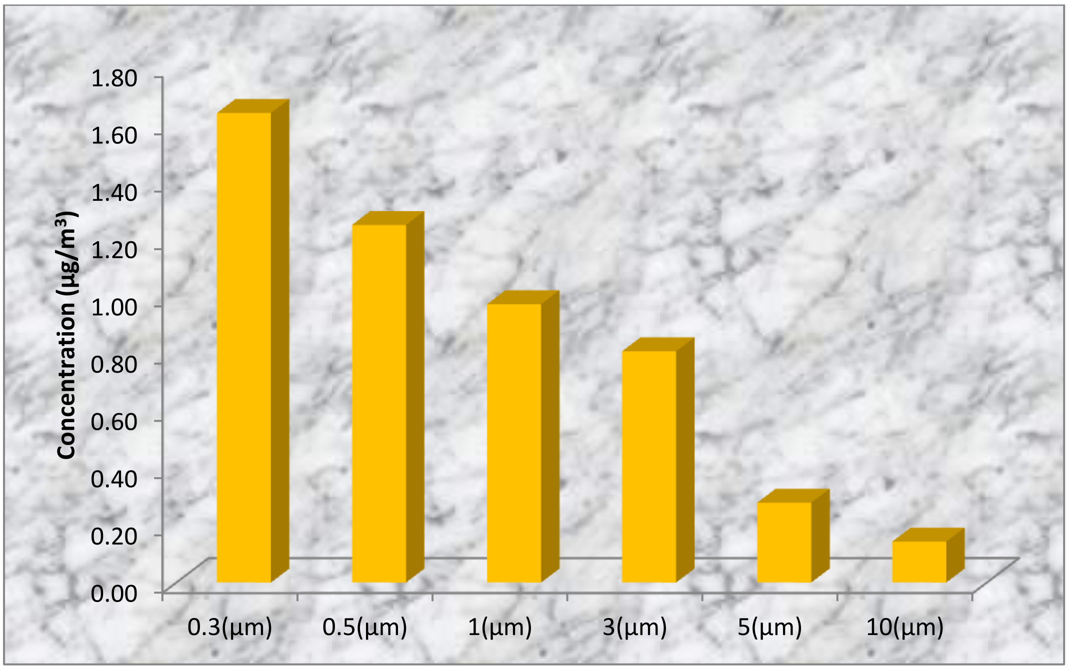


Fig. 4-17: Mean concentrations of suspended particulate matters fraction in the study area

Table 4-5: Nigerian Ambient Air Quality Standard

Pollutant	Time Average	Limit
Particulates	Daily average of hourly values Hourly value	250µg/m^3 600*µg/m^3
SO_x as SO_2	Daily average of hourly values Hourly value	0.01ppm (26µg/m^3) 0.1ppm (260µg/m^3)
NO_x as NO_2	Daily average of hourly values (range)	0.04 – 0.06 ppm (75-113µg/m^3)
Carbon Monoxide	Daily average of hourly values 8 - hourly range	10ppm (11.4mg/m^3) 20ppm (22.8mg/m^3)
Petrochemical Oxidants	Hourly value	0.66 ppm
Non-Methane Hydrocarbon	Daily average of 3-hourly values	160 µg/m^3

**Note: Concentration not to be exceeded for more than once a year*

Source: FMEnv (FEPA - 1991)

Table 4.6: WHO air quality guidelines

Pollutant	Time Weighted Average	Average Time
SO_2	500	10min
	300	1h
	100 - 150[b]	24h
	40 - 60[b]	1yr
CO	30	1h
	10	8h
NO_2	400	1h
	150	24h
Total suspended particulates	150 - 230[b]	24hr
	60 - 90[b]	1yr
Thoracic particles (PM_{10})	70[b]	24hr

[a]*All concentrations in μgm^{-3} except CO in mgm^{-3}*

[b]*Guideline values for combined exposure to SO_2 and suspended particulate matter (they may not apply to situations where only one of the components is present)*

Source: WHO, 2000

3.53.1 Noise Study

The baseline ambient noise levels measured during the field study exercise at selected sampling stations within the project zone of influence are presented in Table 4.7. Noise levels within the project area during the field study were generally low with average minimum ranging from 37.40 – 44.70 dBA and average maximum value of 49.50 – 59.80 dBA. The values recorded at the control stations were slightly higher than what were recorded at the project zone of influence possibly due to their close proximity to the road. Generally, noise levels recorded at the monitoring stations were lower than the 90 dBA FMEnv, 85 dBA DPR and 55 dBA WHO limits (Figure 4.18). The highest mean value of 59.00 dBA recorded at DRAQ10 was as a result of the wood sawing operation at a distance away from the sampling station.

Table 4-7: Noise levels within

Sample Code	Coordinate		Mean	Mean	Grand Mean
	Easting	Northing	Minimum	Maximum	
DFAQ1	615751	713292	39.80	53.20	46.50
DFAQ2	615724	713705	39.30	56.10	47.70
DFAQ3	616370	711594	37.40	48.60	43.00
DFAQ4	615761	711650	41.50	49.20	45.35
DFAQ5	614891	712224	44.70	55.30	50.00
DFAQ6	614875	712614	35.10	46.20	40.65
DFAQC$_1$	617616	710647	42.40	65.3	53.85
DFAQC$_2$	608839	714718	46.30	69.5	57.90
[a]FMEnv Limit					90
[b]DPR limit					85
[c]WHO Limit					55

[a] FEPA (1991); [b] DPR (2002); [c] WHO (2000)

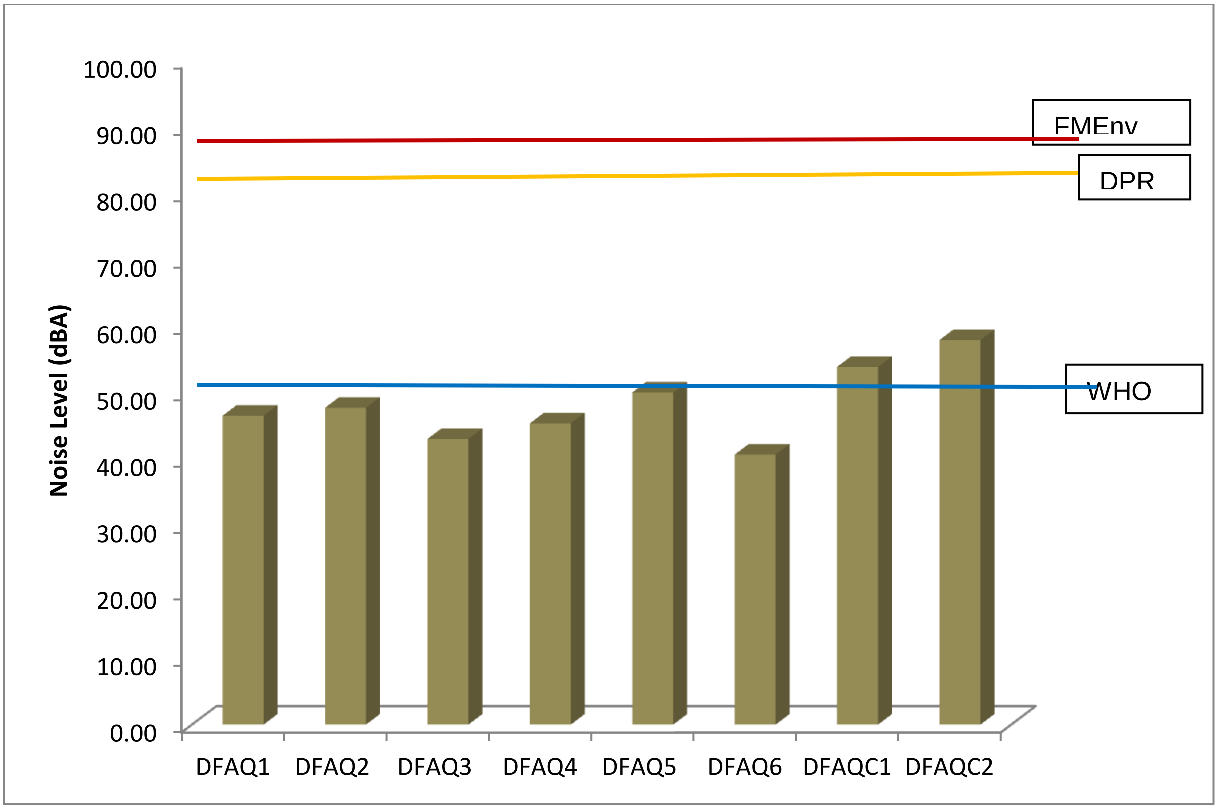


Fig. 4-18: Noise level compared with National and International standards

4.4.5 Land Use

Vast portion of the land cover was swampy and dominated by raffia palm, thus making serious agricultural practice elusive. Notable land uses within the project influence zone include fishing and lumbering (**Plate 4-14**). Changing economic consideration and massive industrial drive of the Lagos State Government in the recent times, however, occasioned a notable and spectacular change in the land use pattern of the area. The development of the area as Lekki Free Trade Zone had attracted multinational companies to invest in the area and this trend is fast changing the land use pattern in the Lekki freshwater swamp forest. Building of residential houses, hotels, office complex and factories are some of the apparent changes in land use pattern observed around the study area.

Plate 4-14: Land use (Cassava Planatation at the fertilizer site)

4.4.6 Soil Quality

4.4.6.1 Soil Physico-chemical Characteristics

The results of soil physico-chemical analysis are summarised in **Tables 4-8a and 4-8b** for the topsoil (0 – 15 cm) and subsoil (15 – 30 cm) respectively. Details for all the sample locations are presented in **Appendix 2-2**

The textural classification of the two soil depths within the study area and control site was predominantly fine-grained consolidated Loamy Sand soil. The sand, clay and silt contents of the topsoil ranged from 68.80 - 79.80%, 12.20 - 19.20% and 8.00 - 12.50% respectively, while the subsoil recorded values ranging from 69.2 - 80.10% sand, 11.2 - 18.30% silt and 8.00 - 14.90% clay. The values obtained from the control sample stations were also within the range obtained for the project influence zone. Similar textural characteristics have earlier been reported for the study area (Lekki Free Zone Development Project, EIA, 2010). The texture of a soil determines the water absorption/infiltration rate, the water holding capacity and migration of pollutants in soil (Margesin and Schinner, 2005). It also determines the amount of soil aeration, ease of tilling, and soil fertility (Udoh 1986). Low clay and high sand soil is porous; it will permit easy leaching of nutrients and pollutants to the groundwater table. Other parameters that determine the dynamics of pollutants in soil include bulk density and porosity. The lower the bulk density, the higher is the permeability (Margesin and Schinner, 2005) . Bulk density varies with structural conditions of the soil, therefore, it is related to packing and often used as a measure for soil structure. The results obtained in the current study revealed the soil bulk density ranging from 0.99 - 1.29 g/cm^3 and porosity 51.32 - 62.64 % for topsoil, while the respective values for subsoil were 1.24 - 1.44 g/cm^3 and 45.66 - 53.21%. Values obtained from the control stations were also within the range. Low spatial variation in the values of the soil physical parameters was recorded for the study area with calculated coefficient of variation less than 27%.

Table 4-8a: Summary of soil physico-chemical characteristics within the project area (Topsoil)

Parameter	*Project Influence Zone*				*Control Stations*	
	Range	Mean	Std. Dev.	C. Var.(%)	Ctrl1	Ctrl 2
Sand (%)	68.80 - 79.80	73.37	4.11	5.61	75.6	74.7
Clay (%)	12.20 - 19.20	15.10	2.96	19.61	12.5	6.5
Silt (%)	8.00 - 12.50	11.53	1.75	15.15	11.9	18.8
B. Density (g/cm^3)	0.99 - 1.29	1.22	0.11	9.41	1.27	1.3
Porosity (%)	51.32 - 62.64	53.93	4.33	8.02	51.65	52.83
pH	4.04 - 5.51	4.97	0.58	11.70	5.51	5.64
TOM (%)	3.27 - 5.14	4.05	0.67	16.65	3.27	2.55
Total N (%)	0.14 - 0.42	0.30	0.11	38.58	0.14	0.33
NH_4^+(mg/kg)	1.15 - 2.97	1.67	0.67	40.30	1.89	0.96
Total P (mg/kg)	3.97 - 12.34	6.31	3.25	51.55	4.22	4.52
Sulphate (mg/kg)	3.65 – 7.11	5.1	1.64	31.78	5.28	3.22
Chloride (mg/kg)	1.40 – 1.72	1.58	0.31	19.6	2.19	1.52
Na^+ (cmol/kg)	0.34 - 0.69	0.48	0.15	31.07	0.35	1.75
K^+ (cmol/kg)	0.87 - 3.02	1.99	0.87	43.73	1.84	2.53
Ca^{2+} (cmol/kg)	1.4 - 2.20	1.78	0.35	19.88	1.40	2.70
Mg^{2+} (cmol/kg)	1.47 - 2.00	1.75	0.19	10.66	1.70	2.30
EA (cmol/kg)	3.00 - 5.20	3.80	0.82	21.57	3.60	2.32
CEC (cmol/kg)	8.93 - 10.96	9.80	0.71	7.27	8.89	11.6
BS (%)	52.56 - 69.29	61.33	6.77	11.03	59.51	80

Table 4.8b: Summary of soil physico-chemical characteristics within the project area (Subsoil)

Parameter	*Project Influence Zone*				*Control Stations*	
	Range	Mean	Std. Dev.	C. Var.(%)	Ctrl 1	Ctrl 2
Sand (%)	69.2 - 80.10	74.65	5.10	6.84	77.8	73.4
Clay (%)	11.2 - 18.30	13.75	2.67	19.43	11.2	7.2
Silt (%)	8.00 - 14.90	11.60	3.06	26.37	11	19.4
B. Density (g/cm^3)	1.24 - 1.44	1.30	0.07	5.52	1.26	1.2
Porosity (%)	45.66 - 53.21	50.96	2.68	5.26	51.88	45.28
pH	4.04 - 5.40	4.79	0.55	11.47	4.26	5.39
TOM (%)	2.51 - 4.19	3.17	0.61	19.35	2.51	2.8
Total N (%)	0.06 - 0.32	0.22	0.10	47.09	0.06	0.27
NH_4^+(mg/kg)	0.65 - 2.97	1.03	0.44	42.51	1.11	0.43
Total P (mg/kg)	4.12 - 12.56	7.74	3.85	49.77	5.91	3.86
Sulphate (mg/kg)	3.40 – 8.38	5.92	2.62	44.26	6.14	3.5
Chloride (mg/kg)	1.35 – 1.96	1.67	0.36	21.56	2.52	1.48
Na^+ (cmol/kg)	0.34 - 0.69	0.53	0.14	27.17	0.34	1.46
K^+ (cmol/kg)	0.75 - 2.79	1.62	0.94	57.87	1.10	2.09
Ca^{2+} (cmol/kg)	1.2 - 2.20	1.68	0.46	27.46	1.20	1.47
Mg^{2+} (cmol/kg)	1.45 - 1.85	1.71	0.16	9.36	1.59	1.60
EA (cmol/kg)	2.20 - 5.20	3.81	1.30	34.10	4.75	2.15
CEC (cmol/kg)	8.33 - 10.79	9.35	0.88	9.41	8.98	8.77
BS (%)	47.10 - 74.75	59.81	11.57	19.34	47.10	75.48

The soil reaction falls within acidic pH range of 4.04 - 5.51 (topsoil) and 4.04 - 5.40 (subsoil). The respective values for the control stations were 5.51 and 5.64 for top soils and 4.26 and 5.39 for subsoil. Spatial variations in measured values were also low (CV <12%) for both topsoil and subsoil. Similar results were also reported for earlier studies carried in the zone (Lekki Free Zone Development Project, EIA, 2010) and from similar terrain (OKFTZ Infrastructural EIA, 2012). pH is often considered in terms of the soil capability and suitability to support plants growth. This is because the value of the free H^+ concentration in a soil influences the availability of nutrient elements and biochemical reactions in the soil (Bohn et al, 1984). In strongly acidic soils for instance basic cation uptake by plants roots is inhibited. Also beneficial soil microorganisms are affected by soil reaction (Isirimah *et al.,* 2003). Hence, soil pH is important for nutrients availability for plants uptake as well as the dynamics of pollutants in soil. The present low pH condition of the soil may enhance the solubility and mobility of heavy metals and their subsequent leaching into the groundwater table, and may slow down microbial degradation. The optimum pH values for pollutant-degrading microorganisms range from 6.5 to 7.5 ((Margesin and Schinner, 2005).

The Organic matter content of the topsoil was high, ranging from 3.27 - 5.14% and for the subsoil from medium values (2.51%) to high (4.19%) according to FAO (1990) classification. (**Table 4-9**) Similar results have been reported for soils in some parts of the zone from previous studies (Lekki Free Zone Development Project, EIA, 2010). Spatial variation in the measured TOM values across the sampling stations for both the topsoil and subsoil was low (CV less than 20%). Many important soil properties including the absorption and retention of water, reserves of exchangeable bases, the capacity to supply nitrogen, phosphorus and other elements to growing crops, stability of soil structure, adequacy of aeration and pollutants bioavailability are dependent to some degree on the quality of organic matter present (Margesin and Schinner, 2005). Thus, pollutant concentrations in soil are usually normalised with respect to the organic matter content in conjunction with clay content (DPR, 2002).

Table 4-9: Classification of Soil Macro and Micro Nutrients

Soil Characteristics	Low	Medium	High
pH	<6	6 – 7	>7
CEC (cmol/kg)	<8	8 – 15	>15
Base Saturation (%)	<50	50	>50
Exchangeable K (cmol/kg)	<0.15	0.15 – 0.4	>0.4
Organic Matter (%)	1.5	1.5 – 3	>3
Total Nitrogen (%)	0.08	0.08 – 0.15	>0.15
Total Phosphorus (mg/kg)	7	7 – 20	>20
Fe (mg/kg)	23	90	360

Source: FAO (1990)

Total nitrogen (N) and ammonium (NH_4^+) ions contents of the soil ranged from 0.14 - 0.42% and 1.15 - 2.97 mg/kg respectively for topsoil, and 0.06 - 0.32% and 0.65 - 2.97 mg/kg) respectively for subsoil. The observed nitrogen levels in both soil depths fall within medium to high soil fertility rating of FAO (1990)l. Soil nitrogen of more than 0.15% is considered optimal for most crops (Sobulo and Osiname, 1986). Nitrogen concentrations in soils generally fall with depth as observed in this studdy, with most of the nitrogen being in the top one-meter layer of soils. Over 90%, of the nitrogen in the surface layers (A-horizon, plow-depth zone) of soil is in organic matter (Bremmer, 1965; Stevenson, 1982).

Total phosphorus (P) contents of the topsoil and subsoil were within low to medium soil fertility classification (FAO, 1990; ISRIC, 1995). The values ranged from 3.97 - 12.34 mg/kg for topsoil and 4.12 - 12.56 mg/kg for subsoil. Phosphorus is an essential macro element because of the relatively large quantity required by plants. Plant growth is limited by phosphorus more than by any other plant nutrient element. Phosphorus is present in soils as: (i) in soil solution (plant-available); (ii) labile phosphate precipitates and adsorbed to soil particles, mainly clay minerals (potentially available to plants); (iii) non-labile phosphate in the form of calcium, iron, and aluminium phosphate (not plant-available); (iv) in organic form, including P in soil organic matter (released after mineralization); and (v) in living soil biomass. Phosphorus is utilized in the fully oxidized and hydrated form as orthophosphate. Deficiency of phosphorus may limit the growth of plants and the microbial decomposition of pollutants in soil. Phosphorus is likely to be deficient in hydrocarbon-impacted soils and subsoils.

Low sulphate (SO_4^{2-}) and chloride (Cl^-) ions concentrations were recorded in the soil samples with values ranging from ranging from 3.65 – 7.11 mg/kg and 1.40 – 1.72 mg/kg respectively for topsoil, and 3.40 – 8.38 mg/kg and 1.35 – 1.96 mg/kg respectively for subsoil. Values recorded from the control stations were also within what was obtained for the proposed project influence zone. Soils that have sulphate and chloride concentrations higher than 500 mg/kg and 250 mg/kg respectively are considered being potentially chemically aggressive. High concentrations of SO_4^{2-} and Cl^- in soils coupled with poor soil drainage condition could enhance external corrosion of metals in such soils. The levels of these anions in soils suggest that soils in the study area are considered chemically non-aggressive.

The exchangeable cations contents in both the topsoil and subsoil were high ranging from 0.34 - 0.69 cmol/kg (Na^{+}), 0.75 - 3.02 cmol/kg (K^{+}), 1.2 - 2.20 cmol/kg (Ca^{2+}) and 1.45 – 2.00 cmol/kg (Mg^{2+}). The exchangeable acidity ranged from 2.20 - 5.20 cmol/kg, while the cation exchange capacity (CEC) and base saturation ranged from 47.10 - 74.75% respectively. Values recorded for the topsoil for these cations were in most cases higher than those obtained for the subsoil. Values from the control stations were also within the range recorded for the project zone of influence.

4.4.6.2 Hydrocarbon Level in Soil

The summary of results of oil and grease, total petroleum hydrocarbon, BTEX and polycyclic hydrocarbons concentrations measured in the soil samples across the project zone of influence and control stations are presented in **Table 4-10.** Oil and grease content of the soil ranged from 10.24 - 12.63 mg/kg (topsoil) and 10.62 - 12.88 mg/kg (subsoil), while total petroleum hydrocarbon (TPH) content ranged from 9.47 - 11.55 mg/kg (topsoil) and 9.45 - 11.72 mg/kg (subsoil). Values in these ranges were earlier been reported in previous studies carried out within the zone (LFZ Infrastructure EIA, 2010) and a similar terrain outside the zone (OKFTZ, Infrastructure EIA, 2012). Spatial variation in the measured concentrations of these pollutants was very low across the sampling stations (CV less than 10%), indicating that they are possibly from the same source of which biogenic is most probable. Benzene, toluene, ethylbenzene and xylenes (BTEX) concentrations measured were below instrument detection limit. Previous workers on similar coastline environment have also reported similar observations. BTEX, which constitutes the volatile organic compounds (VOCs) in soils primarily originate from petroleum products and their analysis is widely used as an indicator of contamination with light petroleum products (Margesin and Schinner, 2005). Thus, the observed values of these chemical substances in the soil reflect an environment not contaminated with petroleum products. In addition, the total petroleum hydrocarbon values obtained in this study were lower than 50 mg/kg DPR Target value. It has been widely reported that soils with a hydrocarbon level below 100 mg/kg are considered unpolluted with hydrocarbon (Concawe, 1975).

The sixteen PAHs analysed in the soil samples showed measurable concentrations across the sampling stations. The total PAHs (sum of the sixteen PAHs) level (28.40 µg/kg for topsoil and 29.48 µg/kg for subsoil) recorded were, however, generally low in the soil falling within what were reported for a similar terrain (OKFTZ Infrastructure EIA, 2012). Low spatial variation in the measured values was observed, while values from the control stations were also within the range recorded for the project influence zone. Polycyclic aromatic hydrocarbons were, however, not determined in the previous Lekki Free Trade Zone Development EIA (2010) for comparison.

Table 4.10: Oil and Grease, TPH, BTEX and PAHs levels in soils within project area

Parameter	Project Influence Zone				Control Stations	
	Range	Mean	Std. Dev.	C. Var.(%)	Control 1	Control 2
			TOPSOIL			
Oil & Grease (mg/kg)	10.24 - 12.63	11.73	0.84	7.15	12.26	13.20
TPH (mg/kg)	9.47 - 11.55	10.47	0.80	7.64	11.34	11.97
Benzene (µg/kg)	<0.01	<0.01	-	-	<0.01	<0.01
Toluene (µg/kg)	<0.01	<0.01	-	-	<0.01	<0.01
Ethylbenzene (µg/kg)	<0.01	<0.01	-	-	<0.01	<0.01
Xylene (µg/kg)	<0.01	<0.01	-	-	<0.01	<0.01
PAHs (µg/kg)						
Naphthalene	2.47 - 5.96	3.95	1.22	30.90	4.28	3.4
Acenaphthylene	2.42 - 6.32	3.94	1.30	32.95	3.35	3.16
Acenaphthene	1.4 - 2.71	2.11	0.58	27.46	2.15	1.6
Fluorene	1.2 - 2.32	1.76	0.53	30.29	2.36	1.26
Phenanthrene	1.16 - 3.17	2.18	0.88	40.44	2.17	1.38
Anthracene	1.42 - 3.86	2.53	0.98	38.66	3.2	1.88
Fluoranthene	0.18 - 0.42	0.33	0.10	29.80	0.3	0.49
Pyrene	1.15 - 2.40	1.69	0.53	31.02	2.16	1.22
Benzo(a) anthracene	1.24 - 2.27	1.77	0.48	27.14	1.4	1.3
Chrysene	0.06 - 0.15	0.10	0.03	30.74	0.15	0.17
Benzo(b) fluoranthene	0.2 - 0.42	0.30	0.09	30.35	0.34	0.28

Benzo(k) fluoranthene	2.13 - 4.16	3.16	0.67	21.09	3.16	2.64
Benzo(a) pyrene	2.56 - 5.09	4.02	0.95	23.63	3.38	2.68
Indeno (1,2,3-cd) pyrene	0.04 - 0.08	0.05	0.02	30.62	0.07	0.12
Dibenzo (a,h) anthracene	0.32 - 0.69	0.50	0.15	29.04	0.46	0.45
Benzo (g,h,i) perylene	<0.01 - 0.01	0.01	0.00	0.00	0.01	0.01
SUBSOIL						
Oil & Grease (mg/kg)	10.62 - 12.88	11.97	0.80	6.71	12.6	12.94
TPH (mg/kg)	9.45 - 11.72	10.72	0.90	8.44	11.08	11.85
Benzene (µg/kg)	<0.01	<0.01	-	-	<0.01	<0.01
Toluene (µg/kg)	<0.01	<0.01	-	-	<0.01	<0.01
Ethylbenzene (µg/kg)	<0.01	<0.01	-	-	<0.01	<0.01
Xylene (µg/kg)	<0.01	<0.01	-	-	<0.01	<0.01
PAHs (µg/kg)						
Naphthalene	2.69 - 6.01	4.05	1.26	31.12	4.72	5.74
Acenaphthylene	2.58 - 6.17	4.06	1.21	29.89	3.59	3.35
Acenaphthene	1.52 - 3.47	2.27	0.78	34.45	2.36	3.24
Fluorene	1.35 - 2.74	1.75	0.55	31.15	2.5	2.6
Phenanthrene	1.25 - 4.12	2.24	1.15	51.47	2.39	3.18
Anthracene	1.34 - 3.92	2.54	1.12	44.11	3.46	2.39
Fluoranthene	0.22 - 0.50	0.35	0.10	29.40	0.37	0.37
Pyrene	1.1 - 2.51	1.72	0.57	33.16	2.81	2.15
Benzo(a) anthracene	1.06 - 2.70	1.83	0.66	35.98	1.32	2.12
Chrysene	0.09 - 0.17	0.12	0.03	24.73	0.14	0.18
Benzo(b) fluoranthene	0.22 - 0.44	0.31	0.09	27.87	0.38	0.53
Benzo(k) fluoranthene	2.18 - 4.83	3.43	0.85	24.71	3.19	3.56
Benzo(a) pyrene	2.59 - 6.09	4.19	1.18	28.19	3.87	3.93
Indeno (1,2,3-cd) pyrene	0.04 - 0.09	0.06	0.02	35.91	0.06	0.12
Dibenzo (a,h) anthracene	0.36 - 0.79	0.57	0.16	28.74	0.53	0.58
Benzo (g,h,i) perylene	<0.01 - 0.01	0.01	0.00	0.00	0.01	0.01

Polycyclic aromatic hydrocarbons (PAHs) occur ubiquitously in the environment and their occurrence in soils within the study area are probably of biogenic origin.

4.4.6.3 Heavy Metals in Soil

The summary of the heavy metals concentrations in the soil of Dangote Fertilizer Plant proposed site is presented in **Table 4-11**.

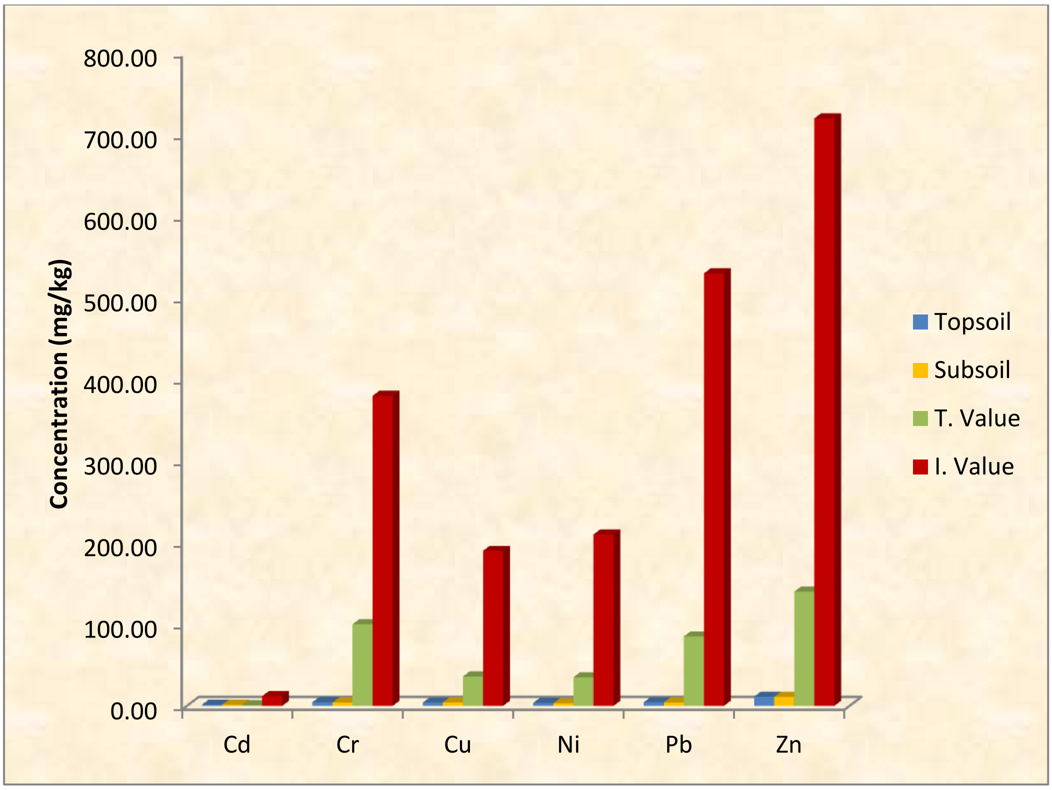
Table 4.11: Summary of heavy metal level (mg/kg) in soil within Project area

Parameter	*Project Influence Zone*				*Control*	
	Range	Mean	Std. Dev.	C. Var.(%)	Range	Mean
TOPSOIL						
Cd	0.64 - 1.98	1.42	0.47	33.30	0.84	1.29
Cr	2.74 - 5.73	4.48	1.11	24.91	5.32	5.1
Cu	3.22 - 4.73	4.03	0.60	14.97	3.83	6.44
Fe	354 – 458	399.78	36.26	9.07	428	471.8
Hg		BDL			BDL	BDL
Pb	2.48 - 4.77	3.66	0.98	26.83	5.29	3.85
Ni	3.68 - 5.29	4.36	0.82	18.74	4.58	2.45
V	0.02 - 0.06	0.05	0.01	30.63	0.07	0.02
Zn	7.89 - 13.50	11.20	2.18	19.45	7.2	7.68
SUBSOIL						
Cd	0.70 - 1.46	1.24	0.28	22.47	0.69	1.46
Cr	2.96 - 5.52	4.18	0.82	19.70	5.77	4.65
Cu	3.64 - 4.69	4.27	0.43	10.17	4.19	5.17
Fe	369 – 440	408.97	26.51	6.48	477.5	471.8
Hg		BDL			BDL	BDL
Pb	1.78 - 4.79	3.24	1.31	40.31	4.42	5.38
Ni	3.73 - 4.66	4.22	0.30	7.04	3.17	2.6
V	0.02 – 0.06	0.04	0.02	38.45	0.03	0.03
Zn	6.90 - 14.62	11.02	2.80	25.39	7.84	8.15

BDL: ***Below instrument detection limit***

All the heavy metals analysed showed measurable concentrations except mercury (Hg) with concentration below instrument detection limit (<0.01 mg/kg). Iron (Fe) recorded the highest concentrations (354 – 458 mg/kg topsoil and 369 – 440 mg/kg subsoil). Concentartions within these ranges were also recorded at the control stations. The observed high Fe contents fall within what was reported for a similar terrian in previous study (OKFTZ Infrastural EIA, 2012). Concentration of iron of this magnitude in soil is common with Nigerian wet-land as reported by earlier investigators (Anderson, 1966; Ojanuga *et al.*, 1996; Aiyesanmi, 2005). However, iron concentration in soil above 360 mg/kg is considered high and may adversely affect crop yield (FAO, 1990).

Varying concentrations of other metals analysed were recorded across the sampling stations with coefficient of variation ranging from 7.04% to 40.31% in both topsoil and subsoil. The measured concentrations (mg/kg) in both soil depths were in the order of Zn (6.90 - 14.62) > Cr (2.74 - 5.73) ≈ Ni (3.68 - 5.29) ≈ Cu (3.22 - 4.73) > Pb (1.78 - 4.79) > Cd (0.64 - 1.98) > V (0.02 – 0.06). The observed heavy metals mean concentrations in soils within the project zone of influence were, however, lower than their Target values in soil (**Figure 4-19**), except Cd which mean value above the target value, but far lower than the intervention value. This implies that the soils within the project zone as it were are not polluted with heavy metals. Target value indicates the soil quality required for sustainability or expressed in terms of remedial policy, the soil quality required for the full restoration of the soil's functionality for human, animal and plant life. Target values therefore indicate the soil quality levels ultimately aimed for. Intervention values indicate the quality for which the functionality of soil for human, animal and plant life are, or threatened with being seriously impaired (DPR, 2002).



T. value: Target value; I. value: Intervention value

Note: Iron and vanadium have no reported target and intervention values.

Fig. 4-19: Comparing heavy metal concentration in soil with target and intervention value

4.4.6.4 Soil Microbiology

The summary of microbiological characteristics of soils within the proposed fertilizer project area is presented in **Table 4-12,** while details are presented in **Appendix 2-3**

Heterotrophic bacteria analysis revealed total viable count of 1.11 – 2.38 x 10^5 cfu/g (topsoil) and 1.04 – 2.67 x 10^5 cfu/g (subsoil), while hydrocarbon degraders constituted about 5.50% (topsoil) and 2.50% (subsoil) (**Figure 4-20**). The most predominant organisms among the isolates are the Bacillus sp, Rhizobium sp, and Micrococcus sp. Similar observation has been reported for OKFTZ Infrastructure EIA (2012), but no microbiological data on soils from previous study of the zone with which the current data could be compared.

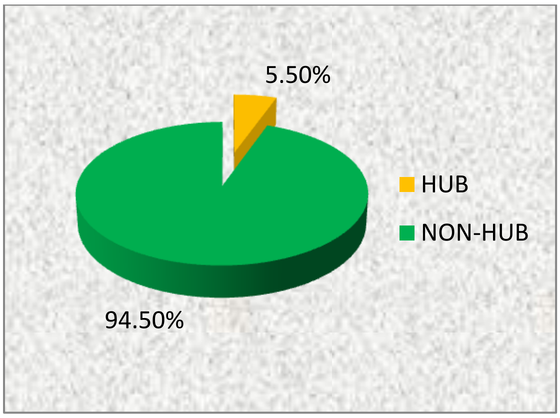
Table 4-12: Summary of microbiological characteristics of soils within Dangote fertlizer project area

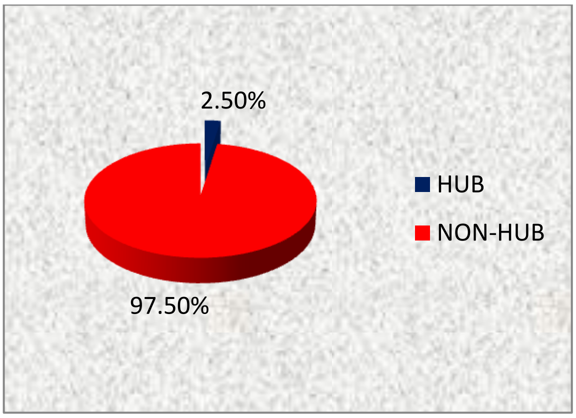
Parameter	*Project Area*		*Control Station*	
Topsoil				
	Range	Mean	Control 1	Control 2
THB (cfu/g)x 10^5	1.11 - 2.38	1.53	1.40	1.60
HUB (cfu/g) x 10^4	0.2 - 1.83	0.85	0.76	0.54
THF (spore/g) x 10^3	0.17 - 1.26	0.56	0.13	0.41
HUF (spore/g) x 10^2	0.04 - 0.59	0.21	0.08	0.12
Sobsoil				
THB (cfu/g)x 10^5	1.04 - 2.67	1.64	1.69	1.20
HUB (cfu/g) x 10^4	0.01 - 0.79	0.41	1.35	0.52
THF (spore/g) x 10^3	0.11 - 1.40	0.55	1.18	0.44
HUF (spore/g) x 10^2	0.02 - 0.34	0.14	0.56	0.16

THB = Total Heterotrophic Bacteria   HUB = Hydrocarbon Utilizing Bacteria

THB = Total Heterotrophic Fungi   HUB = Hydrocarbon Utilizing Fungi

Source: Dangote Fertilizer EIA Field Work July, 2014



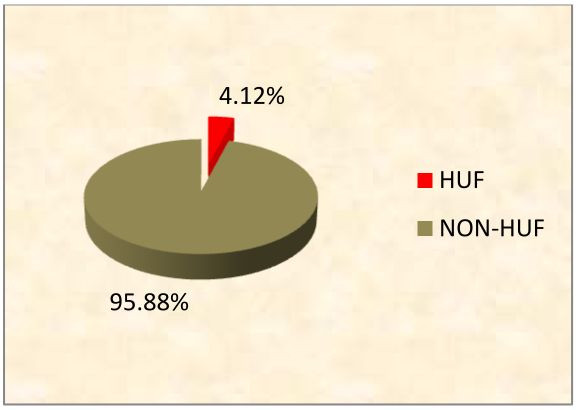


Topsoil   **Subsoil**

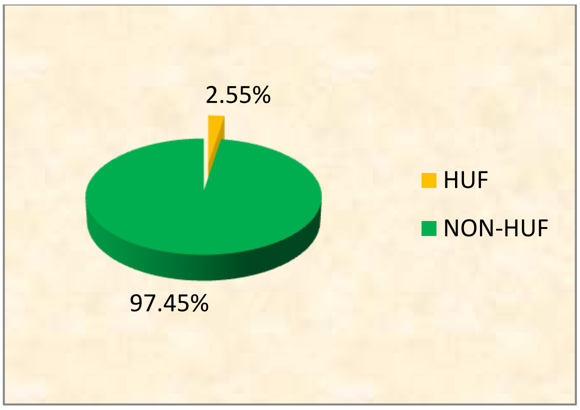
HUB = Hydrocarbon utilizing bacteria   NON-HUB =Non-hydrocarbon utilizing bacteria

Fig. 4-20: Percentage of hydrocarbon and non-hydrocarbon utilising bacteria in soil

Fungi determination in the soils revealed total heterotrophic fungi ranging from 0.17 - 1.26 x 103 spore/g (topsoil) and 0.11 - 1.40 x 103 spore/g (subsoil).. The hydrocarbon utilizing fungi isolate only accounted for 4.12% and 2.55% for the topsoil and subsoil respectively (Figure 4.21). Most predominant among the fungi isolates were Aspergillus sp.



Topsoil



Subsoil

HUB = Hydrocarbon utilizing fungi *NHUB =Non-hydrocarbon utilizing fungi*

Fig. 4-21: Percentage of hydrocarbon and non-hydrocarbon utilizing fungi in soil

4.4.7 Geology, Geomorphology and Hydrogeology of Project Area

The study area lies within the extensive Dahomey basin, containing Recent - Cretaceous sediment built-up. The basin (**Figure 4-22**) extends from the eastern part of Ghana through Togo and Republic of Benin to the western margin of the Niger/Delta basin, just before the Mahin mud coast in Nigeria. The basin is separated from the Benue trough by a basement ridge, the Okitipupa ridge, a paleographic highland. It is bounded in the east by Benin hinge line, a major regional fault structure marking the western limit of the delta basin (Adegoke, 1969).

The sedimentary succession consists of near surface Recent alluvial deposits. These deposits are underlain by the Coastal Plain Sands or the Benin Formation. The sediments of the Coastal Plain, deposited during the Late Tertiary - Early Quaternary (Jones and Hockey, 1964), consist of unconsolidated, coarse to medium sands (Okosun, 1998). The sands are generally moderately sorted and poorly cemented. The Benin Formation is underlain by the Paleocene Akinbo Formation. The formation is predominantly shally.

The Akinbo shale is underlain by the continental Cretaceous sediments of the Abeokuta Group (Omatsola and Adegoke, 1981).

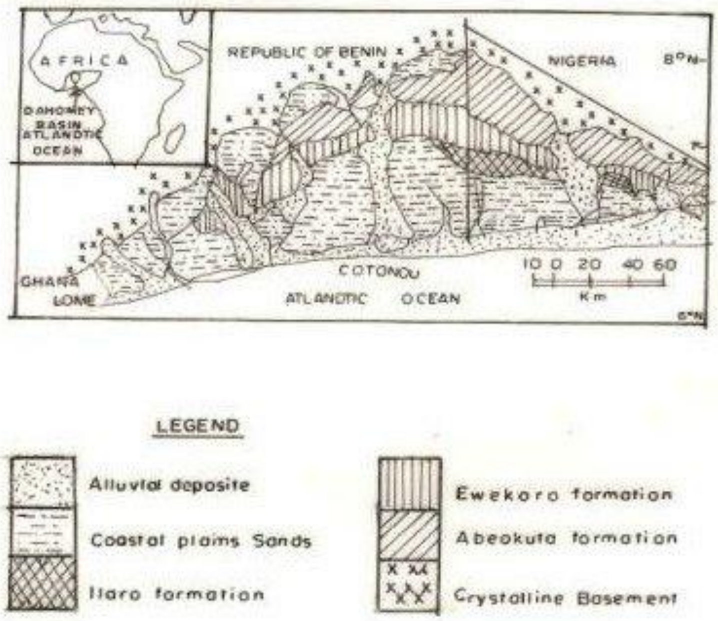


Fig. 4-22: Generalised Geological map of Dahomey Basin

Source: ***Adegoke and Omatsola (1981)***

Two stratigraphic units constitute the major aquifer systems in the study area.

(i) **The Alluvial:** This unit occurs as lenses of sands within less permeable beds of silt and clays. Aquifers within occur at shallow depths, with very erratic lateral extent. Alluvial aquifers in this environment are very susceptible to pollution since they occur mostly at shallow depths and in many locations have direct contact with surface runoff and river waters. There is also the likelihood of saline intrusion into alluvial aquifer systems in the area due to the distance of the site to the shoreline.

(ii) **The Benin Formation:** This stratigraphic unit constitutes the main aquifer system in most parts of the Dahomey Basin. Benin Formation is significantly thick. Its lithologic composition is mostly sand and sandstone (about 90%) while clays and lignitic beds constitute about 10%. The Benin Formation constitutes a large continuous aquifer system with enormous storage capacity.

4.4.7.1 Geomorphology

Topographically, Lagos state lies entirely within the coastal plain which is characterized by sand bars, lagoons and creeks. The land does not rise very much above sea level anywhere in the state (**Figure 4-23**). At the project area, the average elevation is about 7m. The rivers, creeks and lagoons in the state ramify and join each other in a rather intricate fashion. From the west, the Badagry creek enters from the Republic of Benin and it is joined in the north, about 24km from the Nigerian-Benin border, by the Yewa River. There is also Ologe lagoon, looking almost like the Caspian Sea in shape. The rest of the state is dorminated by the Lagos lagoon. Draining into the lagoons are numerous streams and rivers flowing in from the north, the more important ones being the Owo, Ogun, Solode-Baare, Owa, Omu and Osun rivers. The interconnecting pattern of these water bodies creates a large number of islands of varying sizes. One of the consequences of the foregoing is the existence, over most of the state, of swamp lands of low to very low agricultural productivity. Only very thin land on the northern fringe of the state has soils of good potential for agriculture.

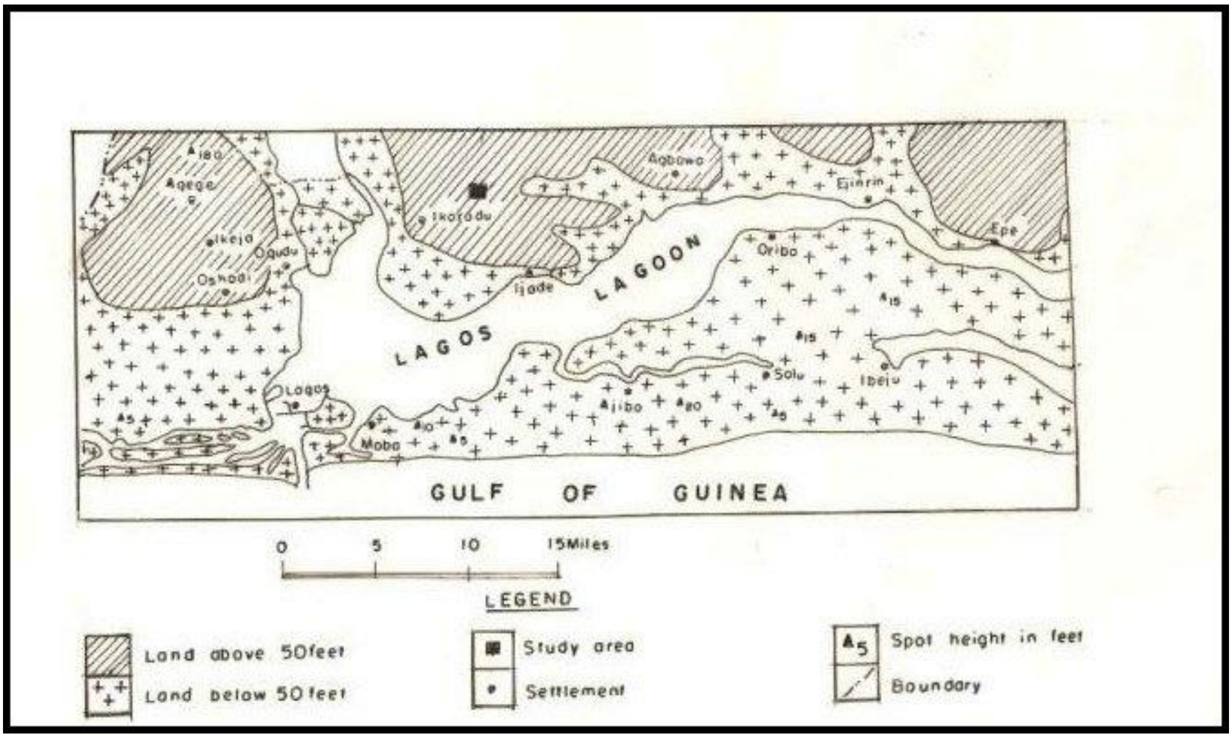


Figure 4-23: The Relief of Lagos Area

4.4.7.2 Local Geology of the Project Site

Geologically, Lagos state lies in the alluvium, littoral and lagoonal deposit and Coastal Plains Sand (**Figure 4-24**). The project site falls within the Coastal Plains Sand unit and comprising soft, very poorly sorted clayey sand, pebbly sands, sandy clays and rare thin lignites which littered sparsely the study area especially at the southeastern and central part of the project site. There are also sediments consists mainly of unconsolidated sands, clays and muds with a varying proportion of vegetative matter. The sediments were probably deposited under littoral and lagoonal conditions and reflect continual shifting lagoon and sea beach patterns as well as varying sedimentation conditions within the lagoons.

4.4.7.3 Topography and Drainage Pattern

The topography of the project site is fairly flat and dips northeast-ward and describes v-shape in a northwest – southeast direction. The up-slopes are at the southern end while the down dips are at the northeastern and southwestern end. The slope describes by the topography is however gentle in a northeast-northwest direction, about 0.16^{o} (less than 1^{o}). The drainage pattern is dendritic (Lekki Free Zone Development EIA, 2010).

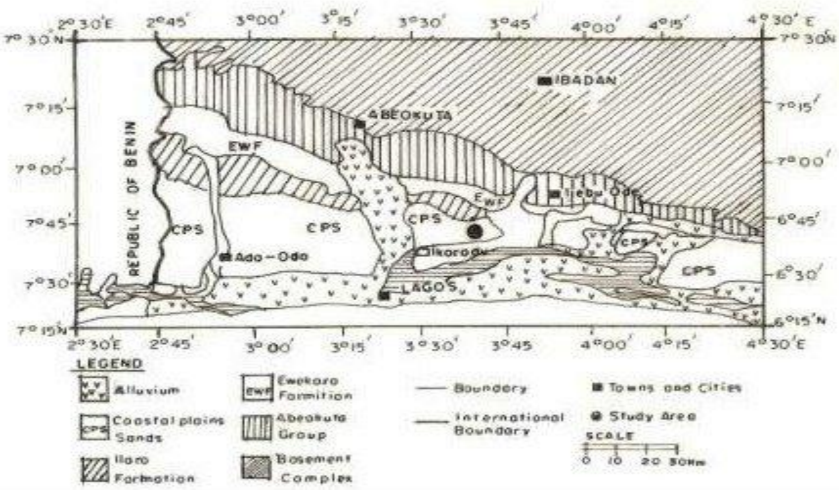


Figure 4.24: Geological map of Lagos area

Source: **Coode Blizard *et al.*, 1997**

4.4.7.4 Hydrology and Hydrogeology

Fresh water resources are an essential component of the earth's hydrosphere and an indispensable part of all terrestrial ecosystems. The fresh water environment is characterized by the hydrological cycle, including floods and droughts. Global climatic change and atmospheric pollution could also have an impact on fresh water resources and their availability. Water is a vital source of life especially for drinking, input for crop, forage, and fodder growth, input for artisan and industrial activities. Groundwater and surface water are fundamentally interconnected. It is often difficult to separate the two because they feed (complement) each other. The source of groundwater (recharge) is through precipitation or surface water that percolates downward. Hence, one can contaminate the other.

4.4.7.5 Borehole Records

One (1) borehole was drilled as test borehole in the area, while leveraging on the other three boreholes drilled in adjacent proposed Dangote Fertilizer site. The drilling followed the initial mapping and geophysical investigations. **Figure 4-25** shows the lithological records of the borehole, while **Figures 4-26a – c** showed that from the adjacent plot.

The lithologic record shows a topsoil configuration, followed by a sequence of clays/silty sands to sands. The dark colour nature of the topsoil and the underlying clays/sands is an indication of high organic matter content in the near surface geomaterials.

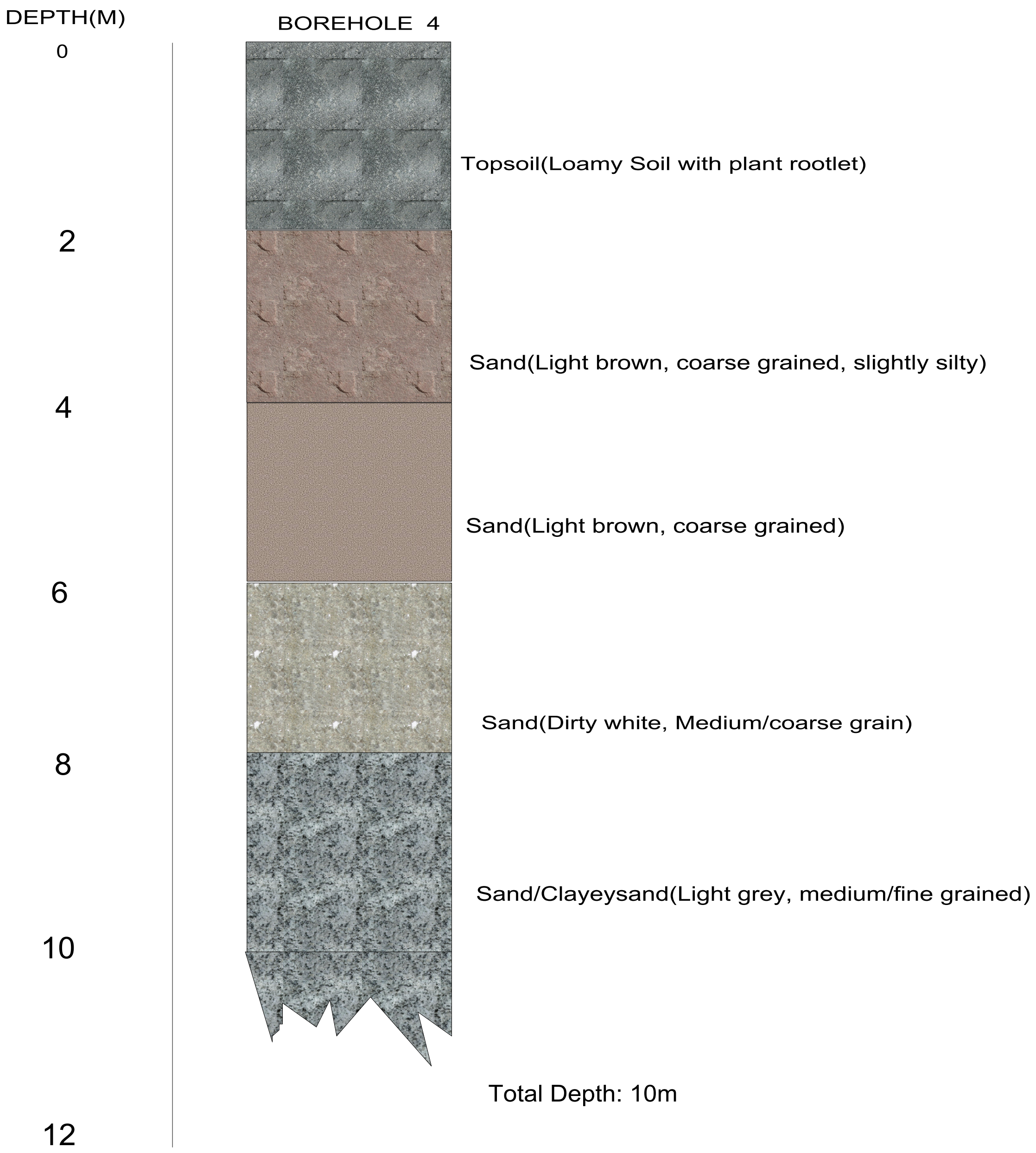


Fig 4-25: Lithologic profile for Borehole 4, Located in the Fertilizer Site of the Study area

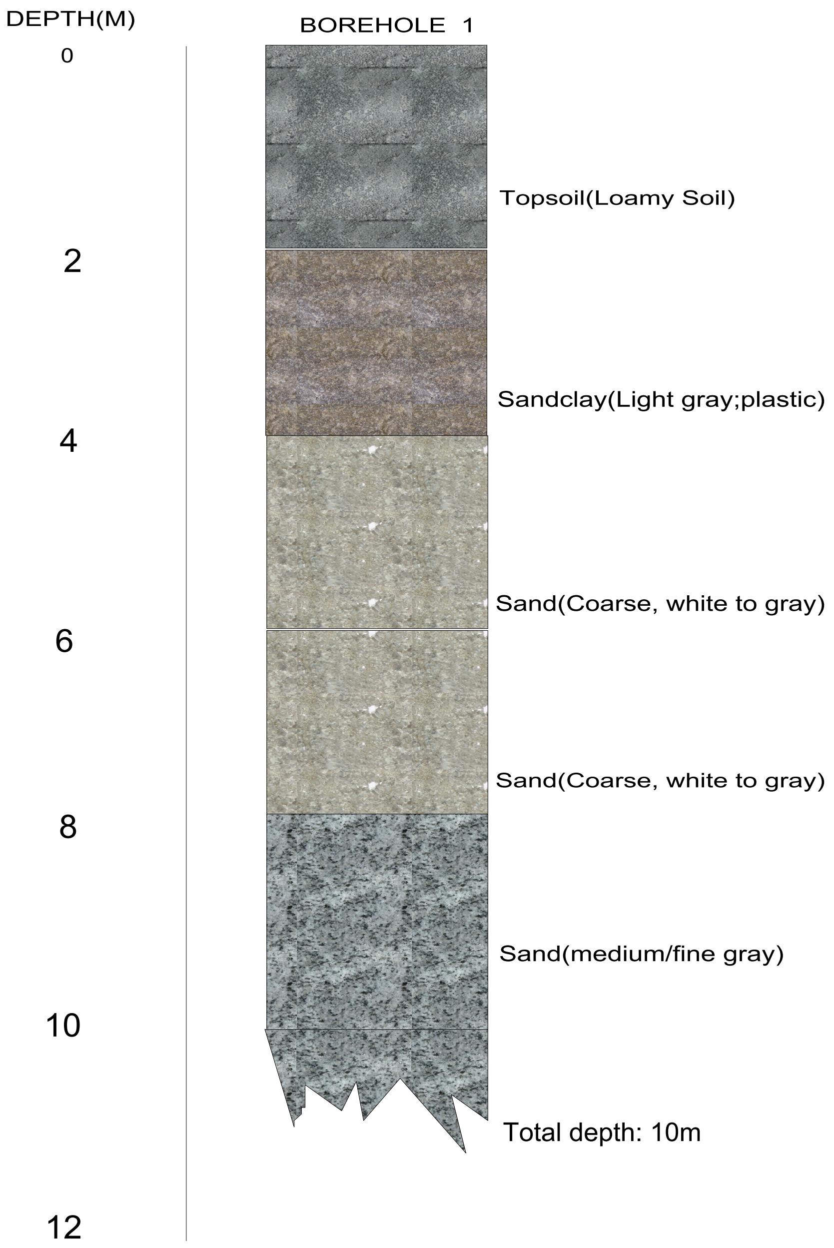


Fig. 4-26a: Lithologic profile for Borehole 1, Located in the Fertilizer Site of the Study area.

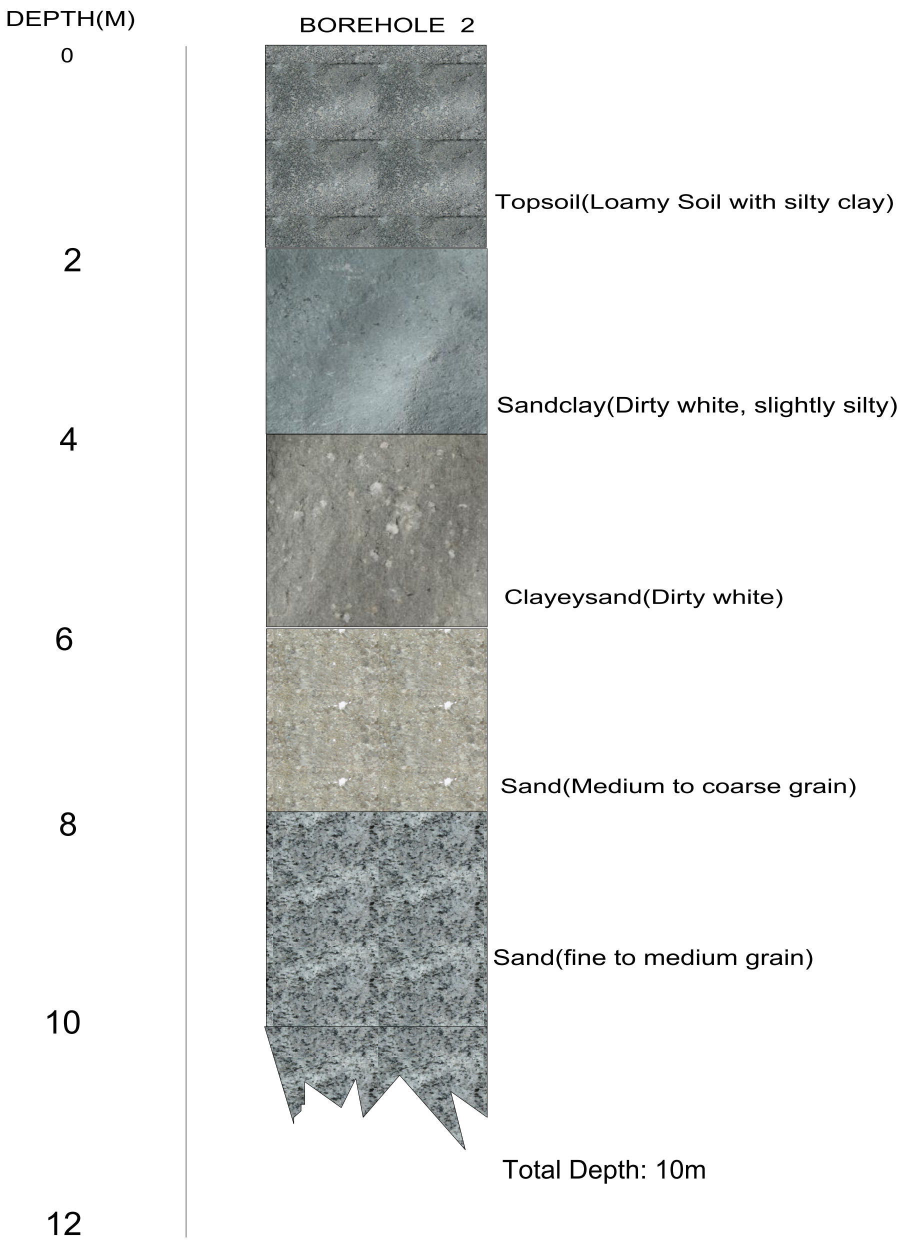


Fig. 4-26b: Lithologic profile for Borehole 2, Located in the Fertilizer Site of the Study area

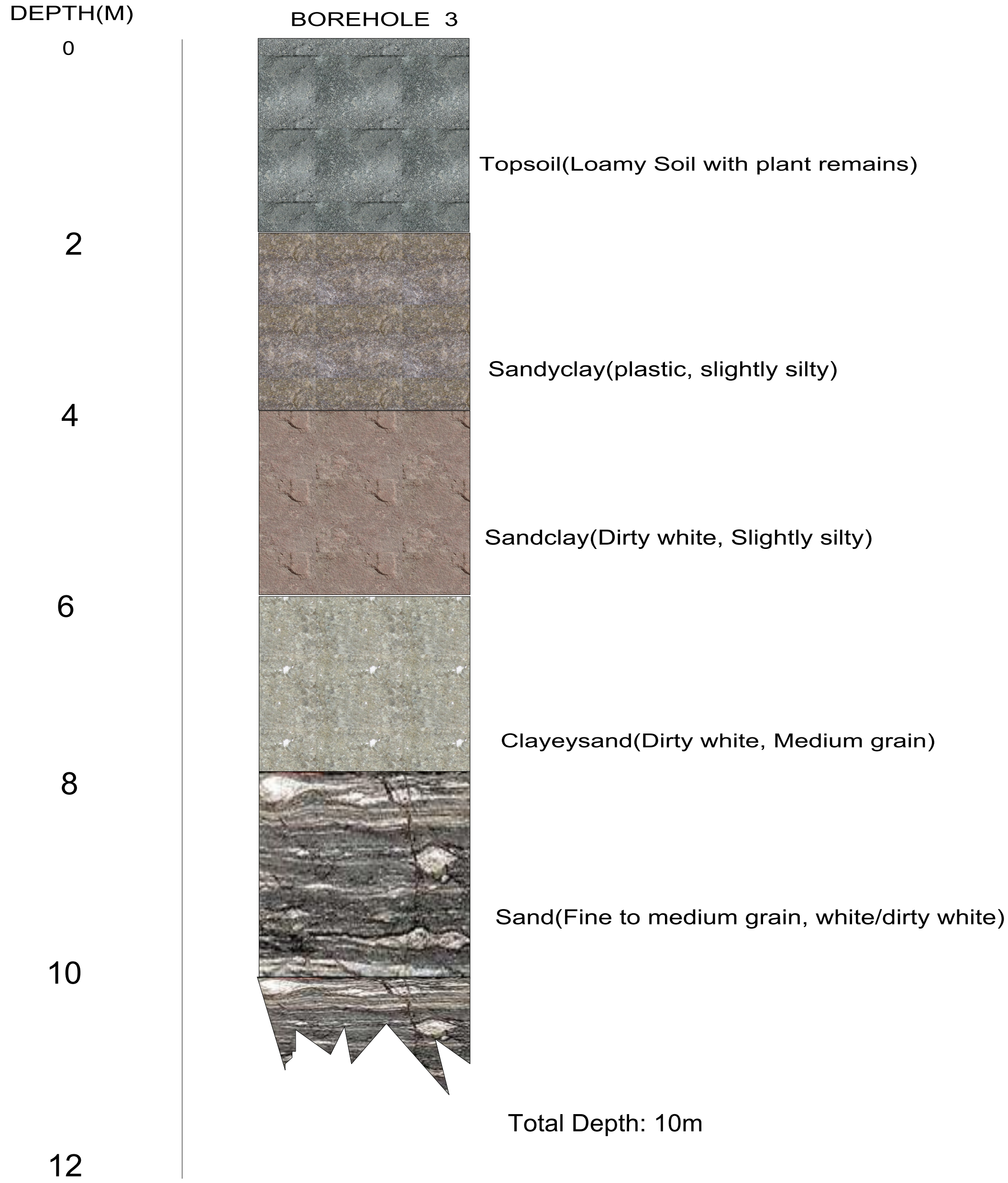


Fig. 4-26c: Lithologic profile for Borehole 3, Located in the Fertilizer Site of the Study area

4.4.7.6 Groundwater Flow Direction

The static water level in the referenced Dangote Fertilizer site boreholes, as well as the elevation above sea level at each well location were used to compute the general hydraulic head (HH) across the boreholes, based on Buddermeir and Schloss (2000). In the subsurface, water flows from the region of high hydraulic head to the region of low hydraulic head. Hydraulic head ranges from 7.63 m to 9.32 m across the area. **Figure 4-27** shows that groundwater generally flows southwards in the study area.

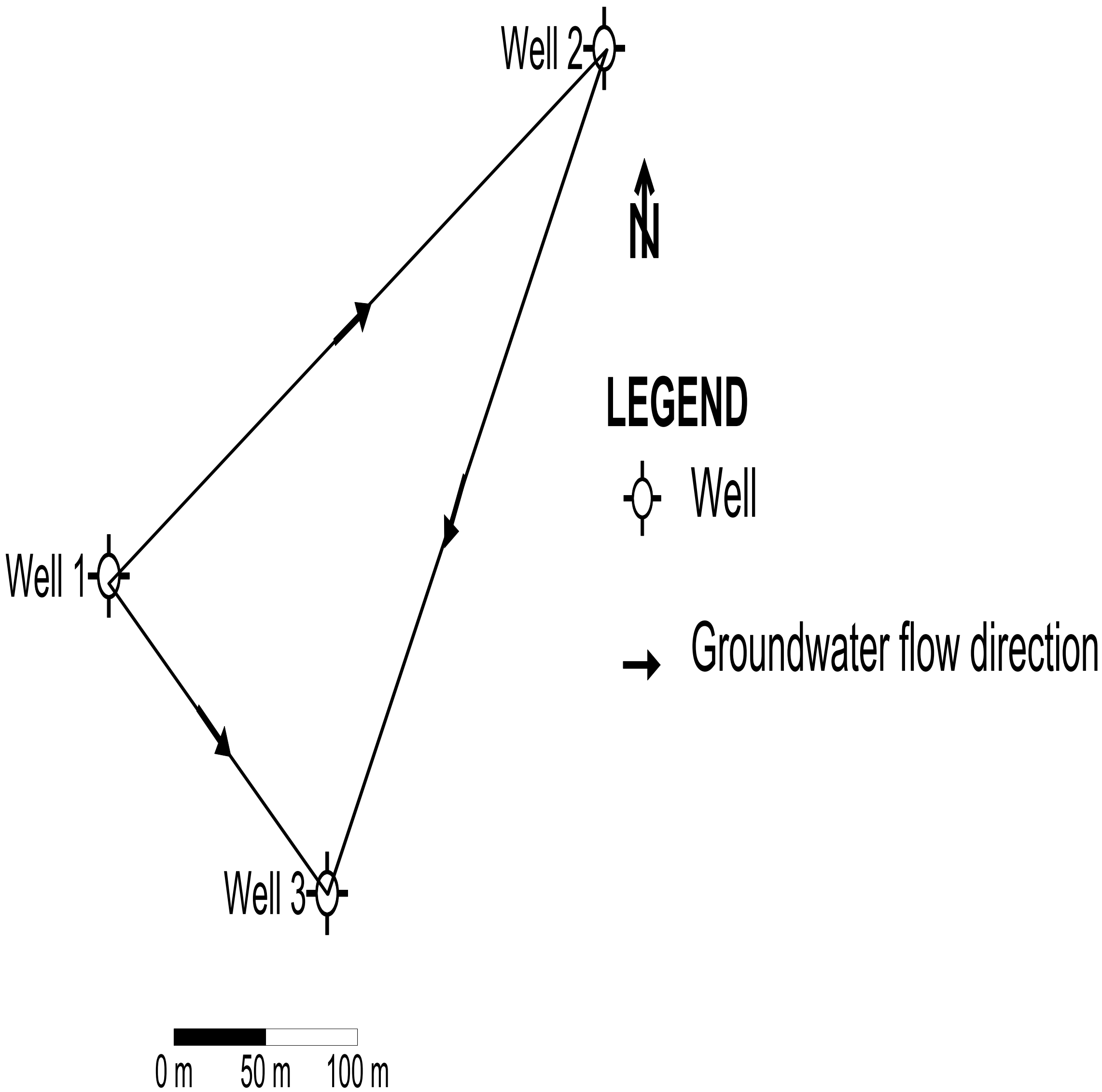


Fig 4.27: Map showing groundwater flow directions as determined from the test boreholes.

4.4.7.7 Groundwater Vulnerability (Hydrogeologic Evaluation)

The concept of aquifer vulnerability derives from the assumption that the physical geologic materials may provide some level of protection to groundwater, especially with regard to pollutants infiltrating from the surface. Consequently, the lithologic variations and the thickness of the unsaturated zone (vadose zone), constitute the focus in aquifer vulnerability assessment.

In the study area, the depth to static water level (water table), an approximation of vadose zone thickness, ranges from 0.37 m in borehole 3 to 0.80 m in borehole 2. Based on index rating for depth to groundwater (Aller et al., 1987), the vadose zone thickness falls within the high vulnerability rating, thus suggesting that the near surface aquifers in the area are vulnerable to contaminants deriving from surface activities.

4.4.7.8 Groundwater Recharge and Discharge

In environmental impact assessment, an understanding of recharges and discharges of an aquifer system is of great importance. It enables the determination of the rate and direction of migration of pollutants in the event of an incident of pollution.

Meteoric precipitation (rainfall), and its movement to the water table is a widespread form of natural recharge. Also, lateral/vertical groundwater movement, flow from streams, rivers and river tributaries are other potential sources of recharge in the survey area. Discharges to rivers accounts for most of the flow from aquifers. Groundwater abstraction from shallow boreholes and evapotranspiration are other major discharge sources in the study area.

4.4.7.9 Static Water Level

Static water levels, an equivalent of depths to water table, was measured in the only borehole here and correlated with other three boreholes in the Fertilizer section. The comparison shows that Static Water Levels ranged from 0.37m to 1.05m across the boreholes in the area. It must be noted however that the measurements were conducted at the peak of wet season (July).

4.4.8 Geophysical Investigation

Four (4) vertical electrical soundings (VES) were conducted, three within and one outside the premises of the study area. The VES data are contained in **Appendix 2-8**.

The VES data are presented as sounding curves. Preliminary quantitative interpretation of the VES curves was carried out using the partial curve matching method (Patra and Nath, 1998). The models derived from manual interpretation were interactively refined using a computer interaction algorithm.

4.4.8.1 Geophysical (Geoelectric) Characteristics

The VES curves are the KQQH and HKQH types, with the HKQH curves predominating.

4.4.8.2 Geoelectric Parameters and Geoelectric/Stratigraphic Sections

The interpretation results of the VES data are presented in **Table 4-13.**

Table 4.13: VES Interpretation Results.

VES NO	*THICKNESS (m)* $D_1/d_2/d_3/\ldots\ldots\ldots d_n$	*RESISTIVITY (Ωm)* $\rho_1\ \rho_2\ \rho_3\ldots\ldots\ldots\rho_n$
1	0.5/1.7/3.3/16.9/33.0	1853.5/509.6/1382.6/58.3/27.7/213.0
2	0.5/1.7/5.0/15.7/11.8	1938.6/671.4/2057.8/47.2/64.3/556.1
3	1.0/3.8/17.1/25.5/13.6	749.3/1098.0/89.6/15.3/26.4/61.9
4	1.0/5.3/5.7/17.4	230.5/1686.3/1084.9/86.3/25.8

Two geoelectric sections were drawn along two approximately orthogonal directions (W-E and N-S). The sections display a geologic sequence of five to six geoelectric layers (**Figure 4-28**). The geoelectric parameters are the following:

1st Layer: Topsoil

Resistivity range: 749 - 1939 ohm-m

Thickness: 0.5m - 1.0m

2nd Layer: Layer underlying the topsoil

Resistivity range: 510 - 1098 ohm-m

Thickness range: 1.7m - 3.8m

3rd Layer: 1st Aquifer layer

Resistivity range: 90 - 2058 ohm-m

Thickness range: 3.3m - 17.1m.

4th Layer: 2nd Aquifer Layer

Resistivity range: 15.3 - 58.3 ohm-m

Thickness range: 15.7 - 25.5m.

5th Layer: Lowermost layer

Resistivity range: 26 - 65 ohm-m

Thickness range(where delineated: 11.8 - 33.0m.

6th Layer: Lowermost Layer delineated

Resistivity range: 62 - 556 ohm-m.

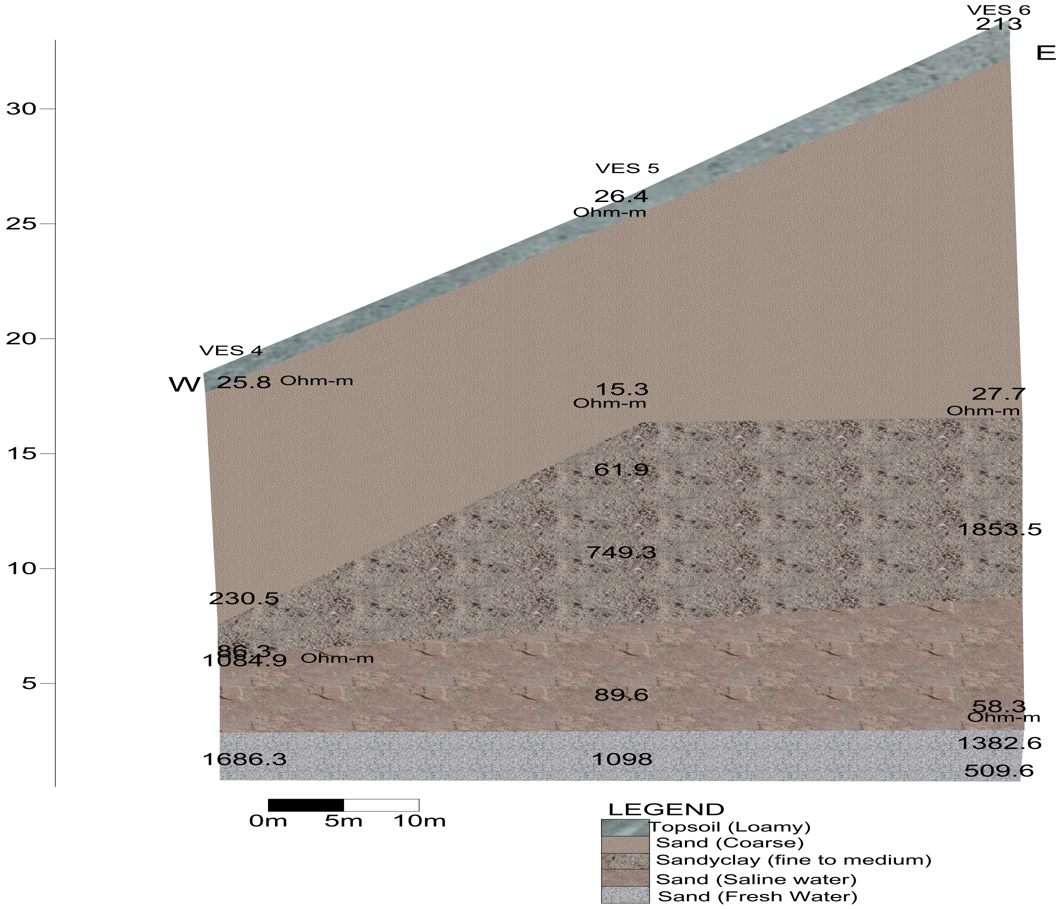


Fig. 4-28: Geoelectric section in the west-east direction the area.

4.4.8.3 Groundwater Prospect

The 3rd (in VES3) and 4th (in VES1 and 2) geoelectric layers constitute the first aquifer horizons across the study area. The depth of occurrence of the first aquifer units ranges from 15.7m to 16.9m, with resistivity parameters ranging from 47 to 90 ohm-m. The low resistivity parameters suggest saline pollution effect on the near surface group of aquifer systems, which may render groundwater saline or brackish in the area.

Groundwater Vulnerability (Geophysical Evaluation)

The protective capacity of the materials overlying the aquifer(s) is assumed to be proportional to its thickness and inversely proportional to its hydraulic conductivity (Henriet, 1976). However, high clay contents generally correspond with low resistivities and low hydraulic conductivities. Hence, the protective capacity of the materials overlying the aquifer(s) can be considered as being proportional to the longitudinal unit conductance (S), defined as the ratio of the thickness of material overlying the aquifer to the resistivity. In essence, the higher the longitudinal conductance value, the higher is the protective capacity, while low values suggest that the underlying aquifer is vulnerable.

The longitudinal conductance values of the materials overlying the aquifer units in the area are shown in **Table 4-14**.

Table 4-14: Table showing Longitudinal conductance values and aquifer protective capacity at the VES locations.

VES No	Longitudinal Conductance (mhos)	Protective Capacity
1	0.005993	Poor
2	0.005220	Poor
3	0.006807	Poor
4	0.012740	Weak

Table 4-14 shows that the aquifer systems in the area are poorly/weakly protected, based on the rating of Henriet (1976). Consequently, the aquifer units in the area are vulnerable to polluting or contaminating fluids infiltrating from the surface.

4.4.9 Groundwater Quality

4.4.9.1 Physico-chemical Characteristics

The physico-chemical characteristics of groundwater within the Dangote Fertilizer proposed project area compared with the reference boreholes from the adjacent proposed Refinery site and control borehole are presented in **Table 4-15**,

These data represent the prevailing water quality characteristics of groundwater system within the project site, and a baseline data with which future environmental performance could be evaluated. The temperature of the groundwater samples taking at the site were within the range reported for the Dangote Refinery site and for similar terrain (OKFTZ EIA, 2012). The conductivity and total dissolved solid (TDS) values were very high compared to what was obtained at the Refinery site and the control station. This indicates high dissolved ions and a characteristic of saline aquifer. Similar results were reported for the OKFTZ (OKFTZ EIA, 2012) and attributable to close proximity to the sea in both cases. Classification of potability based on electrical conductivity ascribes <325 μScm^{-1} for fresh and potable water (McKelvie, 2004), while an aesthetic objective of 500 mg/L has been established for total dissolved solids (TDS) in drinking water (FEPA, 1991; USEPA, 2002; Health Canada, 2003; WHO, 2008) (**Table 4.16**). At higher TDS levels, excessive hardness, unpalatability, mineral deposition and corrosion may occur. The turbidity value (2.50 NTU) was lower than drinking water standard of 5 NTU and within what were reported for the Fertilizer site

Table 4-15: Physico-chemical characteristics of groundwater within project area

Parameter	Fertilizer Site	Refinery Site			Control
	DFBH	DRBH 1	DRBH 2	DRBH3	DBHC
Temp. °C	28.10	26.50	27.50	26.80	26.90
E. C. (µS/cm)	1,620	170.0	210.0	203.0	211.0
TDS (mg/L)	810.0	85.00	105.0	101.5	105..5
Turbidity (NTU)	2.50	2.00	4.50	3.50	4.00
pH	11.14	6.04	6.48	6.30	6.34
CO_3^{2-} (mg/L)	139.60	ND	ND	ND	ND
TA (mg $CaCO_3$/L)	620.0	80.00	86.70	84.20	84.50
T H ($CaCO_3$/L)	511.2	60.50	62.00	61.50	61.75
Ca^{2+} (mg/L)	55.52	10.20	10.00	10.40	10.30
Mg^{2+} (mg/L)	89.38	8.88	9.00	8.64	8.82
Cl^- (mg/L)	243.5	30.8	32.5	28.3	27.5
SO_4^{2-} (mg/L)	157.20	28.3	24.1	148.9	131.7
NO_3^- (mg/L)	28.30	26.65	24.95	22.47	24.06
PO_4^{3-} (mg/L)	BDL	BDL	BDL	BDL	BDL
S^{2-} (mg/L)	BDL	BDL	BDL	BDL	BDL
DO (mg/L)	2.30	2.80	2.86	2.65	2.70
BOD_5 (mg/L)	0.25	0.37	0.67	0.48	0.35
COD (mg/L)	5.60	5.60	9.10	5.75	3.28
Oil & Grease (mg/L)	2.24	2.64	2.06	2.48	BDL
TPH (mg/L)	1.95	2.16	1.30	1.94	BDL
Benzene (µg/L)	BDL	BDL	BDL	BDL	BDL
Toluene (µg/L)	BDL	BDL	BDL	BDL	BDL
Ethylbenzene (µg/L)	BDL	BDL	BDL	BDL	BDL
Xylene (µg/L)	BDL	BDL	BDL	BDL	BDL
Heavy Metals (mg/L)					
Cd	<0.001	<0.001	<0.001	<0.001	<0.001
Cr	0.220	0.190	0.176	0.180	0.120
Cu	0.030	0.02	0.03	0.01	0.01
Fe	0.630	0.540	0.530	0.510	0.430

Parameter	Fertilizer Site	Refinery Site			Control
	DFBH	DRBH 1	DRBH 2	DRBH3	DBHC
Hg	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	0.500	0.550	0.470	0.380	0.350
Ni	0.320	0.390	0.270	0.220	0.200
Pb	0.030	0.040	0.048	0.039	0.015
V	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	0.250	0.230	0.260	0.268	0.248

TA = Total Alkalinity;; TH = Total Hardness; DFBH = Dangote Fertilizer Borehole;

DRBH = Dangote Refinery Borehole; DBHC = Control Borehole

The pH (11.14) showed high alkalinity value far higher than the Guideline values of 6.5 – 8.50 for drinking water (FEPA, 1991; WHO, 2008). The pH value also reflects the intrusion of seawater to the water table due to close proximity to sea. The alkalinity showed the presence of carbonate and bicarbonate alkalinity, with carbonate ions and total alkalinity of 139.60 mg/L and 620 mg/L$CaCO_3$ respectively.

Total hardness value of the groundwater sample was 511.2 mg/L$CaCO_3$ far higher than what were obtained at the Refinery site and control station. Hardness in water comprises the determination of calcium and magnesium as the main constituents. Although barium, strontium and iron can also contribute to hardness, their concentrations are normally so low in this context that they can be ignored. The widespread abundance of these metals in soil formations leads often to very considerable hardness levels in groundwaters. Using one of the several arbitrary classifications of waters by hardness showed that the borehole water was excessively hard (over 350 mg/L$CaCO_3$) (EPA, 2001). Water supplies with a hardness greater than 200 mg/L$CaCO_3$ are considered poor but have been tolerated by consumers; those in excess of 500 mg/L$CaCO_3$ are unacceptable for most domestic purposes (WHO, 2008). It has been suggested that a hardness level of 80 to 100 mg/L (as $CaCO_3$) provides an acceptable balance between corrosion and incrustation.(Hudson, 1976; WHO, 2008).

Table 4-16: Drinking water quality standards

Parameter	FEPA[a]	WHO[b]	EU[c]	USEPA[d]
Ph	6.50 – 8.50	6.50 – 8.50	6.50 – 9.50	6.50 – 8.50
E. C. (µS/cm)	1000	-	2500	1000
TSS (mg/L)	<10.0	-	-	-
TDS (mg/L)	500	-	500	500
Turbi. (NTU)	5.0	5.0	-	-
Alkal. (mg $CaCO_3$/l)	-	30 – 500	-	-
T. Hard. (mg $CaCO_3$/l)	200	80 – 100		
Cl^- (mg/L)	250	250	250	250
SO_4^{2-} (mg/L)	500	250	250	250
NO_3^- (mg/L)	50 (10 as N)	50.0	50.0	50.00
PO_4^{3-} (mg/L)	<5.0	-	-	-
S^{2-} (mg/L)	0.05	-	-	-
THB (cfu/ml)	-	-	100 at 22°C	-
Coliform (MPN/100ml)	-	Nil	Nil	-
E. coli (MPN/100ml)	-	Nil	Nil	-
Heavy Metals				
Cd	0.01	0.003	0.005	0.005
Cr	0.05	0.05	0.05	0.1
Cu	0.1	2.0	-	1.0
Fe	1.0	0.3	0.2	0.3
Hg	0.001	0.001	0.001	0.002
Mn	0.05	0.05	0.05	0.05
Ni	0.05	0.02	0.02	
Pb	0.05	0.01	0.01	0.015
V	0.01	-	-	-
Zn	5.0	3.00	-	5

[a] FEPA,1991; [b] WHO, 2002; [c] EU, 1998; [d]USEPA, 2002

Calcium and magnesium ions measured in the groundwater were 55.52 mg/L and 89.38 mg/L respectively, far higher than the Refinery site and the control. There is no evidence of adverse health effects specifically attributable to calcium and magnesium in drinking water. Hence, guideline values for calcium and magnesium have therefore not been specified (WHO, 2008). Undesirable effects due to the presence of calcium in drinking water may result from its contribution to hardness.

Salinity as chloride (Cl^-) (243.5 mg/L) recorded in the groundwater sample was high confirming its saline condition of the water table, compared with what were recorded at the Refinery site. Sulphate (SO_4^{2-}) and nitrate (NO_3^-) levels recorded in the borehole water were 157.20 mg/L and 28.30 mg/L respectively. These values were, however, lower than WHO limits for drinking water (**Table 4-16**). Phosphate (PO_4^{3-}) and sulphide (S^{2-}) ions were below instrument detection limit (<0.01 mg/L).

The groundwater samples recorded low biodegradable and oxidisable matters content as reflected in the BOD and COD values. The oil and grease (O&G) values measured was 2.24 mg/L, while the total petroleum hydrocarbon value was 1.95 mg/L, though within the range recodred for trhe Refinery site, but higher than DPR Target and Intervention values for mineral oil in groundwater (**Table 4-17**). The source could be attributed to biogenic rather than anthropogenic contribution, since petroleum hydrocarbon related activities was not in existence in the area as at the period of the EIA study. BTEX content of the groundwater were below instrument detection limit, while measurable levels of polycyclic aromatic hydrocarbon were recorded in the groundwater sample (**Table 4-18**).

Table 4-17: Target and Intervention values of some pollutants in groundwater

Parameter	*Target value (µg/l)*	*Intervention value (µg/l)*
Cd	0.40	6.0
Cr	1.0	30.0
Cu	15	75
Hg	0.05	0.30
Pb	15	75
Ni	15	75
Zn	65	800
Mineral oil	50	600

Source: DPR, 2002

Table 4-18: PAHs levels (µg/L) in groundwater within Dangote Fertilizer project area

Parameter	*DRBH1*	*DRBH2*	*DRBH3*	*DRBHC*
Naphthalene	0.462	0.416	0.395	<0.001
Acenaphthylene	1.160	0.439	1.050	<0.001
Acenaphthene	0.194	0.155	0.164	<0.001
Fluorene	0.181	0.204	0.192	<0.001
Phenanthrene	0.321	0.310	0.340	<0.001
Anthracene	0.455	0.269	0.372	<0.001
Fluoranthene	0.074	0.082	BDL	<0.001
Pyrene	0.380	0.299	0.343	<0.001
Benzo(a) anthracene	0.447	0.362	0.405	<0.001
Chrysene	0.087	0.073	<0.001	<0.001
Benzo(b) fluoranthene	<0.001	<0.001	0.060	<0.001
Benzo(k) fluoranthene	1.240	0.930	1.310	<0.001
Benzo(a) pyrene	1.340	1.130	0.864	<0.001
Indeno (1,2,3-cd) pyrene	<0.001	<0.001	<0.001	<0.001
Dibenzo (a,h) anthracene	0.211	0.242	0.246	<0.001
Benzo (g,h,i) perylene	<0.001	<0.001	<0.001	<0.001
Total	**0.211**	**0.242**	**0.246**	**<0.001**

Source: Dangote Fertilizer EIA Field Work July, 2014

Heavy metals determined in the groundwater samples showed varied concentrations with Cd, Hg and V having values below instrument detection limits (<0.001 mg/L). The concentration range of other metals are in the order of Fe> Mn> Ni > Zn> Cr > Pbr = Cu. Copper and zinc recorded concentrations lower than their maximum allowable limits in drinking water, while Cr, Fe, Mn, Ni and Pb were present at higher concentrations than their WHO guideline levels in water (**Table 4-16**). Except Cd and Hg showing undetectable concentrations in the groundwater, other metals analysed showed concentrations higher than their target and intervention values in groundwater (**Table 4-17**) (DPR, 2002). Values in the order recorded for the fertilizer site were recorded also for the Refinery influence zone. The occurrence and concentrations of the metals in the samples reflect the general characteristic of groundwater systems in most parts of Nigeria, especially the Niger Delta region (Ezeigbo, 1989; Aiyesanmi et al., 2004; Aiyesanmi and Tomori, 2005), which are mostly influenced by the soil mineralogy.

4.4.9.2 Groundwater Microbiological Characteristics

The summary of microbial characteristics of groundwater samples from the proposed fertilizer project area is presented in **Table 4-19**. The total heterotrophic bacteria and hydrocarbon degraders (HUB) determined were 0.68 x 10^5 cfu/ml and 1.41 x 10^3 cfu/ml respectively, while lower values were recorded at the Refinery site and the control station. The hydrocarbon degraders (HUB) constituted 2.07% (**Figure 4-29**). Coliform and fungi were not recorded in the sample, showing no growth. Most prevalent among the bacteria isolates are Bacillus sp. and *Micrococcus luteus.*

Table 4-19: Microbial characteristics of groundwater in the project area

Parameter	*DFBH*	*DRBH1*	*DRBH2*	*DRBH3*	*DBHC*
THB (cfu/ml) x 10^5	0.68	0.75	0.36	0.49	0.12
HUB (cfu/ml) x 10^3	1.41	0.44	0.52	0.25	NG
Coliform (MPN/100ml)	NG	NG	NG	NG	NG
E. Coli (MPN/100ml)	NG	NG	NG	NG	NG
THF (spore/ml)	NG	NG	NG	NG	NG
HUF (spore/ml)	NG	NG	NG	NG	NG

NG = No growth

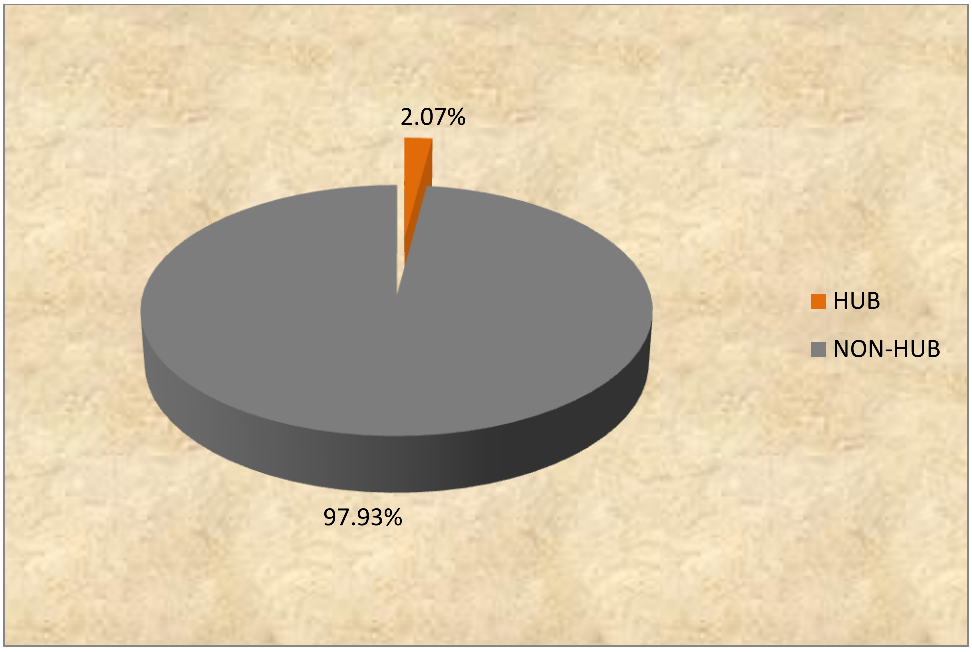


Fig. 4.29: Percentage hydrocarbon utilising bacteria in groundwater

4.4.10 Surface Water Study

4.4.10.1 *Surface Water Hydrology*

Surface water hydrology is required for an understanding of the movement of potential pollutant inputs and their relationship with the water body. The Lekki lagoon which constitutes the main inland river within the influence zone of the Fertilizer project has hydrological features summarized in **Table 4-20**.

The river is perennial and navigable all the year round. It was observed that the flood levels vary between the dry season and the rainy season. Discharge into the river may have significant effect as pollutants input in the river will speedily arrive at the downstream target area.

Table 4-20: Hydrological parameters of Lekki Lagoon

Hydrological Parameter	Mean Values
Flow rate	0.58 m/s
Bathymetry	2.14 – 2.62 m
Flooding regime for the area	Seasonal
Seasonality	Perennial

4.4.10.2 Water Use

The river is used for various purposes by the community including, fishing and recreation. There is no evidence of use for industrial purpose although it serves for the transportation of goods and loggs from Ogun and Ondo States to Lagos. Fishing is conducted in the open waters and the associated swamps.

4.4.10.3 Water Quality

The quality characteristics of the surface water body (Lekki Lagoon) within the influence zone of the proposed project area are discussed in this section.

Physico-chemical Characteristics

The summary of the physico-chemical characteristics of the surface water are presented in **Table 4-21**, while **Appendix 2-10** presents the detailed field and laboratory data.

The surface water temperature ranged from 28.80 - 29.20 ^{0}C with very low spatial variation (CV = 0.96%), which is attributable to the different period of sample collection and measurement. Temperature affects physical, chemical, and biological processes in water bodies, and consequently, the concentration of many variables. Increased temperature also decreases the solubility of gases, the reaction rate of chemicals and the toxicity of ammonia to fish. The metabolic rate of aquatic organisms are also related to temperature and in warm waters respiration rates increase leading to increased oxygen consumption and increased decomposition of organic matter (EPA, 2001).

The colour of the surface water was amber with the high colour units ranging from 23.00 - 28.00 Pt/Co units and could be attributed to run-off into water bodies with high-entrained suspended particles and coloured substances, predominantly of organic origin and, decomposed vegetation in the water body (Black and Christman, 1963). Colour values obtained from the control stations were also within the range recorded within the project influenced zone.

Table 4-21: Physico-chemical characteristics of surface water within Dangote Fertilizer project area

Parameter	Project Influence Zone				Control Stations	
	Range	Mean	Std. Dev.	C. Var.(%)	Ctrl 1	Ctrl 2
Temp. (^oC)	28.80 - 29.20	29.12	0.28	0.96	29.70	28.90
Colour (Pt/Co unit)	23.00 - 28.00	25.00	1.79	7.16	24.00	28.00
E. C.(µS/cm)	100 – 110	105.00	5.48	5.22	130	110
TDS (mg/L)	50.00 - 55.0	60.33	31.31	51.90	65.00	55.00
TSS (mg/L)	116 – 140	126.50	9.95	7.87	128	126
Turbidity (NTU)	6.40 - 7.60	6.85	0.46	6.77	6.40	6.80
pH	5.86 - 6.22	6.09	0.13	2.07	6.43	6.12
CO_3^{2-} (mg/L)	ND	ND			ND	ND
Alkal. (mg $CaCO_3$/L)	41.20 - 45.60	43.34	1.47	3.40	52.3	43.15
Hardness(mg $CaCO_3$/L)	84.6 - 88.3	86.27	1.51	1.76	88.75	85.30
Ca^{2+} (mg/L)	3.20 - 4.09	3.62	0.38	10.45	3.2	16.43
Mg^{2+} (mg/L)	15.60 - 18.32	17.56	1.14	6.50	4.1	17.09
DO (mg/L)	5.67 - 6.41	6.15	0.27	4.34	6.41	5.99
BOD_5 (mg/L)	1.20 - 2.25	1.85	0.36	19.49	1.38	2.3
COD (mg/L)	12.60 - 16.20	14.53	1.59	10.95	15.6	14.5
Cl^- (mg/L)	61.70 - 102.8	77.40	15.33	19.81	68.5	78.3
SO_4^{2-} (mg/L)	24.70 - 32.80	29.32	2.73	9.32	28.3	28.6
NO_3^- (mg/L)	14.00 - 29.00	20.91	6.61	31.63	20.2	14.7
NH_3 (mg/L)	ND	ND			ND	ND
PO_4^{3-} (mg/L)	1.09 - 1.90	1.38	0.30	21.79	1.4	1.6
S^{2-} (mg/L)	ND	ND			ND	ND
Oil & Grease (mg/L)	3.44 - 4.44	4.03	0.37	9.31	3.84	4.33
TPH (mg/L)	3.04 - 4.19	3.64	0.44	11.96	3.32	4.19
Benzene (µg/L)	<0.01	<0.01			<0.01	<0.01
Toluene (µg/L)	<0.01	<0.01			<0.01	<0.01
Ethylbenzene (µg/L)	<0.01	<0.01			<0.01	<0.01
Xylene (µg/L)	<0.01	<0.01			<0.01	<0.01

ND = Not detected

Source: Dangote Fertilizer EIA Field Work July, 2014

Because of its origins mostly in vegetable matter the degree of colour in water may vary widely in space and in time. There is no health hazard associated with colour, rather, limit for colour in potable water has been based on aesthetic considerations, and this has been set at 15.00 Pt/Co units (EPA, 2001; U.S.EPA, 2002; WHO, 2008). This limit is, however, lower than the values recorded for the surface water body.

The electrical conductivity values of the surface water were low ranging from 100 – 110 µS/cm, with low spatial variation (CV = 5.22%). Classification of potability based on electrical conductivity ascribes <325 μScm^{-1} for fresh and potable water (McKelvie, 2004), hence the surface water body is considered fresh. Conductivity is a measure of dissolved ions in water and it is directly related to dissolved solids in water. The total dissolved solids (TDS) ranged between 50.00 mg/L and 55.00 mg/L less than 500 mg/L guideline value in potable water (FEPA, 1991; USEPA, 2002; Health Canada, 2003; WHO, 2008) (**Table 4-16**). Higher TDS levels may cause excessive hardness, unpalatability, mineral deposition and corrosion.

Total suspended solid (TSS) in the surface water ranged from 116.0 mg/L to 140 mg/L The observed high value recorded could be as result of influx of runoff into the water body during the period of study (raining season). During this, period rivers receive large volume of storm water with many suspended materials, which in turn leads to high level of suspended matter in the water body. Closely related to suspended solid is water turbidity, which defines its clarity. Turbidity values measured in the surface water samples (6.40 – 7.60 NTU) higher than 5.0 NTU WHO (2008) limit for potable water. Suspended matter can contain toxins such as heavy metals and biocides and can also harbour microorganisms. In addition, high turbidity could interference with sunlight penetration, thus reducing photosynthesis and interfering with primary food production (green algae), and oxygen for fish and aquatic life (DWAF, 1996).

The pH of the surface water body was within the acidic range with values between 5.86 and 6.22. Most natural fresh waters have pH ranging between 6.5 and 7.5, whereas in marine and brackish waters the presence of borates may extend this range to about 8.3 (DWAF, 1996). The lower pH values recorded in the water body might be due to partial decomposition of organic matter by bacteria and fungi in the water body, thus producing various organic acids that are capable of lowering the pH of aqueous solution (Bowen, 1979). Rainwater of lower pH due to dissolved gases (CO_2, SO_2 and NO_2) may also contribute to low pH values of surface water in the wet season. Lower wet season pH values for surface water have been reported by many investigators (Petters and Odeyemi, 1985; Aiyesanmi *et al*., 2006; Oyakhilome *et al*., 2012). pH is one of the most important operational water quality parameters. Acceptable range for domestic water use is from 6.5 to 8.5 (EPA, 2001; U.S.EPA, 2002). Corrosion effects may become significant below pH 6.5, and the frequency of incrustation and scaling problems may be increased above pH 8.5 (Oyakhilome et al., 2012). The effect of pH on fish is also an important consideration and the range suitable for fisheries is considered to be 5.0 - 9.0 (DWAF, 1998; EPA, 2001), within which the observed water pH fall. Related to pH is the alkalinity, with total alkalinity values ranging from 41.20 – 45.60 mg/L$CaCO_3$. Carbonate alkalinity was however, not detected in the water.

Total hardness of the surface water samples ranged from 84.6 - 88.3 mg/L$CaCO_3$ with a mean value of 86.27 mg/L$CaCO_3$. Values obtained from the control stations were also within the range. Classification of the water quality of the lagoon by hardness showed a moderately soft water body (EPA, 2001). More than 15 mg/L$CaCO_3$ hardness is suitable for fish growth, while less than this value causes slow growth of fish and less than 5 mg$CaCO_3$/L hardness causes death of fish (Ali et al. 2000; Iqbal et al., 2004). Calcium and magnesium ions measured in the surface water ranged from 3.20 - 4.09 mg/L and 15.60 - 18.32 mg/L respectively.

Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD) levels in the surface water ranged from 5.67 - 6.41 mg/L, 1.20 - 2.25 mg/L and 12.60 - 16.20 mg/L respectively. Dissolved oxygen level in water is determined by factors including water temperature, photosynthesis by green algae, salinity and pollution resulting from both natural and anthropogenic activities (Aiyesanmi *et al*, 2006; Oyakhilome *et al.*, 2012). Dissolved oxygen is an important environmental parameter for the survival of aquatic life. Studies have shown that 4 - 5 mg/L of DO below what was recorded in the study area, is the minimum amount that will support a large, diverse fish population (DWAF, 1996). Low BOD_5 load of the lagoon water samples implies an unpolluted environment. Unpolluted, natural waters are expected to have BOD of less than 5 mg/L (Oyakhilome *et al*., 2012). Dissolved oxygen, BOD_5 and COD are important indicators of the overall water quality (EPA, 2001). Hence, the values recorded in the water body along with pH and suspended solid revealed that the surface water body is within the Acceptable Quality according to Pratt's classification of surface water quality (**Table 4-22**) (Aiyesanmi *et al*., 2006).

Table 4-22: Some parameters used in the classification of surface water quality

Parameter	Class I	Class II	Class III	Class IV	Class V
Ph	6.5 – 8.0	6.0 – 8.4	5.0 – 9.0	3.9 – 10.1	<3.9 – >10.1
Dissolved oxygen(mg/L)	7.8	6.2	4.6	1.8	>1.8
BOD (mg/L)	1.5	3.0	6.0	12.0	>12.0
COD (mg/L)	10	20	40	80	>80
Suspended solid (mg/L)	20	40	100	278	>278

Class I = Excellent quality *Class II = Acceptable quality* *Class III = Slightly polluted*

Class IV = Polluted *Class V = Heavily polluted*

Source: *Osibanjo, 1996; Aiyesanmi et al., 2006*

Low salinity (measured as chloride), nitrate, sulphate and phosphate were measured in the lagoon water sample. The respective, chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-) and phosphate (PO_4^{3-}) concentrations in the water bodies were 61.70 – 102.80 mg/L, 13.50 - 29.00 mg/L and 1.09 - 1.90 mg/L, while sulphide (S^{2-}) ion was not detected in the water body. These values were consistent with what were earlier reported for the zone (LFTZ EIA, 2010). The concentrations of this anions recorded were lowere than their guideline values in drinking water (FEPA, 1991; USEPA, 2002; WHO, 2008).

Oil and grease values recorded in the water body ranged from 2.77 - 4.36 mg/L Oil and grease are made up of hydrocarbon oil of both petrogenic and biogenic origin; fats, oils and waxes of both plant and animal origin, all of which must have contributed to the measured oil and grease in this study. Anthropogenic sources may include leakages from outboard engines and spill from transportation of petroleum products through the water course from Lagos to other neighbouring states. However, total hydrocarbons (THC) contents measured in the water bodies were very low, ranging from 2.04 - 3.97 mg/L. Correspondingly, low values of polycyclic aromatic hydrocarbons (PAHs) were recorded in the water bodies (**Table 4-23**). Benzo(a) pyrene, naphhthalenee and Benzo(k) fluoranthene showed the highest concentrations of 0.065 µg/L, 0.035 µg/L and 0.030 µg/L respectively, while other measured PAHs showed concentrations less than 0.030 µg/L. Their source could be attributed to those specified for hydrocarbons above.

Table 4-23: Summary of PAHs concentration (µg/l)) in surface water within fertilizer project area

Parameter	**Project Influence Zone**				**Control Stations**	
	Range	Mean	Std. Dev.	C. Var.(%)	Ctrl 1	Ctrl 2
Naphthalene	0.02 - 0.059	0.035	0.011	31.78	0.036	0.04
Acenaphthylene	0.01 - 0.057	0.029	0.018	63.91	0.047	0.036
Acenaphthene	0.007 - 0.031	0.013	0.006	46.01	0.031	0.014
Fluorene	0.002 - 0.023	0.012	0.008	66.83	0.004	0.023
Phenanthrene	0.001 - 0.020	0.012	0.005	40.07	0.02	0.01
Anthracene	0.01 - 0.017	0.013	0.002	19.15	0.01	0.011
Fluoranthene	0.006 - 0.031	0.015	0.006	39.36	0.016	0.006
Pyrene	0.005 - 0.071	0.019	0.018	95.64	0.005	0.006
Benzo(a) anthracene	0.001 - 0.075	0.023	0.023	97.80	0.008	0.004
Chrysene	BDL - 0.008	0.004	0.003	63.96	0.006	0.007
Benzo(b) fluoranthene	0.002 - 0.016	0.008	0.005	59.79	0.013	0.011
Benzo(k) fluoranthene	0.002 - 0.165	0.030	0.048	162.31	0.003	0.003
Benzo(a) pyrene	0.010 - 0.198	0.065	0.059	91.44	0.029	0.02
Indeno (1,2,3-cd) pyrene	0 - 0.002	0.001	0.001	73.85	0.002	0.001
Dibenzo (a,h) anthracene	0.001 - 0.003	0.002	0.001	41.29	0.003	0.002
Benzo (g,h,i) perylene	BDL	BDL			<0.001	<0.001
Total	**0.135 - 0.701**	**0.279**	**0.152**	**54.69**	0.466	0.338

BDL = Below instrument detection limit

Heavy metal analysis in the surface water samples revealed low concentrations (**Table 4-24**) below the acceptable limits in drinking water (FEPA, 1991; EU, 1998; USEPA, 2002; WHO, 2008). The order of concentrations in the water samples was Zn > Fe > Cr > Ni > Cu > Mn > Pb, while Cadmium (Cd) and mercury (Hg) were below instrument detection limit. The low levels of heavy metals in the water column could be attributed to possible flocculation and subsequent sedimentation of the metals or generally low presence in the water body, an indication of unpolluted state of the water body with heavy metals.

4.4.10.4 Surface Water Microbiology

The summary of microbial characteristics of the surface water bodies within the Fertilizer project influence zone is presented in **Table 4-25.** The heterotrophic bacterial counts ranged from 0.75 x 10^4 - 2.80 x 10^4 cfu/ml. Values obtained from the control points also fell within this range . The coliform and *E.coli* count ranged from 0.58 x 10^3 - 2.10 x 10^3 MPN/100ml and

NG - 0.32 x 10^3 MPN/100ml respectively.

Table 4-24: Concentrations (mg/L) of metals in surface water within Dangote Fertilizer Project area

Parameter	Project Influence Zone				Control Stations	
	Range	Mean	Std. Dev.	C. Var.(%)	Control 1	Control 2
Cd	<0.01	<0.01			<0.01	<0.01
Cr	0.10 – 0.32	0.20	0.08	38.86	0.24	0.22
Cu	0.01 – 0.04	0.03	0.01	32.82	0.04	0.05
Fe	0.20 – 0.36	0.26	0.05	19.69	0.34	0.32
Hg	<0.01	<0.01			<0.01	<0.01
Mn	0.01 – 0.02	0.02	0.01	36.42	0.02	0.02
Ni	0.12 – 0.25	0.19	0.04	20.95	0.18	0.02
Pb	0.01 – 0.02	0.02	0.01	32.27	0.02	0.20
V	<0.02	<0.02			<0.02	<0.02
Zn	1.14 – 1.22	1.18	0.02	2.03	1.18	1.20

Table 4-25: Summary of microbiological characteristics of surface water within the Project area

Parameter	*Project Influence Zone*		*Control Stations*	
	Range	Mean	Control 1	Control 2
Total Heterotrophic Bacteria (cfu/ml)x 10^4	0.75 - 2.80	1.82	1.4	1.42
Coliform Count (MPN/100ml) x 10^3	0.58 - 2.10	1.27	2.2	1.2
E. coli. (MPN/100ml) x 10^3	NG - 0.32	0.22	0.9	0.2
Hydrocarbon Utilising Bacteria (cfu/ml) x 10^3	0.50 - 1.29	1.80	1.2	1.34
Total Heterotrophic Fungi (Spore/ml) x 10^3	NG - 0.57	0.38	NG	0.71
Hydrocarbon Utilising Fungi (Spore/ml) x 10^2	NG - 0.45	0.19	NG	0.22

cfu = Colony forming unit / ml

MPN = Most probable number

NG = No Growth

The hydrocarbon degrading bacteria count ranged between 0.50 x 10^3 cfu/ml and 1.29 x 10^3 cfu/ml constituting 9.89% (**Figures 4-30**). The predominant bacterial species were, *Pseudomonas*, Bacillus sp. and Proteus sp. Most aquatic bacteria are free-living and perform beneficial functions such as the decomposition of organic matter. A few species are opportunistic pathogens and cause diseases in fish, particularly under conditions of stress and immune deficiency (DWAF, 1996).

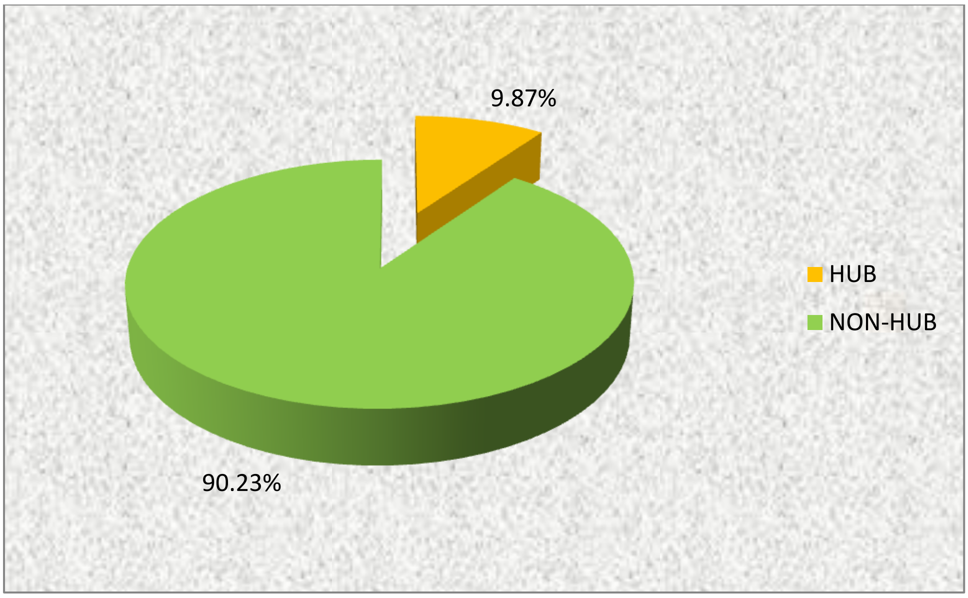


Fig. 4-30: Percentage hydrocarbon and non-hydrocarbon bacteria in surface water

Total heterotrophic fungal counts in the water samples ranged from NG - 0.57 x 10^3 Spore/ml, with petroleum degrader (NG - 0.45 x 10^2 Spore/ml) constituting 5.0% (**Figure 4-31**). Predominant among the fungi isolates were *Aspergillus niger and Mucor mucedo.* The presence of hydrocarbon degraders in the water body indicates the capability of self-purification of the environment in the event of any oil pollution. This does not, however, suggests undue exposure of the water body to oil pollution.

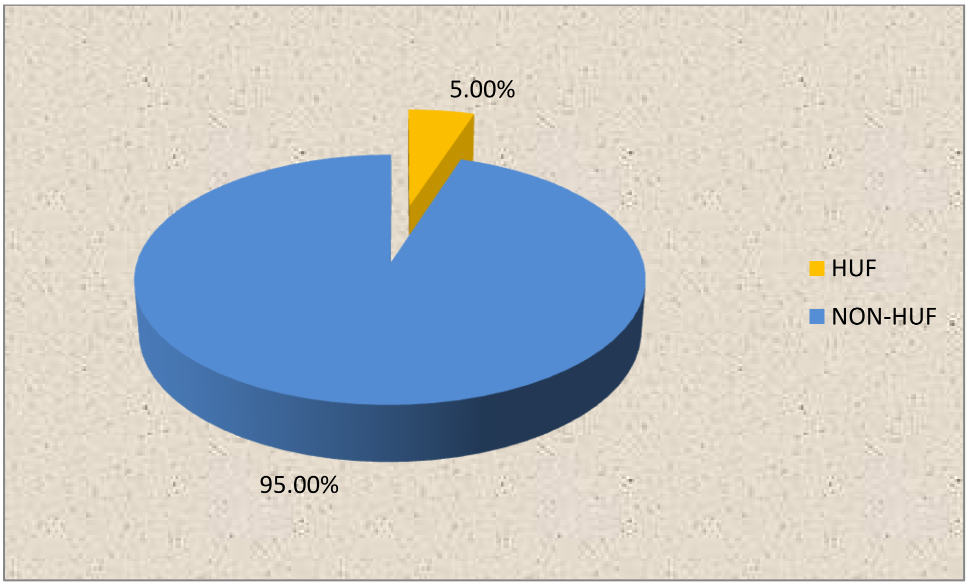


Fig. 4-31: Percentage of hydrocarbon degrading fungi in surface water body

4.4.11. Sediment Study

4.4.11.1 Sediment Physico-chemical Characteristics

The physico-chemical characteristics of sediment samples collected from the Lekki Lagoon within the fertilizer project influence zone and the control stations are presented in **Table 4-26.**

Table 4-26: Summary of *Sediment Physico-chemical characteristics* within the study area

Parameter	***Project Influence Zone***				***Control Stations***	
	Range	Mean	Std. Dev.	C. Var.(%)	Ctrl 1	Ctrl 2
Sand (%)	49.8 - 54.80	52.45	1.74	3.31	52.8	52.9
Silt (%)	16.0 - 24.0	21.02	3.02	14.37	24.2	22.6
Clay (%)	22.8 - 29.3	26.20	2.62	10.01	26.2	24.4
pH	5.07 - 5.25	5.16	0.07	1.41	4.36	4.48
E. Cond. (mS/cm)	1.04 - 1.30	1.13	0.09	7.85	1.15	1.13
TOM (%)	5.21 - 6.02	5.44	0.31	5.63	5.24	5.63
Total N (%)	0.88 - 1.86	1.37	0.41	29.88	2.15	1.69
Total P (mg/kg)	0.48 - 2.77	1.67	0.75	44.96	1.46	1.75
K^+ (cmol/kg)	3.68 - 4.90	4.16	0.40	9.73	4.33	4.38
Na^+ (cmol/kg)	2.92 - 4.52	3.89	0.59	15.11	4.26	4.39
Ca^{2+} (cmol/kg)	3.10 - 5.30	4.33	0.81	18.77	4.1	4.16
Mg^{2+} (cmol/kg)	3.10 - 4.20	3.84	0.40	10.31	4.68	4.33
Ex. Acidity (cmol/kg)	4.50 - 5.60	5.13	0.43	8.33	6.46	7.2
CEC (cmol/kg)	19.90 - 23.24	21.34	1.14	5.32	23.83	24.46
Heavy Metals (mg/kg)						
As	1.35 - 1.50	1.44	0.06	3.86	1.23	1.55
Cd	0.53 - 1.06	0.70	0.22	31.05	0.6	1.15
Cr	7.47 - 22.00	14.22	6.03	42.42	9.5	14.68
Cu	4.95 - 6.25	5.58	0.47	8.33	5.24	5.96
Fe	1317 – 1370	1343.33	23.27	1.73	1242	1360
Hg	0.05 - 0.12	0.08	0.03	38.41	0.15	0.06
Pb	20.82 - 30.0	25.77	3.25	12.62	28.2	30.43
Ni	20.65 - 34.27	27.16	5.45	20.08	22.58	29.47
V	0.47 - 1.02	0.80	0.20	24.84	1.39	1.48
Zn	95.34 - 108.52	100.99	4.78	4.74	110.5	109.26

The particle size of the sediment samples showed sand (49.8 - 54.80%) > clay (22.8 - 29.3%) > silt (16.0 - 24.0%). Spatial variations across the sampling points within the study area were low (CV = 3.31%, 10.01% and 14.37% for sand, clay and silt respectively) and the values recorded for the control stations fell within the range obtained for the proposed project site. Clay and organic matter content of soil/sediment have direct influence on other physical and chemical characteristics, including reserve of exchange bases and the interaction and dynamics of trace metals and organic pollutants in sediment. Maximum soil/sediment capacity for heavy metals and organic pollutants are normally adjusted according to these soil/sediment macro-characteristics (Lacatusu, 2000; DPR, 2002).

The pH values of the sediment samples ranged from 5.07 - 5.25, showing acidic slightly condition of the sediment commonly associated with sediment within the region (Aiyesanmi, 2006; OKFTZ EIA, 2012). Values from the control stations were also within the range recorded for the project influence zone. High sediment acidity has been attributed to combination of possible oxidation of pyrite (FeS_2) in the sediment to produce sulphuric acid, depleted calcium level or increased aluminium concentration in sediment (Odu, 1996; Aiyesanmi, 2006). The low pH condition may affect metal speciation and enhance metals' solubility and possible leaching into the water column.

The conductivity of the sediment solution ranged from 1.04 - 1.30 mS/cm (between 1040 and 1300 µS/cm), showing high dissolved ions content, which may from time to time get leached into the water column during sediment re-suspension. Some of the ions may be beneficial or otherwise to benthic organisms in the water body.

Total organic matter contents ranging from 5.21 - 6.02% were recorded in the sediment samples. The bulk of organic carbon in sediment samples composed of humic substances and degraded plant and animal materials. Many important sediment properties including reserves of exchanged bases, the capacity to supply nitrogen, phosphorus and pollutants bioavailability are dependent to some degree on the quality of organic matter present (Margesin and Schinner, 2005). Pollutants concentrations in soil are normalised with the organic matter in conjunction with clay content (DPR, 2002).

The nutrient content, nitrogen and phosphorus in the sediment samples ranged from 0.88 - 1.86% and 0.48 - 2.77 mg/kg respectively, with values from the control stations also falling within the range. Nitrogen and phosphorus serve as nutrient to benthic floral and some bacteria in sediment. Higher concentration can lead to emission into water column especially under condition of low pH and thus can lead to eutrophication of the water body.

The order of magnitude of exchangeable cations' concentrations in the sediment samples were: Ca^{2+} (3.10 - 5.30 cmol/kg) > K^{+} (3.68 - 4.90 cmol/kg) > Na^{+} (2.92 - 4.52 cmol/kg) > Mg^{2+} (3.10 - 4.20 cmol/kg). The exchangeable acidity and cation exchange capacity of the sediment sample ranged from 4.50 - 5.60 cmol/kg and 19.90 - 23.24 cmol/kg respectively. Relatively higher values of these parameters were recorded at the control stations, although the differences were not significant ($p>0.05$). Cation exchange capacity show the potential of soil/sediment to exchange the exchangeable cations with other metals, especially heavy metals, thus reducing their bioavailability and toxicity potential.

Heavy metals analysed in the sediment were arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), iron (Fe), mercury (Hg), lead (Pb), nickel (Ni), vanadium (V) and zinc (Zn). All the metals showed measurable concentrations with Fe recording very high concentration (1317 – 1370 mg/kg) compared with other metals. The occurence and levels of Fe is more of lithological or crustal origin as high iron level has been reported for most Nigerian sediment (Odu, 1996, OKFTZ EIA, 2012). Generally, the presence of metals in river sediments originates from several sources and they are present in different forms. Most of the metals in their stable state are derived from natural weathering, erosion and anthropogenic inputs. The order of concentrations of other heavy metals in the sediment were: Zn > Ni > Pb > Cr > Cu > As > V > Cd > Hg. The concentrations of these metals from the control stations were not significantly ($p>0.05$) different from that of the project influence zone. The mean concentrations of the heavy metals in sediment samples were lower than their Target values in soil/sediment (DPR, 2002) (**Figure 4-32**), thus showing that the rivers' sediment as it were, was not contaminated with heavy metals except the high iron content.

4.4.11.2 Oil and Grease and Hydrocarbon Levels in Sediment

Table 4.27 presents the oil and grease concentration as well as the hydrocarbon content (TPH, BTEX and polycyclic aromatic hydrocarbons) in the sediment. Oil and grease in the sediment, which is made up of hydrocarbons, fats and waxes from both plant and animal origin ranged from 32.35 - 35.62 mg/kg, while total petroleum hydrocarbon content ranged from 30.52 - 33.48 mg/kg. Distribution of these pollutants across the sampling stations as well as in the control stations (CV < 4.0% respectively), showed that they are possibly from the same source of which biogenic origin is most probable, while anthropogenic input could also not be ignored .

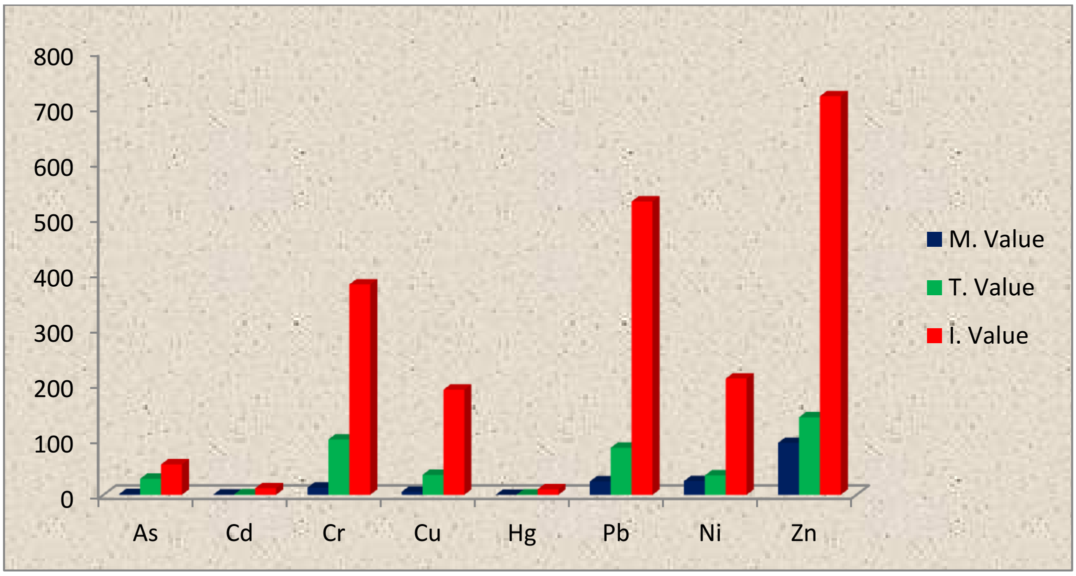


Fig. 4.32: Comparing heavy metal concentrations in sediment with Target and Intervention values

Table 4-27: Oil and grease and hydrocarbon contents in sediment from the project influence zone

Parameter	Project Influence Zone				Control	
	Range	Mean	Std. Dev.	C. Var.(%)	Ctrl 1	Ctrl 2
Oil and grease (mg/kg)	32.35 - 35.62	33.81	1.20	3.56	32.42	32.65
THC (mg/kg)	30.52 - 33.48	31.55	1.10	3.48	30.13	30.29
Benzene (µg/kg)	-	<0.01	-	-	-	<0.01
Toluene (µg/kg)	-	<0.01	-	-	-	<0.01
Ethylbenzene (µg/kg)	-	<0.01	-	-	-	<0.01
Xylene (µg/kg)	-	<0.01	-	-	-	<0.01
Polycyclic Aromatic Hydrocabons (µg/kg)						
Naphthalene	1.90 - 3.58	2.56	0.45	17.58	2.31	2.6
Acenaphthylene	2.22 - 3.70	3.05	0.53	17.38	3.59	2.74
Acenaphthene	2.62 - 4.36	3.99	0.54	13.53	2.48	2.55
Fluorene	2.86 - 3.75	3.40	0.34	10.00	2.68	1.5
Phenanthrene	2.95 - 5.40	4.22	0.70	16.59	4.02	3.18
Anthracene	2.58 - 5.36	3.80	0.79	20.79	2.79	3.2
Fluoranthene	0.42 - 0.86	0.60	0.11	18.33	0.7	0.58
Pyrene	1.90 - 3.63	2.58	0.55	21.32	3.44	3.25
Benzo(a) anthracene	2.30 - 3.37	2.52	0.45	17.86	2.68	2.56
Chrysene	0.05 - 0.10	0.08	0.02	25.00	0.08	0.06
Benzo(b) fluoranthene	0.46 - 0.74	0.53	0.08	15.09	0.5	0.34
Benzo(k) fluoranthene	2.87 - 5.96	3.75	1.02	27.20	3.48	3.26
Benzo(a) pyrene	2.60 - 7.82	5.16	1.45	28.10	4.57	4.12
Indeno (1,2,3-cd) pyrene	0.14 - 0.25	0.22	0.06	27.27	0.35	0.3
Dibenzo (a,h) anthracene	1.16 - 1.90	1.45	0.30	20.69	1.2	1.2
Benzo (g,h,i) perylene	0.01 - 0.01	0.01	0.00	0.00	<0.01	<0.01
Total PAHs	32.52 - 50.46	37.92	7.39	17.58	**34.87**	31.44

Benzene, toluene, ethylbenzene and xylenes (BTEX) concentrations were below instrument detection limit, thus, revealing that the sediment was not contaminated with petroleum products. BTEX are volatile components of petroleum products, usually associated with petroleum products pollution. The total petroleum hydrocarbon values obtained in this study were also lower than 50 mg/kg DPR Target value. Similar observations as recorded in this study have been reported for similar terrain close to the study area (OKFTZ EIA, 2012).

The PAHs (16 components) analysed in the sediment samples showed measurable concentrations in all the sampling stations, with $PAHs_{Total}$ ranging from 32.52 - 50.46 µg/kg with Benzo(a) pyrene showing the highest concentration (5.16 µg/kg). As earlier stated for total petroleum hydrocarbons, the occurrence of the PAHs in the sediment are probably of both biogenic and anthropogenic origin.

4.4.11.3 Sediment Microbiology

The summary of microbiological characteristics of the sediment samples are presented in **Table 4-28**. The heterotrophic bacterial counts ranged from 1.73×10^5 - 2.99×10^5 cfu/g Values from the control stations were also within the range recorded for the project influence zone. The hydrocarbon degrading bacteria count ranged between 0.20×10^4 cfu/g and 2.49×10^4 cfu/ml constituting 8.67% (**Figures 4-33**). The predominant bacteria isolates were Bacillus sp.

Table 4.28: Summary of microbiological characteristics of *sediment* within the Project area

Parameter	*Project Influence Zone*		*Control Stations*	
	Range	Mean	Control 1	Control 2
Total Heterotrophic Bacteria (cfu/g)x 10^5	1.73 - 2.99	2.24	1.68	1.74
Hydrocarbon Utilising Bacteria (cfu/g) x 10^4	0.20 - 2.49	1.94	1.06	1.12
Total Heterotrophic Fungi (Spore/g) x 10^3	0.68 - 1.42	1.10	1.3	1.28
Hydrocarbon Utilising Fungi (Spore/g) x 10^3	0.12 - 0.56	0.38	0.69	0.74

cfu = Colony forming unit / ml

MPN = Most probable number

NG = No Growth

The heterotrophic fungal counts in the sediment samples ranged from 0.68 x 10^3 - 1.42 x 10^3 Spore/g, with petroleum degrader ranging from 0.12 x 10^3 - 0.56 x 10^3 Spore/g, constituting 34.55% (**Figure 4.34**). Predominant among the fungi isolates were Penicillium sp.. The presence of hydrocarbon degraders in the sediment indicates the capability of self-purification in the event of any oil spillage.

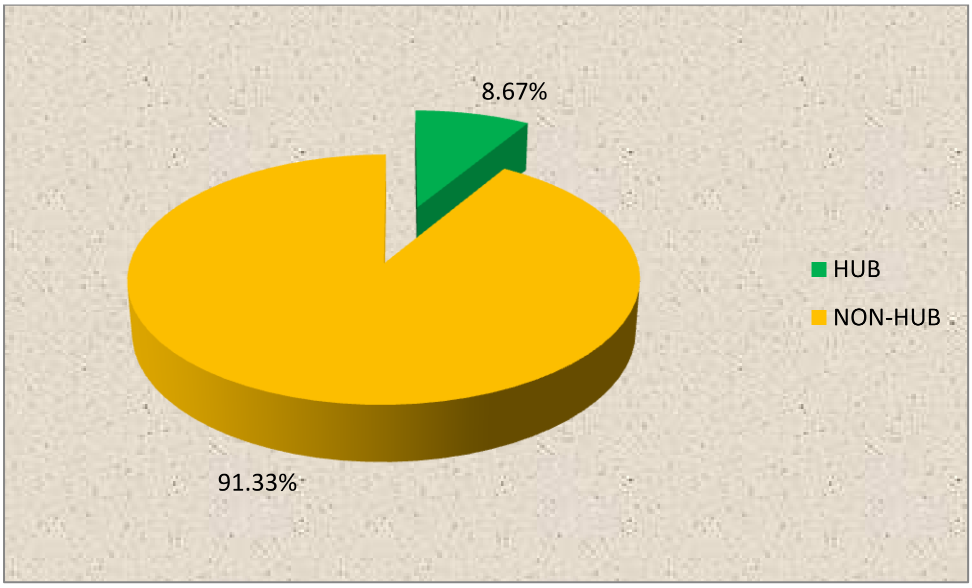


Fig. 4.33: Percentage of hydrocarbon utilising bacteria in sediment

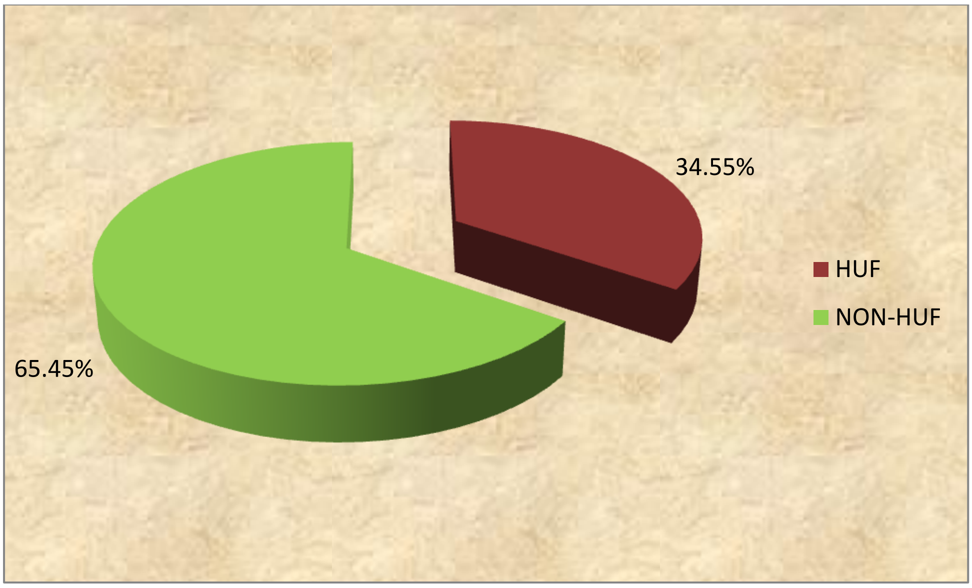


Fig. 4.34: Percentage of hydrocarbon utilising fungi in sediment

4.4.12 Hydrobiology

4.4.12.1 Planktons

The word plankton was from the Greek word planktos meaning drifters (Thurman (1977). They usually refer to the large class of microscopic organisms (2 -200 micrometer) that are carried around by the water current in any natural body of water. Hydrobiologists have divided plankton into two (2) classes; phytoplankton and zooplankton. The phytoplankton is free-floating organisms of the water body that undergo photosynthesis with the help of chlorophyll and thereby contribute to primary production in their endemic aquatic environment. The zooplankton on the other hand is animal component of the plankton spectrum.

The phytoplankton organisms are the basis of aquatic productivity and any alteration in their constitution may have detrimental consequences in the food chain and the entire community structure. The primary trophic roles played by the phytoplankton and zooplankton in the ecology of the aquatic environment cannot be understated. Zooplankton organisms are the various free-floating animals and that plankton is the collective name, zooplankton is extremely diverse consisting of a host of larval and the adult forms representing most of the animals and protistan phyla. Zooplankton further includes those plankton forms that exist temporarily as Plankton. Whereas holoplankton zooplankton are those plankton that spend their entire life as planktonic animals, the Meroplankton zooplankton are those that are found in the plankton spectrum during a cycle of their life, usually the egg or laval stages. Zooplankton based on size can be grouped as larger net zooplankton and smaller microzooplankton. The most abundant of the permanent zooplankton are the copepods.

Phytoplankton Spectrum

The phytoplankton recorded 4 (four) group of species. They were the Diatoms (Division – Bacillariophyta), Blue-green algae (Division – Cyanophyta), Euglenoids (Division - Euglenopohyta) and Chlorophytes (Division – Chlorophyta). The dominant group of phytoplankton was the Diatoms, followed by the Blue-green algae and then the Chlorophytes and then the Euglenoids. Whereas the Diatoms, recorded 55% (Centrales – 22.5% - 9 species, Pennales – 32.5% - 13 species), Blue-green algae (22.5%, 9 species), Chlorophytes (12.5% - 5 species) and Euglenoids reported 10%, 4 species (**Figure 4-35**). A checklist of the phytoplankton spectrum (first / left most column) is presented within Table 1a alongside the distribution of the phytoplankton species at the stations investigated.

The diversity and distribution of phytoplankton per ml per station is shown in **Table 4-29a** whereas **Table 4-29b** tabulates the phytoplankton community's eco-mathematical indices (biological indices). In all forty (40) species were recorded at the 8 stations studied. Total number of species recorded per station ranged between 21 and 29. **Figure 4-36** shows a graphical relationship between Total Number of Species (S) and Total Abundance of the species (N). FSW 2 and FSW 5 recorded the highest number of species (29 species) while FSW C1 recorded 21 species only. Furthermore, FSW 2 recorded the highest number of individuals (1180 individuals per ml) while, FSW C1 recorded 520 individuals per ml. Log of Species diversity recorded ranged from 1.32 to 1.46. Log of phytoplankton abundance was between 2.72 and 3.07. Whereas Shannon-Wiener Index (Hs) was between 0.81 and 1.30, Menhinick Index (D) was between 0.83 and 1.10. Margalef Index (d) values were from 3.20 to 4.16, Equitability on the other hand was between 0.57 and 0.92 and Simpson's Dominance Index ranged between 0.06 and 0.38, for the stations studied. Graphical representations of the ecological indices are show in **Figure 4-37**.

The key species occurring for the study were *Aulacoseira granulata* var. *angstissima* Muller, *Cyclotella striata* (Kutzing) Grunow, *Diatoma elongatum* (Lyngb.) Agardh, *Microcystis flos-aquae* Kirchner and *Oscillatoria limnosa* Agardh in terms of occurrence and abundance.

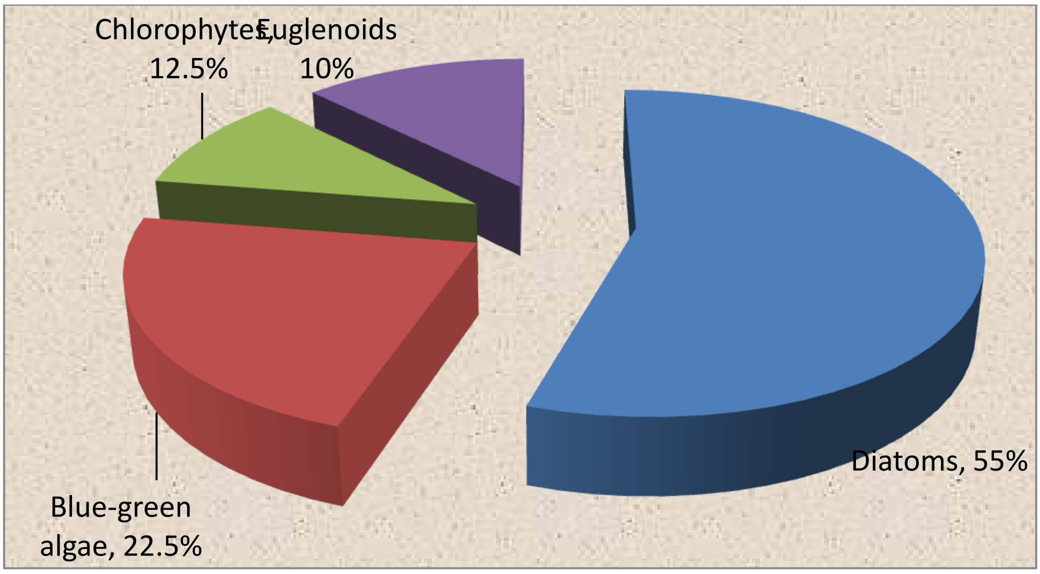


Fig. 4-35: Percentage occurrence of major phytoplankton groups

Table 4.29a: Composition and abundance distribution of phytoplankton per ml.

Taxa	DFSW 1	DFSW 2	DFSW 3	DFSW 4	DFSW 5	DFSW 6	DFSW C1	DFSW C2
DIVISION – BACILLARIOPHYTA								
CLASS-BACILLARIOPHYCEAE								
ORDER I – CENTRALES								
Aulacoseira granulata Ehrenberg (Ralfs)	50	25	30	90	20	80	50	75
Aulacoseira granulata var. *angstissima* Muller	485	405	340	35	75	100	85	105
Aulacoseira islandica (O.F. Muller) Simonson	15	5	5	35	45	45	15	45
Aulacoseira varians Agardh	-	-	10		10	-	-	-
Campylodiscus clypeus (Ehr.) Kutzing	-	15		15	-	5	-	15
Odontella laevis Ehrenberg	-	-	5	-	5	-	-	-
Cyclotella menighiniana Kutzing	10	35	-	45	25	5	10	35
Cyclotella striata (Kutzing) Grunow	70	170	20	110	150		70	170
Terpsinoe musica (Ehr) Hustedt	35	70	5	45	45	5	35	70
	0.	1.	2.	3.	4.	5.	6.	7.
Order II – PENNALES	8.	9.	10.	11.	12.	13.	14.	15.
Amphora ovalis Kutzing	40	35	5	-	10	-	-	5
Diatoma elongatum (Lyngb.) Agardh	25	30	10	35	70	30	25	30
Eunotia glacialis Mesiter	-	10	-	-	15	-	-	10

Taxa	DFSW 1	DFSW 2	DFSW 3	DFSW 4	DFSW 5	DFSW 6	DFSW C1	DFSW C2
Fragillaria construens Ehrenberg	20	45	10	45	50	15	20	45
Gomphonema parvulum Grunner	10	-	5	15	35	45	10	-
Navicula cuspidata Kutzing	45	55	15	60	15	120	45	55
Navicula mutica Kutzing	10	-	-	35	-	15	10	-
Pinnularia major (Kutzing) Rabenh	-	5	5	30	5	35	-	5
Pinnularia gibba Ehrenberg	-	10	-	-	-	10	-	10
Surirella ovata Kutzing	5	15	-	-	10	-	5	15
Surirella striatula Turpin	-	-	10	-	-	5	-	-
Synedra ulna (Nitzsch) Ehrenberg	15	15	15	55	35	55	15	15
Synedra sp.	-	-	5	-	-	-	-	-
	16.	17.	18.	19.	20.	21.	22.	23.
	24.	25.	26.	27.	28.	29.	30.	31.
DIVISION – CYANOPHYTA	32.	33.	34.	35.	36.	37.	38.	39.
CLASS – CYANOPHYCEAE	40.	41.	42.	43.	44.	45.	46.	47.
ORDER I – CHROOCOCCALES								
Microcystis aureginosa Kutzing	75	20	-	5	5	25	15	20
Microcystis flos-aquae Kirchner	40	30	15	30	25	20	15	5

Taxa	**DFSW 1**	**DFSW 2**	**DFSW 3**	**DFSW 4**	**DFSW 5**	**DFSW 6**	**DFSW C1**	**DFSW C2**
Order II – HORMOGONALES								
Lynbgya limnetica Lemm	-	5	-	-	-	10	-	5
Lynbgya martensiana Meneghini	20	-	5	-	-	-	-	-
Oscillatoria borneti Zukal	5	-	5	-	15	20	5	-
Oscillatoria chalybea Gomont	5	10	-	15	25	-	5	10
Oscillatoria curviceps C.A. Agardh	15	25	5	35	35	5	15	25
Oscillatoria formosa Bory	10	30	10	30	35	20	10	30
Oscillatoria limnosa Agardh	55	35	5	35	15	20	55	35
DIVISION – EUGLENOPOHYTA								
CLASS – EUGLENOPHYCEAE								
ORDER – EUGLENALES								
Euglena acus Ehrenberg	5	-	-	-	-	-	-	-
Phacus curvicauda Swirenko	-	5	-	-	-	-	-	-
Phacus acuminatus Stokes	35	20	-	5	10	5	-	-
Trachelomonas hispida (Perry) Stein	25	10	5	10	15	5		10
DIVISION – CHLOROPHYTA								

Taxa	DFSW 1	DFSW 2	DFSW 3	DFSW 4	DFSW 5	DFSW 6	DFSW C1	DFSW C2
CLASS – CHLOROPHYCEAE								
ORDER - CHLOROCOCCALES								
Scenedesmus obliquus (Turp.) Kutzing	5	10	5	15	15	15	5	10
Scenedesmus quadriquada (Turp.) de Brebisson	-	25	-	5	20	5	-	25
ORDER - ZYGNEMATALES								
Closterium ehrenbergii Meneghini	-	-	-	-	5	-	-	-
Gonatozygon monotaenium De Bary	5	10	5	-	-	-	-	-
Gonatozygon sp.	15	-	5	-	-	-	-	-
Total species diversity (S)	28	29	26	24	29	26	21	26
Total abundance (N)	115	118	560	835	840	720	520	880

Table 4.29b: Phytoplankton community composition parameter.

Bio-indices	FSW 1	FSW 2	FSW 3	FSW 4	FSW 5	FSW 6	FSW C1	FSW C2
Total species diversity (S)	28	29	26	24	29	26	21	26
Total abundance (N)	1150	1180	560	835	840	720	520	880
Log of Species diversity (Log S)	1.45	1.46	1.41	1.38	1.46	1.41	1.32	1.41
Log of abundance (Log N)	3.06	3.07	2.75	2.92	2.92	2.86	2.72	2.94
Shannon-Wiener Index (Hs)	1.05	1.11	0.81	1.28	1.30	1.21	1.17	1.22
Menhinick Index (D)	0.83	0.84	1.10	0.83	1.00	0.97	0.92	0.88
Margalef Index (d)	3.83	3.96	3.95	3.42	4.16	3.80	3.20	3.69
Equitability Index (j)	0.72	0.76	0.57	0.92	0.89	0.86	0.88	0.86
Simpson's Dominance Index (C)	0.20	0.15	0.38	0.06	0.07	0.08	0.09	0.08

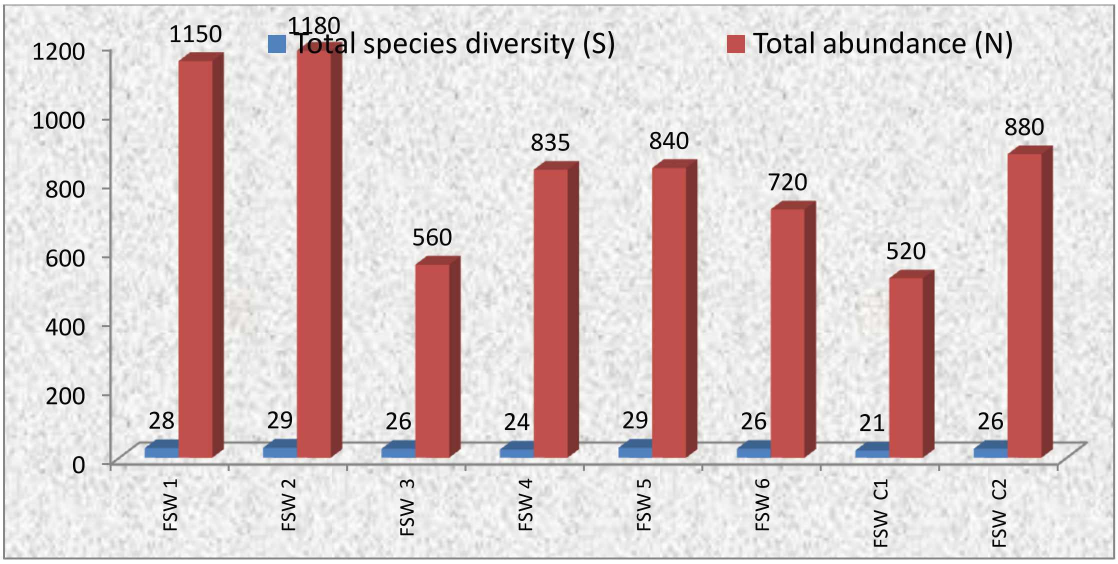


Fig. 4-36: Phytoplankton Total number of species (S) and abundance (N).

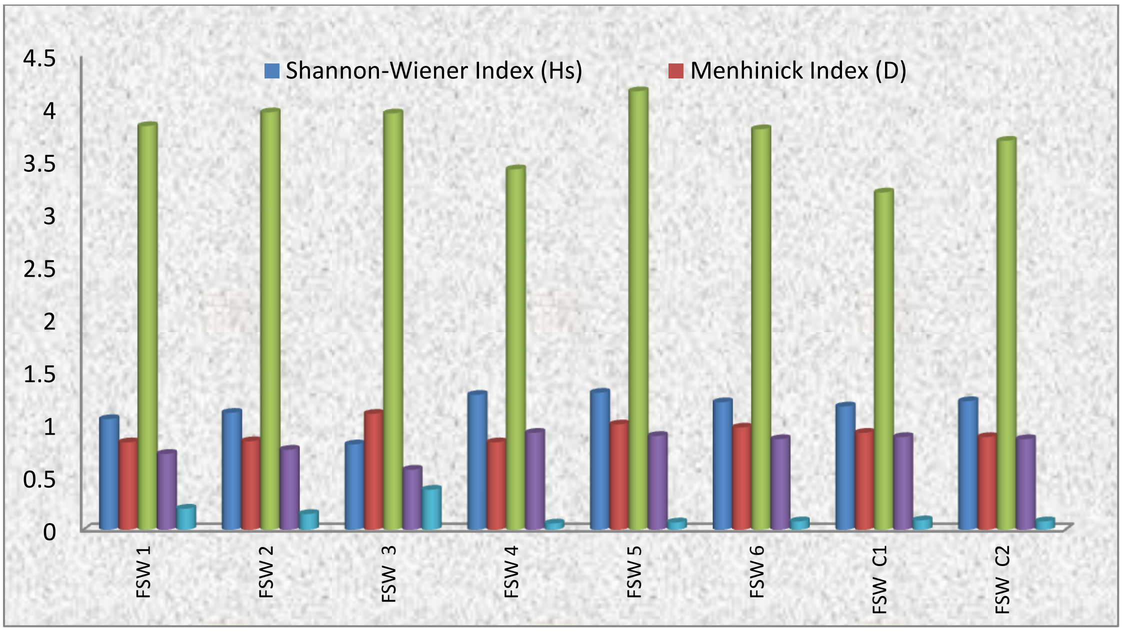


Fig. 4-37: Phytoplankton ecological indices

Zooplankton Spectrum

The zooplankton recorded 3 (three) groups of species for the zooplankton (Holoplankton and Meroplankton forms). They were Phylum – Crustacea, Phylum - Rotifer and the Juvenile stages. The dominant group of zooplankton was the Phylum – Crustacea, followed by the Rotifers. Whereas the Crustaceans recorded 46.7% (Calanoid Copepods, 4 species 26.7% and Cyclopoids, 3 species – 20%), Rotifers (40% - 6 species) and Juvenile stages reported 13.3%, (**Figure 4-38**). The juvenile stages were represented by two forms namely: Rotiferan egg and Copepod eggs.

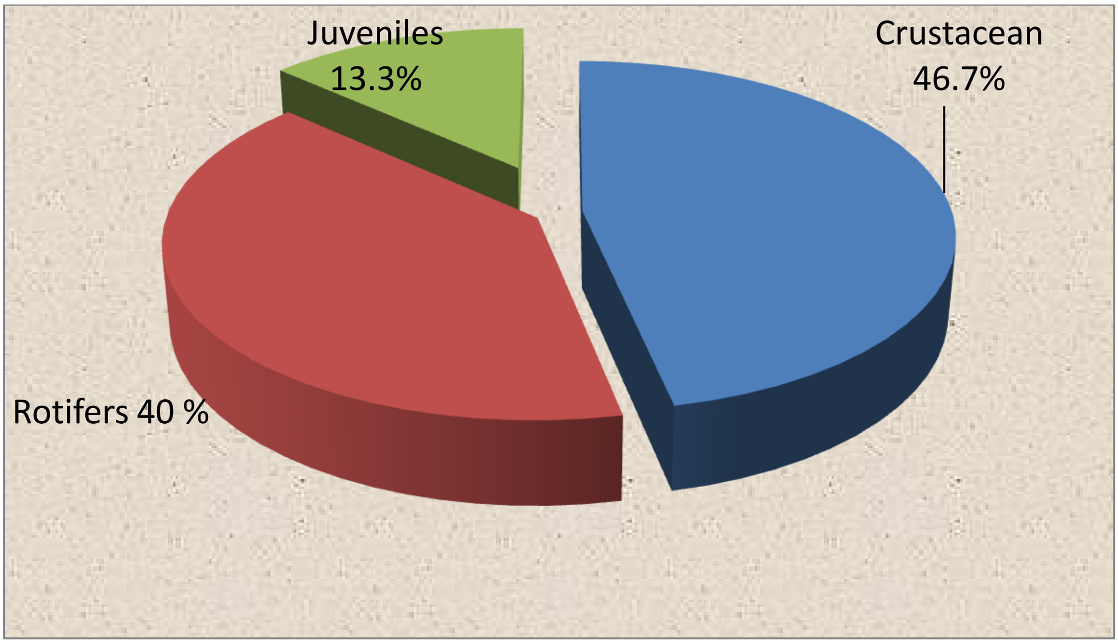


Fig. 4-38: Percentage occurrence of zooplankton phylum and juvenile stages

The diversity and distribution of zooplankton per ml per station is shown in **Table 4-30a** whereas **Table 4-30b** tabulates the zooplankton community's eco-mathematical indices (biological indices). In all a total of 15 species / forms were recorded at the 8 stations studied. Total number of species recorded per station ranged between 12 and 14. **Figure 4-39** shows a graphical relationship between Total Number of Species (S) and Total Abundance of the species (N). FSW 2, FSW 6 AND FSW C2 recorded the highest number of species (14 species) while FSW 1, FSW 3, FSW 4, FSW 5 and FSW C1 recorded 12 species only.

Furthermore, FSW C2 recorded the highest number of individuals (295 individuals per ml) while FSW C1 recorded 180 individuals per ml. Log of Species diversity recorded ranged from 1.08 to 1.15. Log of zooplankton abundance ranged between 2.26 and 2.47. Whereas Shannon-Wiener Index (Hs) was between 0.97 and 1.07, Menhinick Index (D) was between 0.74 and 0.89. Margalef Index (d) values were from 1.98 to 2.34, Equitability was between 0.90 and 0.93 and Simpson's Dominance Index was between 0.08 and 0.11. Graphical representations of the ecological indices are show in **Figure 4-**

40. *Eucyclops* sp., *Lecane bulla* Gosse, *Monostyla* sp. and *Brachionus plicatilis* Muller were the key species occurring in terms of occurrence and abundance. Copepod eggs and Rotiferan egg represented the juvenile forms in this regard.

Table 4.30a: Composition and abundance distribution of zooplankton per ml

ZOOPLANKTON TAXA	FSW 1	FSW 2	FSW 4	FSW 5	FSW 6	FSW C1	FSW C2
PHYLUM: CRUSTACEA							
CLASS: COPEPODA							
ORDER: CYCLOPOIDA							
Cyclops strenus Fisher	10	25	10	10	15	10	25
Eucyclops sp.	55	10	35	25	10	5	10
Mesocyclops sp,	-	5	-	-	5	-	5
CLASS: CLADOCERA							
ORDER: EUCLADOCERA							
Diaphanosoma excisum (Sar)	10	15	10	10	25	10	15
Diaphnia sp. I	-	35	15	15	35	15	35
Bosmina sp.	5	15	5	5	15	15	25
Diaphnia sp. II	-	10	-	-	10	-	10
PHYLUM: ROTIFERS							
CLASS: MONOGONOTA							
ORDER: PLOIMA							
Lecane bulla Gosse	45	30	45	15	30	5	30
Lecane sp.	10	25	10	20	5	25	5
Monostyla sp.	15	25	15	15	25	15	25
Keratella sp	5	10	5	10	10	5	5
Tetrasiphon hydrocoral Ehrenberg	15	-	-	-	-	-	-
Brachionus plicatilis Muller	35	5	20	5	45	35	45
JUVENILE STAGES							
Copepod eggs	25	10	45	40	5	10	20
Rotiferan egg	30	40	30	30	40	30	40
Total species diversity (S)	**12**	**14**	**12**	**12**	**14**	**12**	**14**
Total abundance (N)	**260**	**260**	**245**	**200**	**275**	**180**	**295**

Table 4-30b: Zooplankton community composition parameter.

Bio-indices	DFSW 1	DFSW 2	DFSW 3	DFSW 4	DFSW 5	DFSW 6	DFSW C1	DFSW C2
Total species diversity (S)	12	14	12	12	12	14	12	14
Total abundance (N)	260	260	235	245	200	275	180	295
Log of Species diversity (Log S)	1.08	1.15	1.08	1.08	1.08	1.15	1.08	1.15
Log of abundance (Log N)	2.41	2.41	2.37	2.39	2.30	2.44	2.26	2.47
Shannon-Wiener Index (Hs)	0.97	1.07	0.98	0.98	1.00	1.05	1.00	1.06
Menhinick Index (D)	0.74	0.87	0.78	0.77	0.85	0.84	0.89	0.82
Margalef Index (d)	1.98	2.34	2.01	2.00	2.08	2.31	2.12	2.29
Equitability Index (j)	0.90	0.93	0.91	0.91	0.93	0.91	0.92	0.93
Simpson's Dominance Index (C)	0.10	0.08	0.12	0.09	0.11	0.09	0.12	0.09

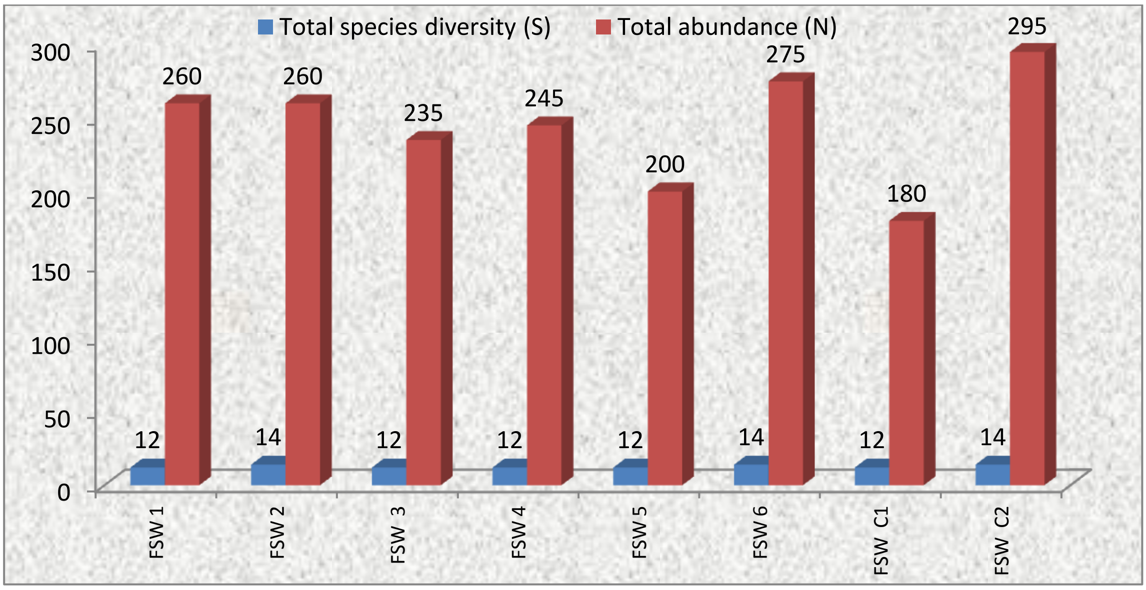


Fig. 4-39: Zooplankton Total number of species (S) and abundance (N)

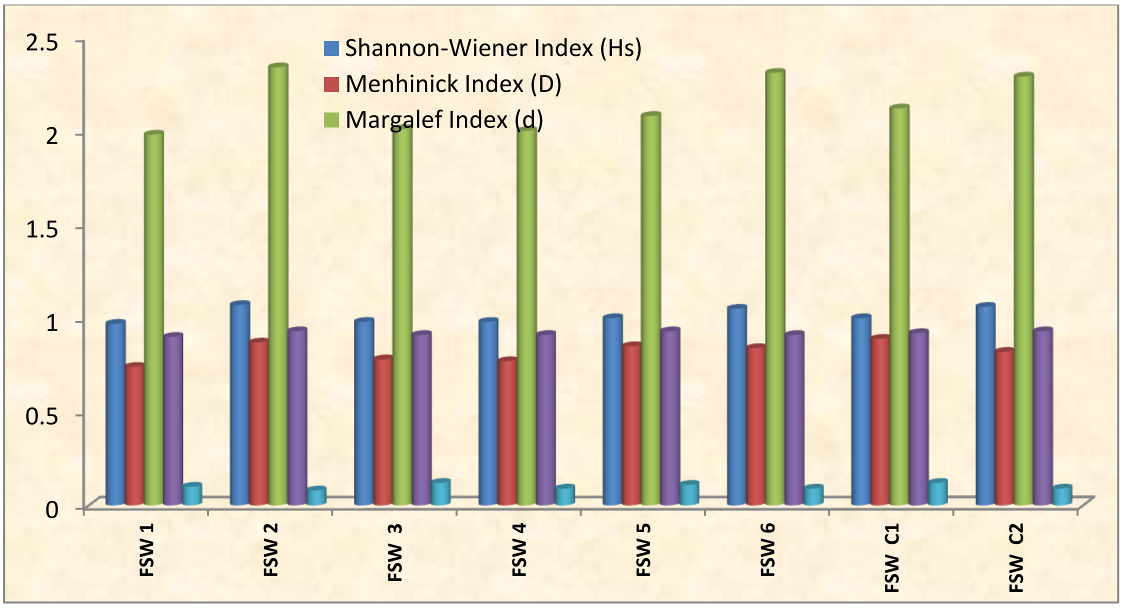


Fig. 4-40: Zooplankton ecological indices

The species recorded for this plankton analysis are indicators of predorminantly freshwater situation. Additionally moderately to high nutrient levels nutrient levels are also possible. All recorded species are known indigenous forms of phytoplankton and zooplankton. They have also been previously recorded in our waters before now (Nwankwo 1988, Onyema 2008, Onyema and Ojo 2008). The high densities of *Aulacoseira granulata* var. *angstissima* and *Aulacoseira granulata* are wothy of note. The key species occurring for the study were *Aulacoseira granulata* var. *angstissima* Muller, *Cyclotella striata*, *Diatoma elongatum* , *Microcystis flos-aquae* and *Oscillatoria limnosa* in terms of occurrence and abundance.

With regard to the phytoplankton, species such as *Microcystis aureginosa*, *Aulacoseira granulata* var. *angstissima* and *Scenedesmus quadriquada* are reported indicators of moderate levels of nutrient pollution either from anthropogenic or natural sources. Species such as *Euglena acus, Phacus curvicauda, Phacus acuminatus* and *Trachelomonas hispida* are indicators of high levels of nutrient in water, sometime occurring around sewage polluted areas. This is further strengthened by the occurrence of five (5) species of *Oscillatoria*.

With regard to the zooplankton assemblage, species such as *Eucyclops* sp., *Lecane bulla* Gosse, *Monostyla* sp. and *Brachionus plicatilis* Muller were the key species occurring in terms of occurrence and abundance and have been reported before now in other studies in the region. The occurrence of these species is a reflection of the stressed quality situation especially with reference to nutrient levels. The occurrence of juvenile stages such as Copepod egg and **Rotiferan egg** is an indication of reproduction occurring within the copepod and rotiferan adult community. *Eucyclops* sp., *Lecane bulla* Gosse, *Monostyla* sp. and *Brachionus plicatilis* Muller were the key species occurring in terms of occurrence and abundance And Copepod eggs and Rotiferan egg were the only juvenile stages represented.

Results from the biological indices for the phytoplankton and zooplankton communities (Shannon-Wiener Index (Hs), Menhinick Index (D), Margalef Index (d), Equitability Index (j) and Simpson's Dominance Index (C) followed a similar regime with the phytoplankton and zooplankton species composition and distributive pattern and were reflections of the species diversity (S) and species abundance (N) at the different stations. Hence, the bio-indices values were a good likeness of the species diversity and abundance.

There were no threatened species recorded for this study. The species of phytoplankton and zooplankton recorded for this study are known tropical and indigenous forms previously recorded in the Nigerian. It is worthy of note that the inferences aforementioned are based on the bio-diagonistic characteristics of the plankton composition, abundance and distribution as recorded in this investigation, hence the presence of a fertilizer company in the area will further increase the nutrient levels in the immediate environment. This may additionally stress the surrounding systems.

4.4.12.2 Benthic Macro fauna

The benthos includes a diverse assemblage of animals across almost all the animal phyla. The benthic ecosystem is a very important component of the aquatic ecosystem, because it assists in the degradation of the organic component that sinks to the sediment, as well as indicator for monitoring the condition of the sediment whenever the environment is impacted.

The summary of species composition and abundance of macrobenthic fauna in all sampled station FSW1 to FSW6 and 2 control points is presented in **Table 4-31** and **Figure 4-41**. The macrobenthic fauna consisted of 5 taxa belonging mainly to three phyla, phyla mollusca (3 taxa), chordata (1 taxa) and insect (1 taxa). The biological indices of the benthic community within the environment are presented in **Table 4-32** and **Figure 4-42**.

The percentage distribution indicated that classes insect dominate by 40% followed closely by class bivalvia (30%), class gastropoda (29%) and the least piesces (1%) as shown in **Figure 4.43**. The species frequency distribution in the study area is presented in figure 4 and the dominant species include *Chironomus sp., Melonoides tuberculata and Aloidis trigona* constituting 40%, 29% and 22% respectively of the total individuals sampled. The control stations FSW 1 has the highest of species diversity indicating a more stable environment (**Figure 4-43**).

Species diversity and abundance was generally low across the study area with stations indicating a stressed environment (**Figure 4-44**). The dominant species *Chironomus sp.* and *Melonoides tuberculata* are pollution indicators (Edokpayi et al., 2004; Stevens et al. 2006 and Bolaji *et al.,* 2012). The collected samples from some stations contained large amount of leaf litter fragment wish might be responsible for the elevated levels of organic matter in sediment as indicated by the high occurrence of the above named species (Ndifon and Ukoli, 1989, Dudgeon, 1989; Gutierrez *et al.,*1997, Duggan, 2002, Giovanelli *et al.,* 2005).

Some important factors governing the abundance and distribution of macro-invertebrate benthic communities includes, water quality, immediate substrates for occupation and food availability (Chukwu and Nwankwo, 2004). Any ecological imbalance arising from any severe alterations of these factors may affect the macrobenthos. The important factors that affects the abundance of macrobenthic fauna in a given community includes: the physicochemistry of the water, immediate substrate of occupation and food availability (Dance and Hynes, 1980).

Table 4-31: Composition and abundance distribution of benthos.

ORGANISMS / PHYLA	FSW1	FSW2	FSW3	FSW4	FSW5	FSW6	FSW C1	FSW C2
MOLLUSCA								
Gastropoda								
Melanoides tuberculata	7	3	2	3	6	1		4
Bivalvia								
Aloidis trigona			1				18	
Aloidis sulcata							7	
Piesces								
Echelus myrus	1							
Insecta								
***Chironomous* sp**					2	2	31	
Total species diversity (S)	2	1	2	1	2	2	3	1
Total abundance (N)	8	3	3	3	8	3	56	4

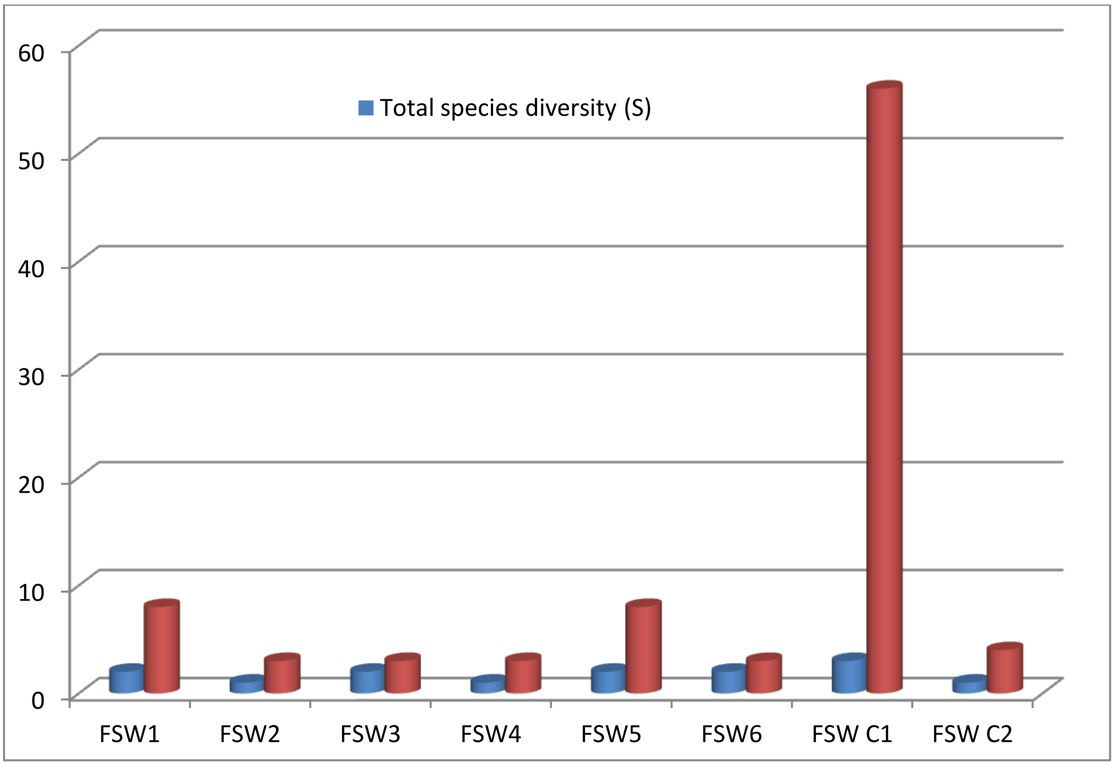


Fig. 4-41: Total number of species diversity (S) and abundance (N).

Table 4-32: Benthic community composition parameter of station F1-27 and four control point's control F1-4.

Bio-Indices	FSW1	FSW2	FSW3	FSW4	FSW5	FSW6	FSW C1	FSW C2
Total species diversity (S)	2	1	2	1	2	2	3	1
Total abundance (N)	8	3	3	3	8	3	56	4
Log of Species diversity (Log S)	0.3010	0	0.301	0	0.3010	0.3010	0.4771	0
Log of abundance (Log N)	0.9031	0.4771	0.4771	0.4771	0.9031	0.4771	1.7482	0.6021
Shannon-Wiener Index (Hs)	0.1636	0	0.2764	0	0.2442	0.2764	0.4135	0
Menhinick Index (D)	0.7071	0.5773	1.1547	0.5774	0.7071	1.1547	0.4009	0.5000
Margalef Index (d)	0.4809	0	0.9102	0	0.4809	0.9102	0.4969	0
Equitability Index (j)	0.5436	0	0	0	0.8113	0.9183	0.8666	0

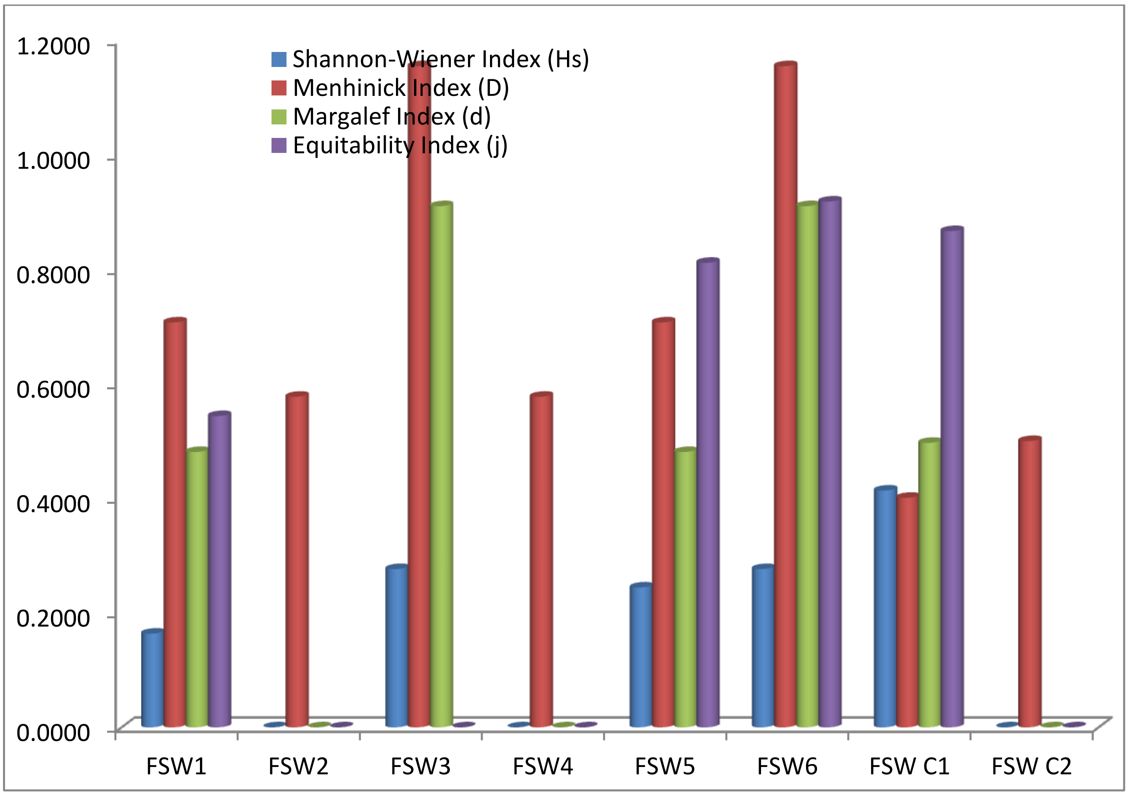


Fig. 4-42: Benthos ecological indices

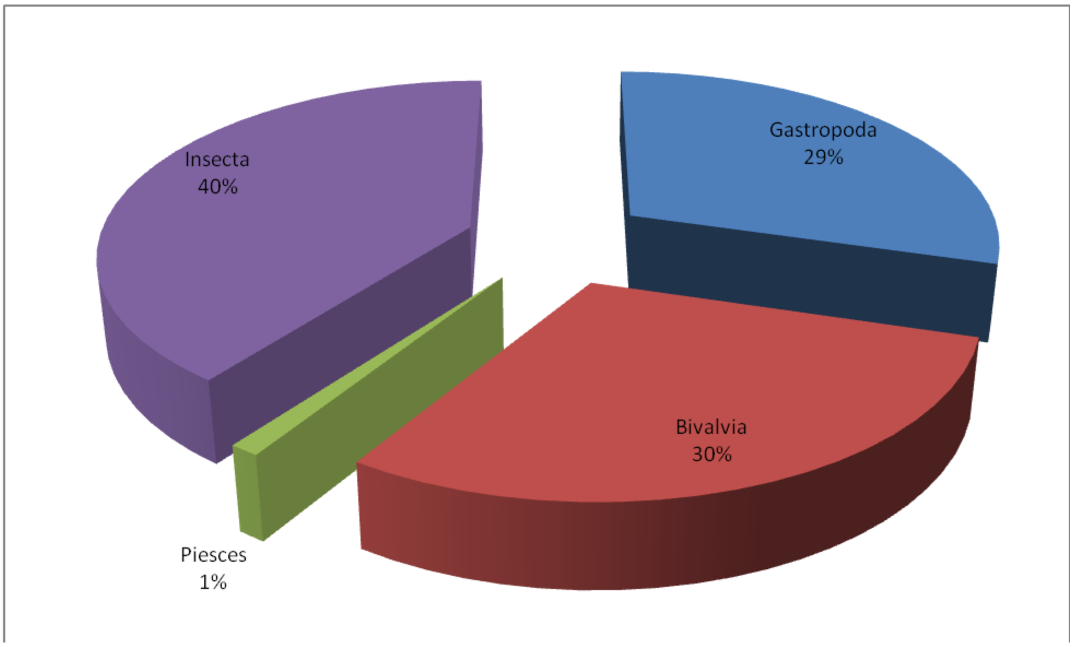


Fig. 4.43: Percentage Distribution of Macrobenthos Community.

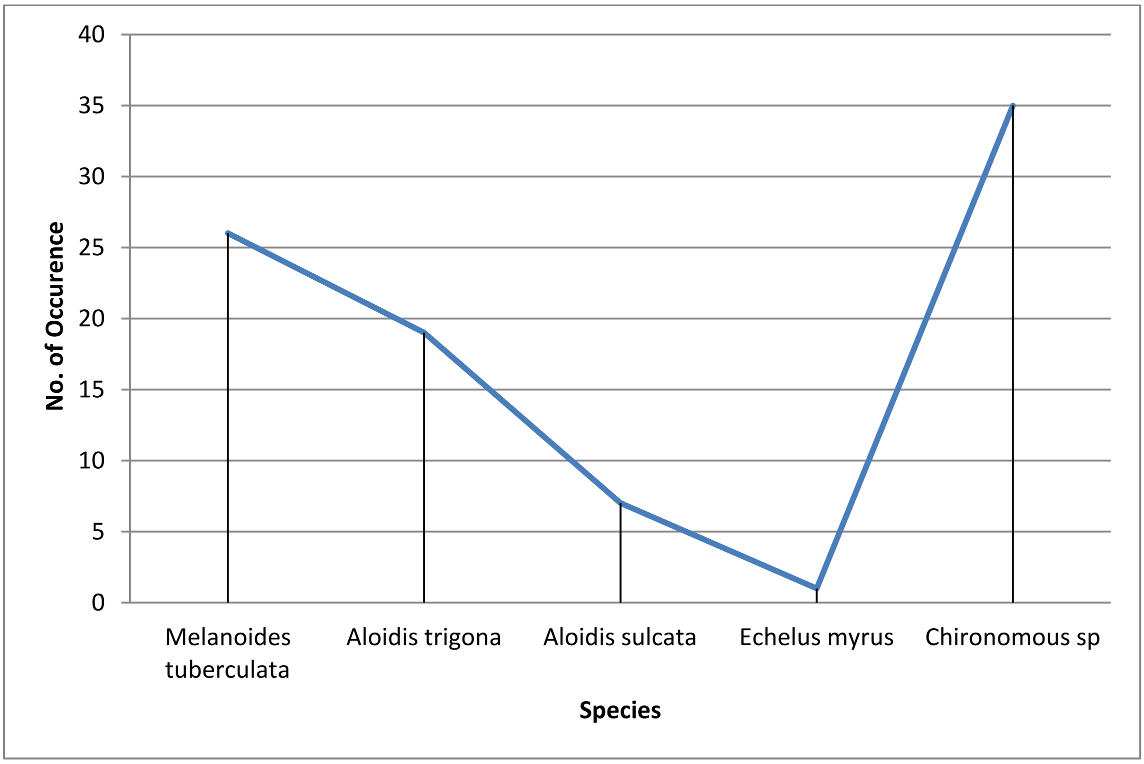


Fig. 4.44: Species Frequecy Distribution in the study area

4.4.13 Fisheries Studies

4.4.13.1 Introduction

The increased concern on the rapid ecological changes in the natural environment has provided major challenges to the scientific community (Chindah 1998). According to Olaniyan (1957), Hill and Webb (1958), two physiographic factors, rainfall and salinity, determine the hydro-climatic conditions of the coastal lagoons of south-western Nigeria. Rainfall in this region is concentrated in one season (May to October) and has two peaks (June and September) but varies from year to year. The dry season is known to extend from November to April. Hill and Webb (1958), Olaniyan (1969) and Nwankwo (2004) highlighted the importance of rainfall in the ecology of the lagoons of south-western Nigeria. Lekki Lagoon is also a relatively shallow body of water. It has three arms, one of which extends to form the Omu Creek by which it is linked with the Mahin Lagoon in Ondo State (Emmanuel, 2009; Emmanuel and Chukwu, 2010). The entire lagoon creek system (Lagos – Lekki – Omu Creek – Mahin Lagoon) constitutes the major coastal feature of southwest Nigeria.

Fishing is one of the major occupations of the people in the project area. Men, women and children alike are involved in this occupation. The fishery productivity of the Lekki lagoon is put above 42.1 kg/ha/yr (Emmanuel, 2009). The fishery is diverse with about 35 landing sites and more than 6000 fishers (Emmanuel 2009). According to Olaosebikan and Raji (1998) the freshwater food fishes found in Nigeria are about 268 different species. Artisanal or small scale fisheries using dugout canoes with or without motorized engines are the predominant fisheries of Lekki lagoon.

Species distribution is an indication of where fish species occur or are located in the aquatic environment. This consists of the vertical aspect (surface, mid water and bottom) and the horizontal or lateral component such as convex, central and the concave sections across the water body. Species distribution thus provides information on whether the fish species is pelagic, demersal etc., which will further inform the choice of the fishing gear to be used. Abundance in this context refers to the total catch in number or biomass of the species. Information on habitat and abundance, amongst others, are very vital for fisheries development and management.

Land use and other human activities influence species diversity and abundance (Victor and Dickson, 1985; Victor and Ogbeibu, 1985, 1986). Scott (1966) identified over 250 species of fish landed in the Niger Delta. Chindah and Osuamkpe (1994) studied the fish assemblage of the lower Bonny River of the Niger Delta with its adjourning creeks and observed 25 families consisting of 57 species. Alfred-Ockiya (1996) observed 28 families and 41 species in Kolo creek, Rivers State, Nigeria. Nwadukwe (1995) observed a total of 23 species from 17 families in 2 habitats in the Lagos Lagoon in which 6 species appeared regularly.

4.4.13.2 Study Approach

In this study, fisheries sampling was done between 10th and 11th of July, 2014.The types of fishing gears used in the area were examined, the fishermen operating in the area were approached and their catches were observed. The fish species were classified to family level using some available identification texts like Schneider (1990), Olaosebikan and Raji (1998) and Emmanuel (2009). Some fishing operation pictures were taken to complement the information acquired. The abundance of each species was estimated according to the following criteria as described by Benech et al. (1983):

≥ 10% = dominant

1 to 9% = subdominant

< 1% (but caught more than once) = occasional

< 1% (and caught only once) = rare.

Samples of the fish species from the area were collected with common fishing gears using the local fishfolks, sorted, preserved with ice chest and transported to the laboratory for further analysis. In the laboratory, the fish specimens were identified with the aid of available literatures (Fischer *et al*., 1981; Schneider, 1990; Holden and Reed, 199l; Olaosebikan and Raji, 1998). Fish species were recorded and were classified to their family level.

4.4.12.3 Observation

The fishing gears used by fisherfolks in this area were bamboo traps (Oparun), castnets (obiriki), gillnets (atafo), setnets (Atamu), pole and hooks (Poro), basket traps (Igun/ Ogun), long line (Ewoolokun), Manatee trap (Ipa), Net trap (Keteku) and liftnets (AwoSalapore). The various fishing gears used in Lekkilagoon are described as follow:

Bamboo trap – This trap is constructed from bamboo tree holed with a blunt end (Plate 4-15). It is pegged to the water bed with a pole which served as the marker. It is operated by two able men/women without bait. These traps target *Chrysichthys spp.* The traps are set for 15 days (they are checked two times a month).

Plate 4-15: A - Bamboo trap bundle after fishing B- A group of pegged bamboo traps in Omu creek

Source: Dangote Fertilizer EIA Field Work July 2014

Basket trap: It is used in the sides of the lagoon and the creek, in between the water hycianths (Plate 4-16). They are baited with giant ant nest locally known as *Kukumaye* (Plate 4-17) and raphia fruit (Iregbe) (Plate 4-18).

Plate 4-16: Basket trap used in Lekki Lagoon

Source: Dangote Fertilizer EIA Field Work July 2014

Plate 4-17: Giant ant nest (Locally called Kukumaye) used as bait for the basket trap

Source: Dangote Fertilizer EIA Field Work July 2014

Plate 4-18: Raphia palm fruit used as bait for basket trap (Igun)

Source: Dangote Fertilizer EIA Field Work July 2014

Gillnet- Netting wall hanging vertically in water by the combined actions of the floats (slippers, raphia) attached to the headline and the lead/ stone sinkers attached at intervals of (1.35 – 2.00) metres to the foot rope to sink the net to the water bed while the floats attached at intervals of (1.1 – 1.95) metres to the headline which allow the heads of the net to float thereby maintaining the vertical opening of the net (Plate 4-19).These nets are operated throughout the year (rainy and dry season). They are operated day and night. The departure time at the base for day operation is 6.00 am while that of night operation is at 4.00 pm. The arrival time for day operation is 6.00 pm and 7.00 am the next day for night operation. These net are operated 4 to 5 times in a week and about 16 to 20 times in a month.

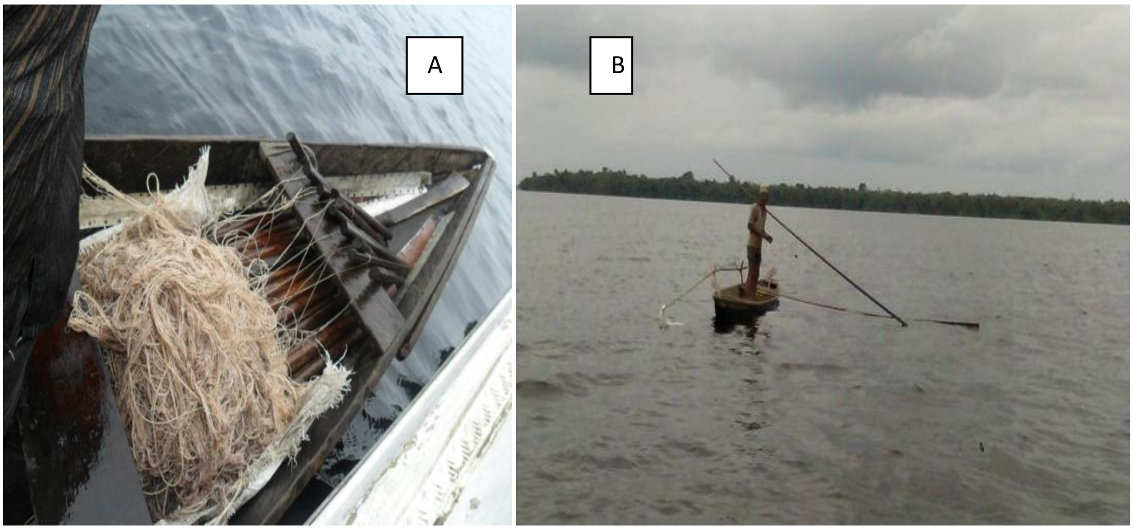


Plate 4-19: A- Gillnet with raphia floats B – A man setting gill net in the Lagoon.

Source: Dangote Fertilizer EIA Field Work July 2014

It is operated mainly by men in the project area, although women at times do participate. They use ratio 3:1 owner to assistant sharing formula for their catches. Other netting materials used for gillnets construction are monofilament polyethylene used for small fishes like *Ethmalosafimbriata, Tilapiaspp, Hepsetusodoe, Hemichromisspp* and so on. These nets can last for 6 to 1 year depend on the maintenance.

Cast nets: it is conical in shape and panels varied from 3 to 4 panels. The sinkers are leads with weight ranging from 46.0 – 86.0 g and are attached to the foot rope at almost regular intervals. The numbers of the sinkers ranged between 71 and 100 depending on the net size. The cast nets are operated between 3 to 4 hours in a day per trip either during the day or at night. This net is operated by both men and women throughout the year. It not species bias because it catches all fishes cover that the girth are bigger than the meshes (Plate 4-20).

Plate 4-20: Castnet operation in Lekki Lagoon
Source: Dangote Fertilizer EIA Field Work July 2014

Longline – It consists of 210D/10 (No.10) main line with No. 9 twine ganglions of variable length (0.25 to 0.35m) spaced 1.5 – 3 m apart. The longline were coiled in round plastic tub or basket with cork rims for fixing the hooks. Each tub contains between 300 and 500 hooks. The most commonly used hook design in the project area was 'Mustard' round bent flattened hooks (Plate 4-21). It is operated throughout the year targeting fish species like *Gymnarchusniloticus, Sphyreana barracuda, Clariasgariepinus*and so on.

Plate 4-21: Long line fishery in Lekki lagoon
Source: Dangote Fertilizer EIA Field Work July 2014

Drum traps – It is constructed using small drum covered with wire gauze. It is operated by placing 1or 2 female *Chrysichthys filamentosus* which make croaking sound to entice the male counterpart (**Plate 4-22**). The small drums are purchased at Idumagbo market at ₦700 per one. These traps can last for between 1 and 2 years depend on the maintenance. It is operated majorly by men in the project area. They used ratio 3:1 owner to assistant sharing formula for their catches.

Plate 4-22: Drum trap operation in Omu Creek

Source: Dangote Fertilizer EIA Field Work July 2014

Pole and hook – it is constructed using poles and hook. It is baited with fish fry, earthworm and *Batangalebritonis*. It is operated by pegging them at the lagoon/ creek banks (Plate 4-23).

Plate 4-23: Pole and hooks ready for operation

Source: Dangote Fertilizer EIA Field Work July 2014

Net traps: It is constructed using polyamide and polyethylene in doomed shape with valve of non – return and framed with sticks and canes (Plate 4-24). The trap is set overnight (5pm to 6am). It either operated by one or two people. The traps are operated 4 times in a week.

Plate 4-24: Net trap made from polyethylene

Source: Dangote Fertilizer EIA Field Work July 2014

Liftnet: It is constructed from mosquito net (0.33mm mesh size) and sticks. It is operated by using light from lantern and generator to attack insects which served as baits for *Pellonulaaf zelluisi* (Plate 4-25). This trap is seasonal and it is used between December and July every year. The net is constructed at ₦2,000 per one. The generator used is fuel with N1000 per night. The catch ranged between 2 to 40 measures (4 litre paint plastic).

Plate 4.25: A typical lift net used in Lekki Lagoon and Omu Creek

Source: Dangote Fertilizer EIA Field Work July 2014

Manatee Trap: The trap is used for catching manatee in the area. Over 12 manatee traps were noticed in the project area during the study (Plate 4-26).

Plate 4-26: One of the Manatee trap around the project area

Source: Dangote Fertilizer EIA Field Work July 2014

The type of boat used in the area are planked and dugout canoe. Out of the 30 canoes counted in the villages around the project area, 95% were planked canoes (Plate 4.27).

Plate 4-27. Planked canoes at Ebute Akodo

Source: Dangote Fertilizer EIA Field Work July 2014

The fish species encountered in the fishermen catches in the study area are shown in Table 4.33: From the assessment of the fishermen catch from the Lekki lagoon, *Chrysichthysnigrodigitatus* was the most abundant species followed by *Tilapia guineensis* (Plate 4-28). Emmanuel (2009) also observed similar high abundance in the two species in the area.

Table 4-33: Fish species composition of the fishermen catches in the project area

Family/Species	Length Range (cm)	Weight Range (g)	Abundance Score
Schilbeidae			
Schilbemystus	6.00 – 12.0	20.0 – 70.0	D
Cichlidae			
Tilapia guineensis	6.00 – 18.00	21.00 – 450.00	C
Sarotherodonmelanotheron	5.00 - 17.00	20.00 – 340.00	C
Hemichromisfasciatus	5.00 – 14.00	18.00 – 160.00	C
Chromidotilapiaguntheriguntheri	6.00 – 10.00	20.00 – 80.00	C
Clupeidae			
Pellonullaleonensis	4.00 – 8.60	14.0 – 34.0	C
Ethmalosafimbriata	5.00 – 10.8	14.0 – 35.0	C

Family/Species	Length Range (cm)	Weight Range (g)	Abundance Score
Mormyridae			
Mormyrusrume	12.0 – 20.0	45.0 – 90.0	D
Bagridae			
Chrysichthysnigrodigitatus	6.00 – 20.0	25.0 – 234.0	C
Chrysichthysfilamentosus	7.00 – 23.00	30.00 – 300.0	C
Claridae			
Clariasisheriensis	10.0 – 24.0	30.0 – 120.0	C
Clariasgariepinus	12.0 – 38.0	50.0 – 800.0	C
Heterobranchuslongifilis	15.0 – 34.0	60.0 – 700.0	C
Characidae			
Brycinuslongipinnis	5.00 – 12.0	23.0 – 45.0	R
Distichodontidae			
Distichodusrostratus	12.00 – 35.0	70.0 – 600.0	R
Elopidae			
Elopslacerta	12.00 – 20.0	34.0 – 98.0	R
Mochokidae			
Synodontisclarias	8.00 – 23.0	23.0 – 98.0	R
Synodontisnigrita	9.00 – 22.5	25.0 – 99.0	R
Sphyraenidae			
Sphyraena barracuda	15.00 – 45.0	67.0 - 1000	R

R = Rear; C = Common; A = Abundance; D = Dorminant.

Source: Dangote Fertilizer EIA Field Work July 2014


Plate 4.28: Fish species caught from Lekki lagoon

Source: Dangote Fertilizer EIA Field Work July 2014

The poor species diversity (19 species) according to Allison *et al.* (1997) was related to human activities such as dredging and the types of fishing gears used (Emmanuel and Kusemiju, 2005). The impact of human activities on species richness has also been reported by Kone*et al*. (2003) in the Go River (Ivory Coast), Gratwick *et al*. (2003) in the Upper Mangame River, Zimbabwe and Allison and Okadi (2009) in the lower Nun River, Niger Delta, Nigeria.

The catch ranged between 4-7 kg/day/person. This is to say between 125–175 kg/month/person; although this catch varies from season to season. The fishermen also alleged that the low catch is primarily as a result of activities of the sand mining activities within the area, which have destroyed the nursery ground of the fishes. In term of the health status of the catch, that is the condition factor, which is the index of the fatness or wellbeing of a species, it can be said that the fishes were healthy.

The major fishing problems in Omu Creek and Lekki Lagoon are crab (*Callinectes amnicola*) attack on gillnets (Solarin, 1998; Emmanuel, 2009), theft of lead sinkers by other fishermen, net destruction by both inboard and outboard engines used for logging and transportation in the area and water hyacinth (*Echhornia crassipes*) infestation that destroy floating nets.

4.4.14 Vegetation Study

4.4.14.1 General

The proposed site of the Dangote Fertilizer project is located within the Lekki Free Trade Zone, Lagos State, Nigeria. It covers a land area of 2,635 hectares. The vegetation is a freshwater swamp forest or flooded forests which are inundated with freshwater either permanently in some part or seasonally in other part. The project site is situated between the Lekki Lagoon and the Atlantic Ocean. The climate is tropical and belongs to Afrotropic freshwater swamp forest. There is an enormous supply of freshwater from inland rivers and run offs from abundant rainfall in the area. The intricate network of creeks and lagoons results in inaccessible swamps of forest vegetation in some parts of the study area.

4.4.14.2 Floristic Composition, Distribution and Density of Vegetation

Terrestrial

The most common species of the study area of Lekki freshwater swamp forest is the raffia palm *(Raffia farinifera*) which dominates the swamps (Plate 4-29). The better-drained area supports oil palm trees (*Eleais guinensis*), coconut trees and vast array of valuable tree species which constitute the dominant layer of closed canopy with few and scattered emergent tree species (Plate 4.30). The ferns, few grasses and herbs constitute the understorey species and occupy the floor of the forest.

Plate 4.29: Swamp forest showing raffia palms

Source: Dangote Fertilizer EIA Field Work July 2014

Plate 4-30: Rain forest showing coconut and other economic trees

Source: Dangote Fertilizer EIA Field Work July 2014

Table 4-34: Tree diversity by families in the study area of Lekki fresh freshwater swamp forest.

S/N	Family	No. of Species
1	*Apocynaceae*	4
2	*Caesalpinoiidae*	1
3	*Euphorbiaceae*	4
4	*Guttiferae*	1
5	*Loganiaceae*	2
6	*Mimosoideae*	2
7	*Moraceae*	1
8	*Olacaceae*	1
9	*Ochnaceae*	1
10	*Palmae*	3
11	*Papilionoidaceae*	1
12	*Rubiaceae*	3
13	*Rutaceae*	1
14	*Sterculiaceae*	1
15	*Unknown*	2
16	*Ulmaceae*	2
	Total	**29**

Source: Dangote Fertilizer EIA Field Work July 2014

A total of 78 plant species belonging to 33 families and comprising of trees, raffia palm, oil palm, ferns and herbs were encountered within the site of the proposed Dangote Fertilizer. The families with the highest frequency of species include *Rubaceae, Euphorbiaceae, Ulmaceae, Apocynaceae, loganiaceae, Guttiferae* and *Mimosoideae* (Table 4.34). Based on 'DAFOR' scale which is an ordinal or semi-quantitative scale for recording the relative abundance of plant species (George *et al.* 2011), the frequent tree species in the study area include *Mitragyna ciliata, Harungana madagascariensis, Raphia farinifera, Elaeis guineensis, Alchomea cordifolia, Celtis Zenkeri, Alstonia boonei, Anthocleista djalonesis, Trema orientalis, Mitragyna stipulosa, Rauvolvia romitoria,Albizia ferruginea* and *phyllantus descoideus.*

Tree species that were occassionally encountered include *Macaranga bateri, Capolobia lutea, Lophira alata, Picralima nitida, Anthocleista nobilis* and *Mitragyna stipulosa*, while the rare species include *Fagara microphylla, Lophira alata, Albizia zygia, Bambusa vulgaris, Uapaca togoensis, Strombosia pustulaca, Cassia nodusa* and *Baphia nitida* **(Table 4-35a).**

Herbs were predominantly abundant in the study area. They were represented by 48 species distributed among 21 families. The families *Asteraceae* was the most diverse with 5 species, followed by *Poaceae* and *Euphorbiaceae* with 4 species each. *Rubiaceae, Apocynaceae* and *Mimosoideae* have 2 species each. Other families which include *Commelinaceae, Sapindaceae, Gultiferae, Zingiberaceae, Cucurbifaceae* and *convolrulaceae* were represented by one species (**Table 4-35b**).

Plate 4-31: Oil Palm Plantation encountered in the study area

Table 4-35a: Relative occurrence of tree species in the study area based on 'DAFOR' scale

S/N	*Species*	Frequency	Status of occurrence
1	*Alstonia boonei*	28	Frequent
2	*Alstonia congensis*	1	Rare
3	*Alchornia cordifolia*	11	Frequent
4	*Anthocleistha djalonensis*	12	Frequent
5	*Anthocleistha nobilis*	4	Occasional
6	*Albizia zygia*	3	Occasional
7	*Albizia ferruginea*	9	Frequent
8	*Bambusa vulgaris*	1	Rare
9	*Baphia nitida*	1	Rare
10	*Carpolobia lutea*	3	Occasional
11	*Cassia nodosa*	2	Rare
12	*Celtis zenkeri*	5	Frequent
13	*Elaeis guineensis*	8	Frequent
14	*Fagara microphylla*	2	Rare
15	*Harunganamadagascariensis*	16	Frequent
16	*Lophira alata*	3	Occasional
17	*Marcaranga barteri*	8	Frequent
18	*Mitragyna stipulosa*	7	Frequent
19	*Mitragyna ciliate*	8	Frequent
20	*Mussanga cecropoides*	1	Rare
21	*Phyllanthus discoideus*	11	Frequent

S/N	Species	Frequency	Status of occurrence
22	*picralima nitida*	3	Occasional
23	*Rauvolvia vomitoria*	10	Frequent
24	*Raphia farinifera*	2	Frequent
25	*Rothmannia megalostigma*	3	Occasional
26	*Sterculia tragacantha*	1	Rare
27	*Stombosia postulate*	1	Rare
28	*Trema orientalis*	16	Frequent
29	*Uapaca togoensis*	1	Rare
	Total	**181**	

***Frequent** – Commonly encountered species*

***Occasional** – Species with low frequency of occurrence*

***Rare** – Species found only once or a very few times.*

Source: Dangote Fertilizer EIA Field Work July 2014

Within the study area, the tree density of frequent species ranged from 260 per hectare to 980 per hectare (Table 4-40). The density of herbs within the study area ranged from 50 per hectare to 1,120 per hectare (Table 4-39). The findings of the floristic composition and plant density in the study area agree with earlier results from similar environment in Nigeria (Agbara and Chimezie, 2011). Similar families have also been reported in tropical forests elsewhere in the world (Deri and Yadara, 2006; Prasad *et al.*, 2007). Diversity studies in ecosystems have become increasingly important to our understanding of the complexity and fragility of the natural world. By quantifying and describing diversity in different habitats, we can identify factors that influence the diversity of species that are supported in an area. Also by comparing biological diversity in a specific area at different points in time, we can examine the effects of natural or human-induced perturbations on diversity within biological communities.

The Shannon-Weiner index of tree diversity in the study area is 1.16 while that of the understorey plants (herbs) 2.26 (Table 4.41). Although the tree species diversity in the study area is high compared to other ecosystems, the diversity index of the understorey plants is 1.9 times higher than that of the tree species. Similar high diversity index was reported for understorey plants in a logged over rainforest ecosystem in Nigeria

(Onyekwelu *et al.,* 2010). These different studies independently confirmed the floristic diversity and richness of tropical forest ecosystems in terms of number of species, genera and families which also typified the vegetation structure observed and being reported for the freshwater swamp forest in Lekki. Even though the plant species diversity is high in the study area, the stem girth measurement of the tree species encountered during the field survey are small ranging between 10 cm and 20 cm dbh, with few trees exceeding 30 cm dbh. The current status of the forest is attributed to high rate of uncontrolled timber exploitation in the freshwater swamp forest where accessibility is permissible.

Table 4-35b: Density of herbs species in the study area of Lekki freshwater swamp forests

Species name	Family name	Species density No/ha
Mitragyna ciliate	Rubiaceae	210
Elaeis guineensis	Palmae	30
Rothmannia megalostigma	Rubiaceae	370
Harunganamadagascariensis	Gittiferae	390
Alchornea cordifolia	Euphorbiaceae	300
Ravolvia vomitoria	Apocynaceae	510
Fagara microphylla	Mimosoideae	210
Baphia nitida	Papilionoidaceae	330
Blighia sapida	Sapodaceae	60
sterculia tragacantha	Sterculiaceae	480
Macaranga barteri	Euphorbiaceae	180
Pentacleithra macrophylla	Mimosoideae	210
Picralima nitida	Apocynaceae	520
Ageratum conyzoidess	Asteraceae	160
Andopogon sp	Poaceae	40
Commelina sp	Commelinaceae	130
Elusin indica	Poaceae	250
Petandra virginica	-	150
Pontederia cordial	-	300
Cephalantus sp	-	180
Aspilia Africana	Asteraceae	120
Brucharia lata	Poaceae	80
Scleria naumanniana	Cyperaceae	250
Veronia sp	Asteraceae	160
Aspilia Africana	Asteraceae	120
Panicum maximum	Poaceae	80
Euphorbia hirta	Euphorbiaceae	300
Portulaca olerecea	Portulaceae	550

Species name	Family name	Species density No/ha
Acanthus monianus	Acanthaceae	80
Mimosa pudica	Mimosaceae	50
Centrosema sp	Caesalpinaceae	80
Phyllanthus amarus	Euphorbiaceae	480
Telfairia occidentalis	Cucurbitaceae	360
Custus afer	Zingiberaceae	1120
Diplazium sammatii	Athyriaceae	520
Emilia sp	Asteraceae	620
Mimosa pudica	Mimosaceae	120
Ipomea sp	Convolvulaceae	60

Source: Dangote Fertilizer EIA Field Work July 2014

Table 4-40: Density of frequent tree species in the Lekki fresh freshwater swamp forest

Species Name	Family Name	Density No./ha
Alchornia cordifolia	*Euphorbiaceae*	650
Harungana madagascariensis	*Guttiferae*	490
Mitragyna stipulosa	*Rubiaceae*	380
Mitragyna ciliate	*Rubiaceae*	460
Raphia farinifera	*Palmae*	980
Elaeis guineensis	*Palmae*	780
Celtis zenkeri	*Ulmaceae*	480
Alstonia boonei	*Apocynaceae*	330
Anthocleistha djalonensis	*Loganiaceae*	420
Trema orientalis	*Ulmaceae*	260
Rauvolvia vomitoria	*Apocynaceae*	500
Phyllanthus discoideus	*Euphorbiaceae*	490
Albizia ferruginea	*Mimosoideae*	600

Source: Dangote Fertilizer EIA Field Work July 2014

Table 4-41: Flora diversity index in the study area of Lekki Freshwater swamp forest

Flora category	Shannon-weiner diversity index
Tree	1.16
Understorey	2.26
Microphytes	0.41

Source: Dangote Fertilizer EIA Field Work July 2014

Aquatic Macrophytes

The aquatic macrophytes encountered during the survey are those at the marginal floral zone. The most abundant in the zone include *Anthopteris palisofi, Cytospermum sensgalense, Ipomea erecta, Echinodoa pyramidalis, Eulophia sp, Ludiriga ereta, Polygonum senegalense, Thalia geniculata* and *Carex ehinochloa*. The macrophytes are important vegetation communities that serve as food for herbivoral fish and some aquatic insects. They therefore occupy an important trophic level in the aquatic food chain.

4.4.14.3 Structure and physiognomy

The vegetation of the study area which is a fresh water swamp forest is luxuriant and the stand is dense. The average stem density (trees 10 cm or above in diameter) was estimated at 356.4 per ha. Wood lianas are apparent and a few monocots such as canes and bamboos are present in some areas. At least three crown layer were distinguishable. The main middle layer is between 15 and 20 m above ground. The top layer consists of few emergent trees whose crown reaches up to 35-40 m. usually these trees are buttressed at the base, have unbranched cylindrical boles and posses an umbrella-shaped crown. The bottom layer consists of shade tolerant species less than 15 m in height (Plate 4-32). It should be noted however that the stratification of the freshwater swamp forests canopy into distinct layers is an abstraction and simplification of a complex structure that is in a dynamic state due to growth of the forest stand. The study area is highly productive but substantial portion have been degraded by illegal logging and slash-and-burn agriculture to establish oil palm plantation and agricultural crop farms.

Plate 4-32: **Forest structure of the study area in Lekki Freshwater swamp forest**

Source: Dangote Fertilizer EIA Field Work July 2014

4.4.14.4 Morphology of the plants

The vegetation ranges from grassy mashes to palm and raffia dominated forest and tree species similar in structure and composition to lowland rainforests. Trees with buttresses, stilt roots and pneumatophores are common in some areas. The trees in this forest type endure prolonged periods of flooding causing the soil to become anaerobic. This pneumatophores which are specialized respiratory structure on the roots assist in respiration during oxygen-poor periods. The mature tree species have smooth bark with white and brown patches with many species having broad leaves. Over 90% of the tree species possess leaves with prominent mid-ribs and veins (Plate 4-33).

Plate 4-33: Physiognomy of Lekki freshwater swamp forest

4.4.14.5 Plant pathology

The plants encountered in the study area are generally healthy except for pockets of pathological problems like chlorotic and necrotic leaf spot diseases recorded which were caused by *cercospora* spp. There was no devastation effects of insect or animal pest observed in the study area. Few of the common diseases observed were in the agricultural fields and they include cassava mosaic caused by virus and bacteria strip on maize caused by pseudomonas (Table 4-36a). It is important to note that the plant communities in the study area are generally in a normal state of health. The disease severity indices revealed that the few diseases encountered in agricultural fields was of very light infections. There was no evidence of endemic vegetation problems. It is pertinent to remark that none of the diseases encountered was unusual either in nature or severity. The few diseases observed are common and are comparable in nature and intensity to those on plant species in similar ecotypes in Nigeria.

Table 4-36a: Pathology status of plant species in the study area during the rainy season.

Plant species	Disease symptom	Causative organisms
Zea mays	bacterial stripe	*Pseudomonas andropogonii*
Manihot esculanta	Cassava mosaic	*Virus*
Musa paradisiaca	Sigatoka	*Pseudomonas andropogonii*
Zea mays	Stem borer	*Weevils*
Elaeis guineensis	Rusts	*Curvularia sp*
Lovoa trichiloides	Parasitics plant attack	*Mistletoe*

Source: Dangote Fertilizer EIA Field Work July 2014

4.4.14.6 Human activities and threat to vegetation

The various anthropogenic activities in the study area include crop farming, fishing logging operation, gathering and collection of non-timber forest products (firewood, leaves, rattan, raffia and palm wine), urban and industrial development. Substantial portion of the forest vegetation has been cleared and converted to oil palm and raffia plantation while other areas suffered slash-and-burn to make way for cultivation of agricultural crops such as cassava, pepper, maize, plantain, banana, rice and leafy vegetables for subsistence of the local people. The forest also provide employment and income to other categories of local people particularly young and middle aged women who are actively engaged in gathering of Abura leaf (*Mitragyna*), *Thaumatococcus* leaf and other rattan for sales. The men folks are also actively engaged in tapping the oil palm and raffia for their natural wine for consumption and for sales.

The creeks and other freshwaters that abound in the forests are important habitat for fishing activities which generate substantial daily income for the local people. Notable members of the men in the communities also engage in hunting activities to capture and kill wildlife for consumption and for sales. They are referred to as local hunters and these activities constitute the main stay of their livelihood. The Freshwater swamp forest is highly desirable to commercial timber activities because of their high stocking level of commercially valuable species. Therefore logging activities are notable human engagement in the study area. There is evidence of indiscriminate and uncontrolled tree felling in the forests, an activity which had drastically degrade the forest leaving it with trees of very small diameter sizes. Heavy presence of urban and industrial activities is notable human activities that have substantially shrunken the entire vegetation coverage of the forests which has been cleared for these activities. The primary threats of the human activities to the vegetation in the study area are deforestation, habitat degradation, loss of plant and animal diversity and change in plant community structure (Plate 4-34).

Plate 4.34: Fuelwood harvesting activities leading to deforestation in the study area

4.4.15 Wildlife

Wildlife is important to the national economy both as a source of meat and as a basis for tourism and recreation. Wild animal meat is the main source of cheap protein in the majority of rural communities in Nigeria. Over 80% of the populations are rural dwellers who depend on bush meat, compared with urban dwellers that depend on ruminant meat (Ajayi, 1971). The wildlife species associated with the study area are the invertebrates represented mainly by insects (Table 4.36b) and the vertebrate animals represented by mammals, amphibians, reptiles and birds (Tables 4.36c and 4.36d).

Table 4-36b: List of invertibratess encountered in the study area during field survey

Scientific name	Common name
Mantis religiosa	Praying mantis
Zonocerus variegates	Varigated grasshopper
Acrae terpicore	Butterfly
Orthetrom branchiale	Dragon fly
Apis mellifera	Honey bee
Anopheles sp	Mosquito
Simulium sp	Blackfly
Glossina sp	Tse-tse fly

Source: Dangote Fertilizer EIA Field Work July 2014

Table 4-36c: Check-list of vertebrates associated with the study area of lekki fresh water swamp forest

Group	Species	Common name	Population status
MAMMALS	*Tragelaphus spekei*	Sitatunga	+
	Tragelaphus scriptus	Bush buck	++
	Cercophitecus mona	Mona monkey	+++
	cercophitecus nictitans	Putty nose monkey	+++
	Thryonomys gregarianus	Cane rat	+++
	Potamochoerus porcus	Red river bog	+
	Atherus africanus	Porcupine	++
	Manis tricuspis	Pangolin	++
	Cephalophus maxwellii	Maxwells duiker	+++
	Choeropsis liberiensis	Pigmy hippo	++
	Civettictis civetta	Civet cat	+++
	Funiscinrus spp	Tree squirrels	+++
	Xerus erythropus	Ground squirrels	+++
	Dendrohyrax dorsalis	Tree hyrax	+++

	Perodicticus potto	Potto	+
REPTILES	*Veranus niloticus*	Monitor lizard	++
	Osteolalaemus tetrapis	Dwraf crocodile	+
	Bitis gabonica	Gabon riper	++
	Echis pyramidium	Egyptian saw-scaled riper	++
	Naja nigricolis	Spitting cobra	++
	Dendroaspis angusticeps	Green mamba	+++
	Python regius	Royal python	+++
	Monamona	puff adder	+
AMPHIBIA	*Bufo bufo*	Toad	+++
	Rana sp	Frog	+++
	Platysternis sp	Water turtle	+++
	Achatina sp	Snail	+++
	Testudinus sp	Tortoise	+++

Key

+ *Present*

++ Common

+++ Abundant

Source: Dangote Fertilizer EIA Field Work July 2014

Table 4-36d: Check-list of birds associated with the study area of Lekki freshwater swamp forests

Scientific name	Common name
Mitrus migrans	Black kite
Treron calra	Green pigeon
Streptopelia semitorguata	Red-eye dove
Stretopelia senegalensis	Laughing dove
crinifer piscator	Plantain eater
Gypohierax angolensis	Vulture
Tockus nasutus	Gray hornbill
Circus spp	Mash hamer
pteronetta hartlanbii	Hartlanb's duck
Charadrius tricollaris	Three banded flover
Vanellus leucurus	White tailed lapwing
Ixobrychus starmii	Little bittern
Ciconia episcopus	Abdimis stork
Phalacrocorax africanus	Comorrant
Alcedo cristala	Malachite kingfisher
Cery lerudis	Pied kingfisher
Halcyon malimbica	Blue-breasted kingfisher
fendrocygna viduata	White face whisling duck
Bycanistes fistulator	Piping Hornbill
Treoncalca sp	African Green pigeon
Lonchura bicolor	Black and White Mannikin
Actophilornis africana	Africana jacana
Merop pusillus	Little bee eater
Malibuss cutatus	Red vented malimbe
Andropadus viriens	Little greenbul

Source: Dangote Fertilizer EIA Field Work July 2014

4.4.15.1 Insects

The species of insects encountered in the study area include *Mantis religiosa, Zonocerus varigatus, Apis mellifera, Acrae terpicore* and others (Plate 4-35). Insects population is the key to ecological balance of any ecosystem particularly the trophic levels. In particular they forage on terrestrial and aquatic weeds while they also serve as food (prey) for other carnivorous invertebrates and vertebrates including birds. In a study conducted in the rainforests of Nigeria, insects in the order *Orthoptera, Coleopteran, Odonata, Hemiptera,* and *Lepidoptera* were isolated from three specimens of chameleons (Akani *et al, 2001).* Others such as mosquitoes constitute health hazards by spreading malaria fever among the forest dwelling communities.

Plate 4-35: A typical insect from the study area found during the field study

Source: Dangote Fertilizer EIA Field Work July 2014

Plate 4-36: Macrofaunna species encountered in the study area

Source: Dangote Fertilizer EIA Field Work July 2014

4.4.15.2 Mammals

Many species of animals in the mammalian category were associated with the study area of Lekki fresh water swamp forests. Some of the abundant species include *Cercophitecus mona* (Mona monkey), *Thryonomys gregarianus* (cane rat), *Funiscinrus* spp. *Cephalophus maxwelli* (maxwells duiker), *Choropsis liberiensis* and others (Table 4-44). There are no studies in Nigeria to show the role of aquatic mammals in the preservation and disturbance of fresh water ecology. However, it is often reported in National newspapers about the menace of hippopotamus on farmlands, and to fishing communities. These events have often necessitated the intervention of the armed forces to kill such nuisance animals.

Some animals such as otter, civet, genet and mongoose feed on fish and small aquatic animals. They therefore play some role in the population dynamics of such aquatic fauna. Bacterial diseases particularly those caused by pseudomonas sp can be transmitted to fish via the droppings of aquatic mammals which contaminate the environment and increase the risk of zoonotic bacterial disease of fish. The large mammals such as hippopotamus, otter, bush buck and others serve as important local sources of bush meat especially during the dry season (December to April). Their meat is also an important international trade commodity because of the considerable demand for the meat. These animals are also hunted for other products such as their skins for leather, their cartilaginous parts, faeces, skin and hoofs for traditional medicine

4.4.15.3 Amphibians

The amphibian groups are represented by *Bufo bufo* (Toad), *Rana sp* (Frog), *Platysternis* sp (Water turtle) and *Testudimus sp* (Tortoise) (Table 4-44). The Amphibians are the dominant group of aquatic vertebrates other than fish in terms of their numbers and distribution, particularly the frog and toads .The *Rana* sp (frog) are edible in Nigeria and are harvested as wild bush meat from ponds and waterlogged areas in both rural and urban centres. Dried, skinned meat of frogs and fresh frogs has been found useful in the feeding of catfish and poultry either as raw materials for processed feed or whole as food for catfish. In Nigeria, it is a common practice for fish farmers to supplement the feeding of *Clarias* sp, and *Heterobranchus bidorsalis* in pond culture by feeding them frogs and toads

4.4.15.4 Reptiles

The reptiles associated with the study area include *Veranus niloticus* (monitor lizard), *Osteolaeleamus tetraspis* (dwarf crocodile) and many snakes species which include *Dendroaspis angusticepts (*green member) *Python regius* (royal python),*Bitis gabonica* (gabon viper) were particularly abundant in the study area (Table 4-44). Among this group of animals are those that feed on fish and those that feed on fish predators, including snakes. While crocodiles and terrapins are among the first group and spend most of their time in water, the tortoises, monitor lizards and snakes spend a greater part of their time on land near water .They all however, contribute to the biological function of the aquatic community. Crocodiles, terrapins and monitor lizards feed on fish while snakes feed on frogs, toads, lizards, and small rodents that inhabit water bodies. Active predation among these groups of animals therefore contributes to the stabilization of the animal communities. Crocodiles and monitor lizards are hunted extensively, even to the point of extinction, for their meat and skins which are important foreign exchange earners. The high demand for crocodile skins, meat and body parts for traditional medicine certainly have contributed to the noticeable decline in their populations in Nigeria. Arround the late 1960s, most large bodies of water in Nigeria harbored crocodiles, but now both crocodiles and monitor lizards are listed as threatened species in Nigeria (Ebin, 1983, Anon,1986) (**Table 4-36e).**

Table 4-36e: Status of some wildlife in the study area with respect to threats of availability

Common name	Species	Endemic	Endangered
pigmy hippo	*Choeropsis liberiensis*	Yes	Yes
Dwarf crocodile	*Osteolaemus tetraspis*	Yes	Yes
Monitor lizard	*Varanus niloticus*	Yes	Yes
Royal python	*python regius*	Yes	Yes
Frog	*Bufo bufo*	Yes	Yes

Source: Dangote Fertilizer EIA Field Work July 2014

4.4.15.5 Birds

Birds are one of the best known faunal group in the world (Tvardikova, 2010). They are ecologically highly diverse and inhabit wide range of habitats. They are frequently used taxa to indicate the effects of environmental changes (Carignan *et al*, 2002). Several birds were encountered in the study area. They include *Treron calva* (green pigeon), *Streptopedia semitorguata* (Red-eye dove), *S.senegalensis* (laughing dove), *Tockus nasutus* (Gray hornbill), *Crinifer piscator* (plantain eater) and many others (Table 4-45). The presence of feathers in birds has distinguished the class and with the advantage of high mobility and their extraordinary hardness made them to be described as earth's ambassadors as they do not recognize human boundary except those set by nature (Matthews, 2008). While in many countries, aquatic birds are hunted for sport, in Nigeria they are predominantly regarded as a source of meat (Ajayi, 1971). Waterfowl and other large birds such as *Golliath heron* and fish eagles are hunted around River Niger and Lake Kainji (Okaema *et al;* 1988). The Lekki fresh water swaps forest where the study was conducted is an important habitat for birds for drinking, feeding, resting, sheltering, nesting, rearing of young, foraging and social interaction.

4.5 Socio-Economics Study

4.5.1 Communities in Dangote Fertilizer Project Area

During field survey, the captive communities around Dangote Fertilizer project area were enumerated. These communities include:

1. Idasho
2. Imobido
3. Olomowewe
4. Idotun
5. Okesegun
6. Ilege
7. Itoke
8. Magbonsegun
9. Okunraye
10. Okenata
11. Elekuru-Lasia
12. Okun Tiye

These 12 communities were captured in an MoU that was signed with the LFZDC (LFZ EIA Infrastructure Report, 2010). It should be noted that 9 communities initially signed this MoU (Appendix 5). However, the other three have been incorporated (LFZ EIA Infrastructure Report, 2010).

The following report assesses and documents the socio-cultural and economic conditions, environmental problems, developmental challenges and needs of the communities in the project area.

4.5.2 Governance

Communities within Dangote Fertilizer project area are governed by traditional rulers otherwise called Baales. Each Baale rules his community with his Chiefs-in-Council. The Council is responsible for all administrative, customary issues and conflict arbitration. Thus, in these communities, leadership structure is made up of the traditional rulers, religious leaders, youths and women leaders. Traditional leaders usually initiate and approve projects for implementation while religious; youths and women leaders assist in sensitization and mobilization of community members for fund raising. In each community, there is a Community Development Committee (CDC) whose concern is on community development advocacy and project/programme implementation. Youth Council with an elected president and executive is usually responsible for law enforcement, social and environmental development in each communit. No doubt, the observed leadership structure in the communities is a useful tool for mobilizing residents for increased participation in decision making, planning and implementation of development programs and projects.

The various self-help projects (construction of schools, health clinics, plank jetty, foot bridges etc) executed in the various communities surveyed coupled with the existing cooperation among the inhabitants throw up the fact that community participation is a cross-cutting issue and there is already a high awareness of the need to develop these communities. This would definitely give stakeholders in community development a soft landing in terms of their intended intervention programs.

In general, the project area is relatively peaceful as youth restiveness is hardly reported. Conflicts between and among communities are unusual. Wherever conflict occurs, the existing traditional norms and administration are sufficient to resolve them as evident by the few court cases ever reported in these communities.

4.5.3 Basic Demographic Features

4.5.3.1 General Characteristics

The population of the people in the Dangote Fertilizer project area comprises mainly of the Ijebus (82%) who have settled in the Ibeju-Lekki LGA of Lagos State over the years. Other Nigerian tribes like the lIajes, Ijaws, Calabars, Hausas and Igbos (11%) are also resident in these communities. Few Ghanaians, Togolese, Cameroonians and Beninois (7%) are currently resident in the various communities in the project area (Figure 4-45). Most of these foreigners reside within this LGA in their attempt to foster their traditional occupation (fishing). In the recent time, the LGA continues to attract the attention of people because of the upcoming Lekki Free Zone and its natural beaches that promote recreation.

The predominant language in the project area is Yoruba with Ijebu dialect as most of these people migrated from Ijebu Land and a few from Ile-Ife. Other settlers in these coastal villages are also believed to have migrated from Epe Town, an Ijebu community.

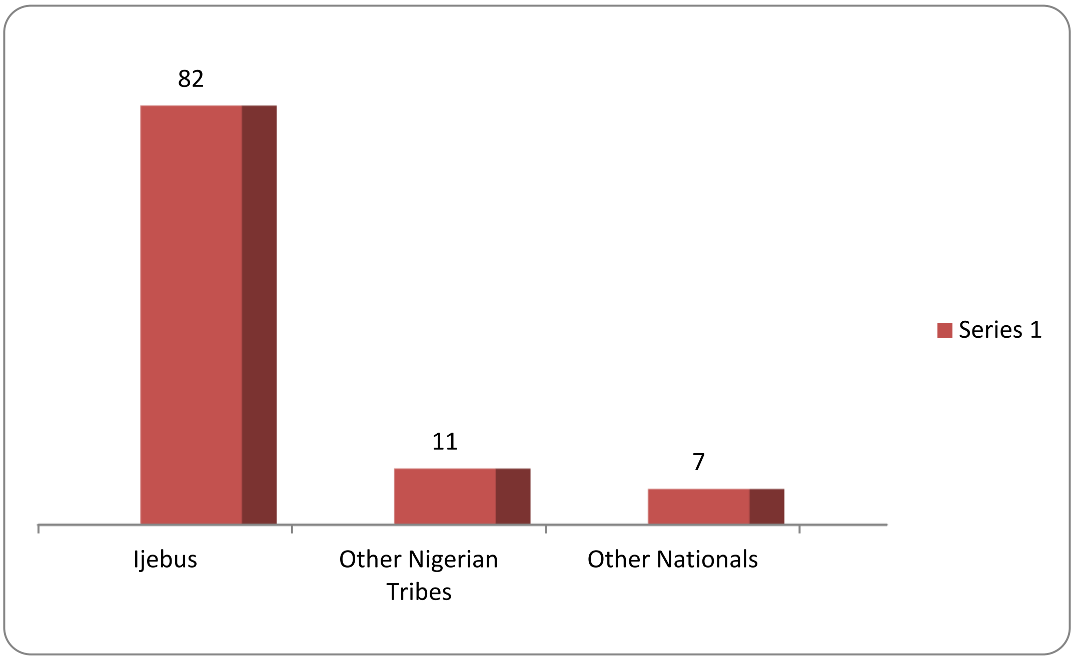


Figure 4-46: Community Status

Source: Dangote Fertilizer EIA Field Work July 2014

Seventy four percent (74%) of the respondents have lived in these communities since birth, 14% have lived between 11 and 20 years, 7% between 6 and 10 years and 5% less than 5 years (Figure 4-46).

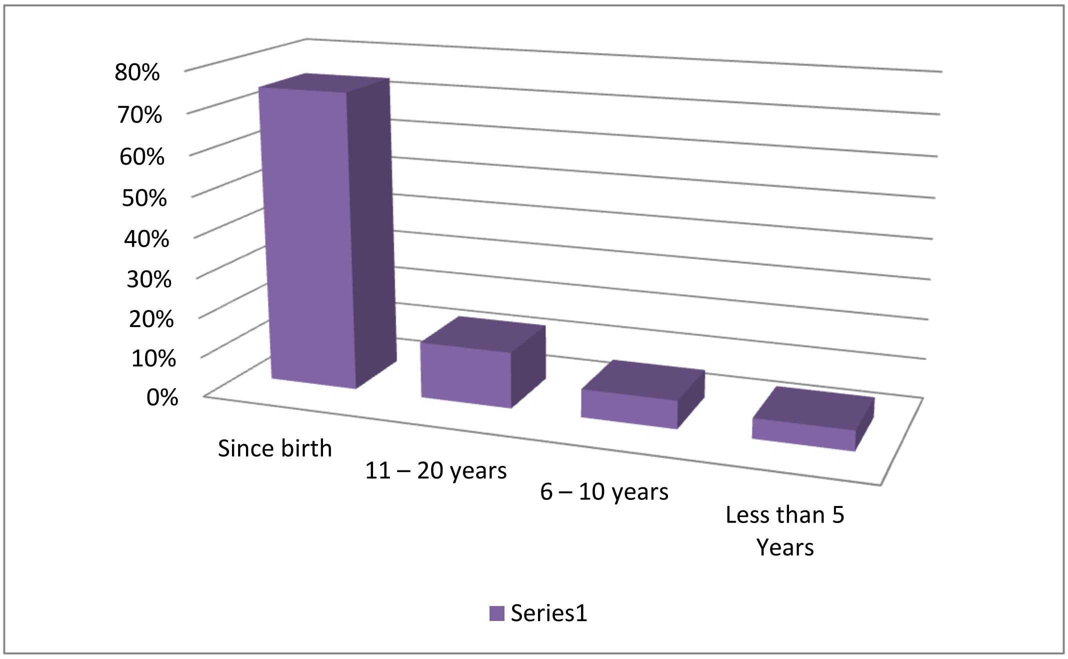


Figure 4-47: Length of Stay in the Community
Source: Dangote Fertilizer EIA Field Work July 2014

4.5.3.2 Population and Housing

Ibeju-Lekki LGA has a total population of at 117,481 (2007 National Population Census). This is comprised of 59,544 males and 57,937 females. The sex distribution of the LGA currently agreed with national average, which puts the ratio of male to female at about 51%: 49%.

For the captive communities, this study relies on housing estimate and average number of persons per housing unit. In general, 2,087 housing units were observed in the project area. Based on the estimated average number of persons per household, a total estimated population of 35,380 was derived for the study area (Table 4-47). In anticipation of the upcoming booming economic activities usually associated with Free Trade Zone, the proposed project is expected to further accelerate the population growth in the study area. This in addition may disrupt sex ratio, since more able-bodied men are likely to immigrate into the area, in search of jobs and employment opportunities. Thus, there may be a further skew in favour of the male population.

Table 4-47: Population, Housing Units and No. of Persons per Housing Unit in Dangote Fertilizer Project Area

S/N	Community	No. of Housing Units (A)	Average No. of Persons per Housing Unit (B)	Estimated Population (A* B)
1	Idasho	600	15	9,000
2	Imobido	75	20	1,500
3	Olomowewe	70	25	1,750
4	Ilege	87	25	2,175
5	Okesegun	40	15	650
6	Magbonsegun	150	15	2,750
7	Itoke	40	10	500
8	Okun Tiye	200	20	4,000
9	Okunraiye	700	15	10,500
10	Elekuru Lasia	30	25	750
11	Okenata	30	20	700
12	Idotun	65	17	1,105
		2,087		**35,380**

Source: Dangote Fertilizer EIA Field Work July 2014

4.5.3.3 Household Size

The family type in the communities of the project area indicated that 26% of the respondents had a nuclear family type while 30% had extended family type. The average number of person per household is 19 persons with 41% having family size of 10–15 persons. Twenty percent (25%) of the respondents had family size of 16–20 persons while 34% had a family size of 21–25 persons (Figure 4-47). Thus, there is an apparent overcrowding in these communities. This situation might further deteriorate with the upcoming activities in the Zone if deliberate efforts are not made to increase housing stock in these communities.

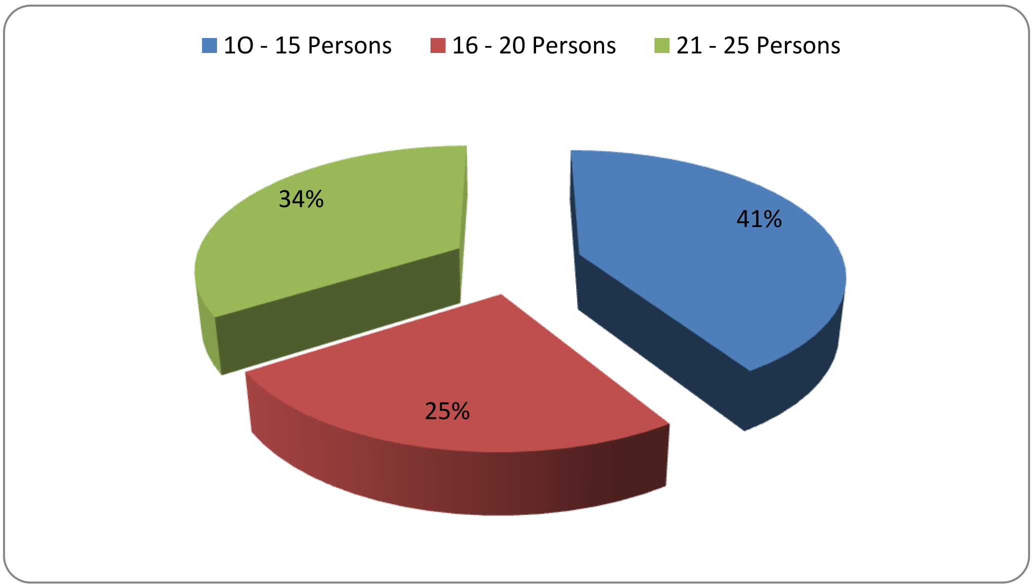


Figure 4-48: Household size
Source: Dangote Fertilizer EIA Field Work July 2014

4.5.3.4 Age-Sex Distribution

In these communities, adult population (18–45 years) constitutes 50% of the total population. 10% are above 45 years while 40% are below 18 years (Figure 4-48). The implication of this is that the communities have able-bodied labour force that could participate actively in the various productive activities that will take place in Dangote Fertilizer. On the average, females constitute about 55% of the population in these communities.

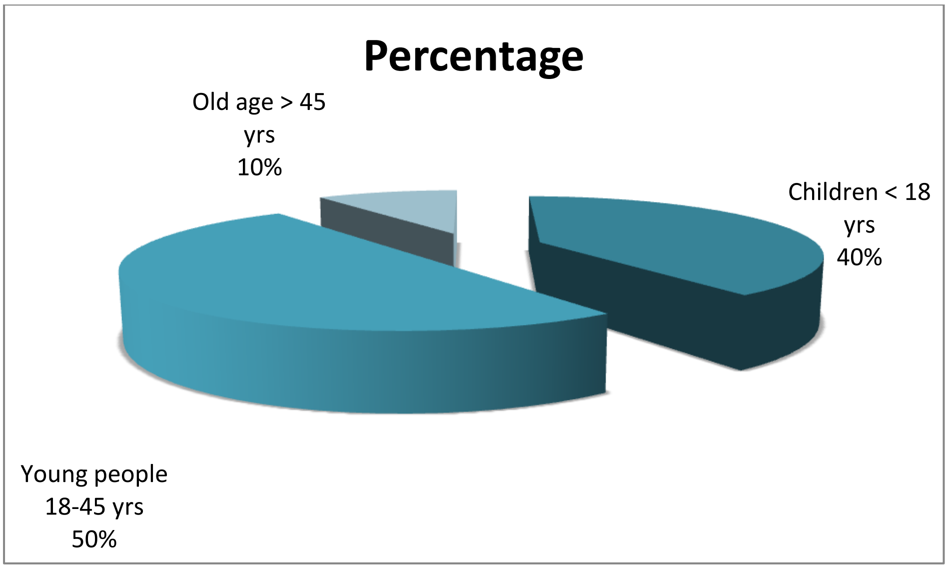


Figure 4-49: Age Distribution

Source: Dangote Fertilizer EIA Field Work July 2014

4.5.3.5 Marital Status

Married people account for 54% which constitutes the majority of the respondents while 33% are single, 9% divorced/separated and 4% are widow/widower (Figure 4-49). Polygamy constitutes over 65% of the married population as indicated in the marriage pattern of these communities while monogamy accounts for 35% (Figure 4-50). The high proportion of the polygamists could be accounted by the Muslims that dominate the population. It was further observed that there was no evidence of family planning in these communities as although the various birth control measures appear known but rarely practised.

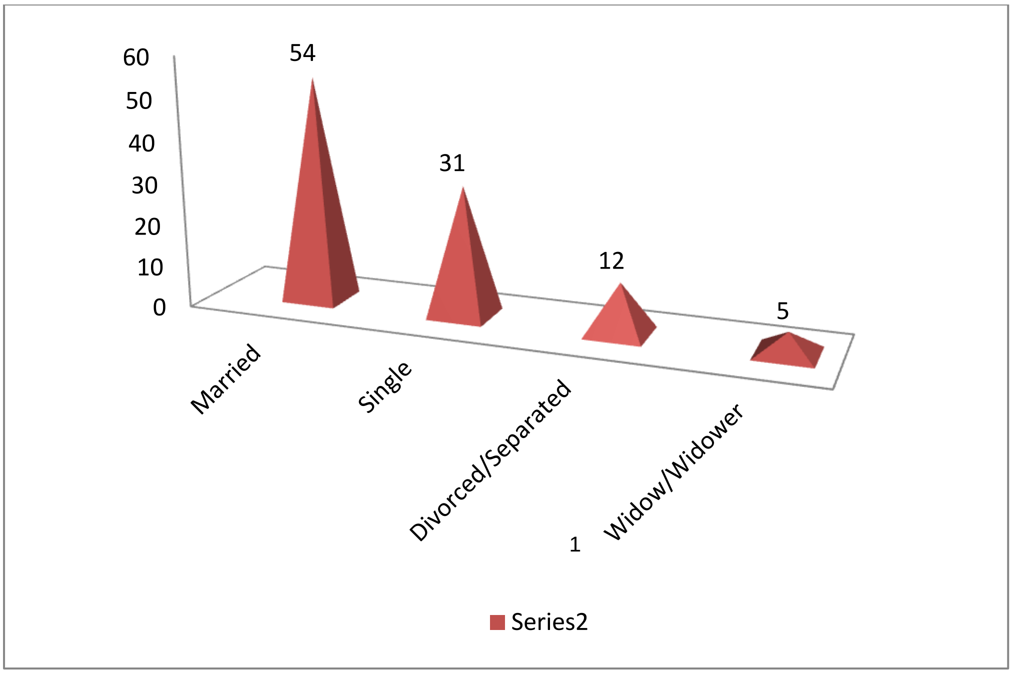


Figure 4-50: Marital Status

Source: Dangote Fertilizer EIA Field Work July 2014

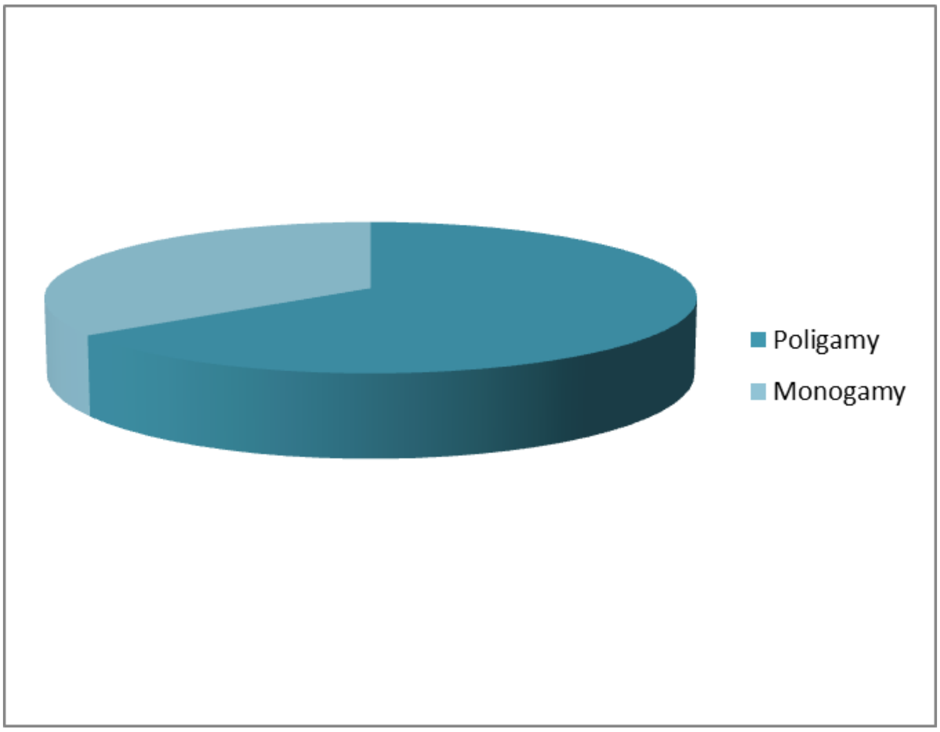


Figure 4-51: Marriage Pattern

Source: Dangote Fertilizer EIA Field Work July 2014

4.5.4 Social Environment

4.5.4.1 Religion and Culture

The dominant religion in study area is Islam (60%), while Christianity constitutes 22% and Traditionalists about 18%. It was revealed that some of the Chrisitans and Moslems combined their beliefs with traditional religion. Predominantly Muslim communities in the area are Olomowewe and Okesegun while Ilege is dominated by the Traditional religion (70%). I

The notable festivals in the area include Etutu Ilu, Obaluwaye, Aaye and Iye Moo, Oluweri, Egungun, Oro, Ogun, Ogun-Ajobo, Ota, Eyinbi, Odun-ota, Odun-Ikele, Odun-moko, Odun-Eriyo, Oya and Sango among others. Near cross-cutting celebrations in these communities are the Muslim Festivals of Eid-El Mulud (Itunu Aawe) and Eid-El Kabir (Odun-Ileya) since most of them are Muslim dominated communities.

These festivals are celebrated with pomp and pageantry and have spiritual, traditional, socio-economic and financial implication for both the indigenes and settlers. Traditional festivals offer opportunities for the people to seek divined favour, prosperity, bumper harvest, peace, security, long lives and good health for the communities.

Sacred places exist in these communities. Some of these are documented in Table 4-48. Most of these places could only be accessed at designated time of the year and by selected group of people especially the initiates. Unauthorised entry could be visited with death or terrible calamities. While some of these sacred places are grounds for traditional prayer and offerings, others serve as incarceration grounds for those who have confessed of evil doing and who the deities of the community recommend should be so confined. Some of these shrines and sacred places fall within the LFZ and the project area and would therefore need to be relocated for traditional and cultural preservation.

Table 4.48: Sacred Places/Shrines and Festivals in DANGOTE FERTILIZER Project Area

S/N	Community	Sacred Place/Shrines	Festivals	Participants
1	Idasho	Igbo Omowoko, Igbo Oro (Iye Moo), Oogbe	Etutu Ilu, Obaluwaye, Aaye, Iye Moo	Male and female adherents
2	Imobido	Oluweri (Water goddess)		Majorly women

		Lasu		Male and female initiates
3	Olomowewe	Ojuota, Ojuodumo	Ogun-ajobo, Eyinbi,	Male and female initiates
4	Ilege	Igbo Omowoko, Igbo Oro (Iye Moo), Oogbe	Odun oro, Odun ota, Odun Ikele, Odun moko, Odun Eriyo	No restrictions for participation
5	Okesegun	Igbo oro, Yemoja		Male and female initiates
6	Itonke	Oluweri (Water goddess), Okesa	Ogun, Oya, Sango	Participations are restricted to only indigenes
7	Okun Tiye	Agbe, Ileje, Eriyo, Moko, Ekine	Annual festivals of the gods and goddesses	Male and female initiates
8	Magbonsegun	Egun Omolara, Sango-dore, Esu, Igbo Ore	Ogun, Agbo-agidi, Aiye-ota	Male and female initiates

Source: Dangote Fertilizer EIA Field Work July 2014

4.5.4.2 Land Tenure

The prominent forms of land ownership in the communities are family and personal land tenure. At the death of the family head, the family land is shared amongst the children. Most of the inhabitants engage in subsistence agriculture on their inherited pieces of land. Some portions of land also usually belong to the traditional institutions. As is common with most societies, for development purpose, overriding communal interest supersedes personal or family land ownership. This was confirmed during survey as communities express their desire to willingly release their land for development purposes.

4.5.4.3 Conflict Resolution

Civil cases in the communities are arbitrated by the Chiefs-in-Council, Elders-in-Council, religious leaders, traditional priests, age grade, women groups or family heads. On the other hand, inter-communal conflicts are resolved by the representatives (Chiefs) of the communities involved. If it cannot be resolved at that level, the case is taken to the Paramount ruler for adjudication. Criminal cases are referred to the government law enforcement agents. It is of interest to note that most of these communities have never recorded any case of security threat. Nevertheless, the communities have organized themselves into vigilante groups to sustain the existing security of lives and properties.

With respect to project development, conflicts may arise as a result of issues surrounding companies' establishment or fueled by them. Usual causes of conflict between communities and companies include:

- Non-recognition of communities as critical stakeholders
- Borderlland disputes
- Agitation for employment
- Refusal of companies to repair damaged roads
- Non-payment of compensation
- Non-compliance with court rulings and orders
- Failure to honour MOUs
- Perceived intimidation of the communities
- Perceived "divide and rule tactics"
- Ineffective communication channels

This study did not find any specific current issue that could conceivably lead to full blown conflicts with Dangote Group. However, agitation remains for the creation of job opportunities and the need to honour MOUs signed with the communities. Dangote Fertilizer Limited should build on the existing cordial relationship between her and these communities through enhanced continuous engagement. It is however canvassed that the company should carefully study the existing conflict resolution strategies in these communities for adoption since conflicts are better resolved at this level for sustained peace rather than adjudication in the court of law.

4.5.5 Economics and Livelihoods of Households

4.5.5.1 Occupation

Ibeju-Lekki LGA is the most rural Local Government Area in Lagos State and is therefore characterized by rural economy. The economic life of the communities revolves mainly around water especially *fishing* (LFZ EIA Report, 2010). The survey reveals that fishing is the most prominent (49.1%) incomes generating activity in Dangote Fertilizer project area. This is because of the predominantly aquatic topography of the communities in the area. Such locational decision was perhaps an attempt to support this occupation. Most of the women in these communities are also mainly engaged in fishing but primarily crayfish, picking periwinkle, fish mongering and fish smoking.

However, the agriculturally rich swampy forest zone of this area supports farming as 19.7% of the households are engaged in this occupation (Table 4-49). The project area is a veritable food basket as the terrain is ideally suited for agriculture. The most commonly cultivated crops in these communities includes cassava, maize, rice, banana, okra, pepper and vegetables. Fruit trees are also cultivated in this area. They include mango, cashew, guava among others. The area is also blessed with oil palm products and different species of timber. Thus, oil processing is common while lumbering is also widespread in the area.

Other occupations in the project area include livestock, boat construction, local gin distilling, artisanship, trading, produce processing, hunting and gathering of timber and non-timber products.

Plate 4-38: Cassava is one of the common farm products in the project area
Source: Dangote Fertilizer EIA Field Work July 2014

In these communities, males are mainly involved in fishing especially in the open sea, while the females are involved in fish processing and fishing in the immediate waters. It should be noted the nearness to the Atlantic Ocean, have given these communities a sort of comparative advantage in fishing which could constitute a launch pad for their socio-economic development.

Plate 4-39: Coconut plantations abound in the project area
Source: Dangote Fertilizer EIA Field Work July 2014

A few men in these communities also combine hunting with farming. Some inhabitants of these communities especially women also engage in raffia weaving, mat weaving and weaving of Aso Oke. However, some inhabitants are also engaged in artisanship like tailoring, carpentry, brick laying, art and craft. The state of artisanship in the communities is worrisome as critical trades that may be required in the plant are in short supply. Such trades include: electrical, refrigeration and air conditioning, welding among others. There is the need to encourage and integrate these trades into the economic milieu of these communities for them to effectively engage in the upcoming activities in the plant if a situation like that of the Niger Delta on Nigeria, the hot bed of crisis, is to be avoided.

Table 4-49: Types of Occupation in Dangote Fertilizer Project Area

S/N	Occupation	Frequency (%)
1	Fishing	49.1
2	Farming	19.7
3	Fish Processing	9.2

4	Livestock	1.2
5	Boat Construction	0.5
6	Local Gin Distilling	1.5
7	Artisanship	1.6
8	Produce processing	3.4
9	Trading	2.7
10	Art and Craft	1.5
11	Gathering of Timber and Non-Timber Products	1.3
12	Civil Servants	8.3
		100.0

Source: Dangote Fertilizer EIA Field Work July 2014

Plate 4-40: Fish processing is a common economic activities among the female dwellers

Source: Dangote Fertilizer EIA Field Work July 2014

4.5.5.2 Income

The income generating activities of the people in the communities of the project area include crop farming, trading, artisanship, livestock rearing, processing of farm produce, hunting, fishing among others. Income level is rather too low in the area. About 89.5% of the respondents earn below N500, 000 per annum while 10.5% earned above N500, 000 per annum from all sources combined (Table 4-50).

The major hindrances to the economic development identified in the study area include low patronage of fishing and crop farming produce, lack of storage facilities for safe keeping of unsold fishing products, inadequate credit facilities to expand businesses, poor access road that hinder intra mobility and inadequate safe drinking water. It is pathetic to observe that fishermen do often throw back their catch to the sea for lack of storage facilities during low patronages. The rural access roads are usually inaccessible during the wet seasons thereby hindering their movement to the market. This results into large scale post harvest loss. In addition, Agriculture Extension Officials from the State Ministry of Agriculture seldomly visit the farmers while the introduction of improved seedlings and modern implements are at the lowest ebb. Through the Corporate Social Responsibility (CSR) programmes of the proposed project, these economic hindrances to a large extent could be addressed.

The project area has a great potential in tourism. This potential is lowly exploited as the beaches are mostly used by religious adherents. If the tourism and recreational potentials of the area can be facilitated, it will go a long way to expand the income generating base of the community.

Table 4-50: Income Level in Dangote Fertilizer Project Area

S/N	Annual Income (N)	Frequency (%)
1	Less than 100,000	10.2
2	100,000 –199,999	17.6
3	200,000 – 299,999	11.2
4	300,000 –399,999	42.5
5	400,000 –499,999	8.0
6	500,000 +	10.5

Source: Dangote Fertilizer EIA Field Work July 2014

In summary, basic challenges to income generating activities in the project area include:

- High cost of transportation;
- High level of post-harvest loss;
- Lack of access to credit facilities;
- Lack of productive inputs and inadequate extension visitation;
- Poor storage and processing facilities, and
- High cost of labour among others.

As pointed out earlier, it was observed with grave concern during the social survey that fish are often wasted or thrown back to the sea during bumper harvest as a result of lack of storage facilities. Dangote Fertilizer and other development partners including governments should take cognisance of this issue in their bids to enhance the economic growth and empowerment of this community in a sustainable manner.

Globally, cooperative societies are becoming a formidable instrument to economic emancipation among the rural economies. Paradoxically, their operation in this area is still at the infancy as they are only found in Ilege where they have Omowumi, Oredegbe, Double star, Omolere cooperative societies. However, some savings/credit societies and occupational groups exist in most communities. Over the years, these groups have positively impacted on the financial capability of the inhabitants through provision of financial assistance to improve their level of production. It is envisaged that the groups will provide a strong base for effective community participation in any strategic intervention by stakeholders in community development, as they would be critically required in identification of development need and approaches for meeting such needs. However, it is desirable if these existing economic groups could consciously scale-up to cooperative societies.

4.5.5.3 Employment

Less than 20% of the population of people who have attained 18 years and above are gainfully employed, hence the unemployment rate is generally high in all the communities. Greater percentage of the youths in the communities claimed to be unemployed because those who are engaged in fishing crop farming did not regard fishing and farming as their primary occupation. With this level of unemployment in the communities, there is great potential for increased social vices such as bullying, prostitution, armed robbery etc. This unemployment scenario is instrumental to the wide acceptance of the proposed Dangote Fertilizer Plant project as the unemployed believed that the project would offer them necessary succour.

4.5.5.4 Industry

The project area has very little industrial presence. However, few ones are upcoming especially within the Zone. Prominent among this is Cadmwell Nigeria Ltd. This is inspite of the vast area of land and water with which the area is endowed. Community members and leaders are appealing to the Government, manufacturing companies and individuals especially the natives to site industries in the communities even if on a small scale. Traditional arts and crafts that are present in the area are essentially small cottage industries whicy include garri processing, oil palm processing, fish processing and weaving. The proposed Dangote Fertilizer is greatly desired by the communities.

4.5.5.5 Access to Productive Assets

A principle of non-excludability is in vogue in all the communities with respect to access to natural resources which include the rivers, creeks, the mangrove forest and the Atlantic Ocean. In addition, such access is without any encumbrance. However, when a natural resource or the immediate environment surrounding is declared sacred, it automatically becomes restricted and in this regard no community person has the right to exploit it.

4.5.6 Social Infrastructure

4.5.6.1 Educational Facilities

Field survey and responses of the inhabitants of the communities revealed that the communities in the project area are grossly deficient with respect to educational infrastructure. Most of the communities in the study area only have access to government owned primary while secondary school pupils travel distances of 3 – 4 km to bigger communities to obtain secondary education as only two communities (Magbonsegun and Idotun) have secondary schools (Table 4-51). The manpower in virtually all the schools is inadequate with high teacher/student ratio of over 1:40. All exisitng schools lack basic facilities like water supply and toilet. In addition, instruction materials are grossly inadequate. The pressure placed by the inadequate educational facilities often compel some parents with children of secondary school age to send their children to relatives and friends in bigger towns in order to access secondary school education.

Table 4.51: Educational Facilities in the Project Area

Communities	Primary School	Secondary School	Tertiary Institution	Adult Literacy
Imobido	1 (private)	Nil	Nil	Nil
Ilege	1	Nil	Nil	Nil
Idasho	Nil	Nil	Nil	Nil
Okesegun	Nil	1	Nil	Nil
Magbonsegun	Nil	1 Senior Secondary School (SSS1 – 3)	Nil	Nil
Itonke	Nil	Nil	Nil	Nil
Okuntiye	1	Nil	Nil	Nil
Olomowewe	1	Nil	Nil	Nil
Alasia	Nil	Nil	Nil	Nil
Okunraiye	1	Nil	Nil	Nil
Idotun	1	1 Junior Secondary school (JSS1 – 3)	Nil	Nil
Okenata	Nil	Nil	Nil	Nil

Source: Dangote Fertilizer EIA Field Work July 2014

As at present there is no single tertiary educational institute in the project area. In addition, there is no adult literacy school in any of these communities which could have helped stemmed down the high rate of illiteracy level among adults, neither are there vocational schools that would have enhanced availability of skilled and trained artisans. Artisanship is critical to the continuous integration of these communities with the upcoming projects in LFZ including the Denote Fertilizer.

In general, educational status among these communities is rather too poor as only about 30% of the males attended primary schools, 25% attended secondary schools while less than 10% had tertiary education. Also, less than 20% of the females attended primary school, while about 15% had secondary education (Table 4-52). The observed scenario is a direct consequence of the dearth of educational facilities in these communities. The youth restiveness that is envisaged from this large army of uneducated youths in these community could constitute a constraint to economic growth and peace if urgent actions are not taken by both the government and development partners.

Table 4-52: Educational Status among the Inhabitants of Denote Fertilizer Project Area

Educational Level	Gender	
	Male	**Female**
Primary	30	20
Secondary	25	15
Tertiary	10	5
Adult Literacy	-	-
No formal Education	35	60

Source: Dangote Fertilizer EIA Field Work July 2014

4.5.6.2 Electricity

Most communities in the project area are not linked with the national power grid line for electricity supply. It is therefore exceedingly difficult to enhance shelf life and market value of agricultural produce in these communities since electricity is an indispensable tool for adding value to agricultural produce such as fish through effective processing techniques and storage. This has deepened poverty level in this area. However, some residents utilize generator as electricity supply for household uses while majority utilize bush lamp/lanterns. A large number of the inhabitants still depend on fire woods as the source of energy especially for fish processing (smoking) (Plate 4-41). The impact of the adoption of firewood for these purposes is too critical to deforestation and climate change phenomena to be so neglected.

Plate 4-41: Fire wood, a prominent source of alternative energy being prepared for 44sales to community dwellers

4.5.6.3 Market Facilities

Market facilities are important for trading of goods among the rural dwellers. A standard market facility will attract other people to trade and as well form an outlet to reduce post-harvest losses and increase the income of farmers. There is no modern market facility in any of the communities in the study area and this has a lot of negative consequences on the socio economic life of the community. It is only in fairly large communities like Okunraiye and Idasho where designated spaces are earmarked for market use. However, these markets lack essential facilities such as lock-up stalls, open stalls, stores among others. The implication of this scenario is that proceeds from sales of products are generally too low to encourage large production. Traders and farmers in these communities take their wares and produce to bigger towns like Epe and Akodo for sale. The high cost of transportation fares to these markets adversely affect their marginal profit.

4.5.6.4 Transport Facilities

The project area is traversed by several roads, amongst which are:

- The Lagos - Ibeju - Lekki - Epe highway;
- The major link road (coastal road) that connects Lekki to the Coastal villages (Eleko to Folu village);
- Smaller feeder roads linking the coastal road with the impacted communities, and
- Unpaved roads connecting small villages and fishing settlements.

The people in these communities are clearly at a disadvantage in terms of transport facilities and cost of transportation as only the Lagos-Ibeju-Lekki-Epe express way and the coastal road are tarred. Communities in the area have poor intra-community access roads which are usually swampy and waterlogged during the wet season except Imobido and Magbon segun where tarred roads link them with other communities. None of the rural access road linking farmlands is tarred. Thus, crops such as cassava often get rotten on the farm during bumper harvest due to non-motorable roads. This situation is further compounded by absence of storage facilities. Virtually all the communities in the study area are accessible through waterways (Lagoon and Sea). However, this medium usually attracts very high costs.

Public buses, cars and motorcycles are the major means of transportation in the project area. Public motor vehicles ply roads that link the project communities to major towns such as Victoria Island, Ajah, Lekki and Epe etc while motorcycle transport is used for shorter shuttles between and within smaller towns in the project area. Motorcycles and bicycles are the most commonly owned means of transportation in the project area, while a small percentage own cars. Canoes (with or without outboard engines) are owned and used in communities fringing the Ebute Lekki and Ode Omi in Lekki lagoon as well as other notable creeks (LFZ EIA Infrastructure Report, 2010).

Plate 4-42: A typical rural access road in the project. These roads are unpaved, narrow and inaccessible most parts of the year.

Source: Dangote Fertilizer EIA Field Work July 2014

4.5.6.5 Communication Facilities

The people in these communities have access to mobile communication through fixed wireless lines provided by communication service providers like MTN, GLO, AIRTEL and ETISALAT. There are no postal services in any of the communities but the inhabitants obtain news about other parts of Nigeria and the world through radio and television

4.5.7 Community Needs

From the survey, provision of electricity is given the highest priority. Next is provision of portable water to reduce vulnerability to water borne diseases. In addition, construction and rehabilitation of the intra-community and rural access roads were considered essential to facilitate intra mobility of goods and the people. Construction of market facility is highly desired to increase the patronage of the farm and fish produce. Establishment of educational institutions was very imperative to ease access to education. Provision of health facilities is equally rated very important in addition to those needs that could enhance their productivity such as provision of agro-processing factories and storage facilities (Table 4-53). Some of the communities also highlighted the need for the provision of public toilet to prevent outbreak of epidemics as most inhabitants practice open defecation. Construction of community halls where traditional ruler, community leaders and members could hold meetings and disseminate information was also advocated. The establishment of vocational/training centre to facilitate diversification of livelihoods and provision banking facilities that would afford them the opportunity of safe keeping of their monies, documents and other valuable properties were equally mentioned as some of the community needs.

Table 4.53: Need Assessment of the Communities

Need	Ranking
Roads	1
Potable Water	4
Health Facilities	3
Electricity	2
Educational Facilities	5
Agro-processing Facilities	8
Storage facilities	7
Market Facilities	6
Community Halls	9

Source: Dangote Fertilizer EIA Field Work July 2014

4.5.8 Community Perceptions and Expectations from Dangote Fertilizer Project

The general perception of Dangote Fertilizer project by the people is positive. Expectations from the project by this people include a complete alteration of their economic fortune through access to massive employment opportunities, improved social and infrastructural facilities, enhanced skill through training in artisanal related trades such as electrical installation, refrigeration and air conditioning, welding among other, water supply, electricity, improved transportation system and credit facilities that could enhance their productivity. The community rigorously advocated for support from the Dangote Fertilizer with respect to provision of good road system, educational facilities, health facilities, supply of safe water, electricity, storage facilities (cold rooms) and credit facilities.

4.5.9 Summary and Conclusion

The captive communities surveyed have long settled in their present locations. The communities are culturally rich in traditional shrines and sacred forests, some of which are located within the projects' areas. The stakeholders need to engage the communities' leaders in due consultation to pave way for the relocation of these traditional deities.

These communities have suffered a serious neglect in terms of infrastructure provision. The number of existing schools in the project area is precariously low, poorly staffed and ill-equipped. Only few communities in the project area are connected to the national gridline; hence the use of generators and fuel wood are very rampant in the communities as alternative source of electricity supply to the households and artisans. The health hazards and the implications on climate change associated with such practice is completely ignored by the people. Market facilities are conspicuously unavailable in the communities and hence the people transport fish and farm produce as far as Epe town almost 60 km away where markets are available. In terms of transport facilities and cost of transportation, the people in these communities are clearly at a disadvantage. Transportation is also done through waterways, but at very prohibitive costs.

Predominant income generating activities in the communities are farming, fishing, hunting, fish processing, livestock rearing, repair of outboard engines and fishing gears, artisanship, gathering of timber and non-timber products, firewood fetching, petty trading, boat transportation business etc. Nearness to the Atlantic Ocean and relatively rich agricultural land in the swampy forest zone of the area have given these communities a sort of comparative advantage in fishing and farming which could constitute a launch pad for their socio-economic development.

Artisanship (bricklaying, carpentry, welding, refrigeration and air conditioning, electrical fittings, metal fabrication, wiring and electrical installation, tailoring and dress making, shoe making and mending) are not well developed in this area because of the preponderance of fishing and farming. As it is known that artisanship work would be very important in the LFZ, youths in these communities should be consciously guided to take to these trades in a bid to making them fit into employment that will be generated in Dangote Fertilizer and other projects that would be springing up in the LFZ.

The residents of the communities are socially organized into religious groups and Community Development Association (CDA). Through the CDA, the communities have undergone several projects such as community halls, waste disposal sites, maintenance of vigilante groups and digging of uncovered wells. With these existing social groups, the stakeholders could realize that the host communities are better organized and necessary interventions to the community development can be undertaken through the groups. This would definitely give stakeholders in community development a soft landing in terms of their intended intervention programmes. Cooperative societies are few among the communities. Realizing the importance of these bodies to economic emancipation in the developing countries, the communities must be consciously directed to show deep interest in the development of cooperative societies among the inhabitants.

In general, the proposed project area is relatively peaceful. Conflicts between and among communities are usually urgently resolved through the intervention of the traditional rulers. The communities have not recorded any serious security threat in recent times. However, communities agitate for conscious efforts by upcoming companies in the Zone including Dangote Fertilizer Limited to create job opportunities opportunities for their citizens. The need for LFDC and companies to honour MOUs signed with the communities was canvassed by the communities.

Expectations from Dangote Fertilizer project by the community people include a complete alteration of their economic fortune through access to massive employment opportunities, improved social and infrastructural facilities, enhanced skill through training, water supply, electricity, improved transportation system and credit facilities that could enhance their productivity. Provision of good road system was rated highest among the needs of most communities. This desire is closely followed by the need for enhanced educational facilities, health facilities, supply of safe water, electricity, storage facilities (cold rooms) and credit facilities.

Conscious and concrete measures need to be taken by the stakeholders to ensuring adequate compensation for communities' land acquired for the proposed Dangote Fertilizer. Both communities' youth and leaders complained about the inadequacy of compensation effected by LFZDC. Failure to resolve this issue could spell doom for LFZ and its upcoming projects including Dangote Fertilizer. In addition, youth employment programme need to be pursued vigorously by all stakeholders including Dangote Fertilizer. Dangote Fertilizer should demonstrate serious concern on the decaying infrastructure in all the communities in a bid to enhance cordial relationship, unalloyed support and full cooperation between the host communities and her management using the resources earmarked for her CSR component.

Deliberate attempt must also be made by Dangote Fertilizer Limited and all stakeholders in community development to build the capacity of the youths to enable them secure job opportunities offered by Dangote Fertilizer and other companies that will be operating in LFZ. Other areas of assistance that could ensure sustainable development of these communities should include functional health and educational facilities and other social infrastructure. All these facilities will go a long way in making the people feel a part of the development process and thus make them give the necessary cooperation for the execution and operation of the Dangote Fertilizer project. It should be remembered that this is the neglected point that has made the Niger Delta area of Nigeria, where petroleum products are explored and exploited, a seemingly irreversible hotbed of crisis.

4.6 HEALTH STUDY

4.6.1 Description of the Health Status of the Project Area

This section presents the baseline health data based on information generated from sampled groups in the study communities. The data relies on self reporting, presumptions by respondents in the survey and data from the health centres in the area. Data obtained from these facilities were subsequently compared with state and National data and averages that are available.

4.6.1.1 Prevalence of Diseases in LFZ Region

The commonest and most prevalent diseases affecting all age groups in the communities are Malaria Fever (32.8%), Upper Respiratory Tract Infection (21.8%), Typhoid Fever (11.7%), Diarrhea/vomiting (10.5%) and Hypertension (7.5%). Other common ailments in this region include Worm Infestation, Diabetes Mellitus, Lower Respiratory Tract Infection, and Arthritis. The high prevalence rate of malaria is explained by the following factors:

- The abundance of mosquitoes (the insect vector of malaria,
  which consists predominantly of *Plasmodium falciparum,* and
  less of *Plasmodium vivax* and *Plasmodium malariae);*
- presence of stagnant water;
- absence of pest control practices, and
- inadequate prophylactic drug supply.

A further cursory look at Table 4-54 shows that water related diseases have the highest prevalence in the region. The observed diseases could be classified as follow:

- Major Water Borne Disease: Typhoid Fever, Diarrhea;
- Water Based Disease: Worm Infestation (Paragonimiasis, Dracuntiasis, Schistosomiasis);
- Water Related Vector Disease: Malaria Fever, and
- Water Chemical Related Disease: Hypertension.

A great concern in this region is the high spate of hypertensive cases. Thus, cases of hypertension in this region could be said to be water-induced as underground intrusion of salty water from the Ocean into the groundwater sources is suspected. Upper Respiratory Tract Infection with second highest prevalence in the region was traced to occupational hazard from fish smoking in the area. This is so since fishing is the predominant occupation in the area while smoking still remains the only means of preserving these products.

Table 4-54: Prevalence of Diseases in LFZ Region

S/N	Disease	Proportion of Infection (%)
1	Malaria Fever	32.8
2	Upper Respiratory Tract Infection	21.8
3	Typhoid Fever	11.7
4	Hypertension	7.5
5	Vomiting And Diarrhea	10.5
6	Worm Infestation	1.4
7	Diabetes Mellitus	4.3
8	Lower Respiratory Tract Infected	3.1
9	Arthritis	2.2
10	Others	2.7

Source: Dangote Fertilizer EIA Field Work July 2014

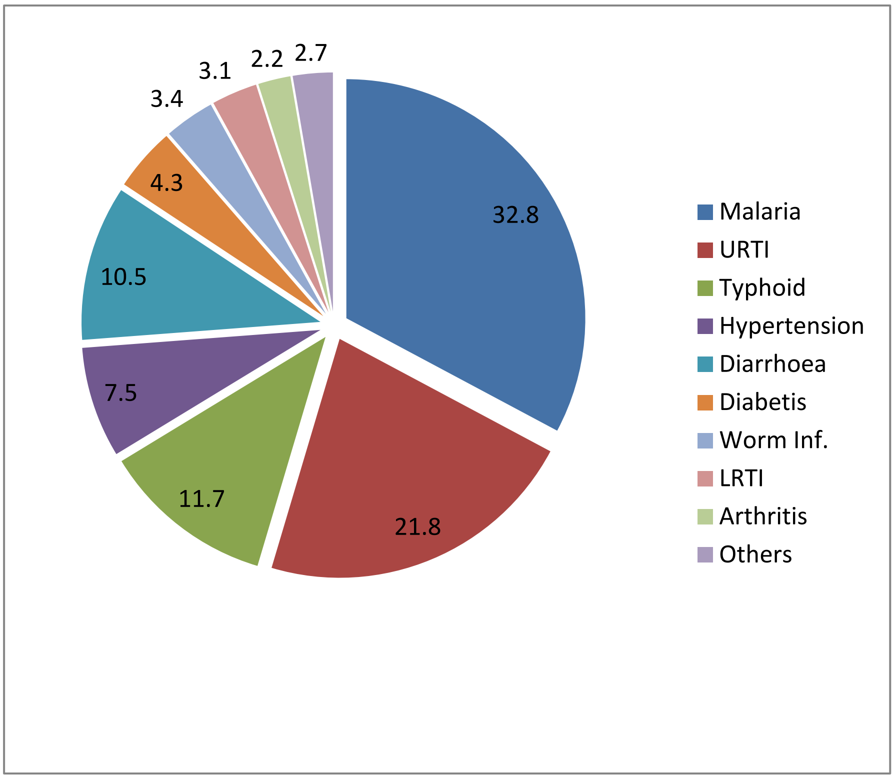


Fig. 4-52: Prevalence of Diseases in LFZ region
Source: Dangote Fertilizer EIA Field Work July 2014

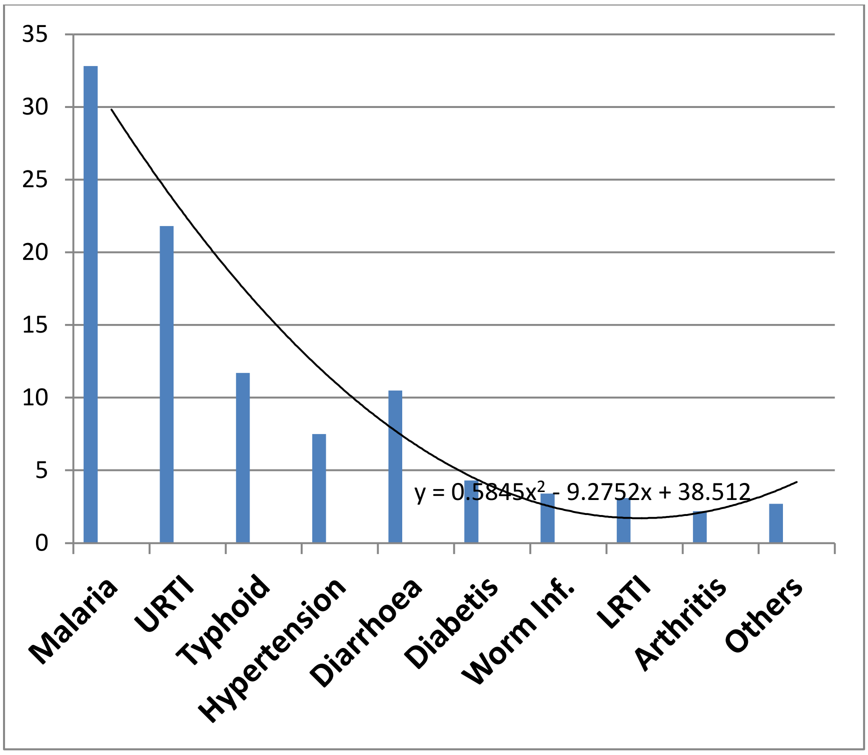


Fig. 4-53: Prevalence of Diseases Curve in LFZ region
Source: Dangote Fertilizer EIA Field Work July 2014

4.6.1.2 Available Health Centres

The health facilities in the area comprise of both primary and secondary health centres. There are five (5) basic health centres which are situated within the communities. The Ibeju-Lekki General Hospital newly established in the area serves all the communities within LFZ. The General Hospital is about 10km from the most distant community in the project area. This centre provides both out-patient and in-patient services. The other health facilities in the region are privately owned. In general, health facilities in the project area are grossly inadequate.

Plate 4.43: A Basic Health Centre in Idasho
Source: Dangote Fertilizer EIA Field Work July 2014

4.6.1.3 Traditional Medical Practice

The practice of traditional medicine was common in almost all the communities. Their practice commonly involved the use of herbs and body charms. Body massaging and scarification were also common. The services offered by these practices are shrouded in secrecy. Traditional birth attendants are popular. In many of the communities their services were the only functional form of ante-natal and maternal services available.

4.6.1.4 Sexual Activities and Knowledge of Sexually Transmissible Infections (STI)

Human Immunodeficiency Virus (HIV) and Acquired Immune Deficiency Syndrome (AIDS) have become very important public health concern in Nigeria. However there are no data on sexual practices, knowledge and beliefs about HIV/AIDS and other Sexually Transmissible Infections (STIs) in the study area. Therefore, several questions were included in this study to ascertain the level of their awareness about these health problems. Both men and women were asked about their sexual practices. They were also asked about what they believed was the mode of transmission of HIV and where they sought treatment for STIs. Condom use and availability were also reported.

Table 4-55 shows that majority (42.3%) of subjects who were sexually active had only one partner. However, keeping of two sexual partners was the most commonly practiced behaviour among those with multiple sexual partners, accounting for 34.1%.

Table 4-55 : Sex Practices among Inhabitants

No of sexual partner	Percentage (%)
1	42.3
2	34.1
3	10.4
4	8.1
5	3.2
Above 6	1

Source: Dangote Fertilizer EIA Field Work July 2014

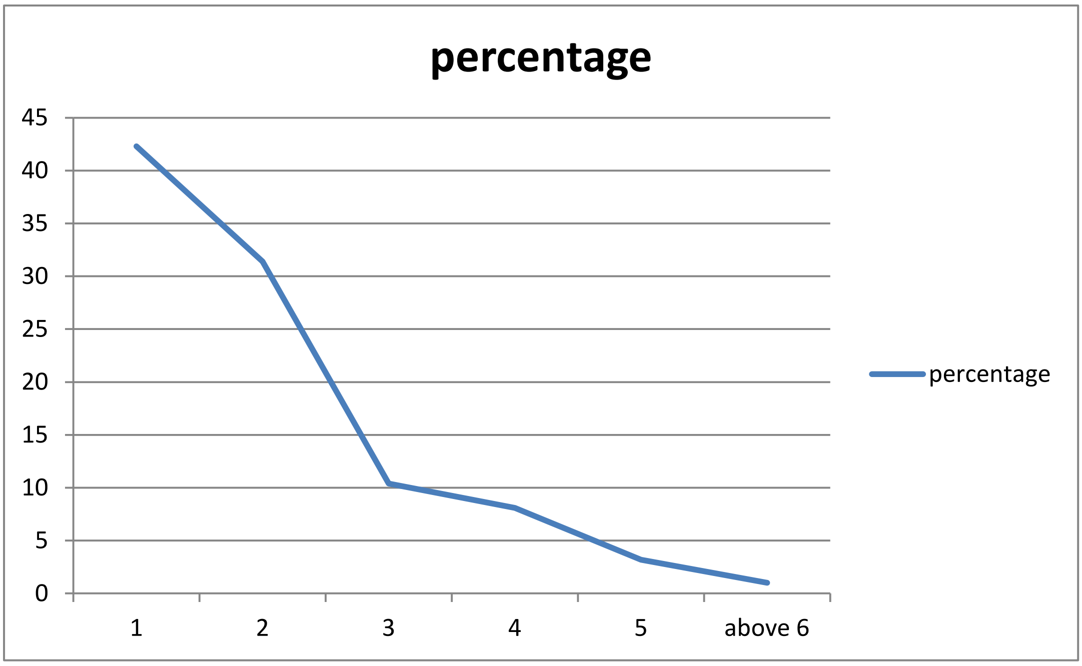


Fig. 4-54: Sex Practices among Inhabitants

Source: Dangote Fertilizer EIA Field Work July 2014

4.6.1.5 Condom Availability and Use

Condoms serve as a good barrier to the transmission of HIV and other sexually transmissible infections. Respondents were asked about condom use. The data presented is limited to those who have ever had sexual intercourse. Condom was readily available in about 90% of the chemist stores visited, but shop owners complained of low sales. However the average number used weekly could not be accurately verified. Survey results indicate that overall, about 24% of males and 34% of females aged above 15 years had never used condom before while about 16% of males and 5.3% females claimed they used condom only occasionally, mainly either for prevention of pregnancy or STI. Only 6.9% of sexually active males and 1.2% females use condom all the time (i.e. during every episode of sexual intercourse) (Table 4-56). Condom use in those aged above 65 is virtually absent. Amongst respondents who use condoms, majority (68% males and 76% females) were less than 30 years. Condom use was also considerably higher in those who have never married (82%) compared to those currently married (18%) (Table 5-57).

Table 4-56: Status of Condom Usage among Inhabitants

S/N	Status of Condom Usage	Male (%)	Female (%)
1	Never used condom before	24	34
2	Used condoms occasionally	16	5.3
3	Used condom during all episode of sexual intercourse	6.9	1.2
	Total	**46.9**	**40.5**

Source: Dangote Fertilizer EIA Field Work July 2014

Table 4-57: Status of Usage according to Age and Marital Status among those that use condoms

S/N	Age (Years)	Frequency (%)	Marital Status	Frequency(%)
1	Above 65	0	Never Married	82
2	30 – 65	68	Newly Married	18
3	Less than 30	32		
	Total	**100**	**Total**	**100**

Source: Dangote Fertilizer EIA Field Work July 2014

4.6.2 Nutrition

The dietary patterns of the communities consisted mainly of carbohydrates like rice, cassava, yam, cocoyam and corn, which were eaten in various forms. Proteinous food such as beans, beef, meat, bush animals, fish etc. were also consumed. The diets eaten by these communities were not balanced diet. As shown in Figure 4-55, only 24.4%, 23.2% and 22.7% of children under 5 years old had carbohydrate, protein and fat respectively included in their diet.

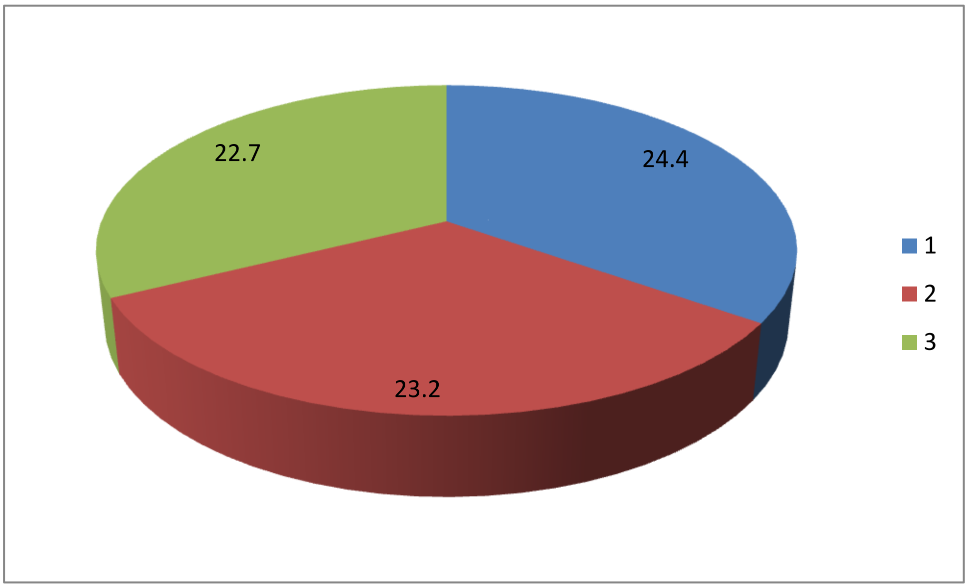


Table 4.55: Proportion of children under 5 years having carbohydrate, protein and fat in their diets

Source: Dangote Fertilizer EIA Field Work July 2014

4.6.3 Immunization Status in Children

The proportion of children under 5 years old immunized against DPT, BCG, OPV and Measles were 75% respectively. These figures were above the national target of 70% (BCG and TT for pregnant women) and 65% for the other antigens in the National Programme on Immunization. Oral polio vaccine (OPV) was the most commonly received vaccine in the studied area. This may partly be due to the OPV given during the National Immunization days (NIDs) set aside by the Federal Ministry of Health through the National Programme on Immunization every year. Each child below 5 years is expected to receive two drops of OPV during each round of NID. The fact that the few health facilities available in the communities had inadequate record of immunization is an indication of the low practice of routine immunization.

4.6.4 Water Supply and Quality

4.6.4.1 Sources of Water

The major sources of domestic water supply in the project area are river/stream, well and rain. It has been confirmed in literature that access to safe water supply is precariously low in most rural areas of Nigeria (Olajuyigbe, 2010). This poor access is amplified in the

Dangote Fertilizer project area. Most households (71%) rely on supplies from streams and rivers (Table 4-58). Piped water is non-existent in all the communities. Rain harvesting is practised and is one of the major sources of drinking water (17%). Water from this source is usually preserved until dry season when there is biting dearth of drinking water. The few existing wells that are observed in the project area are essentially constructed by communal efforts. Only few of the observed wells are covered. In addition, they are shallow and saline. The scarcity of safe water is complicated by the intrusion of saline water from the Atlantic into the fresh water at certain times of the year since all the communities overlook the Atlantic Ocean.

Again, households travel a great distance especially during dry season to obtain fresh water thereby wasting precious time that could be used for other productive activities. Such unnecessary energy dispensation also usually leads to ill health. In general, only very few (22%) of the inhabitants in the communities could be said to have access to improved sources of water (Table 4.57). These are mainly waters sourced from rainwater, covered wells and boreholes.

Table 4-58: Source of drinking water

Source	Frequency (%)
River/Stream/Canal	71
Covered Well	4
Uncovered Well	7
Piped Water	0
Borehole	1
Rain water	17
Total	100.0%

Source: Dangote Fertilizer EIA Field Work July 2014

4.6.4.3 Quality of Water Sources

The chemical constituent of the various water sources is given in the water analysis report earlier presented in this Chapter. In general, physico-chemical and microbial characteristics of drinking water from some selected waters sources within the project area indicate that most water parameters fall within FMEnv, WHO, EU, USEPA acceptable levels. However, of great concern is the high level of e-coli and coliform (Table 4-59). The soaring cases of hypertension in these communities could be suspected to be related to incursion of salty water into the groundwater system as a result of their proximity to the sea. Typhoid and other ailments are also the consequences of the presence of e-coli and coliform that implies largely that quality faecal wastes disposal has been compromised in these communities.

Table 4-59: E.coli. and Coliform Count in Surface Water within the Project area

Parameter	Project Influence Zone		Control	
	Range	Mean	Range	Mean
Coliform Count (MPN/100ml) x 10^3	0.45 - 1.80	1.21	1.20 - 2.20	1.70
E. coli. (MPN/100ml) x 10^3	0.20 - 0.20	0.20	0.20 - 0.90	0.55

MPN = Most probable number

Source: Dangote Fertilizer EIA Field Work July, 2014

4.6.5 Environmental Health

4.6.5.1 Sanitation of the Living Environment

The general sanitary status of the living environments in the communities were rated as poor, fair, or good based on a set of WHO criteria. About 48% of the communities had poor level of sanitation, while about 52% had only a fair level of cleanliness. None of the communities had good or very good sanitary status of the living environments.

4.6.5.2 Sewage Disposal

The most commonly used excreta disposal methods were the hanging toilet - faeces passed directly into the river (53%) and open defecation onto the nearby bush and beachside (23%). 15% of the households also dispose their faeces by burying (Table 4-60). Open defecation is of a great concern in this area. Apart from being unsightly, the practice constitutes a formidable source of food and water contamination in the area. Its contribution to the prevalence of diseases is therefore significant.

Table 4-60: Faecal Disposal Methods

Method	**Frequency (%)**
Water Closet	5
Pit Latrine	4
Bush	23
Burying	15
River/Canal	53
Total	**100**

Source: Dangote Fertilizer EIA Field Work July 2014

4.6.5.3 Refuse Disposal

The refuse generated in the studied area were mainly kitchen waste, which included food peels or remnants (garbage), etc. The non-degradable wastes were mainly plastics, bottles, polythene bags, ashes, cans/tins etc. The commonest refuse disposal method was open dumping on land, riverside/beach and Lagoon/Ocean (72%) while 21% bury their wastes. 7% of the inhabitants bury their wastes (Table 4-61). These disposal methods are unsanitary.

Table 4-61: Refuse Disposal Methods

Disposal Method	**Frequency (%)**
Open dumping	72
Burning	**7**
Burial	21
Total	**100.0**

Source: Dangote Fertilizer EIA Field Work July 2014

4.6.6 Housing Conditions

Housing is a fundamental component of quality of life influencing health, sanitation, social environment and community wellbeing. Few of the houses are still roofed with thatches. Most of the inhabitants live in sub-standard houses as these buildings generally lacked in-house facilities such as toilets and water with almost all households disposing of their human waste by unsanitary methods while only a few has access to improved drinking water. No doubt, the observed housing standard could be assumed to be a vivid reflection of the households' income level and the challenge posed by the environment in the study area.

Housing is a key component in the protection and promotion of health which carries equal priority with nutrition, water supply, sanitation and health care. House needs to be sited properly and constructed in such a way as to provide the physical and social needs of those housed. House needs to protect people from adverse effects of the climate as well as provide fresh air, security and privacy to ensure, dignity, health and wellbeing. All these qualities and attributes of a good housing have been compromised in most of these communities. No doubt, this has contributed to the prevalence and incidence of disease in the Dangote Fertilizer project area.

4.6.7 Summary

The baseline public health assessment of Dangote Fertilizer project area reveals that the general health status of the area is grossly underdeveloped. The various health indices that were considered during the course of the study are at variance with WHO specifications on primary health care. In general, primary health care delivery system which is designed to meet various health challenges that are confronting people within the communities is appalling. Thus, basic health services such as antenatal care, immunization of children and adults, treatment of malaria fever and hypertension among others are generally lacking or poor in these communities.

The few existing health centres in the area are of poor quality both in terms of drugs, personnel and service rendered. Higher and quality health services could only be guaranteed at neighbouring but relatively distant communities that have general hospitals. This explains the high infant mortality rate and high rate of disease prevalence in these communities. Commonest diseases include Malaria Fever, Upper Respiratory Tract Infection, Typhoid Fever, Diarrhoea and vomiting and Hypertension. Others include Worm Infestation, Diabetes Mellitus, Lower Respiratory Tract Infection and Arthritis. In view of the lack of orthodox medical facilities, alternative medicine is often sought to confront these ailments. In addition, Traditional Birth Attendants (TBAs) are found in every community.

Access to safe water supply is precariously low in all communities. Most households rely on supplies from streams and rivers. Rain harvesting is practised and is one the major sources of drinking water. The few existing wells are usually uncovered. The scarcity of safe water is complicated by the intrusion of saline water from the Atlantic into the fresh water at certain times of the year. The dearth of safe water has further aggravated the prevalence of water borne diseases in the area.

Sanitation is unhygienic as open defecation is still in vogue in all communities. Waste management is rather too poor as wastes are disposed in open dumps, buried and burned indiscriminately.

Intervention in the health sector in these communities is critical for enhanced production. Most of the expected benefits accruing from government and development partners' interventions could easily be eroded if this sector is not adequately taken care of. It is therefore canvassed that governments (state and LGA) and development partners should consider this need as critical and therefore intervene without further delay. In an attempt to improve the health status of these communities the following should be considered as minimum. They include:

- Provision of safe drinking water;
- Development of a Comprehensive Health Centre in some selected communities;
- Provision of qualified personnel and quality hospital equipment for the established health facilities;
- Supply of essential drugs;
- Provision of mosquitoes nets;
- Occasional fumigation of water bodies, and
- Occasional de-worming.

CHAPTER FIVE

ASSOCIATED AND POTENTIAL IMPACTS

CHAPTER FIVE

ASSOCIATED AND POTENTIAL IMPACTS

5.1 INTRODUCTION

The essence of the environmental and social impact assessment (ESIA), as a planning tool for environmental management, is to ensure that all associated and potential impacts of a development project (no matter how remote the chances of such impacts occurring), are adequately identified, rated, and mitigated.

The overall assessment of the potential and associated environmental and socio-economic impacts of the proposed Dangote Fertilizer Plant Project is presented in this chapter. The potential and associated impact assessment covers all stages of the project from site clearing and preparation through construction, operation to decommissioning. The methodology used for the assessment was designed to ensure a comprehensive and systematic evaluation of all positive and negative effects associated with the different phases of the project. The main goal of the assessment is to identify where mitigation is required to ensure that appropriate control measures and monitoring programs are developed to minimize the adverse effects.

5.2 ASSESSMENT METHODOLOGY

A list of environmental indicators and likely impacts on the project environment were developed to identify the significant impacts of the proposed project. The impact evaluation was conducted using the modified Leopold Matrix (Larry Canter, 1986), which relies on limited data and provides a logically inclusive identification of potential project impacts on environmental and socio-economic components.

The identification and Impact Assessment methodology included the following steps:

- Identification of major activities of the project during the construction, operational and decommissioning phase of the project;
- Identification of all potential environmental and social aspects (sources of potential impacts) associated with each activity; and
- Assessment of significance of identified environmental and social impacts.

The major project activities were identified, and associated potential environmental and social attributes were based on the project description. Potential impacts were identified by combining the above information with the obtained environmental and socio-economic baseline data. Wherever interactions exist between the identified aspects and sensitivities, they are further analyzed to determine the potential impacts of the proposed project. The impacts may be beneficial or adverse, direct or indirect, reversible or irreversible and could be short or long term.

5.3 SIGNIFICANT ENVIRONMENTAL IMPACTS

5.3.1 General

The potential environmental and social impacts of the proposed project have been identified and evaluated. Impacts have been examined for the site clearing, construction, operational and maintenance and decommissioning phases of the project.

Major activities of the project during the above phases of the project were identified and described and these have been used as the basis for impact identification. The associated environmental and social aspects were identified and assessed based on expert group discussion and meeting, field investigation result, understanding of the environmental characteristic such as ecological and socio economic health baseline conditions of the project area, knowledge of potential impacts of similar projects and knowledge of the project activities and various equipment to be used.

All potential impacts from the proposed project have been identified and evaluated as part of the ESIA process – effluent, ambient air quality, noise, surface water, groundwater, geology, terrestrial and aquatic ecology, and socio-economic (e.g. loss of income, shelter). The project will also have a number of significant positive impacts such as enhanced employment generation and improved accessibility to the communities.

5.3.2 Impact Evaluation Methodology and Leopold Matrix

Impact assessment was conducted using a combination of qualitative and quantitative techniques. In qualitative techniques impacts are rated as “low”, “medium” or “high”, based on the severity of impact (consequence) and the probability of occurrence (likelihood). The severity depends on the nature and size of the activity or environmental aspects and the environment and social sensitivity. The probability depends upon the nature of the activity and the control measures in place. A positive or beneficial impact is assigned a (+) sign while the minus (-) sign is assigned to a negative or adverse impact.

5.3.2.1 Impact likelihood

A likelihood criterion was developed to estimate the probability of occurrence of each potential impact. The impacts, which are rated as low, are considered to be within acceptable levels. For impacts, which are rated as medium, control measures and an environmental and socio-economic management system will be implemented to reduce the impacts. Impacts rated 'high" require additional studies to ascertain if an alternative activity or location will lower its effects on the environment.

Table 5-1 summarizes the impact likelihood, ranking and applicable definitions.

Table 5-1: Impact Likelihood Criteria (Canter, 1996)

Level	Ranking	Definition
Negligible	0	Occurrence of the effect is insignificant (e.g. less than 1 or 2% likelihood of occurring
Low	1	Highly unlikely, (e.g. less than 2-20% likelihood of occurring)
Medium	2	Has been known to occur in rare circumstances.
Major	3	Effect could occur infrequently during normal operations, (e.g., >20-70% likelihood of occurring) could occur readily if unregulated and controlled.

5.3.2.2 Impact Severity

Impact severity criteria were used to identify significant impacts in terms of public health and safety, environmental contamination, and asset/property damage. Taking into consideration the nature and extent of each activity, the following criteria were applied:

- **Magnitude**: The level or intensity of the impact. An impact of high magnitude signifies that a large amount of the resource or population is affected.
- **Areal Extent**: The area of coverage of an impact.
- **Duration:** Estimated time for a population or resource to return to its initial state prior to the impact.

Based on these criteria, the potential impacts of the project have been classified as negligible, minor, moderate or major. Criteria for defining these levels of severity are provided in

Table 5-2: Biophysical impact severity criteria (after Canter, 1996)

Level	Ranking	Definition
Negligible	0	Little or no change in the natural environment, effects is barely measurable above background conditions, much less significant than periodic stress by nature, measurable effects very temporary (a few days or less) before complete recovery.
Minor	1	Localize relatively isolated change in natural environment lasting only a few days to a few months before recovery, with no observable residual effects. Areal extent only up to a Total of 0.5 km^2.
Moderate	2	Local modification of considerable severity in atmospheric, surface or subsurface conditions, lasting from a few months to two years before recovery. Areal extent of affected area 0.5 to 5.0 km^2, or widespread modification of lesser severity.
Major	3	Widespread modification of considerable severity; areal extent of impacts > 5 km^2.

Table 5-3: Socio-economic impact severity criteria (after Canter, 1996)

Level	Ranking	Definition
Negligible	0	Little or no change in socio-economic conditions or commercial activities, any effects are barely measurable above background conditions, much less significant than periodic stress by on-going socio-economic/commercial activities, measurable effects very temporary (a few days or less).
Minor	1	Localize relatively isolated change in socio-economic conditions or commercial activities, lasting only a few days to a few months, with no observable residual effects.
Moderate	2	Local modification of considerable severity in less than 10 percent of those individuals affecting/affected by socio-

Level	Ranking	Definition
		economic conditions or engaging in the commercial activities in the study area, lasting from a few months to two years, or widespread modification (more than 50 percent of those individuals affecting/affected by socio-economic conditions or engaging in commercial activities in the study area) of lesser severity and duration.
Major	3	Widespread modification of considerable severity in socio-economic conditions and commercial activities, lasting beyond two years duration.

5.3.2.3 Impact Risk

A matrix combining the likelihood criterion and the severity criterion was applied to classify the significance of potential impacts as negligible, minor, moderate or major. The matrix enabled the assessment to identify and focus on significant environmental and social issues.

An impact assessment matrix is used as presented in Table 5-4 for combining the two assessment criteria, i.e., the severity of impact and the likelihood of aspect occurrence.

Table 5-4: Impact risk matrix (Canter, 1996)

Likelihood	Severity			
	Negligible	Minor	Moderate	Major
High	Low	Moderate	High	High
Medium	Low	Moderate	Moderate	High
Low	Low	Low	Moderate	High
Negligible	Low	Low	Moderate	Moderate

5.3.2.4 Impact Risk Evaluation (Leopold Matrix)

The impact risk evaluation has been presented in a Leopold matrix (Canter, 1996) to show the impact severity and likelihood ratings on a scale of 0 – 3, using a positive sign (+) to denote a positive or beneficial impact and a negative sing (-) to denote a negative or adverse impact. The Leopold matrix relies on limited data and provides a methodical and comprehensive identification of potential project impacts on environmental, socio-economic and public health components. The use of a risk matrix enhances the ability to systematically identify and focus on resources most likely to be impacted by the project. For example, high risk impacts become high priority issues for further evaluation or management action. Low risk impacts are of low significance, and thus low priority.

5.3.3 Overview of the Quantitative and Qualitative Impact Risk Evaluation

The Leopold Matrix (Table 5-5) gives an overview of the quantitative impact risk evaluation during the site preparation, the construction phase and the operations phase.

An overview of the qualitative impact risk evaluation for the construction and the operations phase is given in respectively Table 5-6 and Table 5-7. These tables give an overview of the impacts before and after implementation of mitigation and management measures. The impact after implementation of mitigation and management measures is called the ***residual impact***. In the next chapter (Chapter 6: Mitigation measures and monitoring), the mitigation measures and monitoring requirements that have been identified through the impact assessment process, are summarized.

Table 5-5: Leopold Matrix used for Quantitative Impact Risk Evaluation during site preparation, site construction and operations phase

Project Phase and Activities		Bio-physical components					Socio-economic components						
		Vegetation and diversity	Water quality	Air Quality	Noise and Vibration	Soil Quality	Demography	Employment	Socio-cultural Values	Community Infrastructure	Public Health	Security	Traffic
Site prep.	Site Clearing	-3/3	-1/2	-2/2	-2/2	-2/2	0/0	+2/3	-1/1	-1/1	-1/1	-2/3	-1/1
	Equipment Mobilization	-3/3	0/0	-1/1	-2/2	-2/2	-1/1	+1/2	-1/1	-1/1	-1/1	-3/3	-1/1
	Equipment Installation	-3/3	-1/1	-2/2	-3/3	-2/2	0/0	+2/3	-1/1	-1/1	-1/1	-2/3	0/0
Site construction	Soil Excavation and Earth Moving works	-3/3	-1/2	-2/2	-2/2	-2/2	0/0	+3/3	-1/1	-1/1	-1/1	-1/1	-1/1
	Foundation Laying	-3/3	-2/2	-2/2	-2/2	-2/2	0/0	+2/3	-1/1	-1/1	-1/1	-2/3	0/0
	Backfilling of Excavated Lot	-3/3	-2/2	-2/2	-2/2	-2/2	0/0	+2/3	-1/1	-1/1	-1/1	-2/3	0/0
	Construction of Storage Tank	-3/3	-2/2	-2/2	-2/2	-2/2	0/0	+2/3	-1/1	-1/1	-1/1	-2/3	0/0
	Concrete Works	-3/3	-2/2	-2/2	-2/2	-2/2	0/0	+2/3	-1/1	-1/1	-1/1	-2/3	0/0
	Installation of Monitoring Well	-3/3	-2/2	-2/2	-2/2	-2/2	0/0	+2/3	-1/1	-1/1	-1/1	-2/3	0/0
	Power Generation	-0/0	-0/0	-2/2	-2/2	-2/2	0/0	+2/3	0/0	0/0	-1/1	0/0	0/0
	Installation of the Mooring system	-3/3	0/0	-1/1	-2/2	0/0	0/0	+2/3	0/0	0/0	0/0	0/0	0/0
	Installation of Offshore Pipeline, End Manifold and Subsea Hoses	-3/3	0/0	0/0	-2/2	0/0	0/0	+2/3	0/0	0/0	0/0	0/0	0/0

Project Phase and Activities		Bio-physical components					Socio-economic components						
	Development of access roads	-3/3	-2/2	-2/2	-2/2	-2/2	0/0	+2/3	-1/1	-1/1	-1/1	-2/3	0/0
	Transportation of Building Materials for Infrastructural development	-3/3	-2/2	-2/2	-2/2	-2/2	0/0	+2/3	-1/1	-1/1	-1/1	-2/3	0/0
Operations phase	Power Generation	-0/0	-0/0	-2/2	-2/2	-2/2	0/0	+2/3	0/0	0/0	-1/1	0/0	0/0
	Onshore Fuel Transfer and Storage Operations	-0/0	-2/2	-1/1	-1/1	-2/2	0/0	+2/3	0/0	-1/1	0/0	0/0	-1/1
	Offshore Tanker Loading and back-loading Operations	0/0	0/0	-1/1	-2/2	0/0	0/0	+2/3	-1/1	-1/1	0/0	0/0	0/0
	Office Facility Operation	0/0	0/0	0/0	-1/1	0/0	0/0	+2/3	+1/1	0/0	0/0	0/0	0/0
	Sewage Management and Disposal	0/0	0/0	-1/1	0/0	-1/1	0/0	+2/3	0/0	0/0	-1/1	0/0	0/0
	Solid Waste Management	0/0	0/0	-2/2	0/0	0/0	0/0	+2/3	0/0	-1/1	-1/1	0/0	0/0
	Maintenance and Replacement of Equipment	0/0	0/0	-1/1	-1/1	-1/1	0/0	+2/3	0/0	0/0	0/0	0/0	0/0
	SPM Operations	0/0	0/0	-2/3	-2/2	0/0	0/0	+2/3	0/0	0/0	0/0	0/0	0/0
	Offshore and subsea infrastructure Maintenance	0/0	0/0	-1/1	-2/2	0/0	0/0	+2/3	0/0	0/0	0/0	0/0	0/0

Severity / Likelihood.
Positive sign (+) = positive or beneficial impact; Negative sign (-) = negative or adverse impact.
Severity: Major (3), moderate (2), Minor (1), Negligible (0)
Likelihood: High (3), Medium (2); Low (1), Negligible (0).

Table 5-6: Summary of Qualitative Impacts for the Construction Phase of the Proposed Project.

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Terrestrial Soils and Geology	Destabilisation of beach-dune system due to construction activities at the shore crossing	Moderate	• Demarcate work areas and minimise dune vegetation clearing • Use appropriate excavation, infill and trenching methods	Minor
Surface and Groundwater	Change in drainage patterns due to clearing and excavations	Moderate	• Proper placement of soil stockpiles • Design permanent drainage installations for heavy rainfall events. • Protect storm water channels from erosion	Minor
Surface and Groundwater	Impacts on water quality from spills and leaks and increased sedimentation	Moderate	• Bunding and containment measures • Use of Impervious concrete surfaces • Design and ensuring integrity of tanks to API standards • Installation of Cathodic corrosion protection • Trained personnel	Minor
Marine Water	Impacts on marine water quality and biodiversity as a result of routine and non-routine discharges	Minor	• Compliance with MARPOL requirements and other ballast management conventions.	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Onshore Biodiversity	Loss and damage to terrestrial habitats and species	Moderate	• Wildlife surveys and implementation of recommended management measures • Minimise clearing • Demarcate work areas • Rehabilitate disturbed land	Minor
Offshore Biodiversity	Loss and damage to marine habitats and species	Moderate	• Wildlife surveys and implementation of recommended management measures • Controlled movement of men and equipment during project phase • Minimise vessel movement	Minor
Noise and Vibration	Increased noise levels from onshore activities and equipment Effect of Noise from underwater infrastructure installation on Marine Ecology	Moderate	• Use of silencers and mufflers • Reduction of project traffic through community areas where possible • Adherence to speed limit • Development and implementation of grievance procedure • Development of noise monitoring and management procedure for managing noise generated.	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Light Spill	Outdoor lighting of the facility site and truck parking on neighbouring communities Impact of light on wildlife within close habitats	Minor	• Control light spill to adjacent properties and identified sensitive areas	Minor
Waste	Impacts related to poor management and disposal of waste	Minor	• Development and implementation of a solid waste management program • Identify Suitable disposal facility(s) • Monitoring of the disposal facility • Development of Waste Management Plan (WMP) • Internal and independent auditing of waste management contractors and waste disposal sites, in consultation with LFZDA	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Traffic	Increased traffic and strain on road network	Moderate	• Development of Traffic Management Plan • No tanker trucks to park next to roads • Vetting of tanker trucks • Detailed traffic study • Liaise with the LFZDA and Local Government Authority regarding safe transport routes	Moderate
Livelihoods and Microeconomics	Negative impacts to Livelihoods and Microeconomics	Moderate	• Minimization of land clearance • Replacement and re-planting of uprooted trees • Information to fishermen regarding underwater operations • Nautical charts with cautionary advice. • Notify other users of the sea and Lagoon of the presence of underwater facilities • Compensate economically displaced people in accordance to Livelihood Restoration Plan	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Livelihoods and Microeconomics	Positive impacts to Livelihoods and Microeconomics	Major positive	• Preferential status to local community with regards to employment as site workers • Assist with construction of stalls for the village to sell goods to trucks • Organise basic skills training programme for locals	Major positive
Social Infrastructure	Impacts to social Infrastructure due to increased pressure on social amenities and road infrastructure	Moderate	• Information to local community about project operations and use or • Upgrade some local infrastructures • Provide health facilities for workers • Possibility of providing water to captive communities.	Minor
Socio-Cultural Institutions and Cohesion	Disturbance of existing socio-cultural institutions and a disruption of current levels of community cohesion as a result of the presence of non-local workers	Moderate	• Ensure closed camp for workforce • Design and implement Employee Code of Conduct • Conduct community relations education programme • Create awareness about transmission of communicable diseases	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Transport and Access	Blockage of transport routes and restricted access to beach	Moderate	• Design and implement Traffic Management Plan • Provide information on temporary road closures and alternative access routes • Improve signage and overall safety of roads with local authorities • Design and conduct traffic awareness training • Provide Information to fishermen about offshore activities	Moderate
Cultural Sites	Damage to cultural sites due to site clearing and grading activities	Minor	• Protection of cultural sites during construction • Design Grievance procedure • Design and enforce Employee Code of Conduct • Chance find procedure	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Community Health	Impacts to community health due to introduction of new communicable diseases, reduced domestic water quality and respiratory health impacts	Moderate	• Closed camp for workforce • Health awareness raising • Code of conduct for workers • Protect drinking water sources • Groundwater monitoring • Waste Management Plan • Dust suppression • Use of condoms	Minor
Occupational Health and Safety	Occupational Health and Safety risks to workers on site	Moderate	• Occupational Health and Safety Plan • Implement Health and Safety communication and training programmes • Emergency facilities and personal protection equipment • Job safety analysis and industrial hygiene surveys • Monitoring and record-keeping • Truck loading procedures • Emergency Preparedness and Response Plan	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Public safety	Public safety impacts as related to soil, surface and groundwater contamination and traffic accidents	Moderate	• Driver training and strict enforcement • Investigate road accidents • Protect surface and groundwater • Emergency Preparedness and Response Plan	Minor
Hydrocarbon Spills	Impacts on sea- and coastal birds, marine mammals, marine turtles, coastal habitats, fish stocks and fisheries	Moderate	• Spill prevention: ○ Spill prevention program design for construction phase ○ Provision of spill response training to all relevant construction workforce personnel. ○ Leakage test prior to start of operations • Spill response: ○ Oil Spill Contingency Plan (OSCP) with detailed procedures that will be followed in the event of a Tier 2 and 3 hydrocarbon spill ○ On site spill response equipment for Tier 1 and 2 spills ○ Adequate oil spill insurance cover to cover costs of clean up in the event of a large spill	Minor

Table 5-7: Summary of Qualitative Impacts for the Operations Phase of the Proposed Project.

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Terrestrial Soils and Geology	Possibility of Oil Spill from leaking pipelines	Major	• Spill prevention program design for operations phase (inspection + maintenance program) • Provision of spill response training to all relevant operations workforce personnel. • A designated area will be developed to allow for the bio-remediation of contaminated soils • Inspection + maintenance program	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Surface and Groundwater	Possibility of aquifer and surface water contamination from spills and leaks and possibility of increased sedimentation	Moderate	• Oils, hydrocarbons and other hazardous materials will be stored in designated locations with specific measures to prevent leakage and release of their contents, including the sitting of the storage area away from surface water drains and on an impermeable base with impermeable containment that has no outflow and is of adequate capacity to contain 100% of the contents; • Plant and machinery will be kept away from surface waters and will have drip trays installed beneath oil tanks / engines / gearboxes / hydraulics which will be checked and emptied regularly; • Collection, retention and testing of any groundwater resulting from dewatering activities within potential contaminated sites; • Re-fuelling and delivery areas will be located away from surface water drains and natural water bodies and courses; • • • • Provision of spill response equipment to contain and clean-up spills;	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Marine Water	Impacts on marine water quality and biodiversity as a result of routine and non-routine discharges	Moderate	• Compliance with MARPOL requirements and other ballast management conventions. • Zero discharge of food waste and sewage	Minor
Onshore Biodiversity	Loss and damage to terrestrial habitats and species	Minor	• Minimise clearing • Demarcate work areas • Rehabilitate disturbed land	Minor
Offshore Biodiversity	Loss and damage to marine habitats and species	Moderate	• Turtle surveys during nesting season • Controlled vessel movements	Minor
Noise and Vibration	Increased noise levels from onshore activities and equipment	Minor	• Construction limited to appropriate hours if possible • Noise monitoring during construction • Equipment with lower sound power levels • Silencers and mufflers • Reduce project traffic through community areas • Adherence to speed limit • Design and implementation of Grievance procedure	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Light Spill	Outdoor lighting of the facility site and truck parking	Moderate	• Control light spill to adjacent properties	Minor
Waste	Impacts related to poor management and disposal of waste	Moderate	• Development and implementation of a solid waste management program • Identify Suitable disposal facility(s) • Monitoring of the disposal facility • Waste Management Plan (WMP) • Internal and independent auditing of waste management contractors and waste disposal sites	Moderate
Traffic	Increased traffic and strain on road network	Major	• No tanker trucks to park next to roads (DFL has a huge parking area foreseen, for short- and long-term parking) • Vetting of tanker trucks • Liaise with the LFZDA and local government authorities regarding safe transport routes	Moderate

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Livelihoods and Microeconomics	Negative impacts to Livelihoods and Microeconomics	Moderate	• Minimise land clearance • Replacement planting of coconut trees • Information to fishermen regarding offshore operations and exclusion zones • Notify other users of the sea of the presence of the exclusion and advisory areas • Nautical charts with cautionary advice	Minor
Livelihoods and Microeconomics	Positive impacts to Livelihoods and Micro-economics	Minor	• Preferential status to local community with regards to employment • Assist with construction of stalls for the village to sell goods to trucks • Basic skills training programme for locals	Moderate
Social Infrastructure	Impacts to social Infrastructure due to increased pressure on social amenities and road infrastructure	Minor	• Information to local community about project operations and use or upgrade of local infrastructure • Health facilities for workers • Possibility of providing water to affected communities	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Socio-Cultural Institutions and Cohesion	Disturbance of existing socio-cultural institutions and a disruption of current levels of community cohesion as a result of the presence of non-local workers	Moderate	• Closed camp for workforce • Employee code of conduct • Community relations education programme • Awareness about transmission of communicable diseases	Minor
Transport and Access	Blockage of transport routes and restricted access to beach	Moderate	• Traffic Management Plan • Information on temporary road closures and alternative access routes • Improve signage and overall safety of roads with local authorities • Traffic awareness training • Information to fishermen about offshore activities	Minor
Cultural Sites	Damage to cultural sites due to site clearing and grading activities	Moderate	• Protection of cultural sites during construction • Grievance procedure • Employee code of conduct • Chance find procedure	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Health	Impacts to community health due to introduction of new communicable diseases, reduced domestic water quality and respiratory health impacts	Moderate	• Closed camp for workforce • Health awareness raising • Code of conduct for workers • Protect drinking water sources • Groundwater monitoring • Waste Management Plan • Dust suppression	Minor
Health	Occupational Health and Safety risks to workers on site	Moderate	• Occupational Health and Safety Plan • Implement Health and Safety communication and training programmes • Emergency facilities and personal protection equipment • Job safety analysis and industrial hygiene surveys • Monitoring and record-keeping • Traffic Management Plan • Truck loading procedures • Emergency Preparedness and Response Plan	Minor

Issue	Impact Summary	Pre-mitigation significance	Mitigation & Management Measures	Residual significance
Public safety	Public safety impacts as related to soil, surface and groundwater contamination and traffic accidents	Moderate	• Driver training and strict enforcement • Investigate road accidents • Protect surface and groundwater • Emergency Preparedness and Response Plan	Minor
Hydrocarbon Spills	Impacts on sea- and coastal birds, marine mammals, marine turtles, coastal habitats, fish stocks and fisheries	Moderate	• Spill prevention: • Mooring design • Operational terminal regulations and offloading / loading procedures • Pipeline protection • Spill response: • Oil Spill Contingency Plan (OSCP) with detailed procedures that will be followed in the event of a Tier 2 and 3 hydrocarbon spill • On site spill response equipment for Tier 1 and 2 spills • Adequate oil spill insurance cover to cover costs of clean up in the event of a large spill	Minor

5.3.4 Detailed Description of Potential Impacts of the DFP Project

This section presents more detailed discussion on the potential and associated impacts of the proposed Dangote Fertilizer Plant Project. The impacts have been assessed. The proposed mitigation actions intended to mitigate potential negative impacts or enhance beneficial effects are presented in **Chapter 6** of this report. The discussions presented in this section are intended to provide insight into the nature, magnitude and duration of impacts on such components as ambient air quality and noise, terrestrial ecology including wildlife, socio-economic and human health and safety.

5.3.4.1 Pre-Construction Phase

Permitting:

Permitting is the process of obtaining permission of communities/individuals and relevant government agencies on issues related to the project.

Acceptance of project and cooperation/participation from communities and government

Prior to commencement of the project, extensive stakeholder consultations will be carried out with communities, State and Local Government agencies, CBOs to enlist their support, cooperation and participation in the project. The occurrence of this is rated as medium and the impact is positive.

Reduction/abatement of threats posed by agitation of communities:

Sometimes there are agitation by communities and other sympathetic third parties over non-disclosure of project activities, employment, contracts, environmental impacts of projects and other community/third party interests. The impact was described as direct, negative, short-term, local, reversible and rated minor.

Survey Line Cutting:

Survey line cutting consists primarily of vegetation clearing for survey activities on a temporary land area. The potential impacts of this activity are:

Destruction of Vegetation (Medicinal, economic and food)

The removal of the vegetation on the survey lines could lead to loss of any medicinal, economic or food crops in the area. The wildlife that used this vegetation for habitat would also be deprived of them. The impact was direct, negative, short term, local, reversible and rated moderate.

Loss/alteration of wildlife habitat

The removal of the vegetation during survey cutting could lead to loss/alteration of wildlife habitat as a result of displacement and destruction of food sources and the wildlife that used this vegetation for habitat would also be deprived of them. The impact was rated direct, negative, short term, local, reversible and rated minor.

Increased access for hunting and logging

The clearing of vegetation for survey cutting could provide access to individuals for hunting of wildlife and logging activities. This impact is rated moderate and would be direct, negative, short term, local and reversible.

Reduction of biodiversity

The removal of the vegetation during survey activities could lead to loss of biodiversity, medicinal, economic or food crops in the area as well as wildlife that used this vegetation for habitat. The impact was described as direct, negative, short-term, local, reversible and rated moderate.

Increased opportunity for contracting and temporary employment

The use of the indigenes in the removal of vegetation on the land section for survey could create income generating opportunity and contracts for the people. The impact was described as direct, short term, local, reversible and rated positive.

Possibilities of lines cutting across sensitive locations, property, economic trees, farms, sacred places, public utilities

The possibility of lines cutting across sensitive locations during operations, properties, economic trees, farms, etc. could arise. This impact is rated as major and is direct, negative, short term, local, reversible.

Third party agitation over damage to property, encroachment and compensations

The third party agitation at this stage could be due to issues of cutting activities across sensitive places and resulting in damage to them: houses and other properties, economic trees, farms, shrines, and public utilities such as water sources. This could lead to agitations for compensations. The impact is considered direct, negative, short term, local, reversible and rated major.

Land-take for Base Camp

Land could be required for the construction of a base camp by the contractor. Where applicable, the land will be re-vegetated with indigenous plant species at the end of the project. The possible impacts from the activity are:

Reduction of Access to Land and its Resources

Physical displacement of household is not expected in the DFP project, based on the site visits the ESIA-team carried out. Nevertheless, economical displacement will occur. The project site contains economic plants such as cassava, yams, coconut trees, and palm trees, etc.

The land acquisition is expected to eliminate the local farming of crops and similarly affect some wildlife species identified in the project area such as grass cutters, snakes and birds. Land take is expected to limit access to these resources. The impact was described as direct, negative, short term, local and reversible. It was rated as minor.

Third Party Agitations:

Land-take sometimes leads to community agitation due either to compensation issues, or stakeholder identification, or incoherence in leadership hierarchy and/or from boundary recognition between communities. The impact was described as direct, negative, short-term, local, reversible and rated moderate.

Increased financial flow due to compensations:

Financial and other compensations accruing to the communities and individuals as a result of land acquisition shall yield direct, short term, local, reversible and rated positive.

Recruitment of Workers:

Creation of opportunities for employment

This project is manual labour intensive and could create opportunity for temporary employment, contracting and increase in income for the communities. The impact is direct, short term, local, reversible, and rated positive.

Conflicts/Third party agitations over employment issues

Due to the fact that all available local labour cannot possibly be engaged for the project, conflicts and agitations could arise over distribution of employment slots to individuals and communities. This impact is direct, negative, short term, reversible and rated moderate.

Influx of job seekers into communities, thereby exerting pressure on infrastructure

The influx of job seekers into the communities for employment opportunities could exert additional pressure on limited community resources such as water supply, available food sources and housing. This impact is rated direct, negative, short term, local reversible and moderate.

Mobilization to Site:

Increase in usage of roads and waterways with possibilities of accidents

Mobilization of workers and equipment to site could result in the increase in traffic in the area and predispose to accidents. This impact is rated as direct, negative, short term, local, reversible/irreversible and moderate.

Increase in usage of roads and resultant damage to existing roads:

In the same vein, increase in road usage could result in increase in road traffic accidents due to road congestion. This phenomenon is rated as direct, negative, short-term, local and reversible. It is a moderate impact.

Site Preparation/Clearing for Base Camp:

The site preparation activity for the project would consist primarily of vegetation clearing of the temporary area that would be acquired for the construction of base camp. Other activities include mobilization of personnel, heavy machinery, equipment and materials to the project area campsite, clearing, to remove vegetation at the site with the use of bulldozers and hydraulic excavator, the latter digs out tree stumps and concrete, vegetation and soil spoils disposal and levelling of cleared area; this requires motor scrappers and grader. The potential impacts of these procedures are:

Air Quality

Air quality can be affected by a number of activities associated with the site preparation such as land clearing, earth moving and levelling, transport of materials and workers, mobile generation of electricity, and short-term operation of facilities producing materials (e.g., concrete) used in construction, labour camp. The chief concerns for this phase are dust generation and diesel engine exhaust. The dust from earthwork and vehicle movement could be significant, particularly during the dry weather conditions. The exhausts from construction equipment, vehicles will result in release of pollutants such as PM_{10} NO_x, SO_2, CO and VOCs.

Concern for dust generation is much lower in wetter areas and during the rainy season, and during dry seasons dust can be controlled by watering and other management practices. The emissions are short-termed and localized to the immediate site area; though the likelihood of occurrence is high, the overall impact risk is low.

Noise

The heavy equipment used in site clearing activities and excavation, diesel generators used for on-site power generation and the road vehicles used for transportation of material and men to site will have an adverse impact on ambient noise levels. This will be short-term and local with the likelihood of occurrence high and the overall impact risk is minor.

Destruction of Vegetation (Medicinal, Economic and Food)/Loss of Wildlife Habitat:

The natural vegetation of the plot will largely be removed in order to create space for construction of the permanent structures. Nevertheless, since not all areas will be put to secondary use, any remaining vegetation, either for aesthetic beauty or as a green area on the plot will benefit from continuous tendering. These could serve good purpose as indicators of environmental change.

In fact, the primary impact is loss of species and their ecosystem services. Many native species will be cleared from the plot. Some will be lost to trampling. Unless prevented, some species would be lost to soil contamination by agro-chemicals and their precursors. Also, since the land will be under continuous anthropogenic traffic and associated pressure, the sandbank will be lost for the most part. Ecosystem services being currently provided by the species, such as erosion control, modification of hydrological cycle, shelter to wildlife and carbon sequestration will be negatively impacted upon.

Secondary impacts include increase in ambient temperature and heat, weather modification, prevalence of particulate matter suspension in the atmosphere. These might further put any plant species and wildlife in the immediate vicinity of the plot at risk of impaired ecology and physiology, leading to stunted growth and reduced productivity.

The removal of the vegetation on the acquired land will lead to loss of any medicinal, economic or food crops in the area. The wildlife that used this vegetation for habitat would also be deprived of it. The impact will be direct, negative, short term, local, reversible and is rated minor.

Exposure of Workers, Community Members to Attack by Poisonous Snakes, Bees, Scorpions, Spiders/Other Wildlife and Contact with Poisonous Plants

The project area contains some dangerous animals like snakes, scorpions, bees etc and poisonous plants. Field workers engaged in vegetation clearing could be exposed to attack by these animals and plants. These attacks could result in injuries, poisoning or even death. The impact was described as direct, negative, short/long term, local, reversible/irreversible and rated moderate.

Increased Erosion of the Cleared Area

The project area experiences high level of rainfall annually. These features render the area prone to erosion when the vegetation is cleared. The impact was direct, negative, short term, local and reversible. It was rated minor.

Increased access for hunting and logging

The clearing of vegetation for the construction of base camp could provide access to individuals for hunting of wild life and logging activities. This impact though minor would be direct, negative, short term, local and reversible.

Opportunities for Employment

The site clearing could be done manually using local hands. This could create opportunities for employment and contracting, and increase in income for the communities. The impact was direct, short term, local, reversible and rated positive.

Injuries during vegetation clearing

The process of vegetation clearing is essentially manual, and so workers are exposed to some degree of risk of injuries. This impact is rated as direct, negative, short term, local, reversible and moderate.

Increased level of disease vectors

Disease vectors such as dangerous insects: Bees and mosquitoes etc. could be dislodged from their usual habitat towards the communities and increase the risk of diseases in the communities. This impact could be direct, negative, short term, local, and reversible. It is rated moderate.

Traditional occupations (farming and hunting) adversely affected

Bush clearing/site preparation after land take could affect the farming and hunting activities. This impact is rated as minor, but could be direct, negative, short term and local.

Loss of resources

Physical displacement of household is not expected in the Dangote Fertilizer Project area since no settlement was observed on the site during the fieldwork. Nevertheless, economic displacement will occur. Compensation for loss of resources is subject of the Livelihood Restoration Plan that will be prepared according to the IFC Performance Standards. The envisaged loss could manifest in:

Loss of fishing resources

It is not expected that the immediate ground around the underwater pipeline route will be regarded as no-fishing ground. Thus, there will be no loss of available fishing ground. Thus, the development of the pipeline would not have an impact on the total fish catches. However, fishing activities shall be disturbed during the construction of these pipelines. This impact was therefore considered as direct, short term, local, reversible and minor.

Reduction of land resources

The vegetation of the required land contains economic plants such as cassava, yams, cocoyam, oil palm, mango and palm trees, etc. The land acquisition is expected to eliminate the local farming of crops, within the project area, and similarly affect some wildlife species identified in the project area such as snakes, grass cutters and birds. Land take is expected to limit access to these resources, within the zone. The impact was described as direct, negative, short term, local and reversible. It was rated as minor.

5.3.4.2 Construction Phase

Building/Civil works:

Air Quality

Demolition and construction activities will result in localized high level of dust and vehicular emissions. The dust rising from earthwork and vehicle movement could be significant particularly during dry season and can cause disturbances to the nearby villages. Potential impacts from dust emissions on site will be significantly reduced by careful management and the implementation of mitigation measures to reduce dust generation.

Other sources of air pollutants include:

- Internal combustion engines of construction machinery;
- Welding and drying equipment on construction site;
- Unloading and storage of inert materials (crushed stoned, sand)
- Dust from the ground surface disturbed by earthmoving operations during dry season.

In addition, welding activity in the proposed Fertilizer will emit manganese dioxide and welding aerosol emissions. Transport vehicles and construction machinery release exhaust gas comprising numerous components divided into several groups based on similar impact on environment and human health. These include:

- Carbon monoxide, the presence of which in large amounts (up to 12%) is characteristic of exhaust gas from internal combustion engines using gasoline;
- Nitrogen oxides;
- Hydrocarbons, aromatic compounds including carcinogen;
- Non-toxic substances such as nitrogen, hydrogen, carbon dioxide and water vapour, and
- Spent gas components.

The emissions are short-termed and localized to the immediate site area; though the likelihood of occurrence is high, the consequence is rated a negligible negative. Thus, the overall impact risk level is expected to be low.

Noise

The heavy equipment used in site excavation and construction works, diesel generators used for on-site power generation and the road vehicles used for transportation of material and men to site will have an adverse impact on ambient noise levels.

With respect to the ambient noise levels, since noise is attenuated by distance (typically noise levels drop by about 40dBA at 100m distance from source) the activities on-site are unlikely to adversely affect receptors at a significant distance. However, during the night-time when the ambient noise levels are low, the level of perception to noise by communities may be more acute. Noise from transport vehicles will be only transient for a given location and can be considered as a nuisance during night-time.

The Nigerian noise standard is 90 dBA for an 8-hour exposure. Hearing impairment could occur from prolonged exposure to high noise level. However, it is envisaged that the site will be demarcated and an exclusion zone created. Thus, it is unlikely that villagers will be exposed to harmful noise level. The noise impact is rated short-termed and localized to the immediate site area; with a high likelihood of occurrence, the overall impact is low, reversible and rated minor.

Besides this, the installation of the offshore pipeline could disturb marine mammals and turtles through underwater noise and movement of marine vessels. Sources of underwater noise will be propellers and thrusters and underwater construction activity. The installation activities will be short-lived and marine mammals are expected to avoid this area during this period. The magnitude of this impact on marine fauna is considered to be low.

Pressure on existing roads with possibilities of accidents

The activities of building and construction would result in the increase of road usage due to movement of personnel, equipment and construction materials. The aftermath of this could be accidents as a result of immense pressure put on the roads. This impact is direct, negative, short term, local and reversible. It was rated moderate.

Pressure on available water for domestic and other uses

Building and construction works will involve a good number of workers on site, and could put unwarranted pressure on communities' domestic water supply and other resources. This could be direct, negative, short term, local, and reversible. It was rated as moderate.

Marine environment

Short-term disturbance directly to the seabed through sediment suspension with secondary impacts on the benthic and demersal community during installation of seabed infrastructure (SPM and pipeline) is envisaged. This impact is direct, negative, short term, local and reversible. It is rated minor.

Permanent changes to habitat arising from the physical presence of subsea infrastructure (e.g. sediment disturbance and reef effects from marine organisms growing on subsea infrastructure) are rated as a minor, long term, local and reversible impact.

During construction and operations various routine and non-routine discharges will be released into the marine environment. Releases of these effluents could have an impact on water quality and marine biodiversity in the water column. Provided that effluents streams are treated to standards (e.g. MARPOL) the impact of routine and non-routine discharges to marine water quality and biodiversity is assessed to be minor and short term given the high dispersion rates in the offshore marine environment.

Labour Requirement/Recruitment of Workforce:

Increased financial flow, social vices (drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labour contracts

The increase in financial flow could lead to social vices such as violence, alcoholism, attraction of commercial sex workers (CSW), substances abuse, and teenage pregnancies. This could lead to increase in sexually transmissible diseases (HIV/AIDS, syphilis among others), injuries, and loss of life or properties. This impact is rated as direct, negative, short term, local, reversible and major.

Increased opportunity for contracting and temporary employment

The project could offer employment for the indigenes at various stages. This could improve income. The impact was described as direct, long term, local/widespread and reversible. It was rated positive.

Influx of job prospectors into communities, thereby exerting pressure on social and health infrastructure

Migrant labour could be attracted to the project area. This increase in population of the area could put pressure on the already deficient infrastructure. This could lead to overcrowding with potential for increase in communicable diseases like malaria, respiratory tract infections and skin diseases. The impact was direct, negative, short term, local and reversible. It was rated moderate.

Conflicts/ Third party agitations over employment issues

Labour issues are always a source of friction between companies and communities and also among community members. The agitation could be either due to requests for a certain number of labour that could not be met or sharing the labour slots in the community. The impact was described as direct, negative, short term, local and reversible. It was rated major.

Increased level of disease vectors (mosquitoes, rats, cockroaches, flies, etc.)

Wastes disposed haphazardly form microenvironments for breeding of disease vectors. The crevices could provide habitats for mosquitoes, rats, cockroaches, flies. The impact is direct, negative, short term, local and reversible with a moderate rating.

Increase in disease conditions like diarrhoea/ respiratory tract diseases

Consequent on disposal of wastes without proper adherence to sanitary guidelines, discharge of sewage into the water bodies, the preponderance of disease vectors could lead to widespread increase in diarrhoea diseases. The impact was direct, negative, short term, local and reversible. The rating is moderate.

Increased opportunity for contracting and temporary employment:

The project could offer employment for the indigenes at various stages. This could improve income. The impact was described as direct, short term, local/widespread and reversible. It was rated positive

Waste Generation:

Impairment of the health of terrestrial flora and fauna:

In the aquatic system, eutrophication could result if food wastes are dumped into them. The algal bloom as well as zooplanktons depletes the dissolved oxygen, increasing the biochemical oxygen demand (BOD). Other wastes could raise the toxicity level (heavy metals) of the water. All organisms linked to the food web including fish and man could be affected. The impact was direct, negative, short term, local and reversible. The rating is moderate.

5.3.4.3 Operation Phase

Background:

The basic chemical that is used to produce nitrogenous fertiliser is 'Ammonia'. Ammonia is produced basically from water, air and energy. The energy source is usually hydrocarbon that provides hydrogen for fixing the nitrogen. The other energy input required is steam and power. This is to be through petroleum products. In general, steam reformation process of light hydrocarbon particularly Natural Gas (NG) is the most efficient route for the production of ammonia. The other routes are the partial oxidation of heavy oils if the available feedstock is residual heavy oil from a Fertilizer. For Dangote Fertilizer Plant, the major source of feedstock shall be natural gas since Dangote Fertilizer is located in close proximity to it. In general, during the operational phase, the likely sources of pollution from the production process include emission from the fertilizer manufacturing plants, storage facility; fumes generated from power generators and vehicular emissions from shipment of materials to and fro the storage facility, bulk handling and storage of materials.

Air Quality Impact Analysis and Modelling:

Introduction

During operational phase, the likely sources of air pollution from fertilizer production process include emission from the fertilizer manufacturing plants, storage facility; fumes generated from power generators and vehicular emissions from shipment of materials to and fro the storage facility, bulk handling and storage of materials. Specifically, the most significant sources of emissions to the air from the operation of the proposed fertilizer plant are the stacks that contain flue via which the pollutants are emitted to the atmosphere. In this sub-section, the study further modelled the extent of the operational air quality impacts from the identified pollution sources that are associated with the proposed Dangote Fertilizer plant. These impacts and predicted future pollutant concentrations at the air sensitive receivers (ASRs) are assessed based on these identified emission sources. The procedures involved in predicting the extent of these impacts through modeling are presented as follows.

Modelling Objectives

The purpose of emission modelling is to determine atmospheric concentrations of gases from source(s) under scrutiny and whether the concentrations are within limits set by regulatory authorities. In this study of the proposed fertilizer plant, the objectives include:

a) Determine the various pollutants and their rate of emission from the proposed source;
b) Model the dispersion of the emissions based on the source group for various averaging periods using AERMOD;
c) Determine the highest ground level concentrations for the emissions at specified receptor points, and
d) Evaluate the results with reference to regulatory limits and risk factor.

Regulatory Guidelines and Standards

Air quality standards and guidelines are set to establish limits to guide regulators and practitioners on what emission level that should not be exceeded and recommended measurement methods. Averaging time is included to determine how long measuring equipment are exposed and the results averaged to characterize the period. Averaging time could be short term (24 hours) or long term (annual). The distinction is made because organisms exposed to pollution of a high magnitude over a short period of time may experience lesser effects than if it is exposed to much lower impact over a longer period. Averaging periods are usually 1, 3, 8 and 24 hours, daily maximum, and annually. In this study, the averaging periods used are 1, 8 and 24 hours. The 8-hour averaging period is important for the occupational environment, which may coincide with shift work routines, but the proposed power plant will operate 24 hours; moreover, the atmosphere has a diurnal cycle which fits into 24 hour averaging.

The most frequently used reference guidelines are those of the World Health Organization (WHO), the European Union (EU), and the standards of the U.S. Environment Protection Agency (U.S. EPA). WHO guidelines are the most stringent of all. The WHO and U.S. EPA guidelines/standards have been set based on clinical, toxicological, and epidemiological evidence. Guideline values of ambient particulate concentrations were established by determining concentrations with the lowest-observed-adverse-effect (implicitly accepting the notion that a lower threshold exists under which no adverse human health effects can be detected), adjusted by an arbitrary margin of safety factor to allow for uncertainties in extrapolation from animals to humans and from small groups of humans to larger populations. Standards determined by the U.S. EPA also reflect the technological feasibility of attainment. Adverse effect is defined as "any effect resulting in functional impairment and/or pathological lesions that may affect the performance of the whole organism or which contributed to a reduced ability to respond to an additional challenge". The EU guidelines have been determined by consultation and legislative decision-making processes that took into account the environmental conditions and the economic and social development of the various regions, and acknowledged a phased approach to compliance. A potential trade-off was also recognized by the guidelines for the combined effects of SO_2 and particulate matter (World Bank, 1995). The proposed general air quality standards, based on international best practice, for this Air Quality Modelling Assessment are set out in Table 5-8

Emission Data

The four identified stacks are the most significant sources of emissions to air from the operation of the proposed Fertilizer Plant. Each stack contains a single flue via which the pollutants are emitted to the atmosphere. The physical properties and emission limits of each stack, as represented within the model, are presented in Table 5-9 and Table 5-10 respectively. This data has been provided by Dangote fertilizer limited. All the four sources have been included in the modeling.

Table 5-8: Air Quality Standards Adopted for this Air Quality Assessment

Pollutant	Averaging Period	Standards	Source
Pm 10 Pm_{10} is fine particulate matter with aerosdynamic diameter of less than 10 mircrometers	24hrs Annual Mean	150µg/m^3 70 µg/m^3	IFC, FEPA, NAAQS
$Pm_{2.5}$ Pm2.5 are fine is fine particulate matter with aerosdynamic diameter of less than 10 mircrometers	24hrs Annual Mean	75 µg/m^3 35 µg/m^3	IFC, FEPA, NAAQS
Nitogen dioxide No2	1 hour Annual mean	200 µg/m3 40 µg/m3	IFC
CO	1hour Annual mean	40mg/m3 10mg/m3	
Oxides of nitrogen	Annual Mean	30 µg/m3	WHO Guidelines for vegetation protection
Sulphur dioxide (So2)	10 minutes mean 24hrs Annual mean	500 µg/m3 125 µg/m3 20 µg/m3	IFC IFC WHO (Guidelines for vegetation protection (forest and natural vegetation
Ammonia (NH3)	Annual mean	8 µg/m3	Guidelines for vegetation protection

Table 5-9: Flue Physical Characteristics

SOURCE	FLUE GAS FLOW RATE (NM3/HR)	EXIT TEMPERATURE (DEG.C)	STACK HEIGHT(M)	STACK DIA(M)	EXIT VELOCITY(M/S)
Primary Reformers 11-L-201 /21-L-201	410288	199	30	4.3	14.88
Granulation Towers 19-L-55/29-L-55	1037531.7	43	44	4.8	19.83
Vent Stack Seperators 10-V-12/20-V-12	88	50	60	1.19	0.03
Auxiliary Boilers 13-B-01/13-B-02/13-B-03	125607	150.6	35	2.1	18.67

Table 5-10: Pollutant Emission Strength and Sources for Various Pollutants Considered

Source	POLLUTANT EMISSION RATE(g/s)			
	NO_2	NH_3	UREA DUST	SO_2
Primary Reformers 11-L-201 /21-L-201	34.19	-	-	3.42
Granulation Towers 19-L-55/29-L-55	-	30.26	8.65	-
Vent Stack Seperators 10-V-12/20-V-12	-	0.47	-	-
Auxiliary Boilers 13-B-01/13-B-02/13-B-03	8.37	-	-	1.05
Note:-Flue gas flow and emission concentration values are referred to a temperature of 273K , a pressure of 101 Kpa and 3% O_2 on a dry basis for the Primary Reformer and for the Auxiliary Boilers and real O_2 percentage for Granulation Towers and Vent Stacks.				

The Figures indicated in the table above and the accompanying notes are individually given as the maximum flow which can occur in each stack. Normal flow will be about 65% of the sum total of all the flows together. However, in order to provide a robust assessment of impacts, a worst case scenario has been considered by modelling the emissions as a sum total of all the flows.

Factors Affecting Emissions

There are a number of factors that will affect how emissions disperse once released to atmosphere. The four factors having the greatest effect on dispersion are:

- Physical characteristics of the emissions;
- Climate;
- Terrain, and
- Building Downwash.

a) Physical Characteristics of the Emissions

Provided that exhaust gases have sufficient velocity at stack exit to overcome the effects of stack tip downwash, which is almost certainly the case for exit velocities of 15 m s-1 or more, the physical characteristics of the flue gases will determine the amount of plume rise and hence the effect on ground level pollutant concentrations. In high winds or when a source has a low exit velocity (eg <5 m s-1), the plume rise will be reduced – the model used accounts for this on an hour-by-hour basis with reference to the exit velocity and the wind speed for that hour. The degree of plume rise usually depends on the greater of the thermal buoyancy or momentum effects.

b) Climate

The most important meteorological parameters governing the atmospheric dispersion of pollutants are wind speed, wind direction and atmospheric stability.

- Wind direction determines the broad transport of the plume and the sector of the compass into which the plume is dispersed, and
- Wind speed can affect plume dispersion by increasing the initial dilution of pollutants and inhibiting plume rise.

Atmospheric stability is a measure of the turbulence of the air, particularly of the vertical motions present. For dispersion modelling purposes, one method of classifying stability is by the use of Pasquill Stability categories, A to F. Another is by reference to the surface heat flux present at the ground.

New generation dispersion models, such as ADMS and AERMOD PRIME, do not allocate the degree of atmospheric turbulence into six discrete categories. These models use a parameter known as the Monin-Obukhov length which, together with the wind speed, describes the stability of the atmosphere.

c) Building Downwash

The presence of buildings can significantly affect the dispersion of the atmospheric emissions. Wind blowing around a building distorts the flow and creates zones of turbulence that are greater than if the building were absent. Increased turbulence causes greater plume mixing; the rise and trajectory of the plume may be depressed generally by the flow distortion. Downwash leads to higher ground level concentrations closer to the stack than those present if the building was not there.

It is commonly accepted that downwash effects only occur for emissions from stacks that are less than 2.5 to 3 times the height of the building structures. The downwash structures also have to be sufficiently close to the source for their influence to be significant. The US Environmental Protection Agency suggests that the zone of influence around a building extends for a distance of no more than five times the lesser of the structures height or width.

For the purpose of this assessment, it has been assumed that the effect on dispersion of building downwash will not significantly affect the overall distribution of predicted concentrations to emissions to atmosphere from the whole site. This is because most of the sources are sufficiently tall to be outside the effects of downwash. For those sources that many be influenced by the presence of buildings or structures, their effect will be to increase on site concentrations close to the source and reduce off-site concentrations. The exclusion of this effect is therefore considered to be conservative and represents a realistic worst case assessment.

d) Nature of the Surface

Terrain

The terrain in the region of the proposed facility is reasonably flat and will not significantly affect dispersion. Terrain with slopes less than 10% (ie 1 in 10) are considered flat for modelling purposes. For the purpose of this assessment it is assumed to be flat.

Roughness

The nature of the surface of the terrain can have a significant influence on dispersion by affecting the velocity profile with height and the amount of atmospheric turbulence. To account for the surrounding nature of the site, a surface roughness length of 0.3 metres has been assumed for wind flow from the land and 0.1 metres for wind blowing from the sea.

Impact Assessment

Following the definition of applicable air quality sensitive receptors and baseline conditions, the air quality impacts resulting from the proposed Fertiliser Plant operation have been assessed. In the case of the plant's operational activities, air dispersion modeling has been undertaken to simulate air concentrations within the site environment during normal plant operation for the following:

- NOx
- CO
- VOCs
- CO2
- SOx
- Ammonia
- Urea, and
- Particulate Matter

All input parameters for the modelling exercise are detailed in the the following sections. Following modelling, airborne concentrations as well as ground deposits have been compared with applicable international standards. This comparison enables conclusions to be made regarding the Project's impact upon air quality.

Selection of Suitable Dispersion Model

Two commercially available new generation dispersion models that are able to predict ground level concentrations arising from emissions to atmosphere from elevated point sources (ie stacks) are:

- **AERMOD PRIME:** The US American Meteorological Society and Environmental Protection Agency Regulatory Model Improvement Committee have developed a 'new generation' dispersion MODdel called AERMOD which incorporates the latest understanding of the atmospheric boundary layer.
- UK Atmospheric Dispersion Modelling System (UK ADMS): This is a new generation dispersion model developed by the UK consultancy CERC. The model allows for the skewed nature of turbulence within the atmospheric boundary layer.

In many respects the models are quite similar and in some situations generate similar predictions of ground level concentrations. Two intercomparison studies commissioned by the UK Environment Agency however found there to be significant differences in calculated concentrations between the models. These reports highlight modelling uncertainties and do not suggest that any one of the models is considered to be the most accurate.

AERMOD PRIME (Version 14134, the latest in the series) was selected as the model for use in this assessment because it has greater flexibility with regard to numbers of sources and has a greater international recognition.

Meteorological Data

An important input to the dispersion model is the meteorological data. These data are important in determining the location of the maximum concentrations and their magnitude. For dispersion modelling it is important to have good quality data that includes all the necessary parameters and has a high data capture rate. These considerations override the need to have data from on-site or nearby. The best case is to have good quality data from on-site but this is rarely available. Meteorological data used for this modelling work are a combination of measured and modelled data. Some of the parameters for which measurements are not available have been calculated well known relationships. Figure 5-1 shows the wind pattern on – site during the wet season. Wind is generally south – westerly.

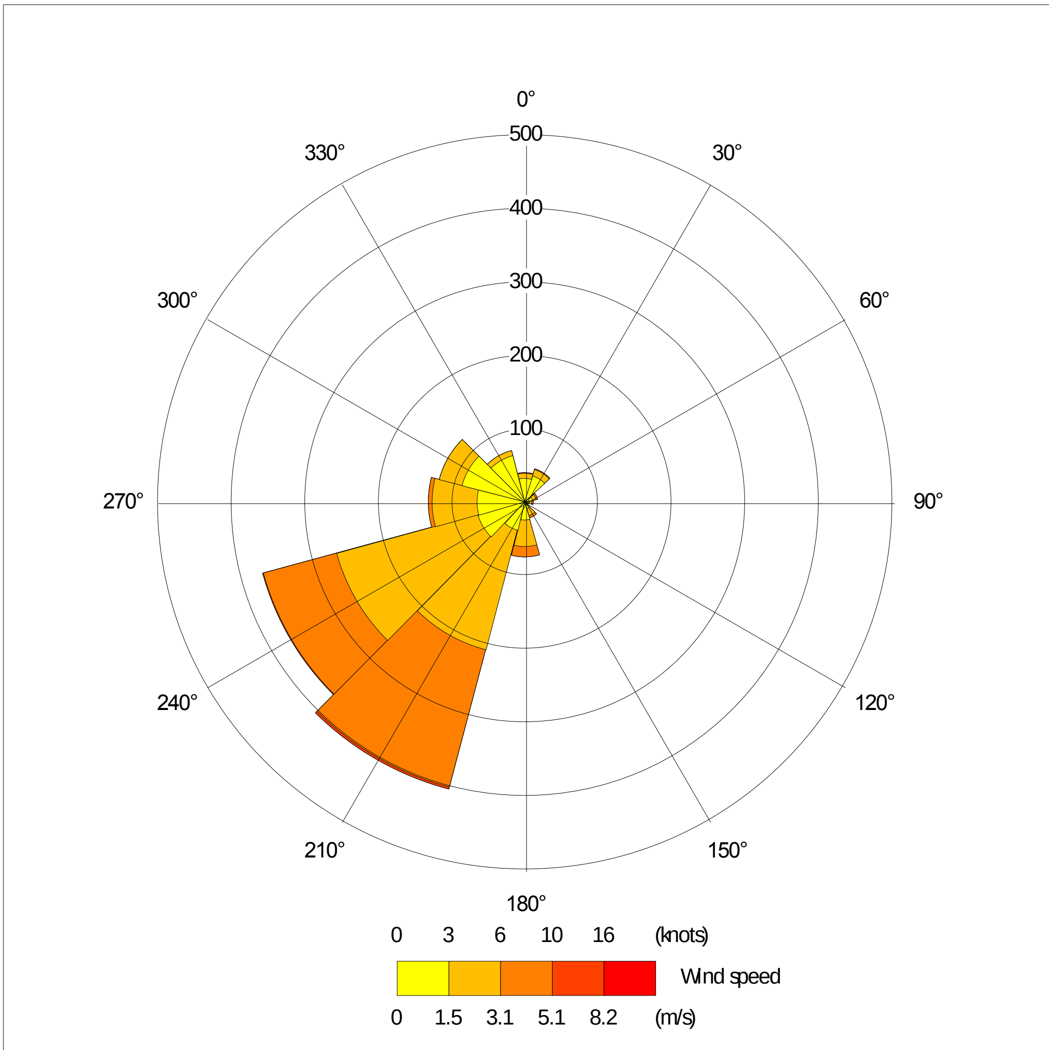


Figure 5-1: On site wind rose

Modelling Assumptions

Percentage Oxidation of Nitric Oxide (No) to Nitrogen Dioxide (NO_2)

Oxides of nitrogen (NOx) emitted to atmosphere as a result of gas combustion will consist largely of nitric oxide (NO), a relatively innocuous substance. Once released into the atmosphere, nitric oxide is oxidised to nitrogen dioxide (NO_2), which is of concern with respect to health and other impacts. The proportion of nitric oxide oxidised to nitrogen dioxide depends on a number of factors and the oxidation is limited by the availability of oxidants, such as ozone (O_3).

As a conservative approach it is assumed that 100% of the nitric oxide is oxidised to nitrogen dioxide for annual average concentrations of nitrogen dioxide. For the maximum one hour average, maximum 24 hr average and first highest of hourly averages ground level concentrations it is assumed that 50% of the nitric oxide is in the form of nitrogen dioxide. The general model conditions used in the assessment are summarized in Table 5-11.

Table 5-11: General AMOD 4 Model Conditions

Variable	**Input**
Surface Roughness at source	1.0m
Receptors	Selected discrete receptors Gridded receptors
Receptor location	X,y coordinates determined by GIS, z=1.5
Source location	X,y cooredinates determined by GIS
Emission	Data provided by GFC
Sources	Primary reformer stack Gas turbine stack Auxillary boiler stack Urea granulation stack
Meteorological data	3 years of hourly interval daytime sequential data (2010-2013)
Terrain Data	Flat
Buildings that may cause building downwash effects	Not included, but compention for the effect on-site buildings is included by using a higher surface roughness

Dispersion Modelling Results

a) Ammonia (NH_3)

The pollution concentration for Ammonia (NH_3) based on the proposed plant emission rate is shown in Table 5.12. The highest predicted concentration is about 29.23 µg/m^3 in the north-east direction of the proposed plant. Although FMEv does have emission limits for NH_3, predicted concentrations are nevertheless insignificant.

Table 5.12: Predicted concentrations for NH_3 on 1 hr, 8hr, 24 hr and annual average basis

Receptor Location	Description of receptor location	1 hr Average (µg/m^3)	8 hr Average (µg/m^3)	24 hr Average (µg/m^3)	Annual Average (µg/m^3)	Distance in the X-direction from plants	Distance in the Y-direction from plants
L1	100 meters directly on the south of the plants	0.45	0.07	0.02	0.000	0	-100
L2	100 meters south- west of the plants	5.24	0.80	0.29	0.002	-100	-100
L3	100 meters directly on the north of the plants	1.47	0.24	0.08	0.000	0	100
L4	100 meters directly on the north-east of the plants	29.23	4.87	0.62	0.002	100	100
L5	100 meters north- west of the plants	2.70	0.46	0.14	0.002	-100	100
L6	100 meters directly on the west of the plants	8.68	1.39	0.47	0.002	-100	0
L7	Far distance from the plant in north- east direction	2.54	0.43	0.16	0.011	2000	2000
L8	Far distance from the plant in south-west direction	2.51	0.37	0.18	0.007	-2000	-2000

b) Nitrogen Dioxide (NO_2)

Nitrogen dioxide is a reddish brown gas (at sufficiently high concentrations) and occurs as a result of the oxidation of nitric oxide (NO), which in turn originates from the combination of atmospheric nitrogen and oxygen during combustion processes. The predicted concentration of NO_2 for the proposed plants is shown in Table 5.13. World Health Organisation (WHO) limits for NO_2 is 40 µg/m^3 annual averages. FMEv standards stipulate 85 µg/m^3 for 24 – hr average which is more stringent than WHO limits. Predicted emissions for proposed plants are insignificant and lower than WHO and FMEv limits.

Table 5.13: Predicted concentrations for NO_2 on 1 hr, 8hr, 24 hr and annual average basis

Receptor Location	Description of receptor location	1 hr Average **(µg/m^3)**	8 hr Average **(µg/m^3)**	24 hr Average **(µg/m^3)**	Annual Average **(µg/m^3)**	Distance in the X-direction from plants	Distance in the Y-direction from plants
L1	100 meters directly on the south of the plants	1.01	0.17	0.06	0.001	0	-100
L2	100 meters south-west of the plants	1.54	0.32	0.12	0.006	-100	-100
L3	100 meters directly on the north of the plants	1.10	0.18	0.06	0.001	0	100
L4	100 meters directly on the north-east of the plants	91.64	5.27	5.09	0.006	100	100
L5	100 meters north-west of the plants	1.47	0.72	0.24	0.007	-100	100
L6	100 meters directly on the west of the plants	1.01	0.22	0.07	0.002	-100	0
L7	Far distance from the plant in north-east direction	5.80	0.97	0.43	0.026	2000	2000
L8	Far distance from the plant in south-west direction	5.01	1.16	0.42	0.014	-2000	-2000

c) Sulphur dioxide (SO_2)

Sulphur dioxide is a colourless gas which is produced from some natural processes, notably volcanoes, but is associated most strongly with the combustion of fossil fuels containing sulphur. Predicted concentrations are presented in Table 5-14. FMEv limit for hourly maximum concentration of SO_2 is 500 µg/m^3. Whereas, WHO standard for annual average is 50 µg/m^3. The predicted concentrations are well below both limits in receptor locations considered.

Table 5.14: Predicted concentrations for SO_2 on 1 hr, 8hr, 24 hr and annual average basis.

Receptor Location	Description of receptor location	1 hr Average (µg/m^3)	8 hr Average (µg/m^3)	24 hr Average (µg/m^3)	Annual Average (µg/m^3)	Distance in the X-direction from plants	Distance in the Y-direction from plants
L1	100 meters directly on the south of the plants	0.10	0.02	0.01	0.000	0	-100
L2	100 meters south-west of the plants	0.17	0.03	0.01	0.001	-100	-100
L3	100 meters directly on the north of the plants	0.11	0.02	0.01	0.000	0	100
L4	100 meters directly on the north-east of the plants	9.57	0.59	0.53	0.001	100	100
L5	100 meters north-west of the plants	0.16	0.08	0.03	0.001	-100	100
L6	100 meters directly on the west of the plants	0.10	0.02	0.01	0.000	-100	0
L7	Far distance from the plant in north-east direction	0.61	0.10	0.05	0.003	2000	2000
L8	Far distance from the plant in south-west direction	0.52	0.12	0.04	0.001	-2000	-2000

d) Urea Dust

Predicted concentrations for urea dust are presented in Table 5-15. The predicted concentrations are not significant and posed no danger to human, plants and animals within the vicinity of the fertilizer plants.

Table 5-15: Predicted concentrations for Urea Dust on 1 hr, 8hr, 24 hr and annual average basis.

Receptor Location	Description of receptor location	1 hr Average (μg/m^3)	8 hr Average (μg/m^3)	24 hr Average (μg/m^3)	Annual Average (μg/m^3)	Distance in the X-direction from plants	Distance in the Y-direction from plants
L1	100 meters directly on the south of the plants	0.13	0.02	0.01	0.000	0	-100
L2	100 meters south- west of the plants	1.50	0.23	0.08	0.001	-100	-100
L3	100 meters directly on the north of the plants	0.42	0.07	0.02	0.000	0	100
L4	100 meters directly on the north-east of the plants	8.36	0.39	0.46	0.000	100	100
L5	100 meters north- west of the plants	0.77	0.13	0.04	0.000	-100	100
L6	100 meters directly on the west of the plants	2.48	0.40	0.13	0.000	-100	0
L7	Far distance from the plant in north- east direction	0.72	0.12	0.04	0.003	2000	2000
L8	Far distance from the plant in south-west direction	0.71	0.10	0.05	0.002	-2000	-2000

Conclusions

Predictions of the maximum on-land, off-site ground level concentrations for all five pollutants considered suggest that even with the inclusion of background ambient pollutant concentrations there are and will be no exceedences of the air quality standards and guidelines. The predictions also show that the effects on the maximum on-land off-site ground level pollutant concentrations of the proposed Fertilizer Plant Fertilizer projects are negligible. However, since Dangote Fertilizer Limited is also proposing the establishment of a Petroleum Fertilizer in the immediate vicinity of the Fertilizer Plant, there is the need to evaluate the pollution statistics and interaction of the combined emissions.

Noise

Noise emissions from continuously and intermittently operating sources such as machines, generators, mobile equipment, forklifts, trucks etc will result in increased noise level. Noise emissions will also occur due to equipment faults, inappropriate operation, and damage to equipment supports and fixtures, etc.

The design considerations are expected to reduce noise level to generally low values compared with regulatory limit. The likelihood of occurrence is high, the effect of the noise will be local and the impact is expected to be moderate.

Offshore, sources of underwater noise will be propellers and thrusters. Marine mammals and fishes are expected to avoid this area during this period. The magnitude of this impact on marine fauna is considered to be low.

Groundwater

The potential sources for groundwater contamination are the discharge of liquid effluents, disposal of solid and hazardous wastes on land and accidental spillages of hazardous materials (oils, chemicals, paints, cleaning solvents, etc.). The liquid effluents include equipment/vehicle wash water, and sanitary wastewater. The likelihood of occurrence is low, since the effect of such spills will be local, and properly abated through the implementation of sound facility management principles. The anticipated impact is expected to be low, and insignificant.

Soil

The potential causes for land contamination are the discharge of liquid effluents, disposal of solid and hazardous wastes on land and accidental spillages of hazardous material. Spill of herbicides, pesticides and fertilizers could result in soil contamination. The likelihood and significance of the impact is high.

Influx of workers:

Increased social vices, drug abuse, commercial sex workers (CSWs), exposure to STDs/HIV/AIDS, unwanted pregnancies

The increase in population could lead to social vices like violence, alcoholism, attraction of commercial sex workers (CSW), substances abuse and teenage pregnancies. This could lead to increase in sexually transmissible diseases (STDs, HIV/AIDS and syphilis, etc), injuries, and loss of life or properties. This impact is direct, negative, short term, local and major.

Pressure on available water for domestic and other uses, health facilities, schools and other social amenities

Increase in population could put unwarranted pressure on communities' domestic water supply and other resources in communities with already poor infrastructure. This could be direct, negative, medium term, local, and reversible. It is rated as moderate.

Pressure on available food with implications for malnutrition in children:

The increase in population of the area could also put pressure on the available food resources in the communities. These could lead to shortages in food supply and with a potential to affect children especially. The impact was direct, negative, medium term, local and reversible. It was rated moderate.

Waste generation:

Contamination of water quality by sewage, resulting in increase in coliforms and thereby diarrhoea and other related water borne diseases

Consequent on disposal of wastes without proper adherence to sanitary guidelines, discharge of sewage into the water bodies, the preponderance of disease vectors could lead to widespread increase in diarrhoea diseases. The impact was direct, negative, short term, local and reversible. The rating is moderate.

Transportation of materials, equipment and personnel:

Increase in usage of roads and waterways with possibilities of accidents

The project activities involve the deployment of several project vehicles which will result in the increase of road usage due to movement of personnel, equipment and materials. The aftermath of this could be accidents as a result of immense pressure put on the roads. This impact is direct, negative, short term, local and reversible. The impact is rated moderate.

Increase in usage and resultant damage to existing roads

In the same vein, increase in the usage of roads could result in increase in road traffic accidents due to road congestion. The pressure exerted on these roads could lead to their early damage. This phenomenon is rated as direct, negative, short term, local, reversible and major.

Loss of resources:

Settlement Displacement/Economic Loss

Physical displacement of household is not expected in the DFP project area, based on the site visits the ESIA-team carried out. Nevertheless, economical displacement will occur. Compensation for loss of resources shall be subject of the Livelihood Restoration Plan that will be prepared according to the IFC Performance Standards by DFL.

Loss of fishing resources

The pipeline route and its accompany noise could result in the loss of some fishing ground. It is expected this would not have an impact on the total fish catches. The impact is considered direct, reversible and minor.

Reduction of land resources

The vegetation of the required land contains economic plants such as cassava, yams, coconut trees, oil palm trees etc. The land acquisition is expected to eliminate the local farming of crops, within the project area and the entire Zone, and similarly affect some wildlife species identified in the project area such as snakes, grass cutters and birds.

Land take is expected to limit access to these resources, within the zone. The impact was described as direct, negative, short term, local and reversible. It was rated as minor.

Repairs and maintenance:

Generation of high intensity welding flash and noise

The welding activity generates high intensity welding flash. This flash could affect unprotected eyes giving rise to conjunctivitis. The impact is considered direct, negative, short term, local, reversible and rated moderate

Burns and injuries from welding sparks/injuries from other maintenance activities

The sparks generated during welding activities could result in injuries on soft tissues of the body. The impact is considered direct, negative, short term, local, reversible and rated moderate.

Contamination of surface soil with used lubricant:

Lubricants used for vehicle, heavy equipment and machinery maintenance could result in the contamination of topsoil. This impact is considered direct, negative, short term, local, and reversible with a moderate rating.

5.3.4.4 Decommissioning Phase

Although dismantling and recovery of the land in original state is a scenario that's highly unlikely to occur in this project, an analysis of potential impacts is mandatory for good ESIA study.

Air Quality

Demolition activities will result in localized high levels of dust and vehicular emissions from civil works and vehicle movement. This is expected to be significant particularly during the dry season.

Potential impacts from dust emissions on site will be significantly reduced by implementation of mitigation measures to reduce dust generation. These emissions are short-termed and localized to the immediate site area; though the likelihood of occurrence is high, the consequence is rated as negligible negative. Thus, the overall impact risk level is expected to be low.

Noise

The heavy equipment used in decommissioning activities and other civil works, diesel generators used for temporary power generation and vehicles used for transportation of material and men to site will have an adverse impact on ambient noise levels.

Noise from transport vehicles will be only transient for a given location and can be considered as a nuisance during night-time. The noise impact is rated short-termed and localized to the immediate site area; with a high likelihood of occurrence, the overall impact is low, reversible and rated minor.

Solid, Liquid and Hazardous Waste Management

Decommissioning activities will generate wastes such as excavated soils and debris, wood piles, fuels, lube oils, chemicals and solid wastes from the demolition camp. Leaching from waste oil could result in groundwater contamination. The solid and hazardous waste generated during the decommissioning activities will be managed using the best management practices. The impact from the hazardous waste management will be negative, short term, local and reversible.

Increased opportunity for employment and contracting resulting in increased income level

The process of decommissioning will involve the repair of damaged roads, removal of structures, and restoration of campsite. These activities could increase opportunities for employment and contracting. The impact was rated as direct, positive, short term, local and reversible.

Nuisance (noise, emission, vibration etc) from heavy machinery

The process of decommissioning could also result in the generation of noise, vibration etc. from heavy equipment. The impact was rated as direct, negative, short term, local, reversible, and moderate.

Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities

As project activities come to an end, there could be agitation by the third parties from loss of employment and contracting opportunities. The impact was direct, negative, short term, local, and reversible, with moderate rating.

5.3.5 Cumulative Effects and Cross-Border Effects

Cumulative impacts of DFP and cross-border effects

Dangote Fertilizer Plant is a project located in the Lekki Free Zone. The Plant is located in a remote area along the Atlantic Coast of Nigeria. In the area, there are few developed industrial/commercial projects. The potential impact of cumulative and cross-border effects of the project is classified as negligible. However, such assessment is temporary as the Zone is expected to house several large scale industrial/commercial establishments. Again, this fact is further reinforced by the fact that the immediate neighbour of this plant is the Dangote Fertilizer Plant.

Assessment of Cumulative Impacts

Presently, only Candel Agrochemical Industries Ltd is fully established in the Zone. Thus, given the high level of uncertainty and the fact that cumulative impacts are not within DFP's direct control, this section suggests strategies that stakeholders, including DFP, may adopt towards managing these impacts in a general way, rather than providing concrete mitigation proposals for specific impacts. In the absence of detailed information, only an indication of the cumulative impacts and the contribution to those impacts by DFP is possible at this stage. The issues are discussed at a high level, and grouped into the following categories:

- Environmental quality;
- Infrastructure and services;
- Socio-economic and health effects; and
- Accidental events.

Many of the recommendations emerging from the analysis are applicable to the Nigerian government, LFZ authorities and future developers and are specifically not commitments or actions for DFP's proposed project.

Environmental Quality:

Atmospheric Emissions

While emissions from DFP project are local and not expected to extend beyond site boundaries, future development of petroleum facilities and other facilities may result in additional VOC emissions. These emissions will last for the lifetime of the facilities. The combined effects of emissions from several facilities could result in a breach of acceptable ground level concentrations and have an impact on local people and the wider environment, even when each on its own is compliant with relevant standards. In addition to VOC emissions, future developments are likely to result in an increase in traffic-related emissions such as PM_{10} and NOx. Dust would also be generated.

With further industrial development in the LFZ, accurate quantification of atmospheric impacts on a regional level will be essential. From DFP's perspective, monitoring of ambient air quality, process emissions and collection of synoptic meteorological data will allow for accurate modelling of these impacts. A wide scale model, using data from all industries in the region would be an invaluable aid in managing cumulative air quality impacts. This should be undertaken in terms of a regional Air Quality Management Plan (AQMP) which has the buy-in of all companies in the LFZ that produce air emissions.

Liquid Discharges

Industrial discharges associated with DFP's project such as treated storm water from onshore facilities, and routine and non-routine discharges from marine vessels will be minimal. However, in combination with other existing and future industrial development, there could be considerable effluents from onshore facilities. In addition, there is the possibility that there would be cumulative effects on surface and groundwater resources from multiple small spills and potential chronic leaks occurring over time from a number of different sources. Individually these accidental spills or leaks could be minor, however, in combination there could be impacts of high magnitude on the freshwater surface and groundwater quality with corresponding ecological and health effects.

Deterioration in water quality could impact biodiversity, fisheries and local communities. As with atmospheric emissions, DFP project's ability to manage this issue is limited to the facilities under its direct control. However, a co-operative management approach and the development of additional infrastructure by the LFZ (i.e. treatment facilities), if necessary, would serve to mitigate these impacts in combination with combined monitoring of groundwater and surface water quality.

Noise

The noise impact assessment considers noise that is likely to be generated by the project in combination with ambient noise levels in the study area. Noise impacts during construction and operation were assessed to be of minor significance. The project will, however, contribute to cumulative noise impact in combination with other industries in the area. Important mitigation in this regard is that the area has been designated for industrial development and higher ambient noise levels are generally acceptable in industrial areas. It will, nevertheless, be important for future companies to co-operate in terms of complying with international best practice as far as acceptable boundary noise levels are concerned.

Solid Waste Management

Industries within the LFZ will generate increased volumes of solid wastes, including potentially hazardous materials. A larger population will also generate more domestic waste. It is likely that local facilities for handling industrial wastes will be required, along with improved domestic waste infrastructure, to avoid significant adverse impacts to local communities and surrounding areas. This could provide a socio-economic opportunity for the development of a local waste handling/treatment/transfer facility by the LFZ or the Lagos State authorities. This will minimise the cumulative impacts of further development.

Infrastructure and Services:

Transport infrastructure

The proposed project will result in significant numbers of additional HDV traffic during construction and operation, with associated impacts on public safety, and transport and access. The traffic assessment addresses both project-specific, taking into account background traffic associated with existing traffic volumes and addition of traffic generated by the proposed project. Future projects will put additional strain on road networks and result in increased congestion from construction and operational traffic. Cumulative impacts on road networks and traffic congestion could have a negative effect on community health and safety. DFP can manage traffic impacts from its own activities through implementing Traffic Management Plans and other mitigation measures. However, the responsibility to ensure adequate and safe road infrastructure for industries within the LFZ lies with the LFZDA and State authorities. DFP should support government initiatives, including detailed traffic studies to determine road network capacity, road integrity, safety hazards and problem intersections in relation to its own operations. Information from this study will form a basis for discussion for the LFZDA and State authorities to plan safe and efficient transport routes.

Social Infrastructure

There will be an increase in the number of workers in the area as a result of the continuing construction and operation of industries in the LFZ. The project area lies within a peri-urban setting, the communities are relatively small and the provision of services and related infrastructure (e.g. health care, education, potable water) in the area is often inadequate.

The development of the LFZ is unlikely to cause an unmanageable increase in pressure on the existing local infrastructure and services, since the new industries will meet the needs of their workforce by, for example, providing the required power, supplying safe water and health services, amongst others.

Socio-Economic and Health Effects

Livelihoods and micro-economics

The livelihoods of local people, particularly those engaged in fishing and farming will inevitably be affected by the presence of the project and future developments in the LFZ.

To mitigate some of the negative impacts on local livelihoods and to manage potential social risks, the project and other upcoming ones will maximise direct employment opportunities for local people in the communities. For people and communities subjected to physical and/or economical resettlement, each project is expected to develop a Resettlement and Livelihood Restoration Framework. This shall be accompanied with implementable Resettlement Action Plans and Livelihood Restoration Plans.

Communicable diseases

For the purposes of this discussion communicable diseases most relevant to the project activities, as identified through the socio-economic and health study, are considered. These are malaria, STDs, HIV/AIDS and typhoid fever. Infectious disease is a potential cumulative impact associated with the presence of workers. Development in the area will attract job-seekers as well as those seeking an opportunity to provide services to the growing population. An increase in workers is often linked to an increase in the incidence (the rate at which infections occur) and prevalence (the number of people infected) of communicable diseases.

DFP cannot accept sole responsibility for the management of these health related matters. DFP will, however, be able to enforce some controls (such as having a closed camp approach to limit interaction of workforce with local communities), specifically related to the project activities and workforce, as well as support government initiatives.

Accidental Events:

Hydrocarbon spills

Additional marine traffic visiting harbour facilities will increase the risks of hydrocarbon spills in the marine environment. There is the possibility that there will be cumulative effects from multiple spills occurring over time from a number of different sources. The probability of major spills, particularly those that could affect the coast or spills occurring simultaneously are very low. Even in such an eventuality, a co-ordinated spill response effort will result in the implementation of an appropriate tier of spill response. In essence, therefore, the actions arising from multiple releases in relative proximity is similar to that required for a single large release.

Fires and Explosions

The additional petroleum facilities of the Dangote Fertilizer to be established in proximity to the fertilizer plant site would be a cumulative increase in fire and explosions risk due to the concentration of petroleum storage facilities in a single geographic area. Future industrial development projects should be required to undertake detailed risk assessments that consider cumulative explosion and fire risks. DFP will coordinate their EPRP with local authorities and neighbouring facilities.

CHAPTER SIX

MITIGATION MEASURES AND MONITORING

CHAPTER SIX

MITIGATION MEASURES AND MONITORING

6.1 INTRODUCTION

The most important objective of an ESIA study is the development and establishment of suitable mitigation measures for the identified significant possible impacts of a proposed project and enhancement measures for beneficial impacts. This chapter summarises environmental and social mitigation measures that have been identified through the impact assessment process and also outlines key monitoring requirements.

6.2 MITIGATION MEASURES

Various components of the biophysical, health and social environments will be impacted by the proposed Fertilizer Plant project as presented in Chapter Five. The identified negative impacts may also be ranked accordingly.

To preserve the environment, a number of steps have been taken to mitigate the significant, medium and high ranking negative impacts identified as a result of the proposed development, as well as enhance those impacts identified as positive. The mitigation measures proposed for the predicted impacts took cognizance of the following:

- Environmental laws in Nigeria and permissible limits for waste streams (FEPA, 1991);
- IFC Guidelines
    - Performance Standards on Social and Environmental Sustainability
    - General EHS Guidelines
    - Industry Sector Guidelines
- Best Available Technology for sustainable development;
- Feasibility of application of the measures in Nigeria;
- Concerns and views of stakeholders during extensive consultations conducted during the study, and

- The residual effects that arise despite the mitigation measures have also been discussed for effective mitigation to a low level.

The mitigation measures for the impacts during the pre-construction, construction, operational and decommissioning phases earlier discussed are summarized below, with respective environmental monitoring and management requirements.

6.3 IMPACT MITIGATION MEASURES FOR PRE - CONSTRUCTION PHASE

The proposed mitigation measures for the associated potential impacts during the pre-construction phase are addressed below.

6.3.1 Air Quality

The major sources of air quality impacts during the pre- construction phase are dust generation and diesel engine exhaust resulting from site preparation activities such as land clearing, earth moving and levelling and transport of materials and workers. The dust from earthwork and vehicle movement could be significant, particularly during the dry weather conditions. The dust exhaust emissions will be short termed and local.

A formidable source of Greenhouse Gas (GHG) emissions generated as a result of project activities include release of carbon from vegetation removal, loss of sequestration potential, fuel consumed by machinery and moving vehicles. Such impact is very significant.

Measures to mitigate dust and GHG emissions include:

- Minimize the area of vegetation to be removed by clearing only the area required for the plant. In addition, retain and maintain the buffer strips along the Lagoon. This Green Zone contains vegetation with high carbon value in terms of both embodied carbon and sequestration potential. Construction and clearance of existing vegetation in this buffer strips shall be prohibited;
- Use of road/ground watering equipment and observation of speed limits in unpaved areas as necessary in dry conditions to reduce dust emissions;
- Use of low sulphur diesel;

- Designation of transport route to minimize distance travelled and overall fuel use and emissions;
- Regular maintenance of vehicle and construction equipment to keep the engines in good operating condition to reduce emission from internal combustion engines, and
- Open burning of vegetation and other solid waste should, where possible, be avoided and managed through a Waste Management Plan

6.3.2 Noise

The likelihood of occurrence of noise impact is high and the overall impact risk is minor, this will however be short-term and local. Site workers shall be provided with adequate Personal Protective Equipment (PPE) such as ear muffs. The use shall be enforced.

All heavy machinery used for site preparation shall be equipped with appropriate and functioning noise suppressor (mufflers) and the use of heavy machinery and heavy vehicle movements shall be prohibited at night.

6.3.3 Vegetation

The primary impact is loss of vegetation species and their ecosystem services, loss of farmland, wildlife migration and regressing of topsoil which could lead to soil erosion. These impacts will be long term and reversible.

These impacts shall be mitigated by careful de-vegetation of the project area during site preparation, retaining and maintaining the buffer strips along the Lagoon, application of appropriate erosion protection measures and sensitization and advocacy on benefit of the proposed project coupled with provision of alternative practice/occupation for people who lost farmlands.

6.3.4 Socio-Economics/Health

Socio-economics and health impacts resulting from pre-construction activities comprises of both positive and negative impacts. The positive impacts of increased financial flow due to compensations, and creation of opportunities for employment shall be enhanced by;

- continuous consultation with and engagement of all the relevant stakeholders such as the project communities, State and Local Government agencies and CBO's;
- adopting policies to encourage short-term employees (through periodic briefings or other means as practicable) to save for future needs following their employment

The negative impacts of exertion of pressure on existing infrastructure resulting from Influx of job seekers into communities, possibilities of lines cutting across sacred places and increase in usage of roads and waterways with possibilities of accidents shall be mitigated by:

- consultation with communities' traditional rulers on relocation of sacred places;
- defensive driving lessons and use of traffic signs;
- posting load limits on certified haulage equipment/vehicles; and
- maintenance of a medical emergency response plan so that injured persons can promptly access appropriate care

6.4 IMPACT MITIGATION MEASURES FOR CONSTRUCTION PHASE

The proposed mitigation measures for the associated potential impacts during the construction phase are addressed below.

6.4.1 Air Quality

The main potential sources of emission are from combustion engines and dust, during construction related activities. These emissions will be short termed and local. Measures to prevent dust and GHG emissions from becoming a source of nuisance include:

- Implementation of BAT;
- Regular maintenance of vehicle and construction equipment to keep the engines in good operating condition to reduce emission from internal combustion engines;

- Operators of dredging vessels shall be required to maintain NO_x and SO_x emissions within the limits established by MARPOL 73/78;
- Construction site shall be periodically dampened with water to minimize dust;
- Regular maintenance of vehicle and construction equipment to keep the engines in good operating condition to reduce emission from internal combustion engines;
- Use of road/ground watering equipment and observation of speed limits in unpaved areas as necessary in dry conditions to reduce dust emissions;
- Training of workforce in safe driving practices that reduces both the risk of accidents and fuel consumption including measured acceleration and driving within safe speed limit;
- Maintenance of plant and vehicles in good working order e.g exhausts, tyres etc;
- Turning off engines when not in use;
- Use of low sulphur diesel, and
- Designation of transport routes to minimize distance travelled and overall fuel use and emissions;

6.4.2 Noise

Site workers requiring hear protection devices shall be provided with it and the use shall be enforced. Noise sensitive areas clearly delineated with a 'NO NOISE" sign post, and construction activities should be restricted to daytime to avoid irritation of neighbouring communities.

Diesel engine construction equipment should be fitted with silencers, and heavy vehicle movements prohibited at night.

6.4.3 Ground Water Quality

As the construction activities are not expected to impact adversely on groundwater flow and quality, no mitigation measures are recommended. However, the handling, storage and disposal of materials and wastes at all stages of the construction of the facility should be based on the ESMP developed for the project. Training on safe practices for personnel involved in handling, storage and disposal of materials and wastes should be provided.

The regular maintenance and inspection of equipment and vehicles will be ensured to prevent potential sources of leaks.

6.4.4 Land Use

The project site is currently moderately used and there are no houses on the project site. Land users will be compensated for the economical displacement and provision of alternative practice/occupation for people who lost farmlands. Enumeration will be done and a Livelihood Restoration Plan will be set up.

6.4.5 Soil Quality

Mitigation measures for the management of erosion and soil contamination will include:

- application of appropriate erosion protection measures;
- careful execution of excavation works under aggressive weather conditions (rains, strong winds);
- storage of any hazardous wastes, as well as sanitary and cleaning wastes shall be done in storage facilities (tanks/containers) and at approved sites;
- tanks for fuel storage shall be leak proof and installed on concrete platform with gutters and grease separators. Fuel storage tanks shall be checked daily and in case of leakage will be replaced until repaired;
- treatment of waste water from maintenance workshops in oil separators prior to discharge, and
- in case of any contamination, removal of contaminated soil and treatment/disposal of in a manner appropriate to the type of contamination.

6.4.6 Vegetation

The construction of the proposed facility is within a densely vegetated area, in a rural section of the LGA. The vegetation resources at the site, is dense and very significant. Initial baseline survey conducted at the site indicated that there is possibility of endangered or rare plant species on site.

Mitigation measures required include:

- Minimize the area of vegetation to be removed by clearing only the area required for the plant;
- Retain and maintain the buffer strips along the Lagoon and prohibit construction and clearance of existing vegetation in this buffer strips.
- Encourage phased development of structures, and
- Promote native restoration programmes/projects of indigenous plant species in the area.

6.4.7 Socio-economics

Construction of the fertilizer plant will have a positive impact on the state and local government economies. New jobs will be created and purchases of goods, services and materials from local companies and businesses will boost the local economy. These beneficial impacts shall be enhanced through the adoption of policies that encourage hiring, as practicable, of appropriately qualified workers from areas in the vicinity of the project for non-specialized positions.

6.4.8 Cultural Resources

Cultural sites/sacred places that fall within the demarcated area of the Lekki Free Trade Zone shall be relocated with the consent of communities' traditional rulers. There are no known historical or archaeological sites within the proposed project site. The probability of discovering historical or archaeological resources during construction activities is low. However, in the event of a discovery, a qualified archaeologist will be retained to evaluate the find.

6.5 IMPACT MITIGATION MEASURES FOR OPERATIONAL PHASE

6.5.1 Air Quality

The production of fertilizer demands large quantities of energy and generates considerable greenhouse gas (GHG) emissions. Kongshaug (1998) estimates that fertilizer production consumes approximately 1.2% of the world's energy and is responsible for approximately 1.2% of the total GHG emissions. The adoption of renewable or low carbon energy sources, reduction of fugitive emissions (from raw material handling area comprising of storage, transportation and stacking; and final product bagging) and avoidance/reduction of gas flaring are critical to reduction GHG in this plant.

Sources of GHG emissions generated as a result of project activities include release of carbon from vegetation removal, loss of sequestration potential, fuel consumed by machinery and moving vehicles, extraction and processing of construction materials, fuel consumed in stationary combustion (generators), waste and wastewater, process emissions (electricity generation), energy used in lighting, energy used in cooling system, energy used in water distribution (pumping) among others.

The air quality baseline survey has been undertaken for nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ammonia (NH_3) and particulate matter (PM_{10}). The result indicated that the existing airshed is not degraded in terms of NO_2, SO_2, NH_3 and PM10 at the time of the year when the survey was undertaken.

An air dispersion modeling study was also carried out for the proposed fertilizer plant to quantify likely emissions arising from the development and model its dispersion in the atmosphere in order to assess likely impacts on receptors in the surrounding areas. The result demonstrated that there is no anticipated decrease in air quality in any surrounding areas and that the prevailing winds which blow towards north east ensure that emissions from the plant are dispersed away from settlements. It is important to emphasize that even though these modeling results showed that the there was no potential for significant impact, the BAT measures and other measures to be implemented shall further improve emissions from those models.

In a bid to enhance air quality and reduce GHG emissions during the operations of the proposed fertilizer plant, the following mitigation measures are proposed. They include:

- Adoption and Implementation of Best Available Technology (BAT)

  As part of the detailed design process for the proposed fertilizer plant, DFL along with the EPC contractor shall undertake a full review of the proposed plant technology against Best Available Technology (BAT) standards. The review shall focus on the key aspects of water and energy use and relevant emissions with the objective of using the BAT to reduce natural resource use and minimize emissions.

  The adopted design shall be based on advanced conventional reforming concept including all up-to-date improvements (state of the art design) with the following features:

  - ✓ Low NO_x burners (towards low NO_x emissions);
  - ✓ BASF state-of-the-art aMDEA process for CO_2 removal that is about 20-25% more efficient than contemporary technologies (towards low energy consumption);
  - ✓ Convection coils for reducing firing in the reformer (towards low energy consumption);
  - ✓ Waste heat boiler and steam super heater (towards low energy consumption);
  - ✓ System to enable the use of small size catalyst (for high catalyst activity and conversions) (towards low energy consumption);
  - ✓ Ammonia recovery from process condensates and purge and flash gases (towards low energy consumption and lower natural resource usage);
  - ✓ Refrigeration system that ensures a highly efficient ammonia condensation and cooling in synthesis loop (towards low energy consumption);
  - ✓ The latest version of ammonia stripping process by Saipem for urea synthesis and UFT process for urea granulation (towards lower raw materials, water and energy usage and lower effluent generation);
  - ✓ Routine energy audits will be applied to characterize energy consumption of the plant and identify opportunities to improve the energy efficiency (towards low energy consumption);

- ✓ Technology to ensure achievement of target BAT NO_x emissions (90 – 230 mg/Nm^3);
- ✓ Technology to ensure achievement of target energy consumption level, and
- ✓ Dedicated control systems/loop and management systems to account for all potential issues and allow contingencies related to startup, shutdown and other abnormal operating conditions.

- Minimize the area of vegetation to be removed by clearing only the area required for the plant. In addition, retain and maintain the buffer strips along the Lagoon. This Green Zone contains vegetation with high carbon value in terms of both embodied carbon and sequestration potential. Construction and clearance of existing vegetation in this buffer strips shall be prohibited;
- Operators of dredging vessels shall be required to maintain NO_x and SO_x emissions within the limits established by MARPOL 73/78;
- Maintenance of on-and off-shore plant and vehicles in good working order;
- Road vehicles/boats used for pipeline inspection and maintenance should be regularly maintained to ensure that air pollution from vehicle emissions is minimized;
- Training of workforce in safe driving practices that reduces both the risk of accidents and fuel consumption including measured acceleration and driving within safe speed limit;
- Maintenance of plant and vehicles in good working order e.g exhausts, tyres etc;
- Turning off engines when not in use;
- Use of low sulphur diesel;
- Designation of transport routes to minimize distance travelled and overall fuel use and emissions;
- Embark on wastewater minimization;
- Set wastewater reduction targets and annual goal;
- Prepare Water Management Plan which shall contain guidelines for:
  - ✓ Waste minimization
  - ✓ Wastewater reduction targets and annual goal setting

  - ✓ Water management alternatives
- Open burning of vegetation and other solid waste should, where possible, be avoided and managed through a Waste Management Plan
- Promote limitation and/or reduction of methane emissions through recovery and use in waste management as well as in the production, transportation and distribution of energy;
- Prepare Waste Management Plan which shall contain guidelines for:
  - ✓ Waste minimization
  - ✓ Waste re-use
  - ✓ Waste recycling
- Put in place strategies that shall enhance energy efficiency;
- Promote the development and increased use of renewable forms of energy;
- Encourage carbon capture and storage technologies;
- Protect and enhance sinks and reservoirs of greenhouse gases (GHGs);
- Undertake a full carbon lifecycle analysis once the plant design has been completed;
- Carry out continuous air emissions monitoring;
- Implement annual carbon footprinting exercise and report to appropriate regulators;
- Provide bag filter with extraction system at the raw material handling area;
- Install scrubber system shall be installed at product bagging area;
- Provide venturi Scrubber and cyclones in the process plant;
- Regular dust suppression with water sprinkler on the haul roads will be practiced;
- A stack of 53 m height will be installed for control of emissions covering all dust generating equipment and product handling system from the de-dusting stack;
- The bagging plant stack will be of 27 m;
- The control of flue gases from bunker filling station, conveyer belt, weighing and bagging m/c system and Material feeding points near tail pulley shall be vented through stack;
- Develop green belt project in the plant.

6.5.2 Noise

The major noise generating activities in the plant site are fans, blowers, compressors, pumps and motors. Aside the noise mitigation measures included in the project design, the following should also be incorporated to achieve the noise limitations around the equipment;

- Provision of Acoustic enclosures;
- Small units like condensate and vacuum pumps, will be designed so as to limit noise emission;
- installation of silencers/noise mufflers on all exhaust systems;
- Appropriate signs should be placed at areas where hearing protection for staff will be required;
- Workers operating the power generators will be provided with hearing protection in areas with high noise levels, and
- Acceptable health and safety standards will be implemented when the facility becomes operational.

6.5.3 Ground and Surface Water Quality

The project operational activities that could have adverse impact on ground and surface water quality are accidental leakage of transportation pipe, exposure of pipe lines, accidental leak or spill of fuel or lubricants, discharged waste water or effluent. Improper handling, storage and disposal of materials and wastes at different stages of facility operation could also lead to contamination of both ground and surface water.

Ground and surface water pollution and/or contamination will be prevented by the following measures;

- Training on safe practices for personnel involved in handling, storage and disposal of materials and wastes and spill clean-up will be provided on a regular basis;
- Monitoring of pipe lines to detect leakages;
- Use of quality and approved pipes for pipe lines construction and proper coverage of pipe lines;
- Clean up and remediation of impacted soil and water;

- Adoption of Zero Discharge concept and reuse of the water in process operation;
- Storage containers should be certified prior to use and periodically checked for leaks during project implementation;
- Spill clean-up equipment shall be made available at fuel transfer and equipment maintenance sites, as well as on fuel supply trucks;
- storage tanks and drums shall be provided with secondary containment capable of holding 110% of the largest vessel;
- Vehicle and equipment maintenance activities shall be implemented using containment or other strategies to guard against spills

6.5.4 Soil Quality

The adverse impacts of the proposed project on the soil will result mainly from the discharge of oil and hazardous material on the ground. However, the operations of the facility will be carried out by trained personnel, who would ensure a minimal impact of the facility on environmental media. The following mitigation measures are therefore recommended:

- Facility personnel should be adequately trained on the appropriate handling and disposal of potentially hazardous solid and liquid wastes, and avoidance of spillage;
- The appropriate clean-up procedure should be followed in case of accidental spills;
- Monitoring programs should be carried regularly to ensure compliance with existing regulatory requirements, and
- azThe operational areas should be impermeable or initially laid with a non-permeable material to prevent absorption of spillages into the ground.

6.5.5 Vegetation

The operation phase of the proposed project will not have an impact on vegetation resources. Therefore no mitigation is recommended.

6.5.6 Socio-economic

The project is expected to contribute to the socio-economic enhancement of the project development area (PDA), specifically in employment generation, which will result in increased earnings for local artisans and small-scale businesses. However, the following negative socio-economic effects are likely from the PDA:

- Socio-cultural conflicts between DFP/contractor personnel and stakeholder communities due to difference in customs and beliefs;
- Changes in demographic/socio-cultural pattern leading to degradation of cultural values in local communities; and
- Pressure on existing infrastructure.

Measures in place to mitigate these possible impacts include:

- Continued consultation with the local communities in the PDA to understand customs and beliefs;
- Education of non-local workers on the socio-cultural norms of and on proper conduct within stakeholder communities prior to mobilization and commencement of operations;
- Provision of follow-up awareness training of workers regarding the importance of proper conduct within the stakeholder communities, and
- Hiring, as practicable, appropriately qualified workers from the communities in the vicinity of the project for possible specialized and non-specialized positions.

6.5.7 Health and Safety

Possible health impacts expected from the proposed project include;

- Introduction of communicable diseases (STDs, HIV/AIDS, Hepatitis B & C, TB and gastro-intestinal) into project communities leading to impairment of health/deaths, and
- Incident/accident from use of heavy duty machines to transfer equipment and materials.

DFP shall prepare and implement specific health and safety measures and present this in a Health and Safety Plan. These measures shall include:

- the use of Personnel Protective Equipment (PPE) by employees;
- the use of hearing protection equipment when working under noisy conditions;

- adequate health and safety training of all employees including training on specific procedures as appropriate to various individual workers groups.
- That qualified personnel handle key positions in machine operations;
- Relevant personnel are trained on equipment handling;
- Equipment inspection and maintenance programme is developed and adhered to;
- provision of rescue equipment and medical first aid facilities;
- medical emergency evacuation plans for different types of incidents and injuries that might occur;
- provision of adequate sanitary facilities at sites and offices;
- procedures for working with heavy equipment;
- procedures for working in confined places;
- procedures for working on and along traffic roads;
- Procedures for handling and use of dangerous substances and wastes;
- Procedures for heavy lifting;
- Provisions of adequate waste and material storage facilities;
- Provide medical review for workers/personnel; upon return to work after absence due to accident or prolonged illness (> 5 days);
- Conduct a health and safety awareness program for its personnel/contractor staff to include communicable diseases;
- Periodically include topics related to STDs/HIV prevention in daily workplace, HSE briefings/toolbox meetings;
- Consider enlightening stakeholder communities on STDs and HIV through sponsored handbill, posters or other mechanisms;
- Ensure ready access to appropriate medical care for injuries to and illnesses of workers/personnel, including the treatment of treatable STDs. Occurrences of communicable illnesses will be recorded and tracked, and
- Maintain a medical emergency response plan so that injured persons can promptly access appropriate care.

6.5.8 Public Safety

With regards to public safety, DFP will ensure the following:

- adequate protection and signalling of work environment (loading and hauling) in particular with clear markings of the safety boarders on the work perimeter;
- establishment of traffic plans at location of (partial) blockage of roads and implementation of appropriate traffic control at such locations;
- Prohibition of access to work sites by any person not having a permit to work, in particular where it concerns areas marked as 'restricted'. The latter shall include at least places occupied by operating mechanical and electrical equipment, open trenches, manholes and chambers.

6.6 IMPACT MITIGATION MEASURES FOR DECOMMISSIONING PHASE

At the decommissioning phase of the project, the impacts shall be mitigated by the following measures:

- rehabilitation across the whole area affected by the DFP footprint, with special emphasis on managing hazardous areas and materials;
- a future site use plan to provide sustainable benefits to the local communities in the long term;
- plans for alternative local, social and economic activities to replace those lost by closure;
- end of life monitoring particularly to measure, diffuse, low level contamination in soil or ground water;
- Before decommissioning/abandonment, DFP shall develop decommissioning plans that will establish:
  - ✓ facilities to be abandoned or removed;
  - ✓ methods for facility removal, disposal, recycling/or reuse;
  - ✓ efforts to mitigate environmental impacts and appropriately rehabilitate and restore the site, and
  - ✓ working guidelines for decommissioning to reduce impacts of transportation, potential accidents, wastes generated from decommissioning activities and physical disturbances to the environment.

6.7 SUMMARY OF MITIGATION AND MANAGEMENT MEASURES

Table 6-1 and Table 6-2 provide a summary of environmental and social mitigation measures that have been identified through the impact assessment process (Chapter Five), for the construction and the operation phases of the project respectively. The mitigation measures presented in this chapter will be adopted by DFP and integrated into the project as commitments.

Table 6-1: Mitigation and Management Measures for the Construction Phase

Potential Environmental Impact	Degree of Impact before Mitigation			Concerns/Benefits	Mitigation/Enhancement Measures	Degree of Impact After Mitigation			Comments
	Major	Minor	None			Major	Minor	None	
Air: Effects on air quality in the vicinity of the site		-X		Air pollution due to production of fugitive dusts as a result of clearing and construction works and vehicular activities	Periodic watering of dusty sites to reduce the dust emission and maintenance of service vehicles will be emphasized.			X	The effect will be short termed
Noise		-X		Noise levels, during construction activities	Provision of hearing protection devices			-X	Impact will be local and short termed
Soil: Effects of compaction, erosion and sedimentation		-X		Minimal compaction expected and potential contamination of soils expected	Proper waste disposal and management will be employed; Adequate erosion control measures will also be employed.			-X	None
Groundwater: Effects on groundwater quality	-X			Possibility of groundwater contamination	Monitoring of contaminants via installed monitoring wells			-X	None

Potential Environmental Impact	Degree of Impact before Mitigation			Concerns/Benefits	Mitigation/Enhancement Measures	Degree of Impact After Mitigation			Comments
Ecology: Effects on vegetation		-X		Insignificant de-vegetation	Care will be taken to minimize de-vegetation of the site.		-X		Impact is insignificant
Land Use			-X	Displacement or loss of livelihood expected	Adequate compensatory package shall be proposed in the Livelihood Restoration Plan			X	None
Cultural Resources: Effects on cultural and sacred places			-X	Impacts on known cultural resources and sacred places	Encroached sacred places/shrines shall be relocated.			X	None
Socio-Economic: Effects on construction related employment	+X			Creation of direct employment opportunities for construction workers and indirectly, for local contractors for supply of goods and services.	Adoption of policies that encourage hiring of appropriately qualified workers from areas in the vicinity of the project.			X	None

Table 6-2: Mitigation and Management Measures for the Operation Phase

Potential Environmental Impact	Degree of Impact before Mitigation			Concerns/Benefits	Mitigation/Enhancement Measures	Degree of Impact After Mitigation			Comments
	Major	Minor	None			Major	Minor	None	
Air: Effects on air quality in the site vicinity		-X		Emissions from power generator and fugitive VOC emission from storage and dispersal activities.	Use of scrubbers and provision of adequate air passages			-X	None
Noise		-X		Noise from power generator and other noise generating machines	Installation of silencers and building of enclosures for generator installation			-X	None.
Soil: Contamination of soil by oil and grease		-X		Contamination of soil by accidental spills of oil and grease	Effective waste oil handling and disposal methods.			-X	Appropriate disposal of waste generated.
Groundwater: Effects on groundwater quality	-X			Contamination of groundwater sources may come from oil spills, chemical leakages and UST leakage.	Use of impermeable surfaces in areas where potential spills are anticipated and proper			-X	Water quality should be monitored regularly through

Potential Environmental Impact	Degree of Impact before Mitigation			Concerns/Benefits	Mitigation/Enhancement Measures	Degree of Impact After Mitigation			Comments
					collection and disposal methods; Use of secondary containment; Systems in storage tanks to prevent the uncontrolled release of fuel or lubricants.				an installed bore hole or on site monitoring well. Oil separators will be used.
Ecology: Effects on vegetation			-X	There is no impact on vegetation resources envisaged	No mitigation measured proposed.			None X	None
Land Use			None X	There is no envisaged impact on land use during the operation phase	None required			None X	None
Visual Intrusion and Aesthetics: Impact of the developed site on aesthetics and			-X	The site will have a positive visual appeal and provide security illumination for the immediate surroundings	None required			None X	None

Potential Environmental Impact	Degree of Impact before Mitigation			Concerns/Benefits	Mitigation/Enhancement Measures	Degree of Impact After Mitigation			Comments
general appearance									
Socio-Economics: Operational effects are inclusive of employment generation.	+X			Positive impacts arising from the operations of the plant will include the creation of employment opportunities for different cadres of workers.	This effect shall be enhanced by the adoption of policies that encourage hiring of qualified workers from areas in the vicinity of the project..			None X	Skilled and semi-skilled labour will benefit from the project.

6.8 Monitoring Plan

6.8.1 Introduction

DFP's monitoring plan will include a detailed environmental and social monitoring plan which will be implemented by DFP and its contractors. This plan will be modified and updated as the project develops and in response to the outcomes of monitoring activities and in discussion with stakeholders as new issues arise.

The purpose of this section is to outline the key monitoring requirements identified through the ESIA process to monitor the environmental and social performance of the project. These requirements will be incorporated into the project ESMP.

The overall objectives of the monitoring activities are to:

- Ensure regulatory requirements are met;
- Check that impacts do not exceed environmental standards prescribed;
- Verify predictions made in the ESIA by obtaining real time measurements;
- Verify that mitigation measures are effective and implemented in the manner prescribed in the ESIA document;
- Provide early warning of potential environmental impacts; and
- Inform about future operations and contribute to continuous improvement in the management of environmental and social issues related to the project.

6.8.2 Monitoring Approach

Monitoring will be carried out by DFP's Health Safety and Environment (HSE) coordinator, and its contractors pursuant to their contractual obligations to undertake inspections, monitoring and reporting. The oversight officer for the monitoring system shall be the HSE Group Head, Dangote Group.

The following four types of inspections and monitoring will be employed.

- Inspections planned and conducted on a regular basis to ensure that mitigation measures and commitments are properly maintained and implemented, and that specific management procedures are being followed (e.g. practices on waste storage and disposal).

- Receptor monitoring undertaken to verify predictions made in the ESIA and to confirm that the activities at the site are not resulting in an unacceptable deterioration in the quality of habitats or infrastructure (e.g. monitoring disturbance to affected residents through a grievance mechanism).
- Compliance monitoring involving periodic sampling or continuous recording of specific environmental quality indicators or discharge levels to ensure compliance of discharges and emissions with project standards (e.g. produced water discharges and air emissions), and
- Auditing (internal and external) to assess compliance of the site activities with both regulatory and site management system requirements (e.g. waste management procedures and systems).

The frequency of inspections, monitoring and audits and subsequent reporting will be based on the project risks. The outputs will be used in the following ways:

- To provide early warning for site management, to adjust mitigation measures on a day to day basis to suit evolving conditions;
- To enable contractors to demonstrate that mitigation measures and procedures laid down in mitigation plans are being followed and operations are being conducted within compliance limits, and
- To provide formal assurance to DFP and third parties, such as Nigerian regulatory authorities, AFC and IFC, that the project is compliant with regulations and agreed limits and that relevant mitigation / enhancement measures are being adhered to.

Monitoring results will be presented in regular reports and reviewed at HSE management meetings. The results of the inspection and monitoring activities will be reported to DFP on a monthly basis, or as required. The approach to HSE management, including responsibilities, and checking and corrective actions relating to monitoring activities are outlined in the provisional Environmental Monitoring Plan (Chapter Seven).

The monitoring plan and parameters will be reviewed periodically and, if necessary, will be modified to include any additional parameters necessary to ensure good environmental and social performance. Similarly, the monitoring methods and frequencies will be subject to periodic review by DFP.

6.8.3 Monitoring Plan for Specific Mitigation Measures

The outline monitoring plan is presented in Table 6-3. Issues are addressed following the approach used in the ESIA. The plan describes what potential impact is to be measured and the frequency.

Table 6-3: Monitoring Plan for Specific Mitigation

Impact	Monitoring	Frequency of monitoring
Impacts on surface and groundwater quality	• DFP will implement an effluent monitoring programme for sampling and analysis of effluent from the onshore facility site. Discharged effluent water will be sampled and analysed for the following parameters in accordance with FMEnv requirements: pH, temperature, Electrical Conductivity, TDS, TSS, Chloride as Cl^-, THC, TPH, BTEX, PAH, COD, BOD_5, sulphide as H_2S, ammonia as NH^{4+}, Total Phosphorus as PO_4^{2-}, nitrate as NO_3^-, Heavy Metals: Ni^+, Cr^{+6}, Pb, Cu, Zn, V, Ti, Cd, Fe^{+3}, Hg.	• Effluent will be sampled and chemically analysed weekly and reported monthly during operation;
Impacts to marine water quality	• Hydro-test water: DFP will monitor and report on separate totals required for various categories of substance (based on hazard types/severities) including quantity used, quantity discharged.	• Daily monitoring and monthly data reporting during commissioning
	• Sewage discharge: DFP will undertake visual observations to check for no floating solids, foam or decolouration of surrounding water. Monitor compliance of discharge in compliance with MARPOL requirements (residual chlorine content of less than 1 mg/l).	• Daily visual inspections and weekly monitoring and recording throughout project.
	• Food waste: Visual observations to check no floating solids or foam.	• Daily visual inspections and weekly monitoring and recording during operation.

Impact	Monitoring	Frequency of monitoring
Impacts to terrestrial fauna and flora	• DFP will undertake checks that work areas have been demarcated and that construction vehicles and workers stay within the work areas; • DFP will appoint an ecologist to monitor growth of rehabilitated vegetation along pipeline route.	• Daily during construction; • Monthly after backfilling of pipeline trench until vegetation is established.
Impacts to marine fauna and flora	• DFP will appoint an ecologist to survey beach area for turtle activity or nests only in the turtle nesting season; • DFP will maintain records of marine mammals sightings and monitor marine vessel movements	• Weekly during construction activity at the beach in the turtle nesting season (June to December); • Continuously throughout the project.
Impacts to air quality	• DFP will visually monitor dust levels and effectiveness of dust suppression methods; • DFP will undertake visual inspection to check that generators and machinery are in good working condition; • Ambient VOC concentrations will be monitored along the perimeter of the facility site.	• Daily during construction; • As required by the project Preventative Maintenance Plan and procedures; • Continuous monitoring downwind and upwind of facility site during operation and reported monthly.
Noise impacts	• DFP will undertake noise monitoring at communities closest to the site to ensure that the project does not raise ambient noise levels at this receptor by more than 3 dB as a result of their construction activities.	• Daily monitoring and weekly reporting against baseline levels during construction phase.

Impact	Monitoring	Frequency of monitoring
Waste segregation, storage and transport	• DFP will verify compliance with project Waste Management Plan, in particular: o Field inspections of storage areas, and transfer and transport equipment and systems to ensure that appropriate mitigation and measures are enforced; o Report of waste volumes generated; o Reporting of waste volumes and types of wastes transported; o Report and record all leaks and spills, including type and quantities of substances spilled.	• Monthly inspection of fuel and chemical storage and transfer equipment (or more frequent dependent on risk); • Monthly field inspections (onshore and offshore) and routine reporting throughout project; • Annual audit of storage facilities and systems
Waste Management and Waste Disposal	• DFP will undertake waste management audits of contractors and waste reception facilities	• Audit of waste contractors prior to agreeing any formal contracts; • Six monthly in first year and thereafter annual audits of facilities that receive project wastes throughout project.

Impact	Monitoring	Frequency of monitoring
Traffic	• DFP will monitor project related traffic volumes and maintain a record of all HDVs travelling to and from the site; • DFP will check that HDVs remain on prescribed routes and adhere to prescribed speed limits. All transgressions will be recorded; • DFP will undertake periodic checks that trucks waiting for loading do not park next to the road; • DFP will undertake routine inspection of integrity of road surfaces, safety hazards and safety signage along transport routes; • DFP will commission a detailed traffic study to determine required capacity of road networks, confirm road surface integrity and identify safety hazards and problem intersections along transport routes.	• Daily monitoring and weekly reporting throughout project as required by Traffic Management Plan and vetting procedures; • At least monthly as required by Traffic Management Plan; • At least monthly as required by Traffic Management Plan; • At least monthly as required by Traffic Management Plan; • Prior to start of operations.
Livelihoods and micro-economics	• DFP will continuously monitor safety exclusion zones and record all vessel interactions between project vessels and other users of the area; • DFP will develop and implement a system for inspection and maintenance of navigation, communication and safety equipment; • DFP will record all complaints/suggestions through the Community Liaison Officer and assign specific remedial actions and responsibilities.	• Auditing with Accident Reporting Procedure; • Monthly audit of equipment inspection reports; • Six monthly reviews of interaction/grievance records and audit of actions arising throughout project.

Impact	Monitoring	Frequency of monitoring
	• DFP will monitor employment levels and local staff content against targets for DFP and its contractors. • DFP will liaise with a development NGO to identify and implement community investment projects. • DFP will monitor training (skill, heath community relations and awareness) provided to staff and local community.	• Quarterly review of HR data and recruitment and organisational development plans; • Prior to start of construction; • Quarterly reviews of training records.
Social infrastructure	• DFP will record all complaints/suggestions through the Community Liaison Officer and assign specific remedial actions and responsibilities. • DFP will record all communications with local community regarding project operations and use or upgrade of local infrastructure, utilities and transport networks. • DFP will investigate the possibility of providing additional water to the affected communities.	• Six monthly reviews of interaction/grievance records and audit of actions arising throughout project; • Six monthly reviews of community interaction / communication records; • Prior to operation of the facility
Socio-cultural cohesion	• DFP will monitor movements of workforce in and out of the compound; • DFP will monitor skills, health, community relations and awareness training provided to staff and local community.	• Continuous monitoring and weekly inspection of records throughout project; • Quarterly reviews of training records.

Impact	Monitoring	Frequency of monitoring
Transport and Access	• DFP will continuously monitor project HDV traffic volumes and traffic related incidents; • DFP will continuously monitor safety exclusion zone and record all vessel interactions between project vessels and other users of the area.	• Auditing with Accident Reporting Procedure.
Cultural Sites	• DFP will check that cultural sites/sacred places are protected during construction; • DFP will monitor levels of complaints through the grievance procedure and check actions taken to resolve complaints.	• Daily throughout construction; • As required in response to complaints and six monthly reviews of records and audit of actions arising throughout project
Health	• DFP will monitor movements of workforce into and out of the compound; • DFP will monitor skills, health, community relations and awareness training provided to staff and local community; • DFP will implement monitoring requirement for waste, air emissions and surface and groundwater.	• Continuous monitoring and weekly inspection of records throughout project; • Quarterly reviews of training records.
Occupational Health and Safety	• DFP will monitor the working environment for occupational hazards relevant to the facility. Monitoring will be designed and implemented by accredited professionals as part of the Health and Safety Plan. DFP will also maintain a record of occupational accidents and diseases and dangerous occurrences or accidents.	• Throughout project as required by Health and Safety Plan

Impact	Monitoring	Frequency of monitoring
Public Safety	• DFP will maintain records of drivers' training and non-compliance with Traffic Management Plan; • DFP will monitor road accidents in collaboration with the local authority to detect trends and introduce necessary measures; • DFP will investigate road accidents involving project vehicles and maintain records of these accidents and actions taken; • DFP will maintain log of all emergency management training and exercises; • DFP will monitor levels of complaints through the grievance procedure and check actions taken to resolve complaints; • DFP will implement monitoring requirements relating for surface and groundwater.	• Throughout project as determined by Traffic Management Plan; • Auditing with Accident Reporting Procedure; • Auditing with Accident Reporting Procedure; • Six monthly reviews of training records throughout project; • As required in response to complaints and six monthly reviews of records and audit of actions arising throughout project.
Hydrocarbon spills	• DFP will develop and implement a system for inspection and maintenance of spill prevention and response equipment; • DFP will maintain log of all emergency management training and exercises; • DFP will record and report all hydrocarbon spills (number of spills and quantities spilled).	• Weekly inspection of critical equipment and quarterly audit of inspection and maintenance reports; • Six monthly review of training records; • Six monthly review of OSCP and oil spill exercises; monthly data report and quarterly audit of spill reporting.

Impact	Monitoring	Frequency of monitoring
Fires and Explosion	• DFP will develop and implement a system for inspection and maintenance of fire suppression equipment; • DFP will perform further risk assessment studies to assist in identifying further risk reduction measures; • DFP will maintain log of all emergency management training and exercises.	• Weekly inspection of critical equipment and quarterly audit of inspection and maintenance reports; • During detailed design; • Six monthly reviews of training records throughout project.

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

7.1 INTRODUCTION

This chapter presents the Environmental and Social Management Plan (ESMP) for the proposed Dangote Fertilizer Plant (DFP) Project. The ESMP is a central link that stipulates the guidelines, strategies and procedures for managing the significant, possible, potential and associated environmental and social impacts of the proposed project. It is also a standalone tool that provides assurance that the proposed mitigation measures are effectively implemented and project activities are appropriately monitored. After EIA regulatory permit is granted, the ESMP becomes the reference document with which the regulatory authorities and the general public will assess the proponent's level of compliance with regulatory authorities.

This ESIA having identified the key environmental and socio-economic aspects, potential impacts, targets and objectives and mitigation measures associated with the project will serve as a basis for the ESMP. For each potentially high or moderate impact, the ESMP identifies and describes the linkage between applicable regulatory requirements and other commitments, the relevant mitigation measures, the monitoring approach and schedule.

The DFP has developed a comprehensive regime for the management of Health, Safety, Environmental and Social issues. This management regime includes a range of companywide policies, management systems, controls and procedures. DFP also adopts the generally accepted definition of Sustainable Development, which involves meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainable Development comprises of the following three closely linked subject areas:

- Economic development,
- Environmental protection, and
- Social responsibility.

The DFP will regularly review its activities and decisions against criteria for Sustainable Development through the inclusion of Sustainable Development in the relevant sections of its policy on the Environmental Management System and related systems.

The DFP will also use indicators to measure progress in its contributions to Sustainable Development and to communicate efforts in this respect to the relevant stakeholders. DFP recognises that the development, implementation and maintenance of a system for the long-term management of the environment must form an integral part of business quality management and has therefore adopted an integrated approach to Health, Safety and Environmental (HSE) management. To achieve uniform standards across the entire company a structured approach is used based upon a HSE Management System (HSE-MS).

Furthermore, environmental management is seen as the means to ensure that the commitments specified in this ESIA for the DFP project are managed and that unforeseen or unidentified impacts of the proposed development are detected. It thus guarantees an effective basis to determine the source and extent of impacts, should they occur.

The long-term objectives of the environmental management programme are to:

- Ensure compliance with legislation, HSE Premises and DFP company policy;
- Achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- Integrate environment fully into the business;
- Rationalise and streamline environmental activities to add value in efficiency and effectiveness;
- Encourage and achieve the highest performance and response from individual employees and contractors;

- Provide the standards for overall planning, operation, audit and review, and
- Enable management to establish environmental priorities applicable throughout the organisation.

The purpose of this part of the ESIA for the DFP project is to set it in the wider context of the company's programme for HSE management. It so indicates where and how this structured management approach will be used to ensure that the on-going process of environmental, social and health assessment for the DFP project will continue to evolve throughout the life cycle of the development. The DFP Cashes Manual (Community Affairs, Safety, Health, Environmental and Security) is of utmost importance regarding the content of this chapter:

7.2 DANGOTE FERTILIZER PLANT HEALTH, SAFETY AND ENVIRONMENTAL MANAGEMENT SYSTEM

Dangote Fertilizer Plant Health Safety and Environmental Management System (HSE-MS) shall be applied to the construction phase of the project, including commissioning and up to the ready for start-up date. The same framework shall further be used for the operational phase of the project. The HSE-MS is defined as a structured set of controls for managing HSE in the business to ensure and to demonstrate that HSE objectives are met. The key elements of the DFP HSE-MS are:

- HSE Commitment and Policy Statement
- HSE Manuals and plans
- Hazards and Effects Management Process (HEMP) and HSE design processes
- HSE risk assessment, management processes and audits
- Emergency Response system and plans
- Waste Management System

7.3 HAZARDS AND EFFECTS MANAGEMENT PROCESS (HEMP)

The management of hazards and effects of activities is central to effective Project Environmental Management. Hazard and Effect Management Process (HEMP) ensures that hazards and potential effects are fully evaluated. Environmental Impact Assessment emphasizes the Hazards and Effects Management Process. The four stages of the process as applied in Environmental Management are:

- Identify hazards associated with project activity and the environment;
- Assess hazards and effects through assessment of magnitude and significance of the hazards and effects;
- Control hazards and effects, through implementing techniques to eliminate, lessen severity of effects, and manage the hazard. and
- Recover from effects by developing plans to manage the consequences of events.

The above form the fundamental principles of the management and control of environmental impacts and effects in the ESIA process. The impacts are enumerated based on hazard identification, risk assessment and application of preventive measures.

7.4 SAFETY AND HAZARD IDENTIFICATION

The objective of managing the Health, Safety and Environment (HSE) risks associated with a system is to reduce them to a level As Low As reasonably Practicable (ALARP). Reasonable practicability was determined in reference to best industry practice and to economic, environmental, technical, health and safety considerations.

The objectives for assessing these risks are to:

- Eliminate the hazard;
- Reduce the probability of hazardous events occurring, and
- Minimise the consequences, in the event of the occurrence of the events.

The activities involved in the construction and operational phases of the proposed project are essentially land take, site preparation (piling, sand filling, grading, concreting), construction (storage tanks and contractors camps, pipelines), power generation, maintenance of facilities during operations, and waste management during the project phases.

7.5 CONTRACTOR MANAGEMENT

Managing the HSE performance of contractors is a fundamental part of the DFP HSE-MS. The objective is to ensure that contractors consistently fulfil DFP's HSE requirements. The mechanism for achieving this includes:

- Defining clear HSE criteria and performance targets that contractors must meet prior to tendering and during work for DFP;
- A pre-qualification and screening process that assesses the HSE performance and abilities of contractors before they are allowed to work for the company;
- Systematic management overview of contractor operations, including site supervision where appropriate, to monitor performance and enforce adherence to agreed standards (including construction services management by DFP Technical Advisers);
- Assistance where appropriate in training and capacity building in order to generate improvements in HSE performance and abilities, thereby allowing more firms, particularly small and local firms, to participate in DFP activities, and
- Monitoring by the Sustainable Development Coordination Committee of the implementation of the Management Plans for the DFP project.

DFPL shall also define the HSE premises and requirements for the design and construction phase of the DFP project. This includes detailed specification of guidelines and procedures to be followed.

The DFP Project Manager and the EPC Contractor will address performance against the contractual provisions, including environmental, social and health requirements, which shall be incorporated into the ESHMP.

Contractors are also required to comply with the DFPL Guiding Principles for Community Relations, which address assistance to communities and communication with communities.

7.6 TRAINING

The EPC Contractor(s) and their subcontractors will operate safety, supervisory and craft training programmes to enhance the status of the workforce in accordance with the provisions of the Nigerian Content Plan.

A site training school will be maintained for this purpose, and a main contractor will require all major subcontractors to offer a minimum number of their peak workforce, to attend the craft skills training program. The craft training courses will cover a wide range of trades and skills sets.

All trainees who successfully complete craft training courses will be awarded a certificate that is hoped to be recognised by other employers in Nigeria. Major subcontractors will also be encouraged to run their own specialised training courses to complement those run by the main contractor.

7.7 COMMUNITY RELATIONS

Dangote Group maintains a clear focus on Community Relations, with a range of programmes and activities in this area. The objective is to catalyse the sustainable development of the host communities by:

- helping to improve infrastructure, health and educational care facilities;
- encouraging and supporting local capacity building enterprise;
- effecting technology transfer in a manner consistent with the company's business principles.

The guiding principles for managing community relations can be outlined in assistance to communities which should:

- benefit communities, not individuals;
- be formulated with full community input and participation, and
- seek for win-win arrangements.

Communication with communities:

- The Company should speak with one voice;
- Agreements should be made through formal channels;
- The Company should promptly respond to correspondence
- The Company through its Community Relations Department will on a continuous basis interact with relevant groups in the community such as youth and women groups etc.

7.8 RESETTLEMENT AND LIVELIHOOD RESTORATION FRAMEWORK

7.8.1 Introduction

The DFP project is one of the first projects to be developed in the LFZ. Like most of the future projects in LFZ, land acquisition shall take place, which will result in involuntary resettlement. The proposed Dangote Fertilizer Plant is located in the project site is used for farming activities, hunting, fishing, etc. This implies that economic displacement will affect the people. As a result, a Livelihood Restoration Plan (LRP) shall be prepared. The first step is the enumeration phase: A detailed census and inventory of assets of the people on the site will take place. However, there are no tangible settlements on the site except some few huts largely used by fishermen and farmers. Thus, the development shall not lead to any significant physical displacement of people. Therefore, a Resettlement Action Plan (RAP) might not be needed.

The Livelihood Restoration Plan will be written in compliance with LFZ's Resettlement and Livelihood Restoration Framework that shall be prepared. The following parts of this sub-chapter reveal some background and the scope of work in the development of the Resettlement and Livelihood Restoration Framework.

7.8.2 Involuntary Resettlement

Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or means of livelihood) as a result of project-related land acquisition (IFC, 2012a).

LFZ is responsible for any required economic and physical displacement from the LFZ, thereby complying with the Nigerian law and IFC's Performance Standards on Social & Environmental Sustainability (particularly Performance Standard 5) (IFC, 2002 and 2012a).

7.8.3 IFC's Performance Standard 5

IFC's Performance Standard 5, Land Acquisition and Involuntary Resettlement (IFC, 2012a), embodies the basic principles and procedures that underlie the IFC's approach to involuntary resettlement associated with its investment projects and stands as the benchmark against which resettlements are measured. Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or means of livelihood) as a result of project-related land acquisition. Resettlement is considered involuntary when affected individuals or communities do not have the right to refuse land acquisition resulting in displacement. A lack of legal title to land does not disqualify people from resettlement assistance.

The objectives of this Performance Standard are:

- To avoid or at least minimize involuntary resettlement wherever feasible by exploring alternative project designs.
- To mitigate adverse social and economic impacts from land acquisition or restrictions on affected persons' use of land by:
  - providing compensation for loss of assets at replacement cost; and
  - ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected.

- To improve or at least restore the livelihoods and standards of living of displaced persons.
- To improve living conditions among displaced persons through provision of adequate housing with security of tenure at resettlement sites.

Three other IFC documents accompanying IFC's Performance Standard 5 are:

a) Guidance Note 5: Land Acquisition and Involuntary Resettlement (IFC, 2012b), which offers helpful guidance on the requirements contained in the Performance Standard;
b) Handbook for Preparing a Resettlement Action Plan (IFC, 2002), which provides step-by-step guidance through the resettlement planning, and
c) IFC's Performance Standard 1, Social and Environmental Assessment and Management Systems, that serves as the core around which the other Standards are framed.

7.8.4 Resettlement and Livelihood Restoration Framework

A Resettlement and Livelihood Restoration Framework should establish the principles, procedures, entitlements and eligibility criteria, organizational arrangements, arrangements for monitoring and evaluation, the framework for participation, and mechanisms for redressing grievances by which the client will abide during the project implementation.

Particular attention will be given to disadvantaged groups. These are distinct groups of people that may suffer disproportionally from project related activities (e.g. female-headed households, children, elderly, ethnic, religious and linguistic minorities, handicaps, etc.) (AfDB, 2003).

7.8.4.1 Enumeration and Compensation

A detailed census and inventory of assets of the people living in and near the DFP will take place with a clear cut-off date well known by the locals. The census-takers will provide the affected people documentation that confirms their enumeration.

The impact of DFP will result in land acquisition based on negotiated settlement that does not result in the physical displacement of people, but only in economic displacement. Because of this, a Livelihood Restoration Plan will be written following the enumeration.

Accordingly to the IFC guidelines, the LRP will contain the following subjects:

- An introduction to the project;
- Summary of project impacts;
- Summary of the social baseline;
- Regulatory framework;
- Results of stakeholder engagement;
- Eligibility criteria;
- Entitlement matrix;
- Timeframe for implementation;
- Organizational capacity;
- Monitoring, evaluation, and reporting, and
- Budget and resources.

7.8.4.2 Compensation

Affected people will be compensated by DFPL for loss of physical assets, revenue, and income resulting from economic displacement whether these losses are temporary or permanent. DFPL will establish transparent methods for the valuation of all assets affected by the project. These methods will include consultation with representatives of the affected communities to assess the adequacy and acceptability of the proposed compensation and will be compliant with IFC Performance Standards and guided by the Handbook for Preparing a Resettlement Action Plan (IFC, 2002).

Where feasible and where desired by the affected people, land-based resettlement options will be provided to displaced people whose livelihoods are based on use of the land (for instance, farmers). These options may include resettlement on or access to land acquired or purchased for resettlement. Such land-for-land compensation will be made according to the following principles (IFC, 2002):

- New land should be equivalent or superior in productive potential to the land from which people will be displaced;
- New land should be located in reasonable proximity to land from which people will be displaced;
- New land should be provided free of any "transaction costs" such as registration fees, transfer taxes, or customary tributes;
- New land should be prepared (cleared, levelled, and made accessible) for productive levels similar to those of the land from which people will be displaced (preferably, affected people should be paid by the project to do this work).

In situations where cash compensation is appropriate (or where affected persons – after informed consultation – choose cash rather than land-for-land compensation), DFPL will calculate and award compensation payments according to the following principles (IFC, 2002):

- Compensation rates should be calculated in consultation with representatives of affected populations to ensure that rates are fair and adequate;
- Compensation for land, crops, trees, and other fixed assets should be sufficient to enable affected people to restore their standard of living after resettlement;
- Compensation for structures should cover full replacement cost exclusive of depreciation and inclusive of all fees (such as construction permits and title charges) and labour costs;
- Compensation payments should be made before any acquisition of assets or physical resettlement takes place unless those payments are staggered to enable affected people to begin preparation of new sites;

- Compensation for dismantled infrastructure or disrupted services should be paid to affected communities, or to local government as appropriate, at full replacement cost, before civil works begin;
- Where necessary and feasible, local currency compensation values should be indexed to the U.S. dollar or other stable currency to protect affected people against local currency fluctuations and inflation;
- Compensation for lost earnings should be paid to proprietors and employees for the duration of work stoppages resulting from the relocation of enterprises.

7.9 THE ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The layout of the ESMP in Table 7-1 provides a complete list of all actions to be taken during the project phases. The ESMP provides actions designed to manage the mitigation of project impacts, and is presented below in Table 7-1 as an extension of the Mitigation Table (Table 6-1).

Table 7-1: List of actions to be taken during the project phases

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Reduction of access to natural environment and its resources	Moderate	• Set up of a Livelihood Restoration Framework	Minor	DFP	Before Land acquisition	Appropriate compensation for all the affected people	Resettlement manager	Monthly during land acquisition period
Traditional occupations could be adversely affected leading to reduced income capacity	Moderate	• Set up of a Livelihood Restoration Plan. • Alternative access to farmlands and hunting grounds shall be provided where applicable • Alternative income generating activities that will empower communities shall be supported • Land take shall be limited to the minimum required • Impact on traditional income shall be assessed and adequate compensatory measures taken, where necessary.	Minor	DFP and LFZ	During construction and operations phase	Status report on traditional occupation Register of DFP sponsored income generating projects	DFP project team	Six months after construction

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Reduced quality of habitat for humans and wildlife	Moderate	• Construction activities requiring continuous light at night shall be reduced to the barest minimum • Construction activities shall be completed on schedule	Minor	DFP	During construction	Site inspection report	DFP project team	Monthly
Increased access for hunting and logging	Moderate	• Awareness campaign of the adverse effects of hunting and logging shall be undertaken/ incentives shall be introduced for compliance • DFP shall support programmes aimed at sustainable use of forest resources	Minor	DFP	During construction and operations phase	Report on stakeholder engagement Availability of forest resources preservation programme	DFP project team	Twice a year
Pressure on available water for domestic use and other water related activities	Moderate	• Providing additional water to the affected communities	Minor	DFP	During Construction and operations phase	DFP site inspection report	project team	Monthly during construction

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Pressure on available food	Moderate	• Agricultural extension services shall cover project area • Awareness shall be created on potential market for food vendors • Food vendors shall be provided for the construction camps if required.	Positive	DFP	During land acquisition, construction and operations phase	Report on engagement activities/ agricultural extension services	DFP project team	Quarterly
Pressure on existing infrastructure (accommodation, health, recreational, educational facilities etc) and could alter the demographic pattern	Major	• Awareness shall be created on the potential of increased use of the facilities • DFL shall support (provision of drugs, upgrading of facilities and staff training) existing health, recreational, educational facilities etc • DFL shall provide accommodation/relevant amenities (health and recreational facilities) for workers to reduce stress and health vulnerabilities	Minor	DFP	During construction	Site inspection report	DFP project team	Periodic

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Pressure on existing roads and increased potential for road accidents	Moderate	• Awareness shall be created on the potential of increased traffic on land and water for road users and community members • DFP policy on road and water borne traffic journey management (all journey must be approved, no night journeys, speed limits on land and water). • DFP shall upgrade existing roads to suite the proposed project activities with additional access roads provided, where necessary • Traffic signs shall be provided on all the approved routes for the project	Minor	DFP	Preconstruction, construction and operations phase	Site inspection/ stakeholder engagement report Inventory of approved journey management forms	DFP project team	Monthly
Increased level of disease vectors	Moderate	• Site specific solid waste management plan in line with DFP waste management guidelines shall be put in place before operations. • Fumigation shall be carried out, where applicable	Minor	DFP	During construction and operations phase	Site inspection reports	DFP project team	Quarterly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Increased morbidity rate thereby putting pressure on existing health facilities	Moderate	• Regular medical check-up for site personnel shall be undertaken, with the above mitigations for air quality impact • Medical facilities shall be provided on site, with critical cases transferred to a DFP retainer clinic. • Standard solid waste collection and segregation area shall be provided on site. • DFP shall support (provision of drugs, upgrading of facilities and staff training) existing health, facilities • Material Safety Data Sheets shall be provided on all sites where chemicals are handled	Minor	DFP	During construction and operations phase	Medical reports	DFP project team	Once a year

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Increased morbidity due to upper respiratory tract infection	Moderate	• DFP shall support (provision of drugs, upgrading of facilities and staff training) existing health facilities. • Appropriate dust masks/respirators shall be provided for workers • At all stages of the construction activities, permit to work system (PTW) shall be enforced	Minor	DFP	During construction and operations phase	Site inspection report Inventory of PTW	DFP project team	Weekly
Exposure of field workers/ community members to attacks by poisonous snakes, bees, spiders, scorpions/other wildlife and contact with poisonous plants.	Moderate	• DFP shall provide and enforce usage of PPE by field workers • Anti- venom shall be provided on site • Awareness shall be created among site workers and nearby communities on the likelihood of exposure to poisonous wildlife and plants	Minor	DFP	During construction and operations phase	Site inspection report and incident reports	DFP project team	Monthly
Opportunities for contracting and employment	Positive	• Indigenous contractors and resource persons shall be used	Positive	DFP	During land acquisition, construction and operations phase	Contract documents/list of community members employed	DFP project team	Quarterly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Increased social vices	Major	• Awareness campaign shall be carried out to enlighten the communities/field workers on the implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values • Movement of field workers shall be restricted to camp/work sites • Alternative recreational facilities shall be provided at camp sites • Alcohol and drug policy shall be implemented to encourage healthy lifestyle for workers	Moderate	DFP	During construction and operations phase	Reports on community engagement sessions Site inspection report/tool box meetings	DFP project team	Periodic
Shift from traditional occupation to western jobs from developed ambition towards civilisation	Positive	• DFP shall introduce and encourage programmes for skills acquisition and development (Youth development schemes etc)	Positive	DFP	During construction and operations phase	Register of DFP sponsored skill acquisition programmes	DFP project team	Quarterly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Increase in population leading to diffusion of culture and traditions	Moderate	• Construction workers shall be accommodated in contractor camps to reduce adverse impact on existing culture and tradition • Awareness campaign shall be carried out on the need to sustain native culture and traditions	Minor	DFP/Community Institutions	During construction and operations phase	Community engagement sessions Site inspection report	DFP project team	Quarterly
Adverse impact to cultural heritage	Moderate	• Historical sites/sacred places, fishing sites/grounds and other areas of interest to the communities shall be avoided during land acquisition, and where unavoidable, agreements shall be reached with the respective communities on relocation.	Minor	DFP	Land acquisition	Agreements with communities	DFP project team	Daily throughout construction. Later as required or six monthly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Increase in cost of living/inflation	Moderate	• Work camps shall be provided with necessary utilities to reduce pressure on local community facilities • Communities shall be empowered through provision of jobs, increased patronage to produce (fishes, farm produce etc) and encourage income generating activities	Minor	DFP	During construction and operations phase	Register of DFP sponsored income generating projects	DFP project team	Quarterly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Emission of noxious substances (emissions) to atmosphere could affect air quality.	Moderate	• Emissions from machineries shall be reduced by the use of standard equipment that meet existing emissions requirements (low NOx burners) and fume catalysers provided on all suitable equipment. • High efficiency (low energy) motors shall be used • Ambient air quality shall be monitored in line with regulatory requirements (NOx, COx, SOx, SPM etc) • There shall be regular maintenance of combustion systems (generators etc) • Water tankers shall be used to sprinkle water on exposed dusty soil surface.	Minor	DFP	During construction and operations phase	Pre-mobilisation inspection report Compliance monitoring report	DFP project team	Monthly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Nuisance (noise, emissions, vibrations) from heavy machinery could lead to loss of habitat for fauna (wildlife etc.) and potential impacts on human hearing	Moderate	• Machinery with noise levels within acceptable limits (85 dB (A) shall be used • Site construction shall be done within the shortest possible time • Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits • High sound energy equipment shall be enclosed in noise insulators in line with DFP policy • DFP HSE policy of wearing ear muffs/ plugs shall be applied in all construction sites • Sufficient separation distances shall be provided for sources of high energy sound to reduce noise levels • Workers with existing hearing impairment shall not be deployed to site • Construction equipment shall be maintained regularly	Minor	DFP	During construction, operations and decommissioning	Maintenance log of equipment Site inspection report	DFP project team	Monthly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Inhibition of reproductive phase of plants	Moderate	• Construction activities requiring continuous light at night shall be reduced to the barest minimum • Construction activities shall be completed on schedule	Minor	DFP	During construction	Site inspection report	DFP project team	Monthly
Disturbance of aquatic life (zooplankton, phytoplankton, benthic communities, fisheries etc)	Major	• Sedimentation basin with effluent drains shall be constructed to allow water to gradually drain back into the river without turbulence • Indigenous aquatic flora and fauna shall be used to restock the aquatic system • Recovery of bottom sediment shall be monitored • Sand filling activities shall be completed on schedule	Minor	DFP	Pre-construction and during construction	Determination of biomass and species of aquatic communities	DFP project team	Twice a year (dry and rainy seasons)

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Decreased quality of habitat (biodiversity)	Moderate	• Clearing shall be done in phases to permit mobile wildlife escape • Awareness shall be created to discourage hunting during site preparation and lumbering subsequently • Studies shall be carried out on biomass and diversity of terrestrial flora and fauna, threatened to endangered species 12 months after construction	Minor	DFP	During construction	Site inspection / community engagement reports Study reports	DFP project team	Quarterly
Health impairment of aquatic and terrestrial life	Moderate	• Discharges from construction activities shall be treated prior to disposal • Studies shall be carried out on species diversity/abundance of aquatic organisms yearly • Where applicable, effluents shall be characterised with eco-toxicity testing carried out	Minor	DFP	During construction and operations phase	Site inspection/ study report	DFP project team	Quarterly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Destruction of indigenous plant communities along the proposed pipeline routes and contractor camps. This could lead to permanent loss of plants of economic/ medicinal importance and habitat for wild life and their emigration to unaffected areas, thereby upsetting the ecological balance.	Major	• Reduction in de-vegetation outside the required areas • Re-vegetation of native plant species where possible • Vegetation studies shall be carried out six months after construction • The areas to be cleared shall be clearly marked, with clearing restricted to the marked areas. • Mature trees greater than 60 cm in girth shall not be felled, where practicable • Adequate compensation shall be paid to affected farmers/land owners • Booms shall be used to cordon off plant materials in swamps to minimise the spread of leaves/ vegetation into nearby rivers/creeks • The leaves shall be collected and allowed to degrade naturally	Major	DFP	During site preparation and construction	Approved design /routing drawings (Permit to Survey approvals) Site inspection report Vegetation studies report	DFP project team	Periodic monitoring at the end of design phase and throughout construction activities

Potential Impact	**Rating before Mitigation**	**Description of Mitigation**	**Residual Impact Rating**	**Responsible Party**	**Timing (Phase)**	**Parameters for Monitoring**	**Monitoring Party**	**Monitoring Frequency**
Movement of wildlife across the ROWs could be impeded if the Pipelines are above ground	Moderate	• Pipeline shall be buried to ensure unimpeded movement of wildlife across ROWs.	Minor	DFP	During pipeline construction	Site inspection report	DFP project team	Throughout pipeline construction activities
Increased erosion of the cleared areas	Moderate	• Re-vegetation of top soil shall be undertaken to reduce runoff, increase moisture retention and facilitate soil stabilisation • Top soil/cleared vegetation shall be used to hedge the proposed project sites to reduce run-off (control flooding and contain sand)	Minor	DFP	During construction and operations phase	Site inspection report	project team	Twice a year

Potential Impact	**Rating before Mitigation**	**Description of Mitigation**	**Residual Impact Rating**	**Responsible Party**	**Timing (Phase)**	**Parameters for Monitoring**	**Monitoring Party**	**Monitoring Frequency**
Change in topography of sand filled areas and this could lead to demise of soil organisms	Major	• Adequate drainage channels shall be provided around the sand filled area and other project sites • Bund walls using top soils /vegetation {tree trunks) shall be erected around the sand filled area to contain sand • The areas to be sand filled shall be restricted to the minimum required • Sand filling activities shall be completed on schedule	Moderate	DFP	During construction	Site inspection reports	DFP project team	Quarterly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Disturbance of soil dwelling organisms from adverse impact on soil quality	Major	• Machinery with very low track pressure (of amphibious type) shall be used to minimise compaction and damage to soil • Excavated top soil shall be retained for reuse in restoration to minimise risks to the organisms • Top and sub-surface soil quality of the immediate environment to the proposed project locations shall be monitored in line with regulatory requirements	Moderate	DFP	During construction and decommissioning	Biomass and types of soil organisms Compliance monitoring report	DFP project team	Twice a year (dry and rainy seasons)
Excavation and deposition of soil materials during pipeline construction activities could change the topography	Moderate	• Excavated soil materials from pipe ditch shall be returned to the ditch (in order of excavation), when backfilling after pipeline laying, in a manner that will avoid changes in natural topography.	Minor	DFP	During pipeline construction	Site inspection report	DFP project team	Throughout pipeline construction activities

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Impairment of water quality by increased turbidity, this could adversely affect the quality of household water and lead to clogging of the gills of fishes and subsequent death of aquatic life	Major	• During sand filling, the generated sand materials shall be used in constructing sedimentation basins, thus allowing the water to gradually drain back without turbulence • Top soil materials shall be used to hedge the surroundings of the site to control flooding and control sand • The potable water quality shall conform to acceptable WHO and FMEnv standards (TSS, TDS, Turbidity, Chemical parameters, Biological parameters)	Minor	DFP	During construction and operations phase	Post Impact Assessment report Compliance monitoring report for potable water supplied	DFP project team	Weekly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Improper treatment and disposal of inhibited water could contaminate soil, surface and underground water	Major	• Waste water from hydro-testing (inhibited water) shall be channelled to a concreted holding basin (impermeable receptacle) for aeration and biodegradation of organic contaminants whilst inorganics shall be precipitated and sedimented as sludge • The inhibited water shall be characterised, with toxicity tests carried out. • The inhibited water shall be within regulatory acceptable limit before disposal • FMEnv/State Ministry shall supervise the disposal of the generated inhibited water	Minor	DFP	During pre – commissioning of pipeline	Site inspection/study report	DFP project team	Prior to disposal of inhibited water

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Contamination of surface/ groundwater/ decreased availability of household water from improper disposal of effluent/ sewage	Moderate	• Alternative source of water shall be provided to nearby communities during construction activities, where necessary • Sanitary wastes shall be treated biologically by sewage treatment plant on site • Emergency response spill control/prevention equipment shall be provided • Storage tank (diesel, lube oil and other chemicals) shall be bunded and adequately lined with concrete to reduce seepage • Surface water quality 500 m upstream and downstream of the well locations shall be analysed in line with regulatory requirement. • Monitoring boreholes shall be drilled to monitor ground water quality (toxic chemicals and faecal microorganisms) in line with regulatory requirement • DFP shall register all discharge point sources and shall ensure that effluents from construction sites are monitored and treated to comply with regulatory limits before disposal • Material safety data sheets (MSDS) shall be provided	Minor	DFP	During construction and operations phase	Site inspection / compliance monitoring reports	DFP project team	Weekly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Improper disposal of solid waste could lead to contamination of soil, surface/ groundwater, disrupt fishing activities and decrease aesthetic value of the environment	Moderate	• Generated solid waste shall be segregated at source by the provision of colour coded bin for different types of waste and disposed off according to DFP waste management guidelines • The generated paper waste shall be shredded and sold to any approved paper recycling company • De-contaminated scrap metals/drums shall be collected and taken to an LFZ waste recycling depot (scrap yard). • Generated glass materials shall be collected for onward delivery to any LFZ approved glass company • Spent batteries shall be taken to any L FTZ approved battery recycling company • Oily waste materials shall be collected and taken to approved incinerator • Kitchen waste shall be collected and handled at any LFZ approved composting plant • Medical waste shall be collected and taken to medical incinerator at LFZ	Minor	DFL	During construction and operations phase	Site inspection reports Availability of waste inventory data/site specific waste management plan	DFL project team	Quarterly

Potential Impact	Rating before Mitigation	Description of Mitigation	Residual Impact Rating	Responsible Party	Timing (Phase)	Parameters for Monitoring	Monitoring Party	Monitoring Frequency
Contamination of soil surface/groundwater from spills, pipeline rupture could lead to impairment of health of aquatic and terrestrial life and decreased availability of household water	Moderate	• Pipelines shall be made of duplex steel materials and coated with a three layer anti-corrosion polyethylene materials and provided with over pressurisation protection system and buried • Pipelines in marshy/swampy areas and at water crossings shall have a yard applied concrete coating over the anti-corrosion coating • The pipelines shall be designed to contain the closed in pressure of the wells and maximum discharge pressure of the manifolds, in order to withstand pressure • The pipelines shall be subjected to hydrostatic pressure tests to prove their strength and leak tightness • Automatic Shutdown Systems, Emergency Shutdown Systems, Pressure Relief System, Leak Detection System, Audible and Visible Alarm Early Warning System, Fire and Gas detection/ protection and deluge systems shall be provided • Safe distances shall be maintained between equipment	Minor	DFP	During designs/operations	Asset integrity report	DFP project team	Quarterly

7.10 ENVIRONMENTAL MONITORING

7.10.1 Introduction

The environmental monitoring plan is designed to ensure that the project complies with applicable international and national environmental regulatory standards and guidelines.

The environmental monitoring plan addresses monitoring requirements for the conformity of all activities with international and national guidelines and determines the effectiveness of proposed protection measures and controls.

Specific objectives of the monitoring plan are to:

- Check the effectiveness of recommended mitigation measures;
- Demonstrate that project activities are conducted in accordance with existing regulations

Impact indicators in this plan are defined in terms of carrying capacity, threshold levels, and regulation and enforcement standards. This action plan will require the baseline data to monitor the impacts against environmental natural conditions and is an effective mechanism for feedback and implementation of monitoring results and recommendations.

The following environmental media and indicators will be monitored during the implementation of mitigation measures;

- Ambient air quality;
- Noise;
- Ground water quality;
- Soil contamination;
- Waste Monitoring.

The monitoring objective will be to assess the mitigation measures and where required, environmental media sampling and laboratory analysis shall be conducted to determine the nature and extent of contamination.

7.10.2 Ambient Air Quality

Ambient air quality measurements showed that air quality was very good and well within Nigerian and World Bank criteria. Ambient air quality will be monitored at the same coordinates as during the baseline and monitored parameters will include VOC, CO, NOx, SOx and suspended particulate matter.

Air quality sampling will be conducted in accordance with acceptable national regulatory standards, set by the FMEnv.

7.10.3 Noise

The main source of noise at the facility during operations will be the power generator and the manufacturing machines. Other sources will be from vehicular movements. The proposed facility will comply with existing national noise limits, and its compliance monitored, for an effective implementation of mitigation measures.

7.10.4 Groundwater Quality

The groundwater supply will be treated as required by the facility for internal uses. The quality will be constantly monitored using organoleptic tests and laboratory analysis as required to determine if the operations of the facility has affected quality. All tests will be conducted in accordance with existing national standard.

7.10.5 Soil Contamination

Soil testing shall be conducted if any sign of ground water contamination is observed from the monitoring well. Samples shall be obtained from a bore around the storage tanks, loading gantry and other production area. Samples will be tested in the laboratories for chemical contamination.

7.10.6 Waste Monitoring

Wastes generated on site will be collected for disposal by licensed waste managers and appropriately disposed of at an approved facility.

7.11 ENVIRONMENTAL TRAINING

Employees of DFP will be trained in the various environmental management programmes, plans and procedures. The objective of the training programme is to educate all employees on the hazards associated with the work that must be performed, the equipment that must be operated and maintained, and the environment to which they are exposed. Employees will be trained in the following:

- Environmental Management;
- Occupational Health and Safety, And
- Contingency Plans and Emergency Procedures.

7.12 OCCUPATIONAL HEALTH AND SAFETY

DFP will establish policies and procedures on occupational health and safety into the operation of the project which meet the requirements of the international and national guidelines. The policies and procedures will be designed to provide a safe and healthy working environment.

Occupational health and safety programmes will be complemented by staff HSE training. The training will include the following:

- General area safety;
- Specific job safety;
- General electrical safety;
- Handling of hazardous materials;
- Entry into confined spaces;
- Hearing conservation;
- Repetitive stress disorders;
- Use of personal protective equipment; and
- First-aid.

7.13 EMERGENCY PROCEDURES AND ACCIDENT RESPONSE

7.13.1 Accident Response

DFP will carry out the following as part of the preparation of emergency procedures and plans for accident response arrangements:

- Review industry-specific, national and international standards and regulations;
- Establish general guidelines on potential safety and accident risks;
- Prepare job-specific operating instructions where appropriate;
- Establish safety and security notices for hazardous materials;
- Prepare specific emergency operating instructions;
- Provide protective equipment as required;
- Evaluate information and feedback from employees, and
- Record and investigate all accidents, injuries and incidents.

Contingency plans and emergency procedures are being developed to cover events due to operational failures and accidents. The plans and procedures will cover, as a minimum, the following:

- Fire;
- Explosion;
- Leaks and spills of hazardous materials;
- Structure or equipment failures;
- Injuries and illnesses;
- Risk from natural disasters (wind, flooding), and
- Third-party risks (potential accident occurring at another facility which may impact on the plant facility).

7.13.2 Risk Evaluation

Risk is the probability of loss. The loss may be of several kinds, such as damage to equipment, infrastructure, environmental damage and injury or death (Tayler, 1994). Risk analysis is the systematic investigation of all the undesired consequences of events. The various event sequences which can lead to an undesirable consequence are described and a measure of the probability of an undesired event obtained.

The major risks associated with the developed facility and assessed are grouped into the following classes:

Risk to the physical infrastructure:

- Structural and material damage;
- Tank, pipes and fittings leakage or failure, and
- Vehicular Collision or accidents within the infrastructure

Risk to the Environment:

- Fire
- Explosion
- Leak of toxic substances into the air
- Ground water contamination
- Soil contamination

Risk to Personnel:

- Fatality
- Impairment/Disability
- Minor Injury

Some of these accidents may result in hazards with large consequences. Hazards include real or potential conditions that can cause degradation, injury, illness or death to personnel, or damage/loss of equipment and property.

7.13.3 Risk Analysis Process

The overall process adopted for risk analysis involves:

- Defining the scope and objectives of the analysis;
- Identifying potential hazards;
- Quantifying the probability or frequency of accidents;
- Quantifying the consequence of accidents e.g. damages, injury and fatality;
- Integrating the information derived from an overall picture of risks;
- Assessing whether the risks are acceptable or tolerable;

- Revising or improving on the site design or construction, and
- Ensuring that assumptions remain valid.

7.13.4 Personnel Risk

Personnel risks include injuries and fatalities and are expressed as:

- Immediate fatalities,
- Escape fatalities, and
- Evacuation fatalities

7.13.5 Environmental Risk

Environmental risk from the plant installation is dominated by leaks from pipe-work leakage and distance of combustible substances or spills from sources of ignition or potential electrical installation fire/failure. Plant failure can be caused by old age and design error. The quantified risk to the environment is expressed as:

- Spill volume;
- Potential ignition sources;
- Proximity to electrical installations, and
- Frequency of event with similar consequence

7.13.6 Infrastructural Risk

This comprises of possible damage to equipment and infrastructure and is expressed as follows: Expected damage to structure and equipment

- Age and integrity of fittings and installation, and
- Extent of vehicular activities

The following hazards may cause accidental events which have potential to damage the assets:

- Ignited and un-ignited leaks of chemicals;
- Hazardous and non-hazardous leaks of chemicals;
- Fire from electrical installations;
- Fires from utility areas e.g. offices, and

- Vehicular accidents within the facility

7.13.7 Risk Assessment Matrix

The hazard risk assessment provides a systematic method for assigning a hazard level to a failure event based on the severity and frequency of the event. The potential hazards consist of:

a) Death, irreversible environmental loss and structural damage
b) Severe injury, occupational illness, major structural damage, or reversible severe environmental damage
c) Injury requiring medical attention, illness, structural damage and mitigatible environmental damage
d) Possible minor injury, minor structural damage or minimal environmental damage.

The frequency of occurrence can be represented as follows:

- Expected to occur frequently within project life cycle
- Will occur several times within project life cycle
- Likely to occur within project life cycle
- Unlikely, but possible to occur in the project life cycle
- So unlikely to be experienced within the project life cycle

A summary of potential hazards are presented below (Table 7-2)

Table 7-2 - Hazard Risk Assessment Matrixes

Frequency of Occurrence	**Severity**			
	(1) Catastrophic	(2) Critical	(3) Marginal	(4) Negligible
• Frequent	1A	2A	3A	4A
• Probable	1B	2B	3B	4B
• Occasional	1C	2C	3C	4C
• Remote	1D	2D	3D	4D
• Improbable	1E	2E	3E	4E

Risk categories:	***HIGH***	**SERIOUS**	***MEDIUM***	***LOW***

The following hazards have been identified:

- Natural Hazards – weather extremes, lightning, flooding, and subsidence
- Man Made hazards – internal/external security breakdown, sabotage
- Environmental Hazards –media contamination and gaseous emissions
- Fire and explosions hazards – stored inflammables, sources of ignition
- Utility/System Failure – leakages, extreme temperature, corrosion and mechanical failure
- Health Hazards – asphyxiation, hazards from toxic materials, mental and physical strain

Table 7-3 gives an overview of the different hazards with their frequency and severity.

Table 7-3: Hazard Risk Assessment

Hazard	Frequency					Severity			
	A	B	C	D	E	1	2	3	4
Natural Hazards									
Extreme weather		X					X		
Lighting		X					X		
Flooding				X					X
Subsidence					X				X
Man Made Hazards									
Security Breakdown				X					X
Sabotage				X		X			
Environmental Hazards									
Media contamination		X					X		
Gaseous emissions		X					X		
Fire and Explosion Hazards									
Stored inflammables				X		X			
Ignition sources		X					X		
Utility/System Failure									
Leakages		X					X		
Extreme Temperature				X				X	
Corrosion and Mechanical Failure				X			X		
Health Hazards									
Asphyxiation				X			X		
Toxic material spills				X			X		
Mental and physical strain			X						X

7.13.8 Emergency Preparedness and Response Plan

This emergency response plan is designed to protect employees during emergency situations, including fires, chemical spills, natural disasters, and sabotage. This plan is applicable to all areas and activities under the construction, operation and maintenance of the project, including storage, use and handling of oil and other hazardous materials.

7.13.9 Responsibilities

The Plant Manager is responsible for the implementation of the contingency plan and ensuring that all site employees are aware of this plan and any subsequent revision.

Supervisors must ensure that their employees are familiar with this plan.

All personnel are responsible for identifying potential conditions, practices or activities that could lead to an emergency situation and communicating this to their supervisor.

7.13.10 Environmental Emergency Scenarios

Spills and releases of chemicals, fuels and other hazardous substances may occur as isolated events or they may occur with other emergencies such as fire, explosion, and natural accident. In the event of a spillage event, the conveyance of the pollutants offsite will be via the site's front exit. Spillage and accidental release management are summarized below (Table 7-4) to minimize their environmental impacts.

Table 7-4: Emergency Response Table.

Location	Nature of risk	Containment Strategies
UST/AST	• Release of chemicals and lubricants	• Chemicals laid on impervious base
Maintenance & Vehicle workshop	• Rainwater infiltration of hazardous workshop waste (e.g. used engine oil etc) storage containers; • Dripping of lubricating oil vehicle/mechanical servicing; • Leakages of acids from used batteries.	• Storage materials should be protected from weather and stored within bunds, contents of containers to be clearly indicated; • Drip pans to be provided for collection of oil; • Batteries to be separated from other waste streams, batteries should be drained and neutralized prior to disposal.

7.13.11 Evacuation Response Procedure

7.13.11.1 General

The facility plans shall indicate exits and fire extinguishers locations and kept posted throughout the facility. Supervisors are responsible for ensuring that employees know the location of fire extinguishers, fire exits, and alarm systems in the areas in which they work.

If a fire emergency exists, employees should immediately activate the station alarm by pulling a pull station. Pull station locations can be found on the floor plans. Employees should evacuate all rooms, closing all doors to confine and reduce the fire and to reduce oxygen. DO NOT LOCK DOORS.

When the building evacuation alarm is sounded, an emergency exists. Walk quickly to the nearest marked exit and alert others to do the same. Smoke is the greatest danger in a fire. If you must pass through a smoke-filled room, stay near the floor where the air may be less toxic.

Leave the building using the nearest exit. Once you are outside the building, move to the assembly area and keep walkways clear for emergency vehicles and crews.

DO NOT RETURN TO AN EVACUATED BUILDING UNLESS TOLD TO DO SO

Note: If you become trapped in a building during a fire and a window is available, place an article of clothing (shirt, coat, etc.) outside the window as a marker for rescue crews.

7.13.11.2 Accounting for Employees

Immediately after evacuation, at the designated assembly area, supervisors should determine if anybody is missing and report to the emergency response coordinator.

7.13.11.3 Evacuation Procedures for Handicapped Employees

Employees should tell their supervisor about disabilities that may require special accommodations when carrying out emergency evacuation plans. The supervisor is responsible for working with the employee to develop procedures that will allow the employee to evacuate safely. For instance, co-workers may be assigned to assist employees in wheelchairs.

7.14 EMERGENCY MEDICAL TREATMENT

Emergency medical treatment or first aid may be required during or after an emergency. Employees trained to provide first aid must remember the following:

- avoid panic;
- inspire confidence; and
- do only what is necessary to stabilize an injured employee's medical condition until professional help arrives.

The following sections cover basic procedures for handling common injuries and illnesses.

7.14.1 First Aid Kits

A basic first aid kit should be available within the work area. First aid kits will include physician-approved supplies suitable for medical emergencies that can reasonably be anticipated at the work area. Suitable contents for first aid kits include sterile bandages, tape, scissors, ice packs, plastic gloves, and a mouth-to-mouth breathing tube. Employees should be informed of the location of first aid kits. Inventory supplies and restock items, as necessary.

7.14.2 Initial First Aid

Employees who are first to arrive on the scene of a medical emergency should follow these guidelines:

- Assess the situation. Can you safely approach the victim? If not, what can you do to help without threatening your own safety? Determine what is wrong with the victim.
- Set priorities and call for emergency. Is the victim conscious? How serious is the victim's condition? Should you call for help immediately or do you need to attend to the victim? Can someone else call emergency medical services so the victim is not left alone? If no one else is available, decide if it is more important to administer

first aid immediately or to call for emergency medical services and leave the victim unattended. Never leave a victim in a life-threatening situation without trying to first stabilize the victim's condition.

- Check the “ABCs” (unconscious victims only):
  - “A”—Airway. Make sure the victim has a clear airway. Place the victim on his/her back. Place one hand on the victim's forehead and one hand under the chin and tilt the head back. Open the victim's mouth and check for obstructions. If the victim is unconscious and an obstruction is visible, remove it with your fingers. NOTE: If you suspect back or neck injury, do not move the victim or adjust the victim's neck. Simply open the victim's mouth to check for obstructions.
  - “B”—Breathing. Place your ear above the victim's mouth and look at the chest. Listen for breathing and look for the rise and fall of the chest. If the victim is not breathing, someone trained in mouth-to-mouth breathing should begin resuscitation.
  - “C”—Circulation. Using two fingers, gently feel for the carotid artery in the neck to check for a pulse. To find the artery, place your fingers on the victim's Adam's apple and then slide them down the side of the neck until you feel the groove between the windpipe and neck muscles. If there is no pulse, someone trained in CPR should begin cardiopulmonary resuscitation.

  Stay with the victim until emergency medical personnel arrive.

7.14.3 Bleeding (External)

Most cuts are minor. However, heavy external bleeding can cause death in three to five minutes. In addition to the procedures for initial first aid, follow these steps to control external bleeding:

- Using a sterile dressing, clean cloths, or other material, apply pressure directly over the wound. (Important: Direct contact with a victim's blood may expose you to various communicable diseases. Always wear latex gloves when assisting a bleeding victim).
- If possible, elevate the bleeding area. Otherwise, lay the victim flat, and elevate the legs.

- Keep the victim lying down.
- Treat the victim for shock, if necessary.
- Do not release pressure or lift the bandage until you are sure the bleeding has stopped.
- Have someone call emergency medical services, if necessary.
- Do not use a tourniquet unless an arm or leg has been amputated.
- For deep chest wounds, use a heavy dressing to keep air from passing through the wound.
- For gaping stomach wounds, use a damp dressing; do not touch any protruding organs.

7.14.4 Burns

Thermal and chemical burns require immediate attention. In addition to the procedures for initial first aid, follow these steps for thermal burns:

- First and second degree burns cause redness and blistering, but leave the victim's skin intact. For first and second degree burns:
- Immerse the burned area in cold water or apply ice packs to the affected area.
- Cover the burned area with a clean cloth.
- Treat the victim for shock, if necessary.
- Do not apply butter, oil, or cream to a burn.
- For serious burns (e.g., large area burns or charred skin:
    - ✓ Remove clothing from the injured area. Cut around clothing that adheres to the skin.
    - ✓ Treat the victim for shock.
    - ✓ If the victim is conscious, provide non-alcoholic fluids.
    - ✓ Call emergency personnel as soon as possible.

7.14.5 Cardio-Pulmonary Resuscitation (CPR)

When a person stops breathing, immediate assistance is necessary. If the person stops breathing due to choking, follow the first aid instructions for choking victims. If the person stops breathing due to a hazardous atmosphere, move the victim to fresh air immediately.

Important: Always wear personal protective equipment when entering hazardous atmospheres. Do not attempt a rescue without adequate protection or proper training.

Someone formally trained in CPR should provide assistance to victims who are not breathing and victims who do not have a pulse, as follows:

- ✓ Try to arouse the victim.
- ✓ Place the victim on his back.
- ✓ Open the victim's airway by placing one hand on the forehead and one hand under the chin and tilting the head back.
- ✓ Check for any obstructions in the mouth or throat.

Look, listen, and feel for breathing. If the victim is not breathing, pinch the victim's nose closed and use a mouth-to-mouth breathing tube to give two slow, deep breaths. Check the carotid pulse and look, listen, and feel for breathing. If a pulse is present but the victim does not start breathing, continue rescue breathing as follows:

- Adult: one breath every five seconds;
- Child: one breath every four seconds; and
- Infant: one breathes every three seconds.

If a pulse is not present, have someone formally trained in CPR begin mouth-to mouth breathing and chest compressions. Continue this procedure until the victim starts breathing or emergency personnel arrive.

7.14.6 Chemical Splashes

Chemical splashes on the skin require immediate attention. Follow these steps:

- Go to the emergency shower or sink.
- Remove any contaminated clothing.
- Wash the affected area with water thoroughly for 15 minutes.
- Seek medical attention.

7.14.7 Choking

Choking victims cannot speak, breathe, or cough forcefully. Follow these steps for conscious choking victims: Ask the victim if he is choking. If the victim indicates yes, begin the Heimlich manoeuvre, as outlined below:

- ✓ Get behind the victim and make a fist with one hand. Grasp your fist with the other hand and place your hands slightly above the victim's navel.
- ✓ Give quick, upward thrusts backwards until the object is expelled.

Important: For obese victims, use a chest thrust. Place your fist on the sternum, and thrust backwards repeatedly.

Follow these steps for unconscious choking victims:

- Call emergency personnel.
- Place the victim on his back. Open the victim's airway by placing one hand on the forehead and one hand under the chin and tilting the head back. Check for any obstructions in the mouth or throat.
- Attempt mouth-to-mouth rescue breathing.
- If the airway remains blocked, place the heel of your hand slightly below the victim's ribs. Give six to ten abdominal thrusts.
- For pregnant or obese victims, use a chest thrust. Place your fist on the sternum, and thrust backwards repeatedly.
- Sweep the mouth to remove any dislodged objects and attempt mouth-to-mouth rescue breathing again.
- Continue this procedure until the object is dislodged or the victim starts breathing.

7.14.8 Eye Injury

If hazardous liquids, particles, or gas irritate a person's eye, have the victim flush the eye with water for at least 15 minutes. Use an eye wash station, sink, or water fountain. Seek assistance from a physician, as necessary.

If a foreign object (e.g., glass, pencil head, etc.) is embedded in the eye, place a plastic cup or gauze over the affected eye. This will keep the eye from moving and inflicting further damage. Seek assistance from a physician immediately.

7.14.9 Poisoning

There are many types of poisons. Each requires a specific type of treatment. The remedy for one type of poison may worsen the condition of an employee affected by a different poison. If you suspect a victim has been poisoned through ingestion, inhalation, or skin exposure, try to determine what the poisoning agent is. Contact emergency personnel or the nearest hospital for specific instructions.

7.14.10 Seizures

Do not try to restrain seizure victims. Move any furniture or objects that could harm the victim and wait for the seizure to end. Contact emergency medical services if this is the victim's first seizure or if the seizure is exceedingly violent or lasts a long time. Do not place anything in a seizure victim's mouth.

7.14.11 Shock

Shock commonly accompanies injuries or severe emotional distress. Symptoms of shock include the following:

- ✓ Cold, clammy skin;
- ✓ Pale skin tone;
- ✓ Shallow breathing; and
- ✓ Chills.

Follow these steps to assist shock victims:

- ✓ Call emergency personnel;
- ✓ Keep the victim lying down;
- ✓ Maintain an open airway. If the victim vomits, turn the head sideways and the chin downward.
- ✓ Elevate the victim's legs;
- ✓ Keep the victim warm, and
- ✓ Reassure the victim.

7.15 SITE SECURITY

The Plant Manager is responsible for security arrangements to prevent workers or members of the public from entering areas where emergency conditions exist. Only authorized rescue and emergency response personnel should be allowed into the area. The emergency response coordinator may decide to cordon off the area with ropes and signs. If necessary, the emergency response coordinator should notify the police or hire private security personnel to secure the area after the emergency.

7.16 SPECIFIC EMERGENCIES

The following sections describe the procedures employees should follow during specific emergencies that may arise at their facilities.

7.16.1 Spill Contingency Plan

Preventing oil and chemical spills is the best strategy for avoiding potential damage to human health and the environment. However, once a spill occurs, the best approach for containing and controlling the spill is to respond quickly and in a well-organized manner. A response will be quick and organized if response measures have been planned ahead of time.

Planning for an oil or chemical spill emergency helps to minimize potential danger to human health and the environment by ensuring a timely and coordinated response. A well-designed site-specific oil spill contingency plan, together with state, regional, and/or national contingency plans can assist response personnel in their efforts to contain and clean up oil spills by providing information that the response teams will need before, during, and after spills occur.

Oil or a chemical spill contingency plan is constantly evolving and improving, because of:

- The approaches and methods for responding to oil and chemical spills are constantly evolving;
- Accidental oil and chemical spills in the project area or abroad, provide opportunities to learn how to better prepare for future incidents;

- Infrastructural alterations, and
- Lessons learnt from exercising the OSCP and training of key personnel.

7.16.1.1 Content of the Contingency Plan

The Spill Contingency Plan covers possible spills during the following activities;

- Delivery;
- Handling;
- Dispensing, and
- Clean-up.

The plan details procedures, responsibilities, chains of command, monitoring and documentation.

The Oil Spill Contingency Plan comprises three parts:

- ✓ *a strategy section*, which describes the scope of the plan, including the geographical coverage, perceived risks, roles / responsibilities of those charged with implementing the plan and the proposed response strategy;
- ✓ *An action and operations section*, which sets out the emergency procedures that will allow rapid assessment of the spill and the mobilization of appropriate response resources; and
- ✓ *A data directory*, which contains all relevant maps, resource lists and data sheets required to support spill response effort and conduct the response according to an agreed strategy.

7.16.1.2 Spill Contingency Response

The guidelines below should be followed in the event of a chemical incident in which there is potential for a significant release of hazardous materials.

7.16.2 Spill Classifications

Spill response procedures vary depending on whether a spill is small, medium, or large. Maximum spill anticipated is based on the following:

- Product being supplied and volume of the supply tanker
- Size of leaking above storage tank
- Size of drums and chemical storage containers

The following are descriptions of each type of spill:

Small spills: This category includes spills where the major dimension of the spill is less than 18 inches in diameter.

Medium spills. These are spills where the major dimension exceeds 18 inches, but is less than 6 feet.

Large spills. This category includes:

- any spill involving a flammable liquid where the major dimension exceeds 6 feet in diameter; and
- any "running" spill, where the source of the spill has not been determined or the flow has not been stopped.

7.16.3 Spill Response

In the event of a spill, the Plant Manager shall be notified immediately. The Manager will assess the situation and determine the level of response required. Responsibility for clean-up lies with a retained subcontractor and personnel will supervise and provide support as required.

7.16.4 Spill Containment

The source of spill shall be stopped where practicable and measures should be implemented to contain the material from spreading without compromising employee health and safety. Larger spill should be recovered using pumps or skimmers appropriate to spill size and location. Residual or small scale spillage should be absorbed using available absorbent materials e.g. sawdust, sand etc.

7.16.4.1 Clean up

Contaminated soil and other materials resulting from a spill shall be collected and disposed of by an adequately licensed waste management contractor.

7.16.4.2 Evacuation

Persons in the immediate vicinity of a spill should immediately evacuate the premises. If the spill is “medium” or “large,” or if the spill seems hazardous, immediately notify emergency response personnel.

7.16.5 General Spill Control Techniques

Once a spill has occurred, the employees at the spill site must decide whether the spill is small enough to handle without outside assistance. Only employees with training in spill response should attempt to contain or clean up a spill.

Spill control equipment should be available wherever significant quantities of hazardous materials are received or stored. MSDS sheets, respiratory protection, absorbents, over-pack containers, container patch kits, spill dams, shovels, floor dry, acid/base neutralizers and “caution-keep out” signs are common spill response items that should be stocked in such areas.

7.16.5.1 Response and Clean-up procedures for small spills

Small spills generally can be handled by internal personnel and usually do not require an emergency response by external personnel. Spills of less than 18 inches normally are cleaned up by the spiller. First, quickly contain the spill by stopping or securing the spill source. This could be as simple as up righting a container and using absorbent pads to soak up spilled material. Wear gloves and protective clothing, if necessary. Put spill material and absorbents in secure containers.

Sometimes the area of the spill should not be washed with water. The spilled material and the absorbent sometimes might be classified as hazardous waste and must be disposed of in compliance with state and federal environmental regulations.

7.16.5.2 Response and Clean-up procedures for medium spills

An external response team maybe required for medium spills. However, common sense also should be used when determining if outside help is necessary. Medium spills require the following actions:

First, try to contain the spill at its source. This might involve quickly up righting a container or putting a lid on a container. Do not use absorbents unless they are immediately available. Once you have made a quick attempt to contain the spill, leave the area and alert emergency response personnel. Close, but do not lock, the doors as you leave. Give emergency response personnel accurate information as to the location, chemical, and estimated amount of the spill.

Second, evaluate the area outside of the spill. Engines and electrical equipment near the spill area must be turned off. This eliminates various sources of ignition in the area. Advise emergency responders on how to turn off engines or electrical sources. Do not go back into the spill area once you have left. Help emergency responders by trying to determine how to shut off heating, air conditioning equipment, or air circulating equipment, if necessary.

If emergency responders evacuate the spill area, follow their instructions in leaving the area. After emergency responders have contained the spill, be prepared to assist them with any other information that may be necessary, such as MSDS sheets and questions about the facility.

Emergency responders or trained personnel with proper personal protective equipment should clean up the spill residue. Do not re-enter the area until the responder in charge gives the all clear. Be prepared to assist these persons from outside the spill area with MSDS sheets, absorbents, containers, etc.

Reports must be filed with proper authorities. It is the responsibility of the spiller to inform both his/her supervisor and the emergency responders as to what caused the spill.

7.16.5.3 Response and Clean-Up Procedures for Large Spills

The response for large spills is much the same as for medium spills, except that the exposure danger is greater. The response for large spills is as follows:

- First, since spill control or containment by the spiller is not likely, the spiller should immediately leave the area and notify the Plant Manager. Again, give the operator the spill location, chemical spilled and approximate amount.
- Second, from a safe area, attempt to get MSDS information for the spilled chemical for the emergency responders to use. Also, be prepared to advise responders as to any ignition sources, engines, electrical power, or air conditioning/ventilation systems that may need to be shut off. Advise responders of any absorbents, containers, or spill control equipment that may be available. This may need to be done from a remote area, as an evacuation that would place the spiller far from the scene may be needed. Use radio or phone to assist from a distance, if necessary.
- Spills greater than 6 feet in any dimension or that are continuous should be handled only by emergency response personnel, in accordance with their own established procedures. Remember, once the emergency responders are on the job cleaning up spills or putting out fires, the area is under their control and no one may re-enter the area until the responder in charge gives the all clear.
- Finally, the spiller will need to provide information for reports to supervisors and responders, just as in medium spills.

7.16.6 Fires

If you see a fire or smoke, take the following steps:

- Activate the alarm to begin evacuating the building.
- If you are not in immediate danger, report the fire to the Plant Manager. Provide information on the approximate location of the fire, the size and type of fire.

- If you are formally trained in fire fighting techniques or if you are not in imminent danger, you may attempt to fight a fire that is small and controllable. Do not place yourself or others in unnecessary danger.
- Exit the building by following posted evacuation routes. Proceed to the designated assembly location.
- Employees must receive permission from their supervisor or the emergency response coordinator before re-entering the building.

Fire fighting devices are incorporated into the design of the DFP facility.

7.17 EMERGENCY INCIDENT REPORTING

When there is a fire or other emergency that poses immediate danger to people or property, employee should sound the fire alarm if they can do so safely before evacuating. Follow emergency evacuation procedures. Employee should calmly notify others, and respond to the emergency as appropriate. Procedures for responding to specific types of emergencies are described below. Do not attempt to handle emergency duties – e.g., fire fighting – for which you do not have training.

The following numbers should be posted near telephones and in other conspicuous locations:

- Outside emergency services (police, fire department, ambulance service)
- Hospital
- Emergency Response Coordinator

7.18 INSPECTION AND PRACTICE DRILLS

Regular inspection of storage tanks should be undertaken. Regular drill should be undertaken to assess the practicability of this plan.

7.19 WASTE MANAGEMENT PLAN

7.19.1 Wastes Sources and Classification

Waste from the proposed facility can be classified into the following:

Domestic waste

These are waste generated from the daily operations of the office and canteens within the facility. Composition of the waste will include the following:

- Paper
- Glass
- Plastics and Nylons
- Metal
- Food residues
- Sanitary wastes

Hazardous waste

These are waste generated from the daily operations of the fuel dispensing area, lube service bay, and above ground storage containments within the facility. These categories of waste include explosive substances or solid/liquid substances or mixtures of substances capable of causing an explosion. It also refers to flammable solids or liquids and substances liable to spontaneous combustion, corrosive and poisonous substances. Composition of waste will include the:

- Used/spent oil
- Wastes/residues containing oil
- Oily sludge/emulsions
- Spent chemicals
- Accidental fuel discharge

7.19.2 Waste Handling and Disposal

Domestic waste

Collection and Storage

The facility will be equipped with waste bins for the collection and segregation of the following categories of domestic waste:

- Biodegradables: food remains
- Incinerables: plastics, waste papers, etc
- Recyclables: metal articles, glass etc

Aspects to be considered in the selection of the waste bin types shall include:

- Hygiene (exclusion of insects, rodents and odour); which may be achievable through provision of adequate cover, and spraying of insecticides or microbial inoculums.
- Adequate capacity to forestall garbage spill;
- Weather resistance (impermeability);
- Convenience of use (colour coding for ease of use), and
- Aesthetic acceptability

Transportation

Transportation implies conveyance from point of collection to the point of final disposal either directly or through a transfer system. The waste generated shall be quickly removed, to forestall cases of garbage accumulation and nuisance, and an evacuation programme shall be developed with a licensed waste contractor. The waste shall be evacuated to the nearest dump site, using a waste compactor truck. Sanitary waste shall also be evacuated from the soak away pit periodically, using a licensed waste disposal contractor. The following factors shall be considered in the choice of vehicle and final disposal site:

- The road network and condition;
- Frequency of collection, and
- Hygiene and aesthetic requirements

Final Disposal

The domestic waste generated from the facility shall be disposed of in the most pragmatic and environmentally acceptable manner. Domestic waste from the facility shall be finally disposed of in a landfill or dump site. The options of recycling, reusing, incineration, burial or composting shall be considered at the dumpsite.

Hazardous waste

Collection and Storage

The facility will be equipped with waste disposal drums for the collection of the used/spent oil, waste residues and other oily sludge with emulsions. Accidental fuel or oily spills shall be contained using chemical absorbents. Plastic kegs will also be used for the storage of spent oils or chemical wastes pending transportation and disposal.

Transportation

The collected hazardous waste shall be transported by a licensed waste disposal contractor, using an appropriate waste disposal vehicle.

Disposal

The final disposal of the waste shall be carried out at an approved waste disposal facility, after due treatment, to an environmentally acceptable level.

The waste shall be managed in the most logical manner. The waste stream shall be managed, treated and disposed of as follow:

Reduction in the amount of hazardous wastes generated;

- Stimulate "waste exchange" to allow generated waste to become feedstock for other production facilities;
- Detoxification and neutralization of liquid hazardous waste streams by chemical and biological treatment;
- Dewatering of waste sludge generated;
- Stabilization and solidification of sludge, and subsequent ashing to reduce leachability of metals;

- Disposal of remaining treated residues in approved (specially designed) landfills (where applicable);
- Recycling of metals, the energy content, and other useful resources contained in hazardous wastes; and
- Destruction of combustible hazardous wastes in high-temperature incinerators equipped with proper pollution-control and monitoring systems.

Final Offsite Treatment/Disposal

The treatment and disposal of hazardous waste generated by the facility shall be conducted at a commercial/third party Government approved facility. The conditions and specifications of the available international, national, state and local governments' standards shall be met during the waste disposal process. The following waste disposal process shall be adopted at the site (as applicable):

Resource Recovery (recycling):

As much as possible all the re-useable components of the hazardous waste should be recovered by using the best practicable technology currently available.

Solidification:

The hazardous waste after some neutralization can be solidified by an appropriate waste: cement ratio.

Landfilling:

The hazardous material/wastes shall be subjected to detoxification (neutralization) procedures before any landfilling.

Encapsulation/Fixation/Stabilization:

Encapsulation, fixation and stabilization processes shall be used to treat hazardous waste sludge, and residues to produce materials of better physical handling, leachability and landfilling characteristics than the wastes from which they are derived.

Incineration:

Incineration shall be carried out for either total destruction and/or recycling (resources recovery) of the hazardous materials.

CHAPTER EIGHT

DECOMMISSIONING

CHAPTER EIGHT

DECOMMISSIONING

8.1 INTRODUCTION

Every project has a life span. The lifespan of a project is usually determined by the following factors: the design basis and construction materials; availability of raw materials and feedstock; market and acceptability of the end-product; facility maintenance and technological development. For this project, the minimum life spans the fertilizer plant and ancillary facilities will be at least 50 years. The facility will be fully operational for 50 years, before consideration for redesign or replacement.

DFP lies in the Lekki Free Zone, a huge industrial site which will be built for the future centuries. In other words, the consideration is already made. With continuous maintenance and replacement of obsolete parts, the DFP project will virtually never be dismantled. Recovery of the land in its original state is a highly unlikely scenario to occur in this project.

However, the project impact consideration on the environment requires a recovery or restorative plan to remediate the facility site to its original state after decommissioning. This will require a good understanding of all applicable environmental components within the project ecosystem during its lifespan. It is therefore environmentally wise to take this component into cognizance during the planning stage. This section of the report provides an overview of the various decommissioning activities that will accompany this project.

8.2 DECOMMISSIONING ACTIVITIES

Decommissioning and demobilization of major construction activities, equipment and personnel in conformance with a plan that meets national regulatory requirements (FMEnv) and international standards are appropriate. This plan will encompass and take into consideration the project specific activities of the DFP.

The programme will include a plan to survey the site for land and water contamination. All materials that could subsequently prove hazardous to the restoration of the site shall be treated. All contaminated material shall be disposed of in a safe and approved manner as stated in the ESMP. The site shall also be restored to meet environmental requirements approved by regulators, and all re-usable items will be disconnected and handed over to the appropriate departments, while the non-reusable items will be carefully segregated, containerized, labelled and conveyed to approved disposal sites. Any polluted and contaminated soil will be treated in-situ or removed from the site and treated/disposed of safely. Bioremediation of any contaminated soils shall be considered where applicable.

DFP will follow the widely accepted demobilization process for onshore and offshore installations. Before demobilization, DFP will develop a construction demobilization plan for the following:

- Facilities and activities to be removed;
- Environmental aspects of the demobilization activity;
- Methods for facility re-use, recycling, disposal and removal;
- Proper consultation with all stakeholders (communities, other land users and regulators);
- Efforts to mitigate negative environmental impacts and appropriately rehabilitate the site
- Programmes for restoring the environment in accordance with national regulations (FMEnv) and international best-practices and requirements, and
- Scope of work to assess possible residual impacts of the Project on the environment, specifically any future restrictions on other activities.

The content of the plan will take into consideration the extent of the demobilization, plans for future use of the abandoned site, and the condition of the site and environment at the time of demobilization. In general, demobilization activities will be conducted in compliance with applicable regulations and guidelines as the definite laws that are in force at the time of decommissioning or demobilization. The plan will also include regulations and a risk & cost analysis of the various options.

At the end of the Project life, all equipment will be demobilized such as camps, crew kits, tanks, lines, vehicles, construction kit, materials and equipment, crane, recording equipment, etc. All installed facilities on project sites will be adequately dismantled and removed to allow for proper remediation of the project site. The clients' HSE and Management Systems will be implemented to ensure safety of personnel and the public during demobilization as well as minimize negative environmental impacts. Particular attention will be paid to the following:

- Protection from air pollutant emissions
- Protection from noise and blasts
- Line production and clearing
- Waste handling
- Spill containment and management

Project components that may be re-used or recycled will be identified and quantified. Vehicles and other equipment and facilities will be moved to other locations. Cleared locations will be re-vegetated using fast growing plant species. Contaminated environmental component attributable to Project activities will be appropriately restored where practicable.

A post decommissioning report (PDR) will be prepared and submitted to the FMEnv.

8.3 REHABILITATION OF CONSTRUCTION ACTIVITIES

DFP lies in the LFZ. Infrastructure used for DFP will also be used for other LFZ activities. As a result of this, a rehabilitation of construction activities is a theoretical issue, since it will never be the case as long as LFZ exists.

8.3.1 Construction Camps

Rehabilitation will be necessary in the following areas:

- Concrete and compacted earth platforms;
- Excavation for septic tank, and
- Access roads running into and through the camps and other facilities

Concrete platforms will be de-constructed and the rubble taken to an approved waste disposal site or used for rehabilitation of borrow pits. The exposed surface must be tested for contaminant at an FMEnv accredited laboratory. Remediation of contaminated surfaces is subsequently carried out while wastes are disposed of at an approved site before re-vegetation of the land is carried out.

All access roads running into and through the camps and any other well-used thoroughfares (whether pedestrian or vehicular), which have been denuded of vegetation and have subsequently been compacted, will be checked for any substantial spillage of contaminants including oils and fuels. The area will be ripped and top-soiled if necessary.

8.3.2 Ware House Materials

Such materials shall be sold to third party for re-use. Any other materials, toxic or nontoxic, that cannot be handled as above will be taken to approved incinerators and/or land fill for disposal.

8.3.3 Re-Generation of Vegetation

The basic re-vegetation steps, which need to be adapted for the project-specific environmental remediation programmes are listed below.

- Prepare top soils for the area to be re-vegetated. This process may require soil ripping and/or scarifying. The scarification should take place to a depth of 150 mm. If ridges are made, they should be about 100 mm high and about 400 mm wide.
- Replace stored topsoil on the slope to be re-vegetated to a depth of between 75 mm and 150 mm (depending on the soil and slope conditions). The topsoil should be spread when it is dry by means of hand raking or mechanical balding and trimmed to a uniform thickness of not less than 100 mm.
- Apply seeds or grass sods according to the supplier's specifications. The seed must be fresh, good quality seed as specified in the seed mix, certified by the supplier and free from contamination by seeds of other species. Seed harvested from the site may be substituted only with the approval of the relevant authorities and/or agencies. If indigenous grass sods are used, they should be placed close together

and level with each other. Gaps between the sods should be filled in with topsoil. A light cover of topdressing may be required to encourage growth and establishment.

- Mulch should be applied to protect the seeded area from erosion. The mulch should be composed of straw or other material of cellulose origin and free of undesirable seeds. The mulch must not be excessively fresh and green or in an advanced state of decomposition as it could smother growth. It must be applied to a depth and density that will prevent erosion by wind and water, but not completely block out the access of sunlight to the soil or prevent penetration by young plants.
- Protect the re-vegetated area from excessive trampling and any other factors that might cause erosion or compaction. No equipment, trucks or other heavy equipment should be allowed onto re-vegetated areas.
- Ensure that suitable temporary and permanent drainage protection is installed ahead of or in parallel with the re-vegetation process.
- Water the seeded/planted area according to need.
- Institute an appropriate maintenance and monitoring programme for a minimum of 1 year. This programme should include monitoring of the success of seed germination, growth of the plants, removal of invasive weeds, replanting of areas where re-vegetation has not been successful once the cause of the inhibiting factor has been identified and remedied, and repair of any funnels or erosion channels. The contractor must not allow erosion to develop on a large scale before implementing repairs.

8.3.4 Project personnel

From the onset, project personnel will be involved in “retirement plans”. All workers will be adequately compensated to ensure that they can continue to live a productive life, even after the project has ended.

For the young and still relatively agile, they may be taught alternative trades and/or crafts, which will sustain them when their job on the project has closed.

Generally, decommissioning activities will be conducted in compliance with applicable regulations and guidelines. The process will include consultation with local communities and incorporation of restoration and remediation activities, if needed.

8.4 POST-CLOSURE MONITORING

Upon the completion of the decommissioning activities, a Clean Bill of Health (CBH) must be issued by concerned regulatory agencies including FMEnv, Lagos State Ministry of Environment and Lagos State Environmental Protection Agency (LASEPA).

However, in an attempt to ensure the fitness of the land for future use, post-closure monitoring will be conducted before transferring the land to the next landowner.

CHAPTER NINE

CONCLUSION

CHAPTER NINE

CONCLUSIONS

The ESIA for the proposed Dangote Fertilizer Plant (DFP) at the Lekki Free Trade Zone (LFZ) was conducted in accordance with applicable National and International regulatory requirements.

The aim of the ESIA process is to provide information for decision-making to contribute to environmentally sound and sustainable development. The overall ESIA process comprised of a number of key steps, namely:

- Screening;
- Scoping;
- Baseline data collection;
- Public participation;
- Impact assessment;
- Management plans; and
- Reporting and disclosure.

This report provides a description of the ESIA process followed to date. It also provides a description of the public participation process that was undertaken during the ESIA whereby stakeholders were notified and consulted regarding the project and its anticipated consequences. Baseline information on receptors and resources was collected during the ESIA from available data sources and from environmental and socioeconomic baseline field surveys undertaken during both the rainy and dry seasons. A description of the existing environmental and socioeconomic conditions is provided as a basis against which the impacts of the project can be assessed. The biophysical, social-economic and health impacts of the proposed project have been assessed and mitigation measures identified to avoid or reduce possible impacts and enhance positive impacts. A register of mitigation measures and monitoring requirements is included in **Chapter 6** and an outline ESMP is provided in **Chapter 7**.

Consultations with the proposed project stakeholders, local government areas and communities, the ESIA regulatory authorities and other stakeholders at various tiers have been carried out and shall continue throughout the project lifecycle.

Environmental and Social Impact Assessment of the DFP showed that **the project will have significant beneficial impacts on the socio-economic life of the host communities and the national economy.** However, some households will be economically displaced. Therefore, a Livelihood Restoration Plan shall be developed and adequate compensation will take place.

The LFZ site is generally suitable for the proposed DFP and all environmental and social risks can be minimised and managed through implementing preventative measures and sound environmental management systems. It is recommended that environmental performance is being monitored regularly to ensure compliance and that corrective measures be taken if necessary. It is also recommended that this information is being made available to the host community on a regular basis.

The possible impacts of the proposed project on land use, vegetation, wildlife, air, socio-economic and health can be controlled and ameliorated if the recommended measures are followed. Also, the SEMP developed would ensure that the procedures for managing the possible impacts of the proposed project as well as for implementing the environmental and social commitments made are developed and maintained throughout the project lifecycle.

Fire and spill prevention should be adequate, as specified in the report, and general Health and Safety regulations should be adhered to in accordance with the requirements of International Health and Safety Standards.

Environmental auditing should be regularly undertaken, in order to determine compliance with the proposed ESMP, and parties responsible for the implementation of the ESMP should be held responsible for any inadequacy during the implementation process. Any polluted soil, groundwater, and surface water or on terrestrial or aquatic ecology encountered during the baseline survey and during the construction process must be reported to the relevant authorities and then disposed of in an applicable manner.

The proposed project is considered to offer substantial net potential and associated benefits and to be environmentally sustainable. This opinion is supported by this impact assessment report.

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APPENDICES

APPENDIX ONE

TERMS OF REFERENCES

APPENDIX TWO

ENVIRONMENTAL BASELINE DATA

AIR QUALITY AND SITE-SPECIFIC METEOROLOGICAL DATA

Appendix 2-1: Air quality and micro meteorological data

Sample Codes	Coordinates N	E	H_2S (ppm)	CO (ppm)	NO_2 (ppm)	SO_2 (ppm)	VOC (ppm)	Pressure (mmHg)
DRAQ1	615751	713292	<0.1	<0.01	<0.01	<0.01	<0.1	757
DRAQ2	615724	713705	<0.1	<0.01	<0.01	<0.01	<0.1	758
DRAQ3	616370	711594	<0.1	<0.01	<0.01	<0.01	<0.1	756
DRAQ4	615761	711650	<0.1	<0.01	<0.01	<0.01	<0.1	758
DRAQ5	614891	712224	<0.1	<0.01	<0.01	<0.01	<0.1	757
DRAQ6	614875	712614	<0.1	<0.01	<0.01	<0.01	<0.1	758
DRAQC1	617616	710647	<0.1	<0.01	<0.01	<0.01	<0.1	758
DRAQC2	608839	714718	<0.1	<0.01	<0.01	<0.01	<0.1	756

Source: Dangote Fertilizer EIA Field Work July 2014

SOIL RESULTS

Appendix 2-2: Soil sampling location in Dangote Fertilizer project area

S/N	Sample Code	Sample Type	Geographic Coordinates Easting	Northing
1	DRS1	Top/Sub Soil	615751	713292
2	DRS2	Top/Sub Soil	615724	713705
3	DRS3	Top/Sub Soil	616370	711594
4	DRS4	Top/Sub Soil	615761	711650
5	DRS5	Top/Sub Soil	614891	712224
6	DRS6	Top/Sub Soil	614875	712614
19	DRSC1	Top/Sub Soil	617616	710647
20	DRSC2	Top/Sub Soil	608839	714718

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-3: Physico-chemical characteristics of soils of Dangote Fertilizer Plant proposed project zone of influence

Sample Code	Sand	Clay	Silt	B. Density	Porosity	pH	OM	Total N	NH_4^+	Total P	Na	K	Ca	Mg	Ex. Acidity	CEC	BS
	(%)	(%)	(%)	g/cm^3)	(%)		(%)	(%)	(mg/kg)	(mg/kg)	Cmol/kg						
FS1 (0 -15 cm)	68.8	19.2	12	0.99	62.64	5.43	5.14	0.31	1.19	5.99	0.34	1.79	2.10	1.90	4.00	10.13	60.51
FS1 (15 -30 cm)	69.2	18.3	12.5	1.24	53.21	5.4	4.19	0.28	0.72	7.36	0.36	1.40	2.00	1.72	4.00	9.48	57.81
FS2 (0 -15 cm)	73.4	14.2	12.4	1.25	52.83	4.71	4.15	0.42	1.15	3.97	0.57	3.02	1.50	1.68	3.00	9.77	69.29
FS2 (15 -30 cm)	70.5	14.6	14.9	1.44	45.66	5.17	3.19	0.32	0.88	4.12	0.57	2.79	1.30	1.85	2.20	8.71	74.74
FS3 (0 -15 cm)	75.6	12.5	11.9	1.29	51.32	5.51	3.27	0.14	2.97	4.22	0.35	1.84	1.40	1.74	3.60	8.93	59.69
FS3 (15 -30 cm)	77.8	11.2	11	1.29	51.32	4.26	2.51	0.06	1.86	5.91	0.34	1.10	1.20	1.59	4.75	8.98	47.10
FS4 (0 -15 cm)	79.8	12.2	8	1.29	51.32	4.04	3.39	0.2	1.72	12.34	0.69	0.87	2.20	2.00	5.20	10.96	52.55
FS4 (15 -30 cm)	80.1	11.6	8.3	1.28	51.7	4.71	2.57	0.15	1.11	12.56	0.62	0.75	2.10	1.82	4.50	9.79	54.03
FS5 (0 -15 cm)	73.4	14.2	12.4	1.26	52.66	4.71	4.15	0.42	1.39	3.97	0.57	3.02	1.50	1.68	3.00	9.77	69.29
FS5 (15 -30 cm)	70.5	14.6	14.9	1.28	51.62	5.17	3.19	0.32	0.65	4.12	0.57	2.79	1.30	1.45	2.22	8.33	73.35
FS6 (0 -15 cm)	69.2	18.3	12.5	1.25	52.82	5.4	4.19	0.28	1.62	7.36	0.36	1.40	2.00	1.47	4.00	9.23	56.66
FS6 (15 -30 cm)	79.8	12.2	8	1.26	52.22	4.04	3.39	0.2	0.97	12.34	0.69	0.87	2.20	1.83	5.20	10.79	51.81
FSC1 (0 -15 cm)	75.6	12.5	11.9	1.27	51.65	5.51	3.27	0.14	1.88	4.22	0.35	1.84	1.40	1.70	3.60	8.89	59.51
FSC1 (15 -30 cm)	77.8	11.2	11	1.26	51.88	4.26	2.51	0.06	1.11	5.91	0.34	1.10	1.20	1.59	4.75	8.98	47.10
FSC2 (0 -15 cm)	74.7	6.5	18.8	1.3	52.83	5.64	2.55	0.33	0.96	4.52	1.75	2.53	2.70	2.30	2.32	11.6	80
FSC2 (15 -30 cm)	73.4	7.2	19.4	1.2	45.28	5.39	2.8	0.27	0.43	3.86	1.46	2.09	1.47	1.60	2.15	8.77	75.48

Source: Dangote Fertilizer Plant EIA Field Work July, 2014

Appendix 2-4: Oil and Grease, TPH and BTEX levels in soils within Dangote Fertilizer project area

Sample Code	Oil & Grease (mg/kg)	TPH (mg/kg)	Benzene (µg/kg)	Toluene (µg/kg)	Ethylbenzene (µg/kg)	Xylene (µg/kg)
DFS1(0 – 15cm)	12.63	11.55	BDL	BDL	BDL	BDL
DFS1 (15 – 30cm)	12.88	11.72	BDL	BDL	BDL	BDL
DFS2 (0 – 15cm)	10.24	9.84	BDL	BDL	BDL	BDL
DFS2 (15 – 30cm)	10.62	9.45	BDL	BDL	BDL	BDL
DFS3 (0 – 15cm)	11.71	10.21	BDL	BDL	BDL	BDL
DFS3 (15 – 30cm)	11.89	10.98	BDL	BDL	BDL	BDL
DFS4 (0 – 15cm)	11.54	9.47	BDL	BDL	BDL	BDL
DFS4 (15 – 30cm)	11.78	9.89	BDL	BDL	BDL	BDL
DFS5 (0 – 15cm)	12.38	11.22	BDL	BDL	BDL	BDL
DFS5 (15 – 30cm)	12.70	11.57	BDL	BDL	BDL	BDL
DFS6 (0 – 15cm)	11.90	10.55	BDL	BDL	BDL	BDL
DFS6 (15 – 30cm)	11.96	10.72	BDL	BDL	BDL	BDL
DFSC1 (0 – 15cm)	12.26	11.34	BDL	BDL	BDL	BDL
DFSC1 (15 – 30cm)	12.60	11.08	BDL	BDL	BDL	BDL
DFSC2 (0 – 15cm)	13.20	11.97	BDL	BDL	BDL	BDL
DFSC2 (15 – 30cm)	12.94	11.85	BDL	BDL	BDL	BDL

BDL = Below Instrument detection limit (< 0.01 µg/kg)

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-5: Polyaromatic Hydrocarbons levels in soils within Dangote Fertilizer project area

Sample Code	PAHs (µg/kg)															
	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Benzo(a) pyrene	Indeno (1,2,3-cd) pyrene	Dibenzo (a,h) anthracene	Benzo (g,h,i) perylene
DFS1(0 – 15cm)	3.46	4.12	1.62	1.30	1.97	1.82	0.24	1.15	1.24	0.08	0.20	2.13	2.56	0.04	0.34	<0.01
DFS1 (15 – 30cm)	3.61	4.39	1.73	1.35	1.42	1.87	0.25	1.17	1.30	0.09	0.22	2.18	2.59	0.04	0.36	<0.01
DFS2 (0 – 15cm)	2.47	2.42	1.40	1.20	1.22	1.80	0.18	1.20	1.56	0.06	0.21	2.83	3.49	0.04	0.32	0.01
DFS2 (15 – 30cm)	2.69	2.58	1.52	1.47	1.30	1.53	0.22	1.10	1.06	0.10	0.22	3.18	3.50	0.04	0.40	0.01
DFS3 (0 – 15cm)	5.96	3.48	2.71	2.14	3.17	3.16	0.40	2.15	2.27	0.12	0.38	4.16	5.09	0.08	0.69	0.01
DFS3 (15 – 30cm)	6.01	4.18	3.47	2.74	4.12	3.92	0.50	2.51	2.70	0.17	0.44	4.83	6.09	0.09	0.79	0.01
DFS4 (0 – 15cm)	4.48	6.32	2.62	2.26	3.08	3.12	0.36	1.88	2.13	0.15	0.31	3.34	4.57	0.06	0.53	0.01
DFS4 (15 – 30cm)	4.80	6.17	2.56	2.03	2.99	2.87	0.35	1.87	2.01	0.13	0.32	3.43	4.36	0.06	0.57	0.01
DFS5 (0 – 15cm)	3.15	3.48	1.75	1.33	1.16	1.42	0.42	1.38	1.24	0.10	0.26	3.28	3.66	0.04	0.60	0.01
DFS5 (15 – 30cm)	2.86	3.65	1.60	1.54	1.25	1.34	0.40	1.47	1.46	0.100	0.28	3.45	3.92	0.04	0.65	0.01
DFS6 (0 – 15cm)	4.15	3.84	2.53	2.32	2.46	3.86	0.40	2.40	2.18	0.10	0.42	3.22	4.74	0.06	0.52	0.01
DFS6 (15 – 30cm)	4.32	3.40	2.76	1.37	2.36	3.70	0.36	2.20	2.43	0.12	0.36	3.51	4.65	0.06	0.65	0.01
DFSC1 (0 – 15cm)	4.28	3.35	2.15	2.36	2.17	3.20	0.30	2.16	1.40	0.15	0.34	3.16	3.38	0.07	0.46	0.01
DFSC1 (15 – 30cm)	4.72	3.59	2.36	2.50	2.39	3.46	0.37	2.81	1.32	0.14	0.38	3.19	3.87	0.06	0.53	0.01
DFSC2 (0 – 15cm)	3.40	3.16	1.60	1.26	1.38	1.88	0.49	1.22	1.30	0.17	0.28	2.64	2.68	0.12	0.45	0.01
DFSC2 (15 – 30cm)	5.74	3.35	3.24	2.60	3.18	2.39	0.37	2.15	2.12	0.18	0.53	3.56	3.93	0.12	0.58	0.01

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-6: Heavy metals levels in soils within Dangote Fertilizer project area

Sample Code	Heavy Metals (mg/kg)								
	Cd	Cr	Cu	Fe	Hg	Pb	Ni	V	Zn
DFS1(0 – 15cm)	0.64	5.73	3.89	458.2	BDL	4.38	3.68	0.05	12.47
DFS1 (15 – 30cm)	0.70	5.52	3.82	439.6	BDL	4.24	4.18	0.04	10.28
DFS2 (0 – 15cm)	1.39	4.29	3.58	418.5	BDL	2.67	2.55L	0.04	7.89
DFS2 (15 – 30cm)	1.46	3.98	3.64	436.7	BDL	2.55	4.19	0.06	6.90
DFS3 (0 – 15cm)	1.35	2.74	4.73	387.6	BDL	4.77	3.78	0.06	11.40
DFS3 (15 – 30cm)	1.42	2.96	4.63	369.3	BDL	4.79	4.25	0.04	11.85
DFS4 (0 – 15cm)	1.98	5.10	4.05	375.8	BDL	2.48	3.84	0.02	13.50
DFS4 (15 – 30cm)	1.23	4.03	4.46	398.2	BDL	1.94	4.28	0.02	14.62
DFS5 (0 – 15cm)	1.30	3.72	3.22	354.3	BDL	3.26	5.29	0.05	9.27
DFS5 (15 – 30cm)	1.36	4.19	4.36	411.5	BDL	1.78	3.73	0.03	9.25
DFS6 (0 – 15cm)	1.83	5.27	4.70	404.3	BDL	4.39	5.22	0.05	12.64
DFS6 (15 – 30cm)	1.26	4.38	4.68	398.5	BDL	4.16	4.66	0.06	13.22
DFSC1 (0 – 15cm)	0.84	5.32	3.83	428.0	BDL	5.29	4.58	0.07	7.20
DFSC1 (15 – 30cm)	0.69	5.77	4.19	477.5	BDL	4.42	3.17	0.03	7.84
DFSC2 (0 – 15cm)	1.29	5.10	6.44	471.8	BDL	3.85	2.45	0.02	7.68
DFFSC2 (15 – 30cm)	1.46	4.65	5.17	471.8	BDL	5.38	2.60	0.03	8.15

BDL = Below Instrument detection limit (< 0.01 mg/kg)

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-7: Microbiological characteristics of soils within within Dangote Fertilizer project area

Sampling Station	Total Heterotrophic Bacteria (cfu/g) x 10^5	Hydrocarbon Utilising Bacteria (cfu/g) x 10^4	Total Heterotrophic Fungi (Spore/g) x 10^3	Hydrocarbon Utilising Fungi (Spore/g) x 10^2	Predominant Bacteria Isolates	Predominant Fungi Isolates
DFS1(0 – 15cm)	1.11	0.20	0.17	0.09	Serratia marcescus, Vibro sp. Bacillus polymyxa, Azomonas agilis, Fusobacterium planti, Proteus vulgaris	Genatobotryum apiculation, Mycogone sp, Mammaria sp
DFS1 (15 – 30cm)	1.25	0.29	0.20	0.06	*Bacillus megatarium, Xanthomonas fragariae, Bacillus cereus, Micrococcus leteus*	*Aspergillus fumigates,* Penicillium sp., Fusarium sp.
DFS2 (0 – 15cm)	1.54	1.83	0.38	0.04	*Vibrio sp, Disulfotomarculum ruminis, Escherichia coli, Klebiella rhinoscleromalis*	*Goratobotrys simplex, Pleurothecium recurvature*
DFS2 (15 – 30cm)	1.04	0.01	0.11	0.02	Aerococcus viridians, Ruminicoccus flavefaciens, Arthrobacter simplex,	Mycotypha sp, Halosporangium parium
DFS3 (0 – 15cm)	1.45	0.41	0.34	0.15	Serratia marcescens, Xanthomonas campestris	Zoopuge sp, Pleurothecium
DFS3 (15 – 30cm)	1.37	0.38	0.27	0.11	Bacillus polymyxa, Acetobacter aceti	*Mucor mucedo, Histoplasma sp., Varicosporium elodeae*
DFS4 (0 – 15cm)	1.32	0.46	0.41	0.17	Bacillus megatarium, Xanthomonas sp, Bacillus polymyxa	Rhizopus stotonifer, Aspergillus fumigates, Peacilomyces sp
DFS4 (15 – 30cm)	2.67	0.44	0.64	0.15	Bacillus megatarium, Xanthomonas sp, Bacillus polymyxa	Rhizopus stotonifer, Aspergillus fumigates, Peacilomyces sp
DFS5 (0 – 15cm)	2.38	0.63	0.79	0.20	*Bacillus megatarium, Xanthomonas fragariae, Bacillus cereus, Micrococcus leteus*	*Goratobotrys simplex, Pleurothecium recurvature*
DFS5 (15 – 30cm)	1.87	0.52	0.68	0.18	Bacillus Sphaericus, Corynebactrium fasciens, Bacillus pumilus	*Articulospora inflate, Acaulopage sp, Aureobasidium sp.*

Sampling Station	Total Heterotrophic Bacteria (cfu/g) x 10^5	Hydrocarbon Utilising Bacteria (cfu/g) x 10^4	Total Heterotrophic Fungi (Spore/g) x 10^3	Hydrocarbon Utilising Fungi (Spore/g) x 10^2	Predominant Bacteria Isolates	Predominant Fungi Isolates
DFS6 (0 – 15cm)	1.35	1.58	1.26	0.59	*Proteus vulyaris, Actimomyces sp., Bacillus subtilis, Bacillus cereus*	*Actinomyces sp, Penicillium notatum,Sporobolomyces sp, Aspergillus oryzae*
DFS6 (15 – 30cm)	1.63	0.79	1.40	0.34	Aerococcus viridians, Ruminicoccus flavefaciens, Arthrobacter simplex,	*Mucor mucedo, Histoplasma sp., Varicosporium elodeae*
DFSC1 (0 – 15cm)	1.40	0.76	0.13	0.08	Bacillus megatarium, Xanthomonas sp, Bacillus polymyxa	Rhizopus stotonifer, Aspergillus fumigates, Peacilomyces sp
DFSC1 (15 – 30cm)	1.69	1.35	1.18	0.56	Aerococcus viridians, Ruminicoccus flavefaciens, Arthrobacter simplex,	*Mucor mucedo, Histoplasma sp., Varicosporium elodeae*
DFSC2 (0 – 15cm)	1.60	0.54	0.41	0.12	*Azomonas agilis, Erwinia amylovora, Cerynebacterium agropyri*	*Penicillium notatum,Sporobolomyces sp, Asteromyces cruciatus*
DFSC2 (15 – 30cm)	1.20	0.52	0.44	0.16	*Azomonas agilis, Erwinia amylovora, Cerynebacterium agropyri*	*Penicillium notatum,Sporobolomyces sp, Asteromyces cruciatus*

cfu = Colony forming unit / ml

NG = No Growth

Source: Dangote Fertilizer EIA Field Work July, 2014

GEOPHYSICAL

Appendix 2-8: VES and borehole locations in Dangote Fertilizer project area

VES Points	Geographic Co-ordinates	
	Northings(mN)	Eastings (mE)
VES1	610501	713631
VES2	611134	714819
VES3	611643	712991
VES4	615979	712464
Control	605928	711280

Source: Dangote Fertilizer EIA Field Work July, 2014

SURFACE WATER

Appendix 2-9: Coordinates and deprth of surface water and sediment sampling points

Sample	Geographical Eastings	Geographical Northings	Depth (m)
SW 1	614047	715069	2.14
SW 2	615177	714902	2.82
SW 3	615927	714073	2.66
SW 4	616757	713796	2.70
SW 5	617361	712993	2.58
SW 6	617803	711828	2.23
SWC 1	612945	716567	1.38
SWC2	619135	711772	2.40

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-10: Physical and chemical characteristics of the surface water within Dangote Fertilizer project zone of influence

Sample Code	PH	E. C. µS/cm	Colour Pt/Co	Temp. ^{o}C	TSS mg/L	TDS mg/L	CO_3^{2-} mg/L	Alkalinity mg $CaCO_3$/L	Hardness mg $CaCO_3$/L	Turbi. NTU	DO mg/L	BOD_5 mg/L	COD mg/L	Cl^- mg/L	SO_4^{2-} mg/L	NO_3^- mg/L	NH_3 mg/L	PO_4^{3-} mg/L	S^{2-} mg/L
SW 1	6.22	100	24	29.4	122	50.0	ND	43.50	85.20	6.50	6.21	1.85	12.80	75.4	24.7	26.24	ND	1.36	ND
SW 2	6.15	100	25	29.1	116	50.0	ND	43.75	84.60	7.60	6.21	1.90	16.20	80.6	29.5	14.0	ND	1.20	ND
SW 3	5.86	110	23	29.5	140	55	ND	41.20	85.10	6.40	6.34	2.25	16.10	82.2	30.5	29.0	ND	1.90	ND
SW 4	6.08	100	26	28.8	137	50.0	ND	42.40	88.30	7.20	6.03	1.80	15.30	61.7	30.3	25.0	ND	1.53	ND
SW 5	6.16	110	24	28.9	126	55.0	ND	43.60	86.80	6.80	5.67	2.10	14.20	61.7	28.1	14.2	ND	1.09	ND
SW 6	6.06	110	28	29.0	118	55.0	ND	45.60	87.60	6.60	6.41	1.20	12.60	102.8	32.8	17.0	ND	1.18	ND
SW C1	6.43	130	24	29.7	128	65.0	ND	52.30	88.75	6.40	6.41	1.38	15.60	68.5	28.3	20.2	ND	1.40	ND
SW C2	6.12	110	28	28.9	126	55.0	ND	43.15	85.30	6.80	5.99	2.30	14.50	78.3	28.6	14.7	ND	1.60	ND

ND = Not detected

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-11: Concentrations of metals in surface water within Dangote Fertilizer Project area

Sample Code	Metals (mg/L)											
	Ca	**Mg**	**Cd**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Pb**	**Ni**	**V**	**Zn**
SW 1	3.45	18.10	<0.001	0.30	0.03	0.27	<0.01	0.02	0.01	0.20	<0.01	1.18
SW 2	4.05	18,52	<0.001	0.29	0.03	0.30	<0.01	0.02	0.02	0.20	<0.01	1.20
SW 3	4.09	18.32	<0.001	0.20	0.04	0.25	<0.01	0.01	0.01	0.18	<0.01	1.18
SW 4	3.20	18.27	<0.001	0.18	0.03	0.22	<0.01	0.02	0.02	0.22	<0.01	1.16
SW 5	3.30	15.60	<0.001	0.20	0.03	0.24	<0.01	0.01	0.01	0.22	<0.01	1.20
SW 6	3.60	17.53	<0.001	0.16	0.02	0.23	<0.01	0.02	0.02	0.19	<0.01	1.23
SWC1	3.20	16.43	<0.001	0.22	0.02	0.25	<0.01	0.01	0.02	0.20	<0.01	1.21
SWC2	4.10	17.09	<0.001	0.24	0.04	0.30	<0.01	0.02	0.01	0.22	<0.01	1.22

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-12: Oil and Grease, TPH and BTEX levels in surface water within Dangote Fertilizer project influence zone

Sample Code	Oil & Grease (mg/kg)	TPH (mg/kg)	Benzene (µg/kg)	Toluene (µg/kg)	Ethylbenzene (µg/kg)	Xylene (µg/kg)
SW1	4.19	3.76	BDL	BDL	BDL	BDL
SW2	4.44	4.19	BDL	BDL	BDL	BDL
SW3	3.44	3.04	BDL	BDL	BDL	BDL
SW4	4.34	3.999	BDL	BDL	BDL	BDL
SW5	3.79	3.26	BDL	BDL	BDL	BDL
SW6	3.95	3.62	BDL	BDL	BDL	BDL
SWC1	3.84	3.32	BDL	BDL	BDL	BDL
SWC2	4.33	4.19	BDL	BDL	BDL	BDL

BDL = Below Instrument detection limit (< 0.01 mg/kg)

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-13: Total Hydrocarbon and Polyaromatic Hydrocarbons levels in surface water around Dangote Fertilizer project area

Sample Code	PAHs (µg/l)															
	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Benzo(a) pyrene	Indeno (1,2,3-cd) pyrene	Dibenzo (a,h) anthracene	Benzo (g,h,i) perylene	Total
SW 1	0.047	0.014	0.012	0.016	0.010	0.015	0.013	0.019	0.044	0.006	0.003	0.010	0.112	<0.001	0.003	<0.001	**0.324**
SW 2	0.030	0.016	0.010	0.020	0.016	0.011	0.014	0.016	0.029	0.005	0.002	0.005	0.034	0.001	<0.001	<0.001	**0.209**
SW 3	0.030	0.011	0.010	0.020	0.012	0.012	0.014	0.015	0.020	0.004	0.003	0.002	0.010	0.001	0.001	<0.001	**0.165**
SW 4	0.042	0.013	0.012	0.020	0.001	0.010	0.012	0.020	0.001	0.001	0.005	0.010	0.021	0.001	0.002	<0.001	**0.171**
SW 5	0.025	0.013	0.011	0.002	0.010	0.011	0.013	0.005	0.004	<0.001	0.007	0.008	0.025	<0.001	0.001	<0.001	**0.135**
SW 6	0.029	0.010	0.007	0.014	0.008	0.012	0.016	0.027	0.035	0.002	0.005	0.036	0.129	0.002	0.002	<0.001	**0.334**
SWC 1	0.036	0.047	0.031	0.004	0.020	0.010	0.016	0.005	0.008	0.006	0.013	0.003	0.029	0.002	0.003	<0.001	**0.233**
SWC2	0.040	0.036	0.014	0.023	0.010	0.011	0.006	0.006	0.004	0.007	0.011	0.003	0.020	0.001	0.002	<0.001	**0.194**

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-14: Microbiological Characteristics of surface water within Dangote Fertilizer project influence zone

Sampling Station	Total Heterotrophic Bacteria (cfu/ml) x 10^4	Coliform Count (MPN/100ml) x 10^3	E. coli. (MPN/ml) x 10^3	Hydrocarbon Utilising Bacteria (cfu/ml) x 10^3	Total Heterotrophic Fungi (Spore/ml) x 10^3	Hydrocarbon Utilising Fungi (Spore/ml) x 10^2	Predominant Bacteria Isolates	Predominant Fungi Isolates
SW 1	2.80	2.10	NG	1.29	NG	NG	*Aeromonas puntata, Zoogloae ramigera, Bacillus subtilus, Nitrobacter sp*	Nil
SW 2	2.10	1.70	NG	0.85	0.42	0.38	*Micrococcus luteus, Bacillus cereus, Aerococcus vindans, Nitrosomonas europaca,*	*Aspergillus flavis, Rhizopus nigricans,*
SW 3	1.96	0.58	NG	0.82	0.57	0.45	*Aeromonas hydrophila, Aerococcus vindans, Proteus vulgalis, Bacillus cereus, Bacillus polymyxa*	*Rhizopus nigricans, Mucor mucedo , Aspergillus niger,*
SW 4	1.80	1.50	NG	1.14	0.35	0.10	*Pseudomonas aeruginosa. Bacillus subtilis, Micrococcus luteus*	*Streptothrix atra, Mucor mucedo*
SW 5	0.75	1.32	NG	0.68	0.34	0.04	*Proteus morganic, Micrococcus luteus, Bacillus cereus,*	*Aspergillus nige, Neurospora crazza*
SW 6	1.10	1.60	0.32	0.50	0.29	0.03	*Escherichia coli, Bacillus cereus, Nitrosomonas europaca*	*Mucor mucedo, Aspergillus nige*
SWC 1	1.40	2.20	0.40	1.20	NG	NG	*Escherichia coli, Proteus vulgalis, Bacillus cereus,*	*Nil*
SWC2	1.42	1.2	0.21	1.34	0.71	0.22	*Erwinia amylovora, Escherichia coli,, Serratia marcescens, Pseudomonas alcaligenes*	*Saccharomyces cerevisiae, Rhizopus nigricaus, Thalospora aspera,*

Source: Dangote Fertilizer EIA Field Work July, 2014

cfu = Colony forming unit / ml

NG = No Growth

SEDIMENT

Appendix 2-15: Physico-chemical characteristics of sediments within Dangote Fertilizer project influence zone

Parameter	SD1	SD2	SD3	SD4	SD5	SD6	SDC1	SDC2
pH	5.10	5.07	5.12	5.25	5.20	5.22	4.36	4.48
Sand (%)	52.5	49.8	52.8	53.5	51.3	54.8	52.8	52.9
Silt (%)	20.7	22.3	24.0	23.7	19.4	16.0	24.2	22.6
Clay (%)	26.8	27.9	23.2	22.8	29.3	27.2	26.2	24.4
E. Cond. (ms/cm)	1.09	1.13	1.13	1.3	1.1	1.04	1.15	1.13
TOM (%)	5.33	5.31	5.24	6.02	5.55	5.21	5.24	5.63
Total N (%)	0.92	1.46	1.86	1.75	1.34	0.88	2.15	1.69
Total P (mg/kg)	1.46	0.48	2.02	1.52	2.77	1.79	1.46	1.75
Exchangeable Cations (cmol/kg)								
K^+	4.15	3.68	4.9	4.17	3.96	4.12	4.33	4.38
Na^+	4.16	3.59	3.78	4.52	2.92	4.35	4.26	4.39
Ca^{2+}	5.3	3.8	3.1	4.1	4.8	4.87	4.10	4.16
Mg^{2+}	4.2	3.9	4	4.1	3.1	3.74	4.68	4.33
Ex. Acidity (cmol/kg)	5.38	5.47	5.60	4.73	5.12	4.5	6.46	7.20
CEC (cmol/kg)	23.24	20.44	21.33	21.62	19.9	21.58	23.83	24.46
Heavy Metals (mg/kg)								
As	1.50	1.43	1.45	1.50	1.35	1.43	1.23	1.55
Cd	0.74	1.06	BDL	0.53	0.62	0.55	0.60	1.15
Cr	11.27	19.35	22.00	16.84	8.39	7.47	9.50	14.68
Cu	4.95	5.34	5.50	6.25	5.47	5.98	5.24	5.96
Fe	1320	1332	1356	1370	1317	1365	1242	1360
Hg	0.05	0.06	0.05	0.10	0.07	0.12	0.15	0.06
Pb	25.18	24.96	30.00	28.72	20.82	24.91	28.20	30.43
Ni	26.18	34.27	31.50	28.92	20.65	21.43	22.58	29.47
V	0.84	0.69	0.81	0.96	0.47	1.02	1.39	1.48
Zn	100.25	95.34	104.50	99.64	108.52	97.66	110.50	109.26

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-16: Oil and Grease, TPH and BTEX levels in sediment within Dangote Fertilizer project influence zone

Sample Code	Oil & Grease (mg/kg)	TPH (mg/kg)	Benzene (µg/kg)	Toluene (µg/kg)	Ethylbenzene (µg/kg)	Xylene (µg/kg)
SD1	34.30	31.46	BDL	BDL	BDL	BDL
SD2	32.35	30.52	BDL	BDL	BDL	BDL
SD3	32.76	30.55	BDL	BDL	BDL	BDL
SD4	33.44	31.30	BDL	BDL	BDL	BDL
SD5	34.40	31.97	BDL	BDL	BDL	BDL
SD6	35.62	33.48	BDL	BDL	BDL	BDL
SDC1	32.42	30.13	BDL	BDL	BDL	BDL
SDC2	32.65	30.29	BDL	BDL	BDL	BDL

BDL = Below Instrument detection limit (< 0.01 mg/kg)

Source: Dangote fertilizer EIA Field Work July, 2014

Appendix 2-17: Polyaromatic hydrocarbons levels in sediment samples of Dangote Fertilizer project influence zone

Sample Code	PAHs (µg/kg)																
	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Benzo(a) pyrene	Indeno (1,2,3-cd) pyrene	Dibenzo (a,h) anthracene	Benzo (g,h,i) perylene	Total
SD 1	3.50	3.54	4.18	3.70	3.47	3.70	0.86	2.59	2.28	0.10	0.64	3.68	4.70	0.16	1.46	0.01	**38.57**
SD 2	2.25	2.47	4.16	3.63	3.79	4.18	0.80	2.20	2.50	0.06	0.48	3.37	2.64	0.19	1.30	<0.01	**34.02**
SD 3	2.80	3.10	3.75	3.42	2.97	3.80	0.67	1.98	2.25	0.09	0.53	3.10	3.45	0.14	1.41	0.01	**33.47**
SD 4	2.68	3.35	4.25	3.50	4.45	4.37	0.60	3.76	2.87	0.12	0.42	3.46	5.25	0.20	1.39	0.01	**40.68**
SD 5	2.81	3.79	2.58	2.93	4.18	2.75	0.72	3.24	3.28	0.08	0.54	3.62	4.50	0.17	1.19	<0.01	**36.38**
SD 6	2.51	2.98	4.10	3.72	4.14	3.60	0.59	2.65	2.69	0.08	0.49	3.13	5.80	0.20	1.70	0.01	**38.39**
SDC 1	2.31	3.59	2.48	2.68	4.02	2.79	0.70	3.44	2.68	0.08	0.50	3.48	4.57	0.35	1.20	<0.01	**34.87**
SDC2	2.60	2.74	2.55	1.50	3.18	3.20	0.58	3.25	2.56	0.06	0.34	3.26	4.12	0.30	1.20	<0.01	**31.44**

Source: Dangote Fertilizer EIA Field Work July, 2014

Appendix 2-18: Microbiological characteristics of sediment samples within Dangote Fertilizer project area

Sampling Station	Total Heterotrophic Bacteria (cfu/ml) x 10^5	Hydrocarbon Utilising Bacteria (cfu/ml) x 10^4	Total Heterotrophic Fungi (Spore/ml) x 10^3	Hydrocarbon Utilising Fungi (Spore/ml) x 10^3	Predominant Bacteria Isolates	Predominant Fungi Isolates
SD 1	2.99	2.49	1.40	0.56	*Enterococcus feacium, Micrococcus inteus Branhamella catorrhalis. Bacillus cereus*	*Pleurothecium sp, Penicillium notatium Sporobolmyces sp*
SD 2	2.01	1.58	0.94	0.22	*Bacillus cereus, Klebsiellasp, Staphylococcus epidermidi,*	*Trichoderina viride, Mucor mucedo, Geotrichum albidum*
SD 3	2.03	1.49	1.42	0.41	*Staphylococcus aureus, Arthrobacter sp, Pseudomonas, mulleii, Klebsiella sp, Micrococcus inteus, Bacillus megatarium*	*Saccharomyces cerevisiae, Pleurothecium sp, Penicillium notatium sporobolmyces sp Acternalia sp*
SD 4	1.86	0.68	1.12	0.47	*Alcaligenes faecalis, Erwinia amylovora, Klebsiella sp, Bacillus cereus,*	*Cyliindrocarpon sp, Trichoderina viride, Verticillium sp, Aspergillus flavus*
SD 5	1.89	1.34	1.06	0.30	*Citrobacter freudii , Alcoligenes feacalis, Bacillus cereus*	*Mucor mucedo, Pseudobotrytis sp, Aspergillus flavus*
SD 6	1.73	0.20	0.68	0.12	*Bacillus cereus, Klebsiellasp, Cytophaga sp, Priteus vulgaris*	*Cylindrocarpon sp, Verticillium sp, Aspergillus flavus*
SDC 1	1.68	1.06	1.3	0.69	*Escherichia coli, Bacillus megatarum, Pseudomonas, mulleii s*	*Cylindrocarpon sp, Penicillium notatium Cylindrocladium sp.*
SDC2	1.74	1.12	1.28	0.74	*Micrococcus inteus Streptococcus feacalis, Citrobacter freundi, Acetobacter aceti*	*Mucor mucedo, Pleurothecium sp, Penicillium notatium sporobolmyces sp*

Source: Dangote Fertilizer EIA Field Work July, 2014

cfu = Colony forming unit / ml

NG = No Growth

APPENDIX THREE

WASTE MANAGEMENT PLAN (WMP)

APPENDIX FOUR

HEALTH SAFETY AND ENVIRONMENT (HSE) PLAN

APPENDIX FIVE

MEMORANDUM OF UNDERSTANDING

APPENDIX SIX

FIELD SAMPLING MAP