DRAFT ENVIRONMENTAL IMPACT ASSESSMENT (EIA) REPORT

FOR

SHAFA ENERGY LTD FACILITY

KM 5, IFIEKPORO ROAD, WARRI –SOUTH DELTA STATE

SUBMITTED TO

THE FEDERAL MINISTRY OF ENVIRONMENT, ABUJA AND DEPARTMENT OF PETROLEUM RESOURCES

BY

SHAFA ENERGY LIMITED

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ACRONYMS & ABBREVIATIONS

AAS	-	Atomic absorption spectrophotometer
AG	-	Associated gas
Al	-	Aluminium
AMU	-	Atomic mass units
APHA	-	America Public Health Association
BH	-	Borehole
BOD	-	Biochemical Oxygen Demand
C	-	Carbon
Ca	-	Calcium
$CaCO_3$	-	Calcium Carbonate
Cd	-	Cadmium
cfu	-	Colony forming unit
Cl	-	Chloride
cm	-	Centimetre
COD	-	Chemical Oxygen Demand
Cu	-	Copper
dB	-	Decibel
DO	-	Dissolved oxygen
DPR	-	Department of Petroleum Resources
DS	-	Dissolved solids
EC	-	Electrical conductivity
ECEC	-	Effective Action Exchange capacity

EDTA	-	Ethylenediaminotetra-acetic acid
EAR	-	Environmental Audit Report
Fe	-	Iron
FEPA	-	Federal Environmental Protection Agency
FMEnv	-	Federal Ministry of Environment
H	-	Hydrogen
HCO_3	-	Bicarbonate
H_20	-	Water
H_2S	-	Hydrogen sulphide
k	-	Kilogramme
m	-	Metre
meq	-	Milli equivalent
Mg	-	Magnesium
mg	-	Milligramme
ml	-	Millilitre
mm	-	Millimetre; million
Mn	-	Manganese
mS	-	Milli-siemen
N	-	Nitrogen
Na	-	Sodium
NaOH	-	Sodium hydroxide
NH_4+	-	Ammonium ion
Ni	-	Nickel

NO_2^-	-	Nitrite ion
NO_3^-	-	Nitrate ion
NO_x	-	Nitrogen oxides
%	-	Percentage
$^o/oo$	-	Parts per thousand
O_2	-	Oxygen
O_3	-	Ozone
P	-	Phosphorus
Pb	-	Lead
pH	-	Hydrogen ion concentration
PO_4	-	Phosphate
ppb	-	Parts per billion
ppm	-	Parts per million
PtCo	-	Platinum cobalt
RH	-	Relative humidity
SiO_2	-	Silicate
SO_2	-	Sulphur dioxide
SO_4^{-2}	-	Sulphate ion
SS	-	Suspended solids
TA	-	Total Alkalinity
TDS	-	Total dissolved solids
TSS	-	Total Suspended Solids
μ	-	Micron

UV	-	Ultraviolet
VOC	-	Volatile organic compounds
WHO	-	World Health Organisation
μs	-	Microsiemen
OML	-	Oil Mining Lease
HDD	-	Horizontal Directional Drilling
NPA	-	Nigerian Port Authority
Zn	-	Zinc
Hg	-	Mercury
K	-	Potassium
Cr	-	Chromium
EMS	-	Environmental Management System

ACKNOWLEDGEMENT

SHAFA Energy Limited acknowledges the cooperation and support of the Federal Ministry of Environment, Department of Petroleum Resources and Clairgold oil and Gas Engineering Ltd (Consultant) for opportunity to undertake this Environmental Impact Assessment (EIA) of its facility. SHAFA Energy Limited wishes to stress that in line with its policy, all information obtained in the course of this exercise as well as those contained in this report will be accorded the strictest confidentiality.

LIST OF EIA PREPARERS

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EXECUTIVE SUMMARY

Introduction and Background Information

SHAFA Energy Ltd (SEL), a Nigerian registered company with offices in Kano wishes to pursue Greenfield development and other investment opportunities in the Oil and Gas sector. SEL is wholly owned by leading indigenous investors, who collectively bring outstanding financial, technical, operational and development resources. The Company is developing a project, which is planned as a simple gas LPG plant of 11,500M3 capacity.. The proposed project, which will be achieved through a Build, Own and Operate (BOO) venture, would be located at Ifie village, along Refinery Road in Warr in south LGA of Delta State.

In pursuit of this investment and in line with the recommendation of the Federal Ministry of Environment, the initial Environmental Impact Assessment (EIA) document for the proposed construction of the LPG Plant was updated. Clairgold Oil and Gas Engineering Ltd, an environmental consultant was commissioned by SEL to carry out this update. The proposed LPG Plant is planned to be powered with electrical.

This EIA takes into consideration findings from extensive literature review, field sampling activities, laboratory and bench data analyses, existing and proposed project facilities, as well as a comprehensive socioeconomic and public consultations exercise.

The environmental regulations, standards and guidelines that governed the preparation of this EIA report consist of local, national and international guidelines. The various decrees, edicts and special instruments that guided this study include the Delta State ministry of Environment, Federal Ministry of Environment (FMEnv), Land use Act, 1978, World Bank OP 4.01, International Finance Corporation (ICF) performance standards and other international treaties to which Nigeria is signatory as well as SEL Policy.

The proposed project is located on approximately 34,000 km South North and lies between Latitudes 7^{o} 27’ 35.066”’N and 7^{o} 27’ 54.138”N and between Longitudes 6^{o} 39’ 51.089”E and 6^{o} 39’ 23.126”E.

Nigeria’s current LPG production capacity annually currently stands at 4 million tonnes. Nigeria currently consumes about 350,000 tonnes of LPG.

Nigeria is a net exporter of LPG in Africa. The country consumes barely 15% of the volume it produces. The rest are exported. LPG in Nigeria is the least utilized. Nigeria’s average consumption per person is just above 1kg, comparatively much less than other West Africa countries like Ghana (4.7kg) and Senegal (9kg). Nigeria spends over $1bn per annum on kerosene subsidy and faces increasing environmental challenges with continuous deforestation.

The demand for gaseous fuel for domestic purpose is high. Liquefied Petroleum Gas, whose components are propane C4 and Butane C4, is one of the products obtained during the processing of natural gas. LPG in gas cylinders can be used as fuel for cooking in homes, restaurant, hotels etc. Individuals prefers LPG to kerosene as fuel for cooking for the following reasons: (1) it is cheap and cylinders are easy to maintain, (2) It is clean when burnt, releasing little or no pollutant to the environment,

(3) The amount of heat released is higher than that released by kerosene, so it takes lesser time to process food.

PROJECT JUSTIFICATION AND ALTERNATIVES

Some of the justification and project benefits of the proposed project include improved efficiency of terminal operations and product distribution within the airport facility. Others benefits are;

– Competitive pricing in products costs through provision of options to consumers;

– Improved operational efficiency in service provision, resulting in a more cost effective terminal operations;

– Increase in national storage capacity for LPG

– Increase in flexibility for storage of imported petroleum product imports due to availability of new storage options

OVERVIEW OF THE FACILITY

The LPG depot and white product tank farm shall be developed to cover a site area of 34,000 Square Meters, and shall store a total volume of 11,000M^3.

The proposed storage tanks shall be secured within a bund-wall.

The proposed development shall also accommodate the following ancillary facility:

- A fire water storage tank, with pumping facilities.
- LPG pumps & LPG Compressors shelter,
- Administrative building and control room,
- A tank truck loading gantry,

- Tank truck loading pumps,
- Workshop,
- Air Compressor Room
- LPG Truck loading bays
- Fences, walls, gates and access/exit control,
- Access road

The Service Buildings shall include the following:

- The Administrative Office buildings and control room,
- workshop,
- Changing Rooms,
- Supply and Discharge Buildings,
- Sample room and laboratory,
- Firefighting station,
- Car park
- Generator house switch room
- Septic tank/Soak away
- Hydrant foam header
- Foam bag
- Borehole
- Slop tank
- Gate In and Out/Guard House

Pipelines

The pipeline shall be constructed and designed in accordance with relevant API/ASME codes. The piping layout design shall be arranged in the smallest possible space, consistent with operability, safety, ease of maintenance and foundation requirements. Optimum piping material shall be used.

The design shall meet all functional and operational requirements; accessibility to all operating equipment, valves and instruments shall at the same time maintain high aesthetics quality.

Pipeline specifications

All product piping will be in accordance with the ANSI B36 10 PE SMNS PIPE STD ASTM A53 Grade B specifications. All line manifolds shall be flexible and all tanks shall be interconnected.

The schematic representation of the pipeline isometrics are presented in Appendix 2.

DESCRIPTION OF SURROUNDING ENVIRONMENT

The Landscape

The physiography of the approved site and is surrounding environment is flat and

The site falls within the larger ecological characteristic of Southern Delta state, which is essentially a disturb area of sandy straw grasses on a mangrove area.

The land use and land covers identified within and around the proposed project site include: industrial sites and some human communities or settlements.

Topography and Drainage

The proposed site is situated on lowland close to other depot facilities, which generally rises from the coast in the south to about 5m above sea level with the adjoining Warri River.

Human Settlements

Human settlements entails the totality of the human community; whether city, town or village; with all the social, material, organizational, spiritual and cultural elements that sustain it. The fabric of human settlements consists of physical elements and services to which these elements provide the material support.

Detailed and specific information on the environmental and socioeconomically descriptive activities of the areas of concerned shall be documented in the EIA Report.

Project Description

The proponents intend to develop and operate the following within their delineated site at Ifie, in Delta State Nigeria

Brief descriptions are provided below for the proposed facilities;

1. 11,000 M^3 LPG Plant composed of two (2) spherical tanks 5,500M^3 each.

Design standards will be in accordance to API 650, API 540, API 2000, API 750, IEC 67, BS 4360, API 2610, BS 476, Part 1 Petroleum Act, DPR Regulations, Standards and Guidelines, NFPA Codes, ISPS Codes. Refer to plate 2 for 3D facility layout plan.

Each of the components of the proposed project is discussed further.

LPG Depot Facility

The proposed capacity is 11,000 M^3. The facility will have a compact storage of 5, 500M^3 each with a total capacity of 11,000 $M^{3.}$

The proposed schedule for the execution of the project once it commences is a maximum of 18 months. Cutting across the following project phases;

1. Design and Project Works

- Development of the project and technical documentation
- Follow Up on Project Performance
- Engineering supervision of construction quality

2. Fabrication
3. Training
4. Pre- Commissioning and Test Run
5. Commissioning and Operations

Characterization of the Existing Environmental

Climate and Meteorology

Climate and Meteorology: The existing meteorological data from the Nigerian Meteorological Agency (NIMET) and the data acquired during the fieldwork micro – climatic study, were relied on in the characterization of the climate of the proposed project area. The project area is located completely in the semi – hot equatorial zone. The climate reflects conditions of the equatorial rain forest with high temperature and humidity all year round. During the fieldwork, the maximum atmospheric temperature recorded was 35.1^{o}c, measured in the dry season and a mean of 30.5 ^{o}c in the wet season. Relatively high humidity values were obtained in both seasons with a range of 58.4 – 80.0% in the dry season and a mean of 73.5% in the wet season. Low wind velocities were observed with a mean of 1.7 m/s in the dry season and a range of 0.1 – 2.8 m/s in the wet season. As anticipated, the wind direction was observed to be predominantly northeasterly in the dry season and southwesterly in the wet season. From existing literature, high and persistent rainfall, even in the dry season months characterize the proposed project area.

Air Pollution Indicators: Solid, liquid and gaseous air pollutants were studied and quantified in this EIA in characterizing the atmosphere of the proposed project area. The gaseous pollutants studied were SO_2, NO_2, CO, H_2S and VOCs. The airborne particles (SPM) and its fractions ($PM_{2.5}$, PM_{10}) made up the solid/liquid component. Quite remarkably, the concentrations of almost all the measured air pollution indicators, inclusive of noise levels were within their national and internationally available threshold limits. However, high concentrations of VOCs were measured at all the created sampling locations in both dry and wet seasons which clearly breached the FMEnv 160 µg/m^3 regulatory limit. A VOC range of 146.0 – 696.0 µg/m^3 was measured from the sampling stations in the dry season and a mean 274.3 µg/m^3 in the wet season. We are of the opinion that fugitive hydrocarbon emissions from the numerous farm tanks that adorn the project area are largely responsible for the high distributions of VOCs in the area. Worthy of note is the fact that SO_2, NO_2 and H_2S were not found in measurable quantities during this full – scale EIA. Except for the VOCs, the atmosphere of the proposed project area could be adjudged good.

Air Quality

Air Quality Measurement Strategy

Sampling/measurement of atmospheric pollutants was carried out at designated seven sampling stations within the proposed project area. One of the sampling locations was created outside of the proposed project area to act as a control. The criteria for selecting the sampling sites, characteristics of the sampling sites (Table 4.1) and the air quality parameters measured are shown below: Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2) Carbon monoxide (CO), Total Volatile Organic Compounds (TVOC), Suspended Particulate Matter (SPM), Fine ($PM_{2.5}$) and Coarse (PM_{10}) Particles, Hydrogen sulphide (H_2S), Noise

On site meteorological parameters measured include: Air Temperature, Wind velocity and direction, Relative humidity.

Sampling Sites:

The selection of the sampling sites was based on the following criteria; Accessibility, Security of the operating staff and equipment, Location of sensitive or vulnerable receptors relative to the location of the project.

Fishes

Five fin species of fishes belonging to four families in the 1st season and Eight fin fishes belonging to Seven families in the 2nd season and four shell fish species belonging to two families were identified during this study for the dry and wet seasons respectively as shown in Tables 1 and 2. The increasing pollution in the Niger Delta zones a result of industrialization and oil exploration etc. affects the aquatic communities including fishes. The number of fish species recorded in this study is very low when compared with 91 species earlier reported by Agada (1994), Okumagba (1987), Dibia (1989) and Aghoghovwia (2008). The reduction in the number of fish species and what appeared to be an extinction of some fish species may be an indication of community changes which result from habitat alteration. Fish species that cannot withstand environmental condition may die or migrate to elsewhere, while those that are hardy enough survives.

Vegetation

Dry and wet seasons vegetation (flora)study as part of Environmental impact assessment of SHAFA Energy depot LNG proposed site in Delta State was carried out to document the floristic composition, plants' diversity, health condition, habitat status and tissue analyses of the vegetation present in this field. Randomly sampled study sites were established where information about the vegetation were acquired following the methods outlined by Kershaw, 1977; Magurran, 1987; Sutherland, 1997; Bamidele and Akinnibosun, 2012. Vegetation found in10 m^2 quadrat samples at fourteen locations within the site and control point were identified to species level and documented using appropriate botanical literature such as (Keay, 1989; Lowe and Soladoye, 2000; Odugbemi, 2006; Hawthorne and Jongkind, 2006; Akinnibosun and Odiete, 2007; 2008; Akinnibosun and Omatsola, 2011; Deni, 2013; Aigbokhan, 2014 and Akobundu*et al.*, 2016).

Plankton

In the phytoplankton sampled, diatoms, dinoflagellates, cynobacteria and Chlorophyta (green algae) species were identified. The diatoms were more dominant with 13 genera (59.1%) followed by *Chlorophyta* 5(22.7%) and cynobacteria with 3(13.6%) each. In terms of genus, the *Nitzchia* sp. was more dominant followed by *Gyrosigma sp.*

Wet Season abundance of benthic taxa showed that station 2 was represented by seven taxa, followed by stations 4 (Control station) was represented by six taxa. Stations 1 was represented by four taxa while stations 3 has the lowest taxa represented by three families.

Benthos abundance showed a variation across stations in both seasons (Dry and wet seasons). While benthos abundance was high in dry season in stations 1 and 2, the reverse was the case in Stations 3 which showed high benthos abundance for wet season than dry season. Furthermore, Stations 4 which was the control station showed a remarkable difference in seasonal abundance with Wet season showing a very high abundance of benthos than dry season.

<u>Soil Study</u>

Textural analyses of the soil within the proposed project area showed a sand, silt and loamy of d particles. Anions and cations fell within acceptable ranges to support the growth of some plants. Heavy metal contamination have not occurred as most samples recorded low ranges of metals that are within acceptable limits. While the concentration of Hydrocarbon Utilizing Bacteria recorded a mean count of $1.5x10^4$cfu/g in top soil of the study area and a higher mean value of $1.1x10^4$cfu/g in the subsoil. On the other hand, a higher mean count of $1.05x10^3$cfu/g was recorded in the top soil for Hydrocarbon Utilizing Fungi relative to a lower mean count of $0.5x10^3$cfu/g in the sub soil. Feacal coliform was detected in all soil samples except for a topsoil sample. Of all the microbial species isolated, ony *pseudomonas, mold and staphylococcus* were recorded in varying concentrations for both top and subsoil samples.

Water Quality

All the heavy metal recorded varying low concentrations in both surface and underground water samples. Similarly, the microbial load in both the surface and underground water were relatively low and they compared favorably. Microbial species isolates include *psuedomonas spp, staphylococcus spp, yeast and mould* in varying degree.

Socio economics

Socio-economic facilities in an area are the development indicators and thus show both the level of development and the attendant quality of life of the residents as well. Such socio-economic infrastructures comprise roads, education, houses, water, electricity, health facilities, markets, banking facilities among others. Further, the quality of these socioeconomic infrastructures can be greatly enhanced with the presence of well-articulated power project capable of propelling different types of economic activities.

The communities in this study area are Ifie, Ijala village; essentially, they have a hierarchical style of leadership, clear ways of meeting punishments to offenders and security system.

Islam is the major religion in the study area and the followers are mainly natives, while the few Christians are primarily non indigenes. There also exist the traditionalists that practice the religion of their forebears in each community of the study area.

The females have well defined roles of fetching firewood, cooking, farming and schooling. The number of people per house of 5 or 7 rooms, ranged between 15 and 20 and these houses lack modern bedding facilities and other comforts of living. The mode of transport generally is by road. Trekking is the major means of transportation. The road networks are unpaved and therefore manageable only in the dry season.

Different lighting types exist in all the communities in the study area. This includes hurricane lamps, traditional stick and oil light and individual generating sets. In the Ifie village, electricity exists but hardly available for effective uses as it mostly epileptic.

The means of communication in the study area are GSM mobile handsets or phones and radio with batteries. There are no forms of recreational centers in the study area. Over 90% of respondents source their water from streams and rivers, while the remaining few have access to pipe borne water, which is often infrequent.

Settlement pattern ranges from being linear to scattered as in the case of ifie village to being fairly nucleated in village. The major occupation is farming. Other form of occupation include, traditional medicine practitioners, hunting, petty trading and company supervisors.

There is high unemployment among the youths in the study area, with the percentage of unemployment males higher than that of the females.

This proposed LPG plant project will undoubtedly strengthen the performance levels of the existing socioeconomic facilities as well as attracting investors to the area for one form of investment or the other.

Essentially, the human population increases at a geometric rate and thus means that within a spate of time the capacities of the existing socioeconomic facilities will certainly not be able to cope with the teaming population. In essence, this LPG project will therefore stand out as a super panacea or solution to solving the problems of congesting the existing socioeconomic facilities due to population upsurge.

Public Health

The study revealed generally overwhelming favorable outcome/response to the proposed project by the host communities. The study identified mostly communicable diseases such as malaria, diarrhea and enteritis as the most prevalent diseases in the area of project influence. Children, women and migrant workers were identified as the most likely vulnerable groups in the area of project influence, to those communicable diseases.

Majority of the respondents believed that the project would bring about some rejuvenation in socio-economic activities and improved health services in the project are. Less than 10% of the respondents however expressed doubt over the sincerity of the proponent. They feared that the project might imply influx of migrant workers with its adverse effects such as inadequate housing facilities, pressure on the almost non-existing health facilities, increase in crime rate, food shortage and inflation as well as surge in sexually transmitted diseases (STDs) through promiscuity.

Potential Environmental Impacts

Evaluation of impacts of the proposed power project was based on a number of impact assessment methods. It identified the potential impacts to the various aspects of the environment based on the activities of the project ranging from pre-construction, construction, operation and decommissioning phases. The impacts which could either be positive or negative were also ranked based on magnitude, extent, duration and consequence.

Primary identified positive impact of the proposed project include; provision and supply of reliable and stable power to Nigerian consumers; increased generation of power in the country, reduced cost of production and reduced cost of items, increased and efficient utilization of natural gas. The project is also expected to provide various classes of employment, from local labor to specialized experienced services. In effect, it will lead to improved economy, both for small business owners who have hitherto relied on liquid fuel to generate there in depended power.

In general, most of the associated and potential negative impacts of the proposed project activities in terms of magnitude and duration are minor to negligible. The potential impact that has a likelihood of being major is fire outbreak. In the event of such an occurrence, the impacts are likely to be major and of long duration. As such, preventive efforts will focus more on ensuring that this impact does not occur. In addition, adequate contingency response plans has been put in place to effectively contain the associated impacts, in the event of such occurrence.

Some of the native impacts include: ambient air deterioration due to gaseous emissions and dusts from construction activities. Others include potential increase in traffic, influx of migrant workers, pressure on limited infrastructure, potential increase in cost of accommodation due to influx of migrant workers, potential increase in road accidents and increase in noise emission in the presently quiet project area. Loss of farmland due to acquisition of the project area is also another significant impact. Prior to commissioning, discharge of untreated hydro test fluid used on the gas supply pipeline may reduce water and groundwater quality of the recipient environment.

The operational phase will engender a number of negative impacts. Some of these impacts include: increase in noise and vibrations from the continuous operation of the gas turbines, which could lead to psychological stress to people in the host communities.

Summarily and based on the impact matrix, there will be a total of 196 impacts resulting from the proposed project. Of these, 14 are positive and from the social component; 168 are minor negative impacts (comprising 64 biophysical and 104 socio-economic impacts); 12 moderate negative impacts (comprising 6 biophysical and 6 socio-economic), and 3 major impacts all of which are socio-economic.

During operation of the NIPP power plants and the proposed LPG, the farthest distance from the proposed SEL project where the most significant noise will be heard is at about 1 km from the fence line and this is anticipated to be about 40 dB(A), which is minor impact.

Cumulative impacts of other environmental attributes considered (water quality, wastes, soil) are also expected to be minor. Only biodiversity is expected to be moderate due to potential cumulative loss of land and vegetation from the proposed LPG and other projects.

Cumulative impact on employment is anticipated to be positive. Other social indices such as land acquisition, infrastructure and Occupational health and safety will minor if the recommended mitigation measures such as due compensation for acquired lands, provision and compulsory use of appropriate

PPEs as well as provision and maintenance of relevant community infrastructures are put in place.

Mitigation Measures

Adequate cost effective and environmentally friendly mitigation measures have been recommended to ameliorate or completely eliminate the few identified minor impacts that may attend to the proposed power project. If the recommended mitigation measures are effectively implemented, along with those built into project design, a number of the moderate negative

Impacts will be reduced to minor, while a large percentage of the minor impacts will diminish to negligible. The potential major impact, which could occur by accident, is fire outbreak and its attendant effect. However, it is important to note that the only effective mitigation for the major impact is complete prevention from occurring.

The responsibility of mitigation most of the negative impacts associated with the proposed rests on the proponent (SEL). Therefore, their commitment to ensuring that these impacts are adequately mitigated is important to the sustainability of the proposed project.

In carrying out this function of mitigation, the following are expected:

- ✓ Provision of relevant PPEs to all operational staff and enforcement of proper use to reduce potential injuries and loss of lives.
- ✓ Train and retrain workers on efficient and effective power plant operation technology.
- ✓ Ensure water is sprinkled on the construction surface during construction to reduce potential dust emissions.
- ✓ Service all construction and operational vehicles regularly to reduce emission of noxious gases,
- ✓ Regularly monitor ambient air quality within the plant station and nearby communities to forestall possible acute or chronic effect on residents and workers.
- ✓ Avoid construction at night to reduce potential noise effect on the environment.
- ✓ Strictly adhere to the recommended maintenance schedule of the proposed plants, gas supply and evacuation facilities to reduce down time and accidents.
- ✓ Provision of mobile toilets during construction and appropriate toilet facilities during operation to reduce the problem of human waste.
- ✓ Treat all effluent to FMEnv acceptable limits before discharge.
- ✓ Engage the community and other stakeholders in continuous consultations
- ✓ Ensure adequate compensation is paid to land acquired

- ✓ Provide a platform that to ensure consideration of qualified indigenes of host communities in available employment opportunities
- ✓ Provision of Social Corporate responsibility to the host communities and ensure maintenance of such provided facilities etc.

Environmental Management Plan

In order to promote sustainable energy development and maintain a healthy environment in the project area, SEL has developed an EMP which assures that the mitigation measures developed for reducing the significant negative impacts of the proposed Power Project to as low as reasonably practicable are implemented and maintained throughout the project lifecycle.

Environmental management involves the two main processes of environmental mitigation and monitoring plans. For effective implementation of the recommendations of this EIA and its management plan as well as to ensure that all environmental (biophysical, social and health) considerations are integrated into project execution, SEL shall:

- ➢ Establish an Environmental Monitoring Team (EMT) with the project HSE Team leader as the focal point for all environmental matters relating to this Power Project;
- ➢ Ensure total compliance to environmental monitoring as recommended in this report.

This team shall liaise at a predetermined level with contractors, engineers, quality assurance officers, supervisors and relevant departments as well as other stakeholders on all environmental matters. All environment-related regulations as they apply to the proposed power project have been documented and described in this EIA report. A set of minimum standards and guidelines have also been developed and agreed upon by the project managers. SEL management shall ensure compliance with these regulations, standards and guidelines.

Throughout the project's lifecycle, SEL shall comply with all mitigation measures for the identified impacts to ensure activities are carried out in an environmentally responsible and sustainable manner. Mitigation measures have been proposed for all phases of the project. Monitoring requirements, duration and frequency of monitoring of key performance indicators as well as the action parties have also been proposed. Monitoring has been proposed for relevant environmental parameters that are subject to change during the course of the project implementation.

The project will have impacts on the surrounding communities through disturbances during construction and operation as well as through the influx of workforce. Public interest is therefore expected to be high. Although effective and realistic measures have been proposed to mitigate the significant negative impacts, stakeholder perceptions and reservations are likely to persist. Specific proposals to manage these perceptions and reservations, in the spirit of securing the social license to operate within the host communities have been made.

Relevant environmental attributes that should be monitored during the implementation of the proposed project include but not limited to the following:

- Ambient air quality
- Noise emission
- Soil and erosion
- Hydro test fluids
- Effluents
- Surface and ground water

Remediation plans after Closure/Decommissioning

These are the plans put in place by SEL to recover and/or restore the environment of the project site after the project life cycle. The various restoration options include: Remediation to pre-project state or condition, partial remediation, remediation to acceptable alternative condition and no remediation. SEL proposes to adopt a combination of partial remediation and remediation to acceptable state. Major decommissioning activities include dismantling and removal of engines, generators/ancillary equipment. These activities will involve excavation and removal of structures from the ground and will engender impacts ranging from soil erosion to accidents to waste management problems as well as air pollution.

The remediation options put in place include; reinstatement of excavated soil to near original state, involvement of an accredited waste manager in waste management, establishment of appropriate pension scheme for workers, reuse/recycling of decommissioned materials.

Conclusion and Recommendations

Assessment of this report concludes that the project is laudable with a number of positive impacts such as increased employment opportunity, increased income, increased power supply, reduced cost of production etc. However, it will also be attended with potential negative impacts ranging from increased air pollution, noise, pressure on infrastructure, electrocution, loss of vegetation, wildlife and crops, surface and underground water pollution etc. Interestingly, most of these impacts will be reduced to minor and negligible if the recommended mitigation measures are judiciously implemented.

It is therefore recommended among others that SEL implements specifications and standards for design and construction, waste management plan, mitigation measures and EMP as prescribed in this report. SEL is also advised to continually implement its emergency procedures as well as closely consults with host communities throughout the life cycle of the proposed project.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Nigeria's current LPG production capacity annually currently stands at 4 million tonnes. Nigeria currently consumes about 350,000 tonnes of LPG. Nigeria is a net exporter of LPG in Africa. The country consumes barely 15% of the volume it produces. The rest are exported. LPG in Nigeria is the least utilized. Nigeria's average consumption per person is just above 1kg, comparatively much less than other West Africa countries like Ghana (4.7kg) and Senegal (9kg). Nigeria spends over $1bn per annum on kerosene subsidy and faces increasing environmental challenges with continuous deforestation.

The demand for gaseous fuel for domestic purpose is high. Liquefied Petroleum Gas, whose components are propane C4 and Butane C4, is one of the products obtained during the processing of natural gas. LPG in gas cylinders can be used as fuel for cooking in homes, restaurant, hotels etc. Individuals prefers LPG to kerosene as fuel for cooking for the following reasons: (1) it is cheap and cylinders are easy to maintain, (2) It is clean when burnt, releasing little or no pollutant to the environment, (3) The amount of heat released is higher than that released by kerosene, so it takes lesser time to process food.

Low consumption and growth of LPG market in Nigeria has been attributed to many factors. There is a question of availability, affordability, income, government and international oil policies. It is evident that LPG market responds to market changes in international oil price, from primary law of demand that increase in international price of LPG affect domestic consumption. Consumers move down the energy chain towards other energy alternatives. Researchers argued that consumers may continue to make purchases on the basis of habit even if prices changed. Other hindrances to the growth of the LPG market include subsidization of kerosene by successive governments in Nigeria, Low public awareness, poor infrastructures, and lack of investment in the gas value chain. Like in other markets in Nigeria, LPG market is constrained by poor market infrastructure and logistics challenges. The implication of poor market access is low energy utilization with adverse effect on economic growth.

With the completion of the project, which will produce 11,000M^3 of LPG, Shafa Energy Limited is poised to play a prime position to supplement these gaps and improve on the supply shortfall affecting Nigeria and improving this supply in a sustainable and environmental friendly manner, thus necessitating this preliminary impact assessment study for the proposed LPG project and its ancillary activities.

1.2 PROJECT SITE DESCRIPTION-GENERAL

The proposed facility is to be located in Ifie Community, off Ode-Itsekiri, Warri South L.G.A Delta State, Nigeria. Delta State is a state in Nigeria; it was carved out of the former Bendel State in 1991. The state has twenty five (25) local government areas. The capital city is Asaba. Warri is the biggest commercial city in the state. Other major towns are Agbor, Ughelli, Oghara, Sapele and Ogwashi-uku.

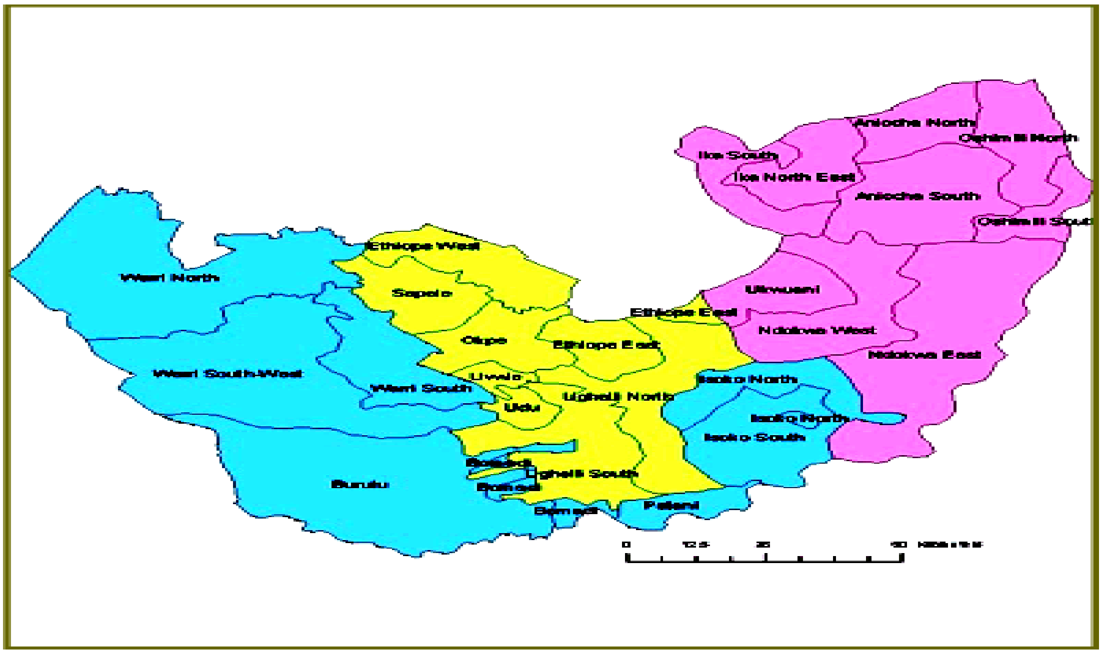
Map 1: Niger Delta with Delta State

Delta State

Delta State covers a landmass of about 18,050 Km of which more than 60% is land. The State lays approximately between Longitude 5°00 and 6°.45' East and Latitude 5°00 and 6°.30' north. It is bounded in the North by Edo State, the East by Anambra State, South-East by Bayelsa State, and on the Southern flank is the Bight of Benin which covers about 160kilometres of the State's coastline.

It is generally low-lying without remarkable hills. The State has a wide coastal belt inter-lace with rivulets and streams, which form part of the Niger-Delta.

Delta State supplies about 35% of Nigeria's crude oil and some considerable amount of natural gas. There are several industries in the state participating primarily in the processing of raw materials such as rubber and timber, such as the African Timber and Plywood (AT&P) in Sapele, Asaba Textile Mill, Ughelli Glass Factory, Delta Boatyard, and the Delta Steel Company, Delta State is blessed with. Fresh fish, crabs, shrimps and dried fish abound in almost all the local governments. Major occupation within the area is fishing and carvings of canoes, nets weaving, hunting, clothes dying, trading and farming.



Map 2: Delta State Map Showing the Local Government Areas

Project Community-Ifie Community

Ifie, the community where the project is proposed to be located is the headquarters of the Warri North Local Government Area of Delta State. Warri North Local Government Area of Delta State is located in -South Region of Nigeria with tributaries and distributaries of the River Niger and Benue a d distributaries of the River Niger and Benue (after their confluence) abundant within the State.

These tributaries and distributaries form much of the Deltaic environment where the state derives its name.

The community is predominantly riverine and inhabited by the Itshekiris. The village closest to the depot is called Ijala, about 500meters apart.

The LPG approved site is flanked on the south by the Warri River and access road on the North and surrounding tank farm in its environs namely Matrix Energy, Pinnacle depot, Aida, Blue fin and AYM depot .The closest depot is Pinnacle which is within 15-20meter distance. The land size of the facility is 3,400hectares; the size of the depot storage is 11,000M^3 and it is to house two cylindrical tanks with capacity of 5,500M^3.The GPS coordinates given is Latitude N5˚32"15" longitude E5˚41'12'.

Map 3: Google Map of the Existing Environment

The Need for the EIA Study

The need for the study stems from moral environmental considerations by Shafa Energy Limited, and also from the need for strict compliance to environmental guidelines and Laws within any operational environment.

The identification, assessment and management of environmental effects have become an integral part of development planning in the last two decades in Nigeria. An impact on the environment is defined as any incremental change (positive or negative) in the biophysical and/or socio-economic and health environment caused by or directly related to a former, on-going, or proposed activity.

This study serves the purpose of documentation and incorporation of environmental concerns and requirements at the conceptual and feasibility stages of the project in accordance with the "Environmental Guidelines and Standards of the Petroleum Industry in Nigeria, 2002 and the EIA Decree 86 of 1992.

The proposed SHAFA LPG Plant project process was scrutinized for all the possible environmental issues and respective impacts. Mitigation measures have been proposed to comply with the environmental concerns and to eliminate the possibilities of any impact on the environment. The ESHIA also proposes an Environmental Management and Monitoring Program for ensuring that the project would remain environmentally sound throughout its operation and up to its decommissioning stages.

1.3 AIMS AND OBJECTIVES

The Aims of the EIA Study and Report is to present an evaluation of environmental, social-economic and health impacts of the proposed LPG depot project, with supporting information on baseline environmental conditions, to assist the project proponents, the regulatory agencies (e.g. DPR, FMENV, DSMENV etc.), the community within the project vicinity and other NGOs with environmental interests, to take an informed view on environmental and social sensitivity of the project and the level of required mitigations measures to meet environmental and social norms.

The report also details the environmental monitoring program that should be put in operation during construction and operation phases of the project to provide a timely feedback on the adequacy of recommended mitigation measures.

Mainly the objectives of the EIA are to:

1. Introduce the project proponent and present the project design and technology for the Proposed LPG plant.
2. Review and understand all regulatory requirements that may affect the project design and execution.
3. Establish the existing baseline ecological and socio-economic conditions of the Proposed project area in Warri South Delta State.
4. Identify, evaluate and predict the environmental impacts of the project on the affected area.
5. Develop control strategies and impact mitigation measures (process, technologies, Engineering design, etc.) with a view to mitigating /ameliorating significant impacts.
6. Identify any environmental issues and concerns, which may, in the future affect the development.
7. Provide bases for support and control documentation and consultation with regulators, interest groups and the public at large.
8. To develop environmental management plan; including monitoring programmes for the entire activities of the power plant development;

from site preparation to operation, as well as plans of remediation after decommissioning.

9. To consult with all relevant stakeholders to establish their views and concerns regarding the project.

10. To comply with relevant national and international standards in the preparation of the EIA.

1.4 SCOPE OF EIA/TERMS OF REFERENCE

The Terms of Reference (TOR) for this EIA are based on standard EIA requirements and stakeholder engagement (community representatives, DPR, FMEnv etc.). The scope of the study aims to envisage the environmental changes anticipated due to the proposed project. In order to assess the environmental attributes of study area, core area of 500 meter radius around the proposed project site is considered.

The EIA will establish the environmental issues associated with the proposed LPG plant, predict their impacts and magnitudes; suggest and evaluate project alternatives with regard to cost effectiveness and environmental friendliness. In addition, it will recommend mitigation measures and put in place an Environmental Management and Monitoring Plan.

The scope of the EIA includes:

1) Review of relevant literature; including, previous studies related to the proposed project, engineering designs management plans, etc.

2) Updating existing baseline information (biophysical, social and health);

3) Prediction and evaluation of potential impacts.

4) Development of appropriate and practicable mitigation measures for all identified negative impacts. Mitigation measures are expected to either completely prevent or ameliorate impacts to barest minimum. Cost effective and international best practice mitigation measures were recommended.

5) Preparation of an environmental management plan.

6) Stakeholder engagement (sensitization of the communities, involvement of the chief regulators DPR).

7) Elements of the physical environment such as; climate and meteorology, ambient air quality and noise, surface water quality, ground water quality, geology, vegetation, soil and wildlife

8) Human attributes such as; socioeconomic characteristics, demography, cultural values, land use, concerns and interests of the potential affected persons/communities, standard of living etc.

9) Assessment of all potential and associated impacts from the activities of LPG depot development; from site preparation to operation. Impacts were assessed using a multi-criteria approach to evaluate their significance, duration, extent and possible interaction with other impacts.

10) National and international standards were as much as necessary and available.

11) Preparation of the Final EIA Report of the Environmental Impact Statement (EIA) Report and Document production in hard and soft copies.

The following environmental issues associated with the proposed development were also scoped to be addressed in detail in the Full EIA:

- Air Quality and Micro Climate (wind, plume, emissions, odor etc.)
- Noise and Vibration
- Geomorphology soil/ ground Conditions, Flood Risk, Erosion
- Water Resources , Ground Water Conditions;
- Ecology and Biodiversity;
- Socio Economics;
- Townscape & Visual;
- Archaeology, Cultural Heritage;
- Transport and Access;
- Safety Fire and Explosion;
- Pollution Control and Waste Management

EIA Procedure

Generalized EIA flow chart is presented below which depicts the flow of activities from the concept identification, through screening, scoping and other activities carried out before the realization of the environmental impact statement. Compliance to these stages and any directives given by regulatory agencies will be duly followed and adhered to.

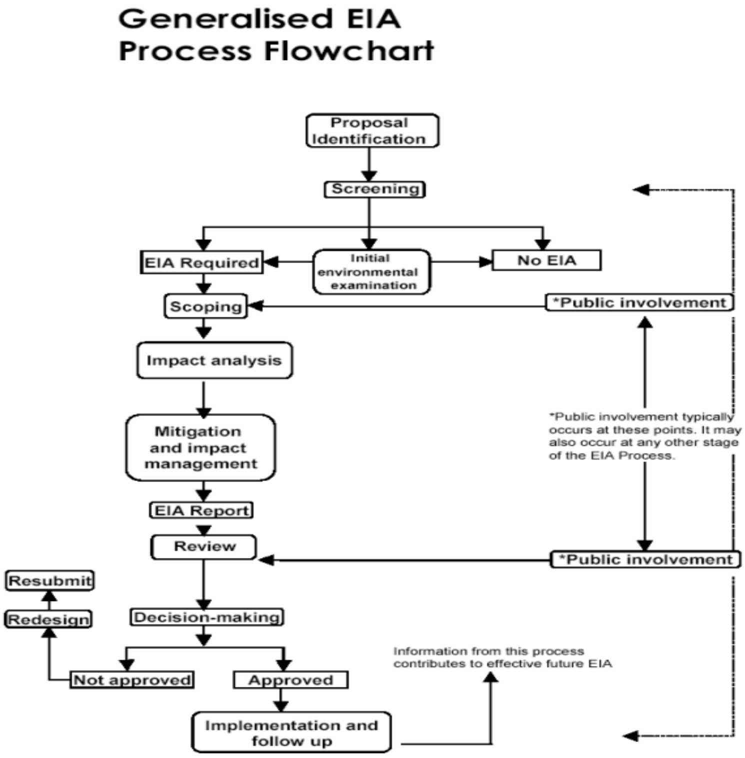


Figure 1.1: Generalized EIA Process Flowchart

1.5 RELEVANT REGULATORY AND ADMINISTRATIVE FRAMEWORK

Applicable Regulations and Hierarchy

Hierarchy of regulatory control for the regulatory and statutory guidelines for the EIA process is defined as follows based on the risk assessment of regulatory show stoppers for the project;

a. Country Laws, Regulations and Policies (Federal, Regional, State, Local, Sectorial and Standard Organisations)-on EIA, Land Use and LPG Plant Design and Construction, Safety of Industrial Establishments etc.; e.g. EGASPIN 2018, etc.

b. International Codes and Practise (Intergovernmental, Treaties, Standards

Organisations etc.)-on EIA, Land Use, LPG Plant Construction Standard, Pollution Control, Waste Management, etc.

c. SHAFA Energy Limited Policy and Guidelines-General on EIA and HSE Management and specific to facilities in the proposed LPG Plant Project and ancillary facilities.

In the event that there is a parallel and conflicting guideline between any of these regulations, standards, code of practise and guidelines, the most stringent will be adopted, adhered to and complied with.

The list of Nigerian Federal, State and Local Environmental Legislations relevant and having direct and indirect bearing to the LPG depot Project at Ifie, In Warri South Local Government Area of Delta State are as follows:

1.5.1 The National Policy on the Environment (1999)

The National Policy on Environment was launched by the Federal Government of Nigeria on 27th November, 1989. The documents prescribe guideline and strategies for achieving the Policy Goal of sustainable development. This policy identified key sectors requiring integration of environmental concerns and sustainability with development. It presented specific guidelines for achieving sustainable development in the following fourteen sectors of Nigeria's economy: Human Population; Land Use and Soil Conservation; Water Resources Management; Forestry, Wildlife and Protected Natural Areas; Marine and Coastal Area Resources; Sanitation and Waste Management; Toxic and Hazardous Substances; Mining and Mineral Resources; Agricultural

Chemicals; Energy Production; Air Pollution; Noise in the Working Environment; Settlements; Recreational Space, Green Belts, Monuments, and Cultural Property.

- **Petroleum Act, 1969 and its Amendments**

This is an act that provides for the exploration of petroleum from territorial waters and the continental shelf of Nigeria and to vest the ownership of, and all on-shore and off-shore revenue from petroleum resources in the Federal Government. It is organized into five sections: Oil Exploration Licences, Oil Prospecting Licenses and Oil Mining Licenses; Rights of Pre-Emption; Repeals; and Transitional and Savings Provisions. In this act all licensees and operators are directed to ensure that their operations do not impact on the environment. The regulations direct all companies to take all necessary steps in ensuring environmental protection. It places the principle of Duty of Care of the environment on all operators.

- **Environmental Impact Assessment (EIA) Act 86 of 1992**

The passing of the Environmental Impact Assessment (EIA) Act No. 86 in 1992 was a direct response to the outcome of the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992.The Act outlines the goals and objectives of an EIA, the minimum content of an EIA and a list of activities that are not permitted to go ahead until the Agency has been consulted and has given its approval. The main aim of the Act is to ensure environmentally sound and sustainable development projects.

This is to be achieved through ensuring that the possible negative impacts of development projects are predicted and addressed prior to project take-off. The objectives of the EIA according to the EIA Act include:

i. To establish the likely environmental effects of proposed activities before a decisions taken to implement them;

ii. To promote the implementation, in all federal lands, state and local government areas, of appropriate policies consistent with all laws and decision-making processes through which the above goals may be reached; and

iii. To encourage the development of procedures of information exchange, notification and consultation between institutions and people when proposed activities are likely to have a significant effect on boundary or trans-state or on the environment bordering towns and villages. To this end, the Act in section 13 makes it mandatory for an EIA to be carried out for certain types of projects comprising various industrial, mining and petroleum activities. The regulations also include the process of screening projects and reviewing and approving an EIA. Like every other law, the Act stipulates penalties for non-compliance (see Section 62).This decree makes an EIA mandatory for major development project and prescribes the procedure for conducting and reporting an EIA. It involves submission of a project proposal by the proponent to the FMEnv. An initial evaluation of the proposal is done by the ministry to categorize the project after which it undergoes scoping, production of a draft report, public hearing, review, preparation of the final report before approval by a technical committee.

- **(Nigeria) National Inland Water Way Act 13 of 1997 and Cabotage Act, 2003**

As general services, Nigerian Inland Waterway Authority (NIWA) collects river tolls, acquire, lease and hire properties; produce, publish and broadcast navigational materials such as notices, hydrological year books, river charts and river maps; carry out consultancy and contractual services represent the Government of Nigeria at national and international commissions that deal with navigation and inland water transportation and also advise government on all border matters that relate to the inland waters. NIWA pursues an ecologically sound inland water transportation policy. NIWA issue licenses for inland navigation, piers, jetties and dockyard; examine and survey inland watercraft and shipyard operators, grant permit and licenses for sand dredging, pipeline construction, dredging of slot and approve designs and construction of inland river crafts.

- **Environmental Guidelines and Standards for the Petroleum Industry in Nigeria EGASPIN, 2018**

This compendium of guidelines and standards for the petroleum industry in Nigeria stipulated guidelines and standards for the petroleum industry in Nigeria. It stipulates these from the exploration phase to the refining and processing as well as retailing segments of the oil and gas value chain. It further stipulates guideline on environmental studies like EIA and Environmental Audits and Evaluations. Contained in this document are also standards for pollution control and spill response capability as well as Environmental Management System.

- **Mineral Oils Safety Regulations, MOSR, 1997**

The MOSR, (1997) stipulates various duties from the management of oil and gas installations and facilities licensees and lessees. It stipulates basic duty of care and provides guidelines on carrying out major hazardous activities like confined space access/entry for petroleum product tanks, use of explosive materials and use and handling of radioactive materials etc.

- **Land use Act No 6 of 29 March 1978**

This act sets the legal basis for land acquisition and resettlement in Nigeria. It vests in the Governor of each State, and provides that land shall be held in trust for the use and common benefit of all people. The administration of land area is divided into urban land which will be directly under the control and management of the Governor of each State; and non-urban land, which will be under the control and management of the Local Governments. The Governor of each State will have the right to grant statutory rights of occupancy to any person for any purposes; and the Local Government will have the right to grant customary rights of occupancy to any person or organization for agricultural, residential and other purposes. The Act gives the government the right to acquire land by revoking both statutory and customary rights of occupancy for the overriding public interest. In doing so, the Act specifies that the State or Local Government should pay compensation to the current holder or occupier with equal value. Section 29 (1) of the Act States If a right of occupancy is revoked, the holder and the occupier shall be entitled to compensation for the value at the date of revocation of their un-exhausted improvements. Compensation under subsection (1) of this section shall be, (a) the land, for the amount equal to the rent, if any, paid by the occupier during the year in which the right of occupancy was revoked, (b) buildings, installation or improvements thereon, for the amount of the replacement cost of the building, installation or improvement, that is to say, such cost as may be assessed on the basis of the prescribed method of assessment as determined by the appropriate officer less any depreciation, together with interests at the bank rate for delayed payment of compensation and in respect of any improvement in the nature of reclamation works, being such cost thereof as may be sustained by documentary evidence and proof to the satisfaction of the appropriate officer, (c) crops on land apart from any building, installation or improvement thereon, for an amount equal to the value as prescribed and determined by the appropriate officer.

- **DPR Guidelines for the establishment of an LPG Plant**

The full guidelines and requisite documents for the establishment of a LPG processing plant are contained in this document. The guideline clearly stipulates and requests for an Environmental Impact Assessment Report as a pre requisite for the submission of an application for the approval to construct an LPG Plant Facility.

- **DPR Guidelines for the establishment of a Tank Farm/petroleum products Depot**

The full guidelines and requisite documents for the establishment of a Tank Farm/Depot are contained in this document. The guideline clearly stipulates and requests for an Environmental Impact Assessment Report as a pre requisite for the submission of an application for the approval to construct a petroleum products depot facility.

- **Harmful Wastes (Special Criminal Provisions etc.) Act No 42 of 25 November1988**

The Harmful waste (SCP) act is an Act to prohibit the carrying, depositing and dumping of harmful waste wherein a harmful waste is considered as a waste injurious, poisonous, toxic or noxious substance and, in particular, includes nuclear waste emitting any radioactive substance if the waste is in such quantity, whether with any other consignment of the same or of different substance, as to subject any person to the risk of death, fatal injury or incurable impairment of physical and mental health; and the fact that the harmful waste is placed in a container shall not by itself be taken to exclude any risk which might be expected to arise from the harmful waste; on any land, territorial waters in Nigeria.

- **Federal Environmental Protection Agency Act No 58 of 30 December 1988**

The Federal Environmental Protection Agency (FEPA) was established by Decree No. 58 of 1988 and charged with the responsibility for environmental protection. Following the upgrading of the agency to a Federal Ministry of Environment (FMEnv) in 1999, the Ministry was mandated to coordinate environmental protection and natural resources conservation for sustainable development. The ministry is responsible for ensuring the formulation of and compliance monitoring of environmental standards. It has put in place statutory documents to aid monitoring, control and abatement of industrial waste including the indiscriminate pollution of environment.

- **National Environmental Protection (Effluent Limitation) Regulations of 15th August 1991**

This imposes binding emissions limitations in each state. The limits are binding, but individual states may enact stricter emissions limits. The period between 1991 and 1995 allowed for industries to upgrade their facilities to comply with this legislation.

- **National Environmental Protection (Pollution Abatement in Industries and Facilities Producing Waste) Regulations of 15 August 1991**

Restricts the release of toxic substances into the environment while stipulating monitoring of all and discharges of waste products into the Nigerian Environment. The Agency/ministry of environment also demands environmental audit from existing industries and environmental impact assessment from new industries and major developmental projects and the industries shall comply within 90 days of the receipt of the demand. It also stipulates penalties by stating that a person or body, whether corporate or unincorporated, who contravenes any provision of these Regulations shall be guilty of an offence and liable on conviction to the penalty specified in section 35 or 36 of the Act.

- **National Environmental Protection (Management of Solid Hazardous Waste) Regulations of 15 August 1991**

The Harmful Waste (Special Criminal Provisions) Act of 1988 prohibits, without lawful authority, the carrying, dumping or depositing of harmful waste in the air, land or waters of Nigeria.

- **FEPA Procedural and Sectorial Guidelines for Oil and Gas Industries of 1995**

This guide stipulates guidance for environmental impact studies, monitoring and waste management for the oil and gas industry.

- **Nigerian Urban and Town Planning Act**

This Act It also further state that a developer shall at the time of submitting his application for development submit to an appropriate Control Department a detailed environmental impact statement 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 four floors or 5,000 square meters of a let table space, or

c) permission for a major recreational development

1.5.2 Delta State Ministry of Environment Regulations

The Ministry of Environment was created in 2001 to handle pollution and related Matters that affect the living environment in Delta State. It is charged with the obligation of developing and creating environmental policies, environmental protection and control, environmental technology including efficient implementation of Research and Development. The assigned responsibilities to the Ministry of Environment include:

- Environmental Policies
- Environmental Protection and Control
- Environmental Technology including initiation of policy in relation to environmental research and technology
- Environmental Sanitation and Urban Waste Disposal and Management

- Planning designing and construction of ecological and environment facilities
- Environmental Sanitation and Urban Waste Disposal and Management
- Provision of Sanitary means of human disposal
- Liaising with oil companies on pollution and Environmental Matters
- Supervision of Delta State Environmental Protection Agency \

(DELSEPA)

- Forestry
- Soil and water conservation
- Wild life Preservation
- Botanical Gardens

- **National Environmental (Sanitation and Waste Control) Regulations**

The National Environmental (Sanitation and Waste Control) Regulation of 2009 makes adequate provision for waste control and environmental sanitation.

- **The Harmful Wastes (Special Criminal Provision) Act, 2004:**

This Act was enacted by the Military as Decree No. 42 of 25thNovember 1988. It was necessitated by the illegal dumping of toxic wastes in the port town of Koko in Delta state, Nigeria. The Act defines what constitutes harmful wastes to mean any injurious, poisonous or toxic substance which is capable of subjecting anybody to the risk of death. The Act prohibits the carrying, depositing and dumping of harmful wastes on any land or territorial waters of Nigeria. It creates offences relating to the purchase, sale, importation, transportation, deposit, and storage of harmful wastes (section 1).The offence is deemed to have been committed by any person who does any of the prohibited acts, omits to do any act, aids, counsels or procures any person to do the prohibited act as stipulated in section 2. Any person found guilty of the crime shall on conviction be sentenced to imprisonment for life, and in addition whatsoever thing used in committing the offence, including land on which the harmful wastes was deposited or dumped shall be forfeited to and vested in the Federal Government as contained in section 6. A peculiarity of this Act is that there are no immunities in the offence created under the Act. This legislation is particularly important in view of the indiscriminate ways in which certain industrial wastes are dumped or discharged into the streams especially by battery manufacturing industries, textile factories and photograph processing industries and petro-chemical industries that use dangerous chemicals in production or have some dangerous chemicals as waste products.

- **The Federal Environmental Protection Agency Act, Cap F10 LFN, 2004:**

This Act was enacted by the Military as Decree No. 59 of 1988. The Act established the Federal Environmental Protection Agency (FEPA) and specified the method of governance, functions and financial regulations. The Act charged the Agency with overall responsibility for the protection of the environment as well as with the responsibility of encouraging the states and local government councils to set up their own environmental protection bodies. The Act also mandates the Agency to establish instruments for water quality standards; air quality standards and atmospheric protection, protection of the ozone layer and noise control (see sections 15, 16, 17, 18 and 19). In discharging its mandates, the Agency in 1991 published a number of regulations for the protection of the environment. These include:

(a) The National Guidelines and Standards for Industrial Effluents, Gaseous emissions and Hazardous Wastes Management in Nigeria, 1991*:* The guidelines are forms of prescription directing industries on how best to improve the quality of the environment and free it from pollutants in order to reduce environmental hazards. The guidelines set standards for environmental good behavior for the industries. The guidelines relate to six areas of environmental pollution control:

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

(b) National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations, 1991*:* These regulations specify parameters for effluent limitation by industry. They prohibit the release of hazardous or toxic substances into the environment beyond the limits approved by the Agency and provide other regulations and procedures, for example, in cases of accidents or unusual discharges. In addition, the regulations require industries to obtain permits for the discharge of toxic substances whose levels of concentration are beyond permissible limits**.**

(c) National Environmental Protection (Effluent Limitation) Regulations, 1991*:* The regulations were formulated to control the release of hazardous or toxic substances into the environment. They require any industry that releases an effluent into the environment with constituents beyond permissible limits to apply for a waste discharge/disposal permit. The regulations are also aimed at enjoining industries to install anti-pollution equipment for the detoxification of their effluents and chemical discharges and to treat these effluents to stipulated levels of concentration before being discharged. It also states that the agency shall demand an environmental audit from existing industries and an environmental impact assessment from new industries.

(d) Waste Management and Hazardous Waste Regulations, 1991: The regulations provide a comprehensive list of chemicals and chemical wastes by toxicity categorization. They intend to regulate the collection, treatment and disposal of solid and hazardous wastes from both municipal and industrial sources. By these regulations all industries are enjoined to adopt in- plant waste reduction and pollution control strategies. To this end, the collection, treatment, transportation, and final disposal of industrial wastes are the responsibility of the generating industry**.**

(e) **National Guidelines on Environmental Management Systems, 1999*:*** These guidelines establish the requirement for an environmental management system (EMS) in "all organizations/facilities in Nigeria. They also state that this EMS should be audited annually or as deemed necessary by the Agency. The guidelines specify the core element for an EMS and the requirements for the audit.

(f) **National Guidelines for Environmental Audit, 1999:** The guidelines are designed to serve as a reference for compliance with the environmental audit requirements of the Federal Ministry of Environment. The regulations state that it is mandatory for a company to carry out an audit every three years or at the discretion of the Federal Ministry of Environment. The regulations list the types of audit, namely, regulatory compliance, process safety, occupational health, product quality, liability and management, as well as the scope of each type of audit.

(g) **National Guidelines on Waste Disposal through Underground Injection, 1999:** These guidelines are designed to control the underground disposal of oilfield and industrial wastes. Industrial wastes are classified as either hazardous or non-hazardous and disposal of either underground requires a permit from the Federal Ministry of Environment.

(h) National Guidelines and Standards for Water Quality, 1999: These guidelines contain an exhaustive list of water quality parameters designed to protect public health and welfare and enhance the quality of water. Because of the lack of background data in Nigeria, they are based on water quality standards and guidelines from a range of other developed and developing countries. They address the following major uses of water:

- Drinking;
- Recreational
- Freshwater aquatic life;
- Agricultural (irrigation and livestock watering); and
- Industrial.

In addition to these regulations made pursuant to the powers vested in the FEPA, the Act in its section 20 criminalizes the discharge of hazardous substances into the air or upon the land and the waters of Nigeria or on the adjoining shorelines. Penalties for contravention range from a fine of N100, 000 for individual offenders to N500, 000 for corporate offenders. This is in addition to terms of imprisonment of up to 10 years. The FEPA Act, 2004 was repealed by the National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 2007 (See NESREA Section 36). Much of the characteristics of the FEPA Act, 2004 are retained in the NESREA Act, 2007. The Act is essentially a substantive regulation, leaving it to the Agency it created to establish further substantive and procedural aspects of environmental control through legislative-type regulations and sectorial environmental protection laws. The Act also retained all regulations and guidelines made under the FEPA Act, 2004 (See NESREA Section 35).

National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, No. 25 of 2007*:*

Section 1 of the NESREA Act, 2007 established a body known as National Environmental Standards and Regulations Enforcement Agency. The Agency shall be the enforcement Agency for environmental standards, regulations, rules, laws, policies and guidelines. It shall be a body corporate with perpetual succession and a common seal and may sue and be sued in its corporate name. The objectives of the Agency are stated in section 2 of the Act which provides that the Agency shall have responsibility for the protection and development of the environment biodiversity conservation and sustainable development of Nigeria's natural resources in general and environmental technology, including co-ordination and liaison with relevant stakeholders within and outside Nigeria on matters of enforcement of environmental standards, regulations, rules, laws, policies and guidelines. The functions of the Agency are provided for in section 7. Thus, the Agency shall:

a) enforce compliance with laws, guidelines, policies and standards on environmental matters;

b) co-ordinate and liaise with stakeholders, within and outside Nigeria, on matters of environmental standards, regulations and enforcement;

c) 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 wildlife, pollution, sanitation and such other environmental agreements as may from time to time come into force;

d) enforce compliance with policies, standards, legislations and guidelines on water quality, environmental health and sanitation, including pollution abatement;

e) enforce compliance with guidelines and legislations on sustainable management of the ecosystem, biodiversity conservation and the development of Nigeria's natural resources;

f) enforce compliance with any legislation on sound chemical management, safe use of pesticides and disposal of spent packages thereof;

g) 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;

h) 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;

i) ensure that environmental projects funded by donor organizations and external support agencies adhered to regulations in environmental safety and protection;

j) enforce environmental control measures through registration, licensing and permitting systems other than in the oil and gas sector;

k) conduct environmental audit and establish data bank on regulatory and enforcement mechanisms of environmental standards other than in the oil and gas sector;

l) 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;

m) Carry out such activities as are necessary or expedient for the performance if it functions.

Under section 8 paragraph (12) of the Act, the Agency is required to submit for the approval of the Minister, proposals for the evolution and review of existing guidelines, regulations and standards on environment other than in the oil and gas sector including atmospheric protection, air quality, ozone depleting substances, noise control, effluent limitations, water quality, waste management and environmental sanitation, erosion and flood control, coastal zone management, dams and reservoirs, watershed management, deforestation and bush burning, other forms of pollution and sanitation, and control of hazardous substances and removal control methods.

- **The Management of Solid and Hazardous Waste Regulations**

The Management of Solid and Hazardous Waste Regulations regulate the collection, treatment and disposal of solid and hazardous waste for municipal and industrial sources and give the comprehensive list of chemicals and chemical waste by toxicity categories.

- **Regulations from any financial institution that may be approached for financing e.g. the IMF, ADB, World Bank, etc.**

Various lending organisations have robust guidelines and standards for environmental impact assessment and environmental protection and management for financed projects. In the event that Shafa Energy intends on applying for financial assistance to any of the financial institutions, the regulations and guidelines of these financial institutions will apply to the project.

National Environmental Standards and Regulations Enforcement Agency (NESREA)

NESREA Act 27 of 2007 established the National Environmental Standards and Regulations Enforcement Agency (NESREA). The Agency, which works under the Federal Ministry of Environment. NESREA is saddled with the responsibility of the protection and development of the environment, biodiversity conservation and sustainable development of Nigeria’s natural resources in general 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. The functions of the Agency include:

a) enforce compliance with laws, guidelines, policies and standards on environmental matters;

b) coordinate and liaise with, stakeholders, within and outside Nigeria on matters of environmental standards, regulations and enforcement;

c) 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;

d) enforce compliance with policies, standards, , legislation and guidelines on water quality, Environmental Health and Sanitation, including pollution abatement;

e) enforce compliance with guidelines, and legislation on sustainable management of the ecosystem, biodiversity conservation and the development of Nigeria's natural resources;

f) enforce compliance with any legislation on sound chemical management, safe use of pesticides and disposal of spent packages thereof;

g) 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;

h) 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;

i) ensure that environmental projects funded by donor organizations and external support agencies adhere to regulations in environmental safety and protection;

j) enforce environmental control measures through registration, licensing and permitting Systems other than in the oil and gas sector;

k) conduct environmental audit and establish data bank on regulatory and enforcement mechanisms of environmental standards other than in the oil and gas sector;

l) 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

m) Carry out such activities as are necessary or expedient for the performance of its functions.

The Health and Safety code

a) Defines the level of observance of occupational health and safety in the electricity supply industry while rendering normal services in Generation, Transmission, Distribution and Metering. The main objective is to ensure safety of personnel during construction or servicing of electrical installations as well as safety and healthy surroundings for the public during operation.

b) Compliance by the Distributor with the EPSRA and the Grid Code.

c) Preserve the safety of equipment, to prevent damage to Plant and/or Apparatus and public safety to prevent personal injury.

1.5.3 International Regulations

World Bank Guidelines on Environmental Assessment (EA)

This is one of the ten (10) environmental and social Safeguard Policies of the World Bank. It is used in the Bank to examine the potential environmental risks and benefits associated with Bank lending operations. Under OP/BP 4.01, Bank lending operations are broadly defined to include investment lending, sector lending, and rehabilitation lending through financial intermediaries, and investment components of hybrid lending. Prototype Carbon Fund (PCF) and Global Environmental Facility (GEF) co-financed projects are also subject to the provisions of OP/BP 4.01.

Under this guideline, The Bank requires environmental assessment (EA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable, and thus to improve decision making. EA evaluates a project's potential environmental risks and impacts in its area of influence; examines project alternatives; identifies ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts; and includes the process of mitigating and managing adverse environmental impacts throughout project implementation. The Bank favors preventive measures over migratory or compensatory measures, whenever feasible.

EA takes into account the natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, and physical cultural resources); and trans-boundary and global environmental aspects. EA considers natural and social aspects in an integrated way. It also takes into account the variations in project and country conditions; the findings of country environmental studies; national environmental action plans; the country's overall policy framework, national legislation, and institutional capabilities related to the environment and social aspects; and obligations of the country, pertaining to project activities, under relevant international environmental treaties and agreements.

The Bank does not finance project activities that would contravene such country obligations, as identified during the EA. EA is initiated as early as possible in project processing and is integrated closely with the economic, financial, institutional, social, and technical analyses of a proposed project. The Bank undertakes environmental screening of each proposed project to determine the appropriate extent and type of EA. The Bank classifies the proposed project into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts.

Category A: A proposed project is classified as Category A if it is likely to have significant adverse environmental impacts that are sensitive, diverse, or unprecedented. These impacts may affect an area broader than the sites or facilities subject to physical works. EA for a Category A project examines the project's potential negative and positive environmental impacts, compares them with those of feasible alternatives (including the "without project" situation), and recommends any measures needed to prevent, minimize, mitigate, or compensate for adverse impacts and improve environmental performance. For a Category A project, the borrower is responsible for preparing a report, normally an EIA (or a suitably comprehensive regional or sectoral EA) that includes, as necessary, elements of the other instruments referred to in paragraph above.

Category B: A proposed project is classified as Category B if its potential adverse environmental impacts on human populations or environmentally important areas--including wetlands, forests, grasslands, and other natural habitats--are less adverse than those of Category A projects. These impacts are site-specific; few if any of them are irreversible; and in most cases migratory measures can be designed more readily than for Category A projects.

The scope of EIA for a Category B project may vary from project to project, but it is narrower than that of Category A. Like Category A, it examines the project's potential negative and positive environmental impacts and recommends any measures needed to prevent, minimize, mitigate, or compensate for adverse impacts and improve environmental performance. The findings and results of Category B EIA are described in the project documentation (Project Appraisal Document and Project Information Document). Environmental: A proposed project is classified as Category C if it is likely to have minimal or no adverse environmental impacts. Beyond screening, no further EA action is required for a Category C project.

Category FI: A proposed project is classified as Category FI if it involves investment of Bank funds through a financial intermediary, in subprojects that may result in adverse environmental impacts.

The borrower is responsible for carrying out the EA. For Category A projects, the borrower retains independent EA experts not affiliated with the project to carry out the EA. For Category A projects that are highly risky or contentious or that involve serious and multidimensional environmental concerns, the borrower should normally also engage an advisory panel of independent, internationally recognized environmental specialists to advise on all aspects of the project relevant to the EA. The role of the advisory panel depends on the degree to which project preparation has progressed, and on the extent and quality of any EA work completed, at the time the Bank begins to consider the project.

Depending on the project, a range of instruments can be used to satisfy the Bank's EA requirement: environmental impact assessment (EIA), regional or sectorial EA, environmental audit, hazard or risk assessment, and environmental management plan (EMP). EA applies one or more of these instruments, or elements of them, as appropriate. When the project is likely to have sectorial or regional impacts, sectorial or regional EA is required.

The Bank advises the borrower on the Bank's EA requirements and reviews the findings and recommendations of the EA to determine whether they provide an adequate basis for processing the project for Bank financing. When the borrower has completed or partially completed EA work prior to the Bank's involvement in a project, the Bank reviews the EA to ensure its consistency with this policy. The Bank may, if appropriate, require additional EA work, including public consultation and disclosure.

Other Banks guidelines and procedures that were considered in this study include the following:

i. Environmental Action Plans;

ii. Natural Habitats;

iii. Water Resources Management;

iv. Physical Cultural Resources;

v. Involuntary Resettlement;

vi. Forests;

International Finance Corporation (IFC) Performance Standards (PS)

IFC is a member of World Bank Group which provides investment assistance to private sectors in developing countries. IFC applies its PSs to manage social and environmental risks and impacts and to enhance development opportunities in its private sector financing in its member countries eligible for financing. The PSs may also be applied by other financial institutions electing to apply them to projects in emerging markets. Out of the eight IFC's Performance Standards established to enable the clients ensure sustainability in projects throughout the life of an investment by IFC or other relevant financial institution, the following were considered in this EIA:

Performance Standard 1: Social and Environmental Assessment and Management System

This PS underscores the importance of managing social and environmental performance throughout the life of a project (or business activity that is subject to assessment and Environmental management). An effective social and environmental management system is a dynamic, continuous process initiated by management and involving communication between the client, its workers, and the local communities directly affected by the project. Drawing on the elements of the established business management process of "plan, implement, check, and act," the system entails the thorough assessment of potential social and environmental impacts and risks from the early stages of project development, and provides order and consistency for mitigating and managing these on an ongoing basis. A good management system appropriate to the size and nature of a project promotes sound and sustainable social and environmental performance, and can lead to improved financial, social and environmental project outcomes. PS1 has the following objectives:

- To identify and assess social and environment impacts, both adverse and beneficial, in the project's area of influence;
- To avoid, or where avoidance is not possible, minimize, mitigate, or compensate for adverse impacts on workers, affected communities, and the environment;
- To ensure that affected communities are appropriately engaged on issues that could potentially affect them;
- To promote improved social and environment performance of companies through the effective use of management systems.

Performance Standard 3: Pollution Prevention and Abatement

This PS recognizes that increased industrial activity and urbanization often generate increased levels of pollution to air, water, and land that may threaten people and the environment at the local, regional, and global level. On the other hand, along with international trade, pollution prevention and control technologies and practices have become more accessible and achievable in virtually all parts of the world. This Performance Standard outlines a project approach to pollution prevention and abatement in line with these internationally disseminated technologies and practices. In addition, this Performance Standard promotes the private sector's ability to integrate such technologies and practices as far as their use is technically and financially feasible and cost-effective in the context of a project that relies on commercially available skills and resources. The PS3 has the following objectives:

- To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities;
- To promote the reduction of emissions that contributes to climate change.

Performance Standard 4: Community Health, Safety and Security

This PS recognizes that project activities, equipment, and infrastructure often bring benefits to communities including employment, services, and opportunities for economic development. However, projects can also increase the potential for community exposure to risks and impacts arising from equipment accidents, structural failures, and releases of hazardous materials. Communities may also be affected by impacts on their natural resources, exposure to diseases, and the use of security personnel. While acknowledging the public authorities ' role in promoting the health, safety and security of the public, this Performance Standard addresses the client's responsibility to avoid or minimize the risks and impacts to community health, safety and security that may arise from project activities. The level of risks and impacts described in this Performance Standard may be greater in projects located in conflict and post-conflict areas.

- To avoid or minimize risks to and impacts on the health and safety of the local community during the project life cycle from both routine and non-routine circumstances;
- To ensure that the safeguarding of personnel and property is carried out in a legitimate manner that avoids or minimizes risks to the community's safety and security.

Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management

This performance Standard recognizes that protecting and conserving biodiversity—the variety of life in all its forms, including genetic, species and ecosystem diversity—and its ability to change and evolve is fundamental to sustainable development. The components of biodiversity, as defined in the Convention on Biological Diversity, include ecosystems and habitats, species and communities, and genes and genomes, all of which have social, economic, cultural and scientific importance. This Performance Standard reflects the objectives of the Convention on Biological Diversity to conserve biological diversity and promote use of renewable natural resources in a sustainable manner. This Performance Standard addresses how clients can avoid or mitigate threats to biodiversity arising from their operations as well as sustainably manage renewable natural resources. PS6 has the following objectives:

- To protect and conserve biodiversity; and
- To promote the sustainable management and use of natural resources through the adoption of practices that integrates conservation needs and development priorities.

Performance Standard 8: Cultural Heritage

This Performance Standard recognizes the importance of cultural heritage for current and future generations. Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to protect irreplaceable cultural heritage and to guide clients on protecting cultural heritage in the course of their business operations. In addition, the requirements of this Performance Standard on a project's use of cultural heritage are based in part on standards set by the Convention on Biological Diversity. The objectives of this PS are as follows:

- To protect cultural heritage from the adverse impacts of project activities and support its preservation; and
- To promote the equitable sharing of benefits from the use of cultural heritage in business activities.

Other International Conventions

In her responsiveness and responsibility in regional and global efforts towards sustainable development particularly in the safeguard of the environment and natural resources, Nigeria has entered into a number of international treaties and conventions. Being signatory to the conventions, Nigeria pledges to uphold their principles. Some of the conventions considered in this project include:

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

This convention came into force in Nigeria 7th May, 1974. The objectives of the convention is to encourage individual and joint action for the conservation, utilization and development of soil, water flora and fauna for the present and future welfare of mankind, from an economic, nutritional, scientific, educational, cultural and aesthetic point of view.

Convention on Wetland of International Importance, Especially as Water Flow Habitat, Ramsar, Iran 1971

This provision came into force in Nigeria on 2nd February, 2001 with the objective to stem the progressive encroachment on and loss of wetlands now and in the future, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value. l Protocol on Substances that Deplete the Ozone Layer, Montreal, 1987 (As Amended).

This came into force in Nigeria on 7th January, 1993 with the objective to protect the ozone layer by taking precautionary measure to control global emissions of substances that deplete it.

Convention on Biological Diversity, Rio de Janerio, 1992

This convention came into force in Nigeria on 27th November, 1994. The objectives are to conserve biological diversity, promote the sustainable use of its components and encourage equitable sharing of the benefit arising out of the utilization of genetic resources. Such equitable sharing includes appropriate access to genetic resources as well as appropriate transfer of technology, taking into account existing rights over such resources.

1.6 SHAFA ENERGY LTD POLICY

The company operates under the guidelines of national and International laws and complies strictly with them. Where national standards and regulations are more stringent than other guidelines, SHAFA Energy's policy is to comply with the existing national legislation.

1.6.1 SHAFA Policy

This policy states that, SHAFA:

a) Has a systemic approach to HSE management designed to ensure compliance with the law and to achieve continuous performance improvement

b) Sets targets for improvement and measures, appraises and reports performance

c) Requires the proponent and contractors to manage HSE in line with this policy

d) To demonstrate commitment to HSE, SHAFA Energy is committed to

e) Pursue the goal of no harm to the people

f) Protects the environment

g) Uses materials and energy efficiently to provide our products and services

h) Develops energy resources, products and services consistent with this aim

i) Consults our stakeholders and publicly report our performance

j) Plays a leading role in promoting best practice in our industries

k) Manages HSE matters as any other critical business activity

l) Promotes a culture in which all SHAFA Energy's employees share this commitment.

In pursuance of this policy, SHAFA shall:

a) Carry out Environmental Impact Assessments and Evaluation in relation to all aspects of the natural and social environment that may affect or be affected by its activities;

b) Identify any such interface for the complete life cycle of both new and existing facilities and operations;

c) Enhance positive effects, prevent intolerable impacts from occurring;

d) Limit the nature and extent of any residual negative impacts, however caused, such that they are as low as practicable;

e) Consult relevant stakeholders;

f) Leave the environment at the end of the useful life of any operation in a condition suitable for future use;

g) Routinely monitor the environmental status of each operation and take corrective action as necessary.

1.6.2 Waste Management Policy

It is the policy of SHAFA to:

- Take all practical and reasonable measures to minimize the generation of solid and liquid wastes, as well as emissions from flares and otherwise;
- Manage and dispose of wastes in an environmentally responsible manner;
- Track and maintain records of waste streams and provide an auditable trial as to their management and disposal.

1.6.3 Emergency Response Policy

This states that the response to any emergency within SHAFA shall be directed towards

- Saving life
- Care for the injured
- Protection of the environment
- Limitation of damage to assets
- Defense of SHAFA's good corporate image
- SHAFA Energy shall provide appropriate organization, facilities, procedures and training so that immediate coordinated action can be taken to manage the situation in line with the above

- Maintenance of emergency equipment shall receive high priority. Close liaison will be maintained with appropriate Government and industry organization and communities
- Regular exercises will be carried out to confirm effectiveness, and any necessary improvements made promptly so as to maintain our readiness at all times.

1.6.4 Community Relations Policy

In order to pursue mutually beneficial relations with host communities, SHAFA shall:

- Establish and maintain close relationships with all segments of the local population to better understand their concerns, needs and aspirations
- Continuously assess and abate social and economic impact of all business activities and take needed preventive or mitigating measures
- Respond to formal community request in an appropriate and timely manner
- Bring relevant issues affecting host communities to the attention of appropriate authorities and other bodies that can be of assistance
- Manage settlement of compensation for land acquired for company operations and for damages in a demonstrably fair, accountable and transparent manner and in accordance with statutory provisions and approved procedures.

1.7 STRUCTURE OF REPORT

In this draft final report, a concise description of the activities so far undertaken and findings of the field survey are presented. The report consists of the following chapters:

Chapter 1: Introduction and Background Information

Chapter 2: Project Justification and Alternatives

Chapter 3: Project Description

Chapter 4: Description of the Environment

Chapter 5: Associated and Potential Impacts

Chapter 6: Mitigation Measures

Chapter 7: Environmental Management Plan

Chapter 8: Remediation Plans after Decommissioning

Chapter 9: Conclusion and Recommendations

References

Appendices

CHAPTER TWO

PROJECT JUSTIFICATION AND ALTERNATIVES

Some of the justification and project benefits of the proposed project include improved efficiency of terminal operations and product distribution within the airport facility. Others benefits are;

- Competitive pricing in products costs through provision of options to consumers;
- Improved operational efficiency in service provision, resulting in a more cost effective terminal operations;
- Increase in national storage capacity for LPG
- Increase in flexibility for storage of imported petroleum product due to availability of new storage options

2.1 OVERVIEW OF THE FACILITY

The LPG depot and white product tank farm shall be developed to cover a site area of 34,000 Square Meters, and shall store a total volume of 11,000M^3.

The proposed storage tanks shall be secured within a bund-wall.

The proposed development shall also accommodate the following ancillary facility:

- A fire water storage tank, with pumping facilities.
- LPG pumps & LPG Compressors shelter,
- Administrative building and control room,
- A tank truck loading gantry,

- Tank truck loading pumps,
- Workshop,
- Air Compressor Room
- LPG Truck loading bays
- Fences, walls, gates and access/exit control,
- Access road

The Service Buildings shall include the following:

- The Administrative Office buildings and control room,
- workshop,
- Changing Rooms,
- Supply and Discharge Buildings,
- Sample room and laboratory,
- Firefighting station,
- Car park
- Generator house switch room
- Septic tank/Soak away
- Hydrant foam header
- Foam bag
- Borehole
- Slop tank
- Gate In and Out/Guard House

Pipelines

The pipeline shall be constructed and designed in accordance with relevant API/ASME codes. The piping layout design shall be arranged in the smallest possible space, consistent with operability, safety, ease of maintenance and foundation requirements. Optimum piping material shall be used.

The design shall meet all functional and operational requirements; accessibility to all operating equipment, valves and instruments shall at the same time maintain high aesthetics quality.

– *Pipeline specifications*

All product piping will be in accordance with the ANSI B36 10 PE SMNS PIPE STD ASTM A53 Grade B specifications. All line manifolds shall be flexible and all tanks shall be interconnected.

2.2 DESCRIPTION OF SURROUNDING ENVIRONMENT

2.2.1 The Landscape

The physiography of the approved site and is surrounding environment is flat and

The site falls within the larger ecological characteristic of Southern Delta state, which is essentially a disturb area of sandy straw grasses on a mangrove area. The land use and land covers identified within and around the proposed project site include: industrial sites and some human communities or settlements.

2.2.2 Topography and Drainage

The proposed site is situated on lowland close to other depot facilities, which generally rises from the coast in the south to about 5m above sea level with the adjoining Warri River.

2.2.3 Human Settlements

Human settlements entails the totality of the human community; whether city, town or village; with all the social, material, organizational, spiritual and cultural elements that sustain it. The fabric of human settlements consists of physical elements and services to which these elements provide the material support.

Detailed and specific information on the environmental and socioeconomically descriptive activities of the areas of concerned shall be documented in the EIA Report.

2.3 ENVIRONMENTAL EFFECT OF CONSTRUCTION /WELDING AND FABRICATION

Construction / Welding and fabrication can create disturbance to aquatic ecosystems, often with adverse impacts. In addition, construction/welding and fabrication spoils may contain toxic chemicals that may have an adverse effect on the disposal areas; furthermore, the process of construction/welding and fabrication often dislodges chemical residing in benthic substrates and injects them into the water column (OSPAR, 2004).

The activity of construction/welding and fabrication can create the following principal impacts to the environment:

Release of toxic chemicals (including heavy metals and PCB) from bottom sediments into the water column.

Short term increases in turbidity, which can affect aquatic species metabolism and interfere with spawning secondary effects from water column contamination of uptake of heavy metals DDT and other persistent organic toxins, via food chain uptake and subsequent concentrations of these toxins in higher organisms including human.

Secondary impact to march productivity from sedimentation

Tertiary impacts of avifauna which may prey upon contaminated aquatic organisms

Secondary impacts to aquatic and benthic organism metabolism and mortality.

Transport of Excavated Materials: Transporting materials from the construction/welding and fabrication area of the site of utilization, disposal or intermediate treatment is generally achieved by one of the following methods.

a. In self – contained hoppers of the construction/welding and fabrication

b. In barges

c. Pumping through pipelines

d. Using natural forces of waves and currents

Others rarely used transport methods are truck and conveyed belt transport. The method of transport is generally linked to the type of fabrication been used.

2.4 LIFE CYCLE ANALYSIS

Life Cycle Analysis / Assessment (LCA) is a methodology used for studying the potential impacts on the environment of a specific product, service or system. The amount of energy needed to produce the specific product and the environmental impact.

There are two main types of LCA studies; attribution and consequential. The attribution LCA study focuses on describing the flows to and from a studied life cycle. The consequential LCA focuses on describing how flows will change in response to possible decisions. Attribution LCAs are mainly used for existing systems, while consequential LCAs are used for future changes (Baumann & Tillman, 2004) but according to Finnveden et al (2009), both types of LCA can be used for evaluating past, current and future systems. Life Cycle Assessment (LCA) is required by law in Nigeria as part of Environmental Audit to provide a guide for reducing the environmental footprint in any industrial set up. It is the compilation and evaluation of the inputs, outputs, and potential environmental impacts of a product system throughout its life cycle (ISO14040) and commonly referred to as a "cradle-to-grave" analysis. Its key elements include identification and quantification of the environmental loads involved; e.g. the energy and raw materials consumed, the emissions and wastes generated, evaluation of the potential environmental impacts of these loads and assessment of the options available for reducing these environmental impacts. Material and energy balances, the key elements of life cycle analysis, if properly done, can assist industrial operations in energy consumption reduction, waste generation reduction, increased operation efficiency, liability reduction, increased worker health and safety, and better monitoring of operation performance (USEPA, 2001) among others.

2.5 ANALYSES OF ALTERNATIVES AND PROJECT SUSTAINABILITY

In terms of the Environmental Impact Assessment (EIA) Regulations, feasible alternatives should be considered within the Environmental Scoping Study (ESS).All identified, feasible alternatives should be evaluated in terms of social, biophysical, economic and technical factors. A key component in the EIA process is the consideration of alternatives. Most guidelines use terms such as ‘reasonable’, ‘practicable’, ‘feasible’ or ‘viable’ to define the range of alternatives that should be considered. Essentially there are two (2) types of alternatives:

1) Incrementally different (modifications) alternatives to the project; and
2) Fundamentally different (totally different) alternatives to the project.

Incrementally different alternatives are the major considerations in this project. As a matter of facts, the need for the project is justifiable given the current supply of refined petroleum products and the epileptic functional conditions of the local refineries in Nigeria.

Basically, different alternatives are assessed by SHAFA Energy Ltd. This preliminary impact study focuses on alternatives considered in terms of the proposed LPG plant facility in the Warri South Area.

2.5.1 No Action

One alternative to the SHAFA Energy Project would be to do nothing. This alternative would avoid all of the impacts associated with the proposed LPG plant, including the beneficial impacts on the economy of the Niger Delta Region and Nigeria as a whole. The rate of demand of LPG has exceeded 600% nation-wide over the past two years. Meeting this increased demand and maintaining supply system reliability will require the addition of private LPG depots to be built. The SHAFA Energy Ltd Project is therefore an integral part of increasing over all capacity to meet this surging demand. Therefore, the "no action" alternative would involve a deficiency or shortfall in the supply of Liquefied Petroleum Gas. Such a deficiency could impede economic growth and lead to a deterioration in the quality of life for people in the Niger Delta Region and other parts of Nigeria.

2.5.2` Location Alternatives

From the study and assessments of various sites during the screening / site selection process conducted by SHAFA, various candidate sites were identified for the possible location of the proposed petroleum product LPG.

The most promising sites were selected for more detailed investigation during the site selection screening. Optional layouts at the respective sites were also investigated, though only to a pre-feasibility level of detail. Primary variables used in the comparison of the identified candidate sites included the following:

- Topographic profile
- Existing developments and infrastructure
- Biophysical
- Social
- Economic
- Security Etc.

Based upon the screening / site selection study as described above, three alternative sites were selected as being potentially the most viable of all the candidate sites investigated at the pre-feasibility level. These three alternative sites were then investigated in more detail, and a preferred alternative (site Ifie) was nominated from the three alternatives, based on a number of factors and site selection criteria as presented above. The three alternative sites are described below. These alternative sites were then evaluated by the EAP and the team of specialists in order to determine which site(s) would be most viable from an environmental (bio-physical and socio-economic) perspective.

a. Koko Delta State

b. Lokoja, Kogi State

c. Apapa, Lagos State.

d. Port Harcourt, Rivers State

e. Warri Delta State

These are discussed in detail in the Concept Environmental Screening Report.

2.5.3 Alternative Designs

During the development of the detailed plant design, the Project Proponent should consider and evaluate appropriate alternative designs. Plant features that will have a potential impact on the environment, and for which alternative designs should be evaluated, include the following:

- Cooling water intake and discharge structures.
- Wastewater treatment facilities.
- Oil and chemical storage tanks and secondary containment structures
- Air pollution and water pollution monitoring instruments and facilities
- Flexibility of upgrade and down grade of facility etc.

The evaluation of alternative designs should include both environmental and economic factors. As much as possible, the monetary costs and the environmental advantages and disadvantages of each alternative should be quantified. The basis for selecting the proposed design should be clearly stated.

2.5.4 Project Sustainability Outlook

a. **Legal Sustainability:** Legal sustainability of the proposed LPG Plant and ancillary facility is ensured and guaranteed from the initial regulatory review which identifies all applicable regulatory requirements (general, fiscal, environmental, operational) that may apply in the establishment of this proposed facility. Chapter one (1) on Legal and Administrative Framework presents in details all legal considerations during the Regulatory and Administrative Risk Assessment and Review. The regulations presented in chapter 1 are with respect to environmental protection. Other regulatory requirements for product quality etc. will apply and will be completely considered. Also, SHAFA Energy Limited will contract a legal team for the regulatory and legal services in order to ensure full compliance to all laid down laws and guidelines that may affect the facility.

b. **Economic/Investment Sustainability:** Nigeria with 180 million people, it is Africa's most populous nation. Demand for LPG in Nigeria is at about 400,000 tonnes annually. This opens ample opportunities for institutional investors to small and medium scale business to build and operate an LPG plant in Nigeria.

LPG availability will increase to further satisfy national consumption.

c. **Engineering/Technical Sustainability:** Over the years the construction of facilities or components of facilities for LPG Plant, and tank farms have become common in Nigeria. The process safety considerations are also available as local skills exist for process hazard analyses and installation of safety instrumented systems for the process. Engineering sustainability is also guaranteed by the availability of international and local codes and standards for the design of LPG facilities.

d. **Environmental and Safety Sustainability:** The construction of the proposed project is guided by the National and sectorial guidelines. In this regard, the best environmentally acceptable techniques / methods would be employed to ensure minimum negative impacts on the environment. The incorporation of findings and recommendations of this EIA at the various stages of the project activity, and adherence to the EMP would ensure environmental sustainability. In conducting this EIA study the requirements of the Federal, State and Local Authorities on environmental management practises were considered.

Proper Process Safety considerations were also adopted and introduced into the design of the facility. Fire fighting design systems and codes from the State and Federal Fire Service were also considered during the front-end engineering design phase of the facility.

CHAPTER THREE

PROJECT DESCRIPTION

3.1 INTRODUCTION-PURPOSE OF THE PROJECT

SHAFA Energy Limited is an indigenous company operating in the downstream sector of the Oil and Gas Industry in Nigeria and proposes to construct and develop the following projects in one single facility:

1) 11,000 M^3 LPG Plant

The purpose of the proposed project is to:

a. Increase and support the company profitability;

b. Keep and increase the participation in the LPG commercialization market;

c. Ensure that products to be sold will be of the highest quality with the Department of Petroleum Resources (DPR) and the Standards Organization of Nigeria (SON).

The SHAFA Energy Project seeks deliver high quality gas delivered at its depot to its customers by aligning with international specifications. In addition to LPG depot project and a dedicated tank farm/depot is also envisaged. The LPG and tank farm projects shall enhance the plant’s capability of producing and storing greater volumes of LPG, gasoline and diesel.

As part of strategies to achieve the set objectives emphasis will be towards the following:

1. Motivating the interest of internationally-recognized, experienced, highly qualified Contractors and Licensor organizations to cooperatively participate in the development, design, procurement, construction commissioning, testing and start-up of the Project within established cost and schedule targets;
2. Modernize the LPG Plant capabilities and operational flexibility by including state-of-the-art technologies and processes;
3. Consider the use of qualified Nigerian local resources, including labor suppliers, manufacturers, etc.; according to the Social management plan of the employer;
4. Minimize impact on local environment and infrastructure during construction and operation of the modernized facilities;
5. Recognize and adopt appropriate "best practices and value improving practices to maximize the success potential of the project and achieve top performance.

To comply with the objectives, the following will be considered:

i. Comply with DPR and SON standards and install relevant treatment units to improve quality;
ii. Align international products quality specs at competitive prices;
iii. Improve profitability by reducing dependence on a single crude oil, and develop operating flexibility to permit the processing of different crude oils;

iv. Improving operating expenditure through utilization of bottom conversion processes and energy consumption optimization;

v. Make provision for future expansion or debottleneck of LPG plant;

vi. Design bulk storage tanks to receive LPG product from other sources.

vii. Optimize the prospect in the growing Nigerian LPG Market by the production and distribution of quality Gas and specialty oils;

viii. Minimize impact on local environment and infrastructure during construction and operation of facilities;

ix. Minimize interference to LPG operations during future tie-ins, construction and start-up of facilities to maximum extent that is practicable.

Facility Description

The proponents intend to develop and operate the following within their delineated site at Ifie, in Delta State Nigeria. Brief descriptions are provided below for these proposed facilities;

2. 11,000 M^3 LPG Plant composed of two (2) spherical tanks 5,500M^3 each.

Design standards will be in accordance to API 650, API 540, API 2000, API 750, IEC 67, BS 4360, API 2610, BS 476, Part 1 Petroleum Act, DPR Regulations, Standards and Guidelines, NFPA Codes, ISPS Codes. Refer to plate 2 for 3D facility layout plan.

Each of the components of the proposed project is discussed further. \

LPG Depot Facility

The proposed capacity is 11,000 M^3. The facility will have a compact storage of 5, 500 each with a total capacity of 11,000 $M^{3.}$

The proposed schedule for the execution of the project once it commences is a maximum of 18 months. Cutting across the following project phases;

6. Design and Project Works

- Development of the project and technical documentation
- Follow Up on Project Performance
- Engineering supervision of construction quality

7. Fabrication
8. Training
9. Pre- Commissioning and Test Run
10. Commissioning and Operating

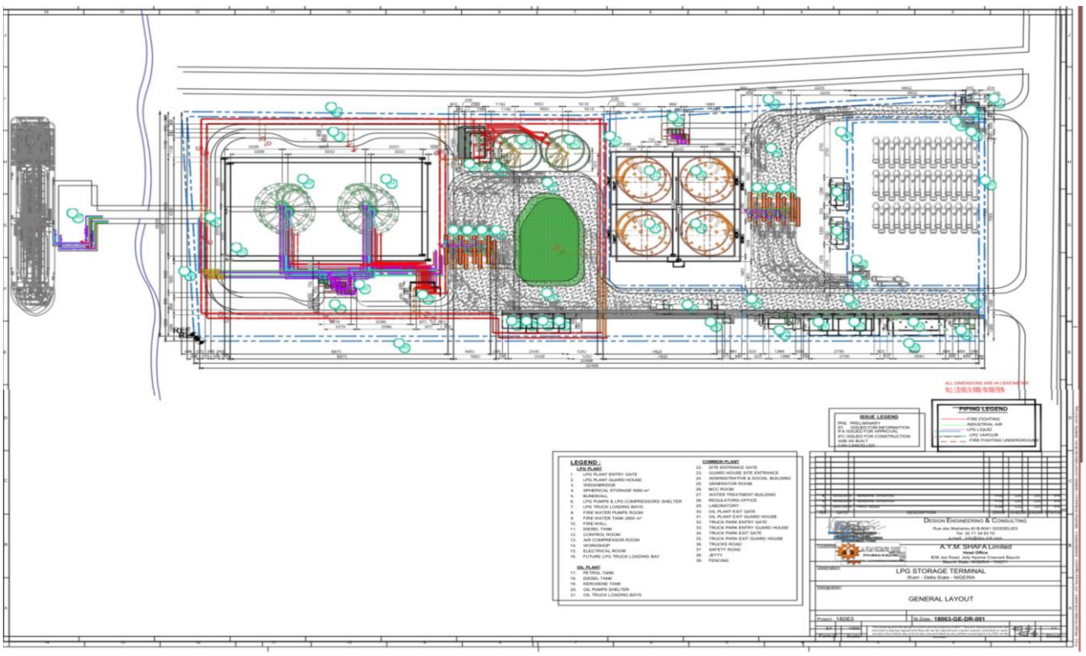


Figure 3.1: Facility Layout

Tank Farm (Depot)

The Tank farm will be designed with a level of independence to take LPG products from tanker vessels. As stated earlier the facility will be designed as bulk liquids storage, handling and dispensing facility to road tanker trucks through a loading gantry.

The tank capacities are provided in the table below;

Other ancillary facilities/components of the bulk storage tank will include;

1. The LPG Truck Loading Bays
2. LPG Pumps & LPG Compressors Shelter
3. Fire Water Tank
4. Diesel Tank
5. Administrative Building
6. Control and Power System (Generator House)
7. Air Compressor room
8. Workshop
9. 55Security System and Gate House
10. Future LPG Truck Loading Bay
11. Petrol Tank
12. Oil Pumps Shelter
13. Oil Truck Loading Bays
14. MCC room
15. Water Treatment Building
16. Laboratory

17. Safety Road

18. Jetty

Access (Dual Carriage) Road

The project will see the construction of a dedicated access road linking the proposed facility into the Ode-Itsekiri Road. The road network will be dualised and asphalted.

Jetty Facility

The jetty facility will be another major component of the SHAFA Energy project. The purpose of the proposed jetty will mainly be for berthing/docking of vessels that will supply Liquefied petroleum gas and equipment.

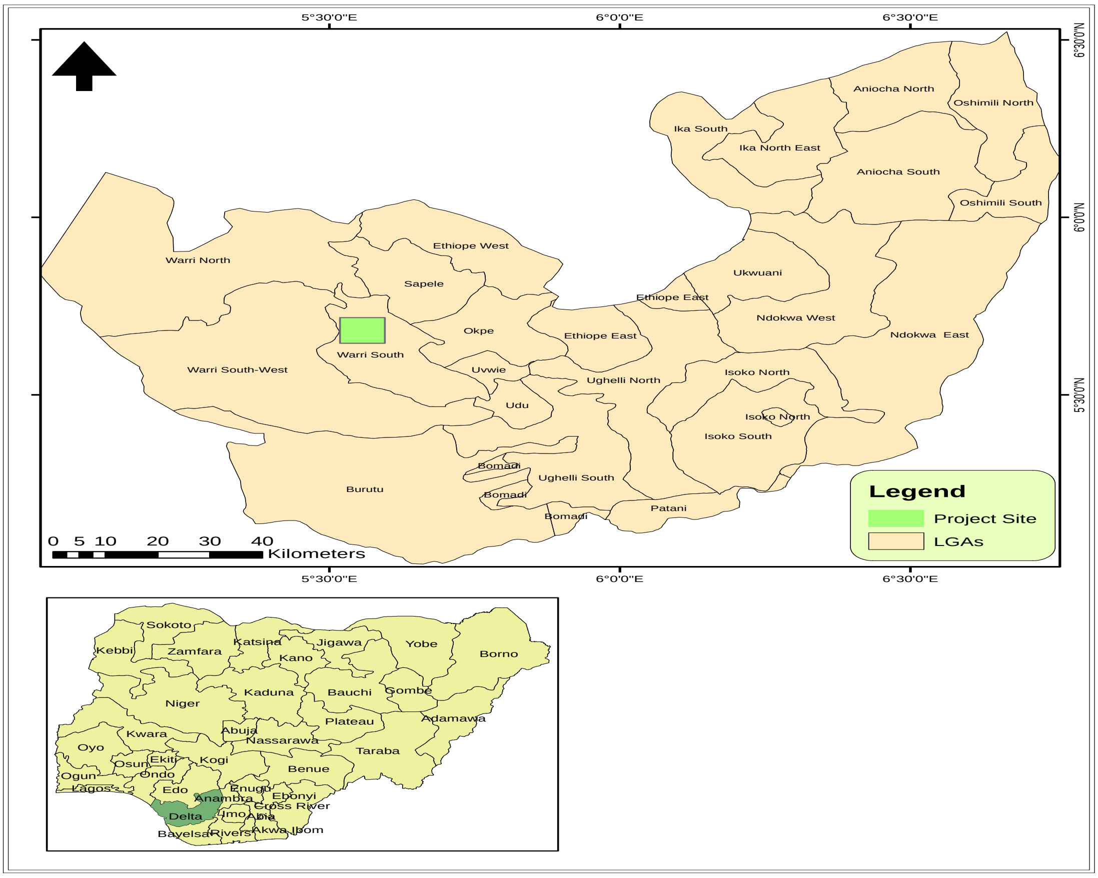
3.2 DESCRIPTION OF PROJECT LOCATION

Delta State lies roughly between longitudes 5°00 and 6°45'E and latitudes 5°00 and 6°30'N. It has a total land area of 16,842 sq. km. The states bordering Delta State are Edo to the north, Ondo to the northwest, Anambra to the east and Bayelsa and Rivers to the southeast. On its southern flank is 160 km of the coastline of the Bight of Benin.

The proposed SHAFA Energy Limited LPG Plant project will be located on a landed property of total area of 34,000Sqm located at Ode Itsekiri Road, Ifie – Kporo Community, Warri South Local Government Area of Delta State**.** Directly behind the project site is AYM Depot and other oil facility (very close) such as Matrix and Bluefin Energy petroleum products tank farm and

Pinnacle Oil petroleum products tank farm which is also directly opposite Matrix Energy while Warri Refinery Jetty is located after Pinnacle oil on Warri River. Accessibility to the site is through access roads (new Ode - Itsekiri expressway) and water ways (Warri River).

The project site is located on Latitude: 5° 32' N, Longitude: 5° 41' E. **Map 4** represent map of Nigeria showing Delta State and LGA map of Delta State showing the project location LGA (Warri South). It is worthy of note that Matrix & Bluefin Energy petroleum products tank farm and Pinnacle Oil petroleum product tank farm are all located on same 5° 32' N, Longitude: 5° 41' E as the proposed project site.



Map 4: Map of Nigeria showing Delta State and LGA Map of Delta State Showing Warri South where the Proposed Project is Located

A list of sampling locations covered in the course of sampling activities during the matrix facility EIA study, the coordinates of these points and the type of sampling activities undertaken at each point is presented in chapter four.

Map 5: List of Sampling Location Covered In The Course Of Sampling

(Showing immediate environment and existing facilities).

3.3 DESIGN CONDITIONS

3.3.1 Civil Work on SHAFA Energy Ltd LPG Plant LPG Terminal & Berthing Facility

Introduction

<u>Project Description</u>:

- 2 spherical tanks with a geometrical capacity of 5,500m^3 each with design pressure of 12 bar(a);
- The stock product is a mixture of propane and butane (with propane content of max 50%);
- Three roads Tanker loading bays as well as all necessary utilities (water
- firefighting Network, electrical power supply etc.

➢ Construction of LPG Tanks to be based on API standard 2510, API publ. 2510A and regulation in Nigeria as well as international rules, standards and codes for construction of a Liquefied Petroleum Gas (LP-GAS) plant.

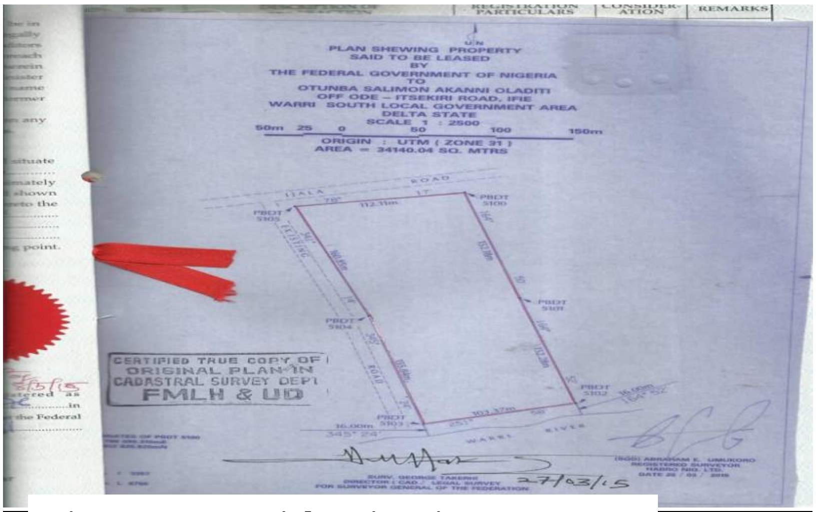


Figure 3.2A: Aerialea Site View

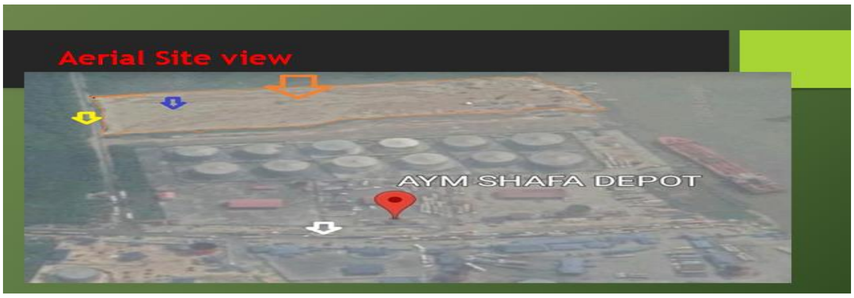


Figure 3.2B: View of SEL LPG Jetty Facility

Figure 3.2C: View of SEL LPG Facility Equipment

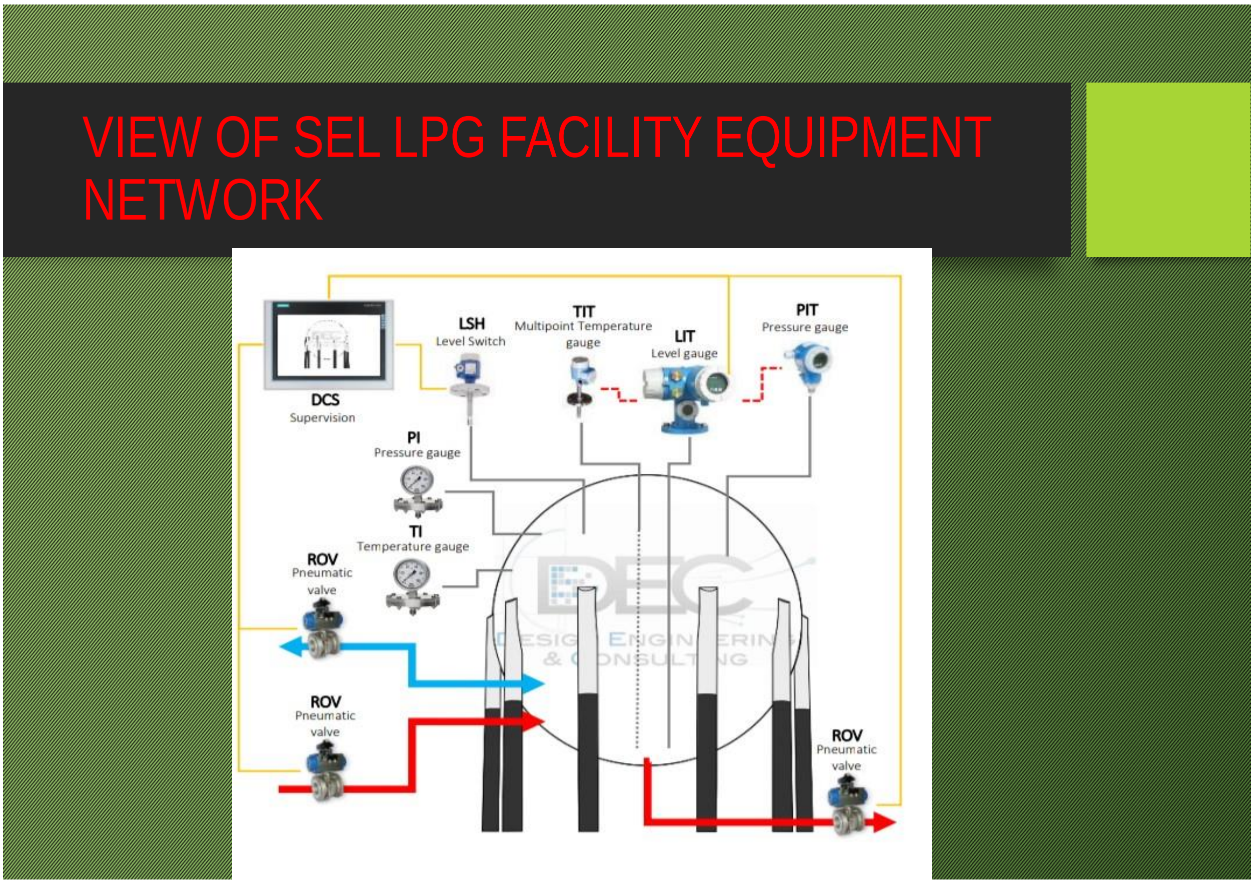


Figure 3.2D: View of SEL LPG Facility Equipment Network

Figure 3.2E: View of SEL LPG Facility Weigh Bridge

PLANT CAPABILITY – CAPACITY

DESIGN BASIS

<u>Climate Condition:</u> Maximum average temperature at 30^0C, maximum temperature at 45^0C, minimum average temp at 15^0C, minimum temperature at 5^0C.

<u>Product:</u> Stored product is a mixture of propane and butane. Vapour pressure about 10bar (g) at 45^0C, Specific gravity 0.55-0.56kg/dm^3 at 15^0C, Tank design pressure 11bar (g)-12bar (a).

<u>Terminal Capacity</u>: 111,000m^3 LPG storage, total raw capacity at 11,000m^3. Type of storage tanks: Spherical Number of tanks: 2 Maximum filling rate: 85-90%Design Code: ASME. Design pressure: 11bar (g) Corrosion allowance: 1.5mm.

3.3.2 Mechanical Specifications

- **<u>LPG tank instrumentation equipment and accessories</u>**: The sphere is equipped with the main following accessories: One multiport support for pressure relief valves (to allow dismounting one of them, while the other relief valve is on duty). Two pressure relief valves, one automatic level gauge LIT - servo gauge type, one pressure gauge and transmitter – PIT, one multipoint temperature probe and transmitter – TIT, one independent maximum switch level - LSH - with alarm signal in control room closing LPG loading valve etc. The remote operated valves are interactive with the DCS and can be operated from the control room.

- **LPG Compressors:** The proposed compressor unit is designed for gas handling as vapour recovery; truck unloading, spherical storage emptying, LPG network emptying, and LPG pumps for truck loading (3x). The proposed pump unit is designed for liquefied gas handling as Truck loading, Spherical storage transfer LPG vessel unloading system.

The vessel unloading system is composed of: Flexible hose 6'' for liquid phase – length 2 x 8 meters, Flexible hose 3" for vapor phase – length 2 x 8 meters ● "Y" filter, Manual ball valves, Drain, Venting Breakaway coupling, Remote operated pneumatic shut off valve – ROV. Pressure indicator – PI, Pressure indicator and transmitter – PIT, Temperature indicator and transmitter – TIT

- **LPG Truck loading bay:** Our proposal includes three (3) unloading/loading bays. The unloading/loading bay is composed of: Flexible hose 2"1/2 for liquid phase, Flexible hose 1"1/2 for vapor phase "Y" filter, Vapor separator, Manual ball valves, Drain, Venting. Automatic shut off valve – ROV, Breakaway coupling on liquid phase, Vortex flow meter with transmitter – FIT with connection to DCS, Pressure indicator ACME connections, Safety grounding connection ZSLPG piping network.

The LPG piping network comprises all the necessary equipment for the good working of the plant; Manual ball valves, Remote operated ball valves, Flow/pressure regulating valves "Y'' filters, Check valves, Manometers, Flow switch, Thermal safety valves, Ground connections, Instrumentations, Pipes, Fittings (elbows, tees, flanges, etc).

- **Fire-fighting system:** The fire-fighting network is mainly composed of the following elements: Two diesel fire water pumps of Capacity 1400 m^3/h with differential head: 9 bars electrical jockey pump capacity $10m^3/h$ with differential head: 10 bars.

- **Fire, gas, smoke and FACP detection system**: The Fire, Gas, Smoke and FACP detection system is composed by two sub-systems: Stand-alone Fire, Gas and FACP detection system, Stand-alone Smoke detection system. This quotation includes smoke detection system for the followings building: Technical building (with electrical substation) Administrative building, Guard House Fire, Gas & FACP detection system.

The system is composed by the followings equipment: A detection Alarm panel ATEX & Non ATEX FACP Flame detectors measuring range 0–100% LEL, Ex d enclosure with M20 cable gland thread suitable for use in safety related systems (ATEX 94/9/EC) stainless steel body. Water resistant (with accessories if needed), with operating humidity range 5% to 95% RH non-condensing.

- **The Weigh Bridge System**: The weigh bridge system is composed of On-ground built-in specification suitable for vehicle of free road circulation. Bridge - Capacity 60 T - Dimensions 20 x 3 m, Weight Indicator.

3.3.3 Compressed Air Network

- **Air Compressors:** The system is composed by two electrical driven air compressors (with one in stand-by) Compressor specification: Quantity: 2, Type: screw, Pressure: 7 bar(g) Included with 1 air filter Integrated refrigeration dryer, Isolating valve & Pressure transmitter, 1 air receiver (200 l).

3.3.4 Electrical Specifications

The Main Switch Board (MSB) is designed to be supplied by a 500kVA (3x400VAC+N) power supply from high voltage transformer. The board will also be connected to one generator of about 300kVA (3x400VAC+N). 6.1.1. Low voltage Network. The distribution of the 3x400VAC+N power supply is designed considering the following characteristics: Nominal service voltage: 3 x 400VAC +/- 10%– three phases + neutral. Neutral mode: TN-S system (Neutral solidly grounded) Nominal frequency: 50Hz +/- 5%, Harmonic distortion rate (U & I): maximum 5%.

▪ **Motor Distribution Board:** The base components of the frame structure are modular type. The enclosures are made of hot galvanized steel sheets with a polyester-epoxy powder anti-corrosion treatment. The MSB is composed by different cells. All the cells are coupled with suitable accessories according to supplier specifications. All the boards are equipped with removable lifting lugs to. For coupled frame, special coupling accessories must be used to allow handling with crane. The minimum IP rating of the board is IP 20.The construction of the different cells and equipment meet the following general characteristics: Key-lock handle, Internal lighting with door switch, Power socket 230VAC / 4A for maintenance, fixation rail for cable entry (by the basement) natural ventilation or forced if required, Protective cover plate.

- **Emergency Shutdown System (ESD):** The Emergency Shutdown system is composed by a stand-alone PLC to control all the Emergency shutdown action. The construction of the different cells and equipment meet the following general characteristics: Key-lock handle Internal lighting with door switch, Power socket 230VAC / 4A for maintenance fixation rail for cable entry (by the basement), natural ventilation or forced if required Protective cover plate.

Remarks:

Construction of LPG Tanks to be based on API standard 2510, API publ. 2510A and regulation in Nigeria as well as international rules, standards and codes for construction of a Liquefied Petroleum Gas (LP-GAS) plant

CHAPTER FOUR

CHARACTERIZATION OF THE EXISTING ENVIRONMENT

4.1 INTRODUCTION

This section of the EIA report presents baseline information on the biophysical and social environment of the project area. The information presented here has been collected from a number of collateral sources, including literature (published and unpublished), field data gathering, laboratory analyses, and discussions with various experts on relevant themes relating to the environment and impact assessment.

Data collection activities covered the following aspects of the environment:

- Climate and Meteorology
- Air Quality
- Land use/GIS
- Geology
- Surface water
- Ground water
- Sediment
- Soil
- Vegetation
- Wildlife
- Socio economics and public health

In conducting the field environmental and social data gathering for the EIA study, emphasis was placed on the generation of accurate and up-to-date information on the environmental and social components of the project area, particularly with regard to those aspects that are deemed most vulnerable to impacts from the project activities.

4.2 STUDY APPROACH

The study mainly involved literature research and field data collection/sampling and laboratory analysis in line with the FMEnv environmental guidelines and standards. Table 4.1 shows the environmental attributes and coordinates of collected field samples, while map 4.1 is the project area showing the sample location.

4.2.1 Study Team

The field sampling and preparation of this report were implemented by a multidisciplinary team consisting of environmental scientists from Clairgold Oil and Gas Engineering Ltd and University Professors. The team included thematic experts in sociology, ecology, air quality, dispersion modeling, wildlife, vegetation etc. The laboratory analyses was conducted in Jacico Environmental Laboratory Warri .The QA/QC protocol during sampling collection, handling, preservation and laboratory analysis were enforced to ensure that quality data was generated to characterize the baseline conditions of the study area.

4.2.2 Literature Review

Relevant literatures of similar studies around the project area were reviewed. These literatures include previous accredited Environmental Impact Assessment reports of SHAFA Energy Petroleum Depot Project (2020) and Matrix Depot Environmental Impact Assessment Report. e (2013) other environmental studies reports, publications and journals that relates to the study area, Gas plants. This activity commenced before the field studies and the information obtained used in designing the field study methodology.

Table 4.1: Coordinates of Field Samples

No	ID	Longitude	Latitude
SURFACE WATER			
1	SURFACE UPSTREAM	5° 32' 11''N	5° 41' 25'' E
2	SURFACE MIDSTREAM	5° 32' 7''N	5° 41' 21''E
4	SURFACE WATER DOWNSTREAM	5° 32' 1''N	5° 41' 27''E
5	SURFACE WATER CONTROL 1	5° 32' 1°N	5° 41' 41''E
6	SURFACE WATER CONTROL 2	5° 31' 5°N	5° 41' 57''E
GROUNDWATER			
1	GW1	5° 32' 12.7''N	5° 41' 21''E
2	GW2	5° 32' 14''N	5° 41' 9''E
3	GW2	5° 34' 8'N	5° 44' 38''E
SOIL			
1	SS 1 ὰ TOP BOTTOM	5° 32' 20''N	5° 41' 18''E
2	SS 2	5° 32' 15''N	5° 41' 20''E
3	SS 3	5° 32' 13''N	5° 41' 28''E
4	SS 4	5° 33' 43''N	5° 41' 30''E
5	SS CONTROL	5° 34' 8''N	5° 43' 30''E

SEDIMENT			
1	SEDIMENT UPSTREAM	5˚ 32’ 11’’N	5˚ 41’ 25’’E
2	SEDIMENT MIDSTREAM	5˚ 32’ 7’’N	5˚ 41’ 21’’E
3	SEDIMENT DOWNSTREAM	5˚ 32’ 1’’N	5˚ 41’ 27’’E
4	SEDIMENT CONTROL 1	5˚ 32’ 1’’N	5˚ 41’ 41’’E
5	SEDIMENT CONTROL 2	5˚ 32’ 50’’N	5˚ 41’ 57’’E
FISHERIES			
1	WARRI RIVER	5˚ 24’ 6˚N	5˚ 24-6˚-2E
AIR QUALITY			
1	AQ 1	05˚ 32.180’’N	05˚ 41.388’’E
2	AQ 2	05˚ 32.266’’N	05˚ 41.367’’E
3	AQ 3	05˚ 32.348’’N	05˚ 41.316’’E
4	AQ 4	05˚ 32.333’’N	05˚ 41.561’’E
5	AQ 5	05˚ 32.278’’N	05˚ 41.617’’E
6	AQ 6	05˚ 32.260’’N	05˚ 41.193’’E
7	AQ 7	05˚ 38.138’’N	05˚ 46.288’’E

4.2.3 Sampling Design

The following was critical to our sampling strategy:

- likely impacted locations/areas during construction and operational phase of the project;
- vulnerability of environmental attributes during project operation and
- Buffer zone

4.2.4 Data Collection and Observation

Field investigations were conducted in two seasons, the dry (December 1st - 3rd, 2019 and wet (July 16th-19th, 2020 seasons. The two-season study was intended to investigate the range of biophysical, social and health features of the local environment of the proposed project. However, with the recommendation of the Department of Petroleum Resources and Federal Ministry of Environment, was followed to document the ecological and social baseline of the project area as well as to augment the existing data with current baseline data. The sample collection methodologies were in line with the DPR& FMEnv field sampling guidelines.

The laboratory methodologies used for sample analyses were based on the American Society for Testing and Materials (ASTM) and American Public Health Association (APHA). Details of laboratory methods used are presented in this section of the report.

4.3 METHODOLOGY FOR FIELDWORK AND LABORATORY ANALYSIS

4.3.1 Air Quality and Noise Levels

Various monitors employed in air quality measurement include Kestrel 4500 Weather Tracker, ToxiRAE Model PGM-1140 NO Monitor, ToxiRAE Model PGM-1150 NO_2 Monitor, ToxiRAE Model PGM-1130 SO_2 Monitor, ToxiRAE Model PGM-1110 CO Monitor, ToxiRAE Model PGM-1110 NH_3 Monitor, MultiRAE PGM50-5P Monitor for VOCs and H_2S, GT-331 Particle Counter/Dust Monitor and sound pressure level meter.

The detail sampling methodology is reported in Appendix 4.1. For all the air pollutants measurements, a sampling period of 15 minutes was adopted while 60 seconds sampling period adopted for noise measurements with sampling taking place on every day of the week for one week. Plate 4.1 shows some sampling stations in the proposed LPG plant project area during the field campaign.

4.3.2 Soil Study

In order to fully capture the soil types and characteristics across the project area, soil samples were collected around the project area. Sample collection was based on soil and vegetation type of the project area. While 4 sample locations were established within the project area, 1 control stations were also established for soil sampling.

At each sampling location, two (2) soil samples were collected with a hand screw auger, at 0-15 and 15-300cm depth, representing surface soil and subsurface soil conditions respectively.

Samples were collected into polythene sample bags and labelled accordingly and sent to the laboratory for analyses.

The samples collected were subjected to detailed physio-chemical and microbial analyses in the laboratory. The methods utilized for the physio-chemical analyses are listed in Table 4.2.

Table 4.2: Soil Parameters and Analytical Method Used

Soil Parameters	**Analytical Methods**
Particle grain size	Mechanical sieve Shaker (ASTM)
Organic content	Walkley-Black
Total nitrogen	Kjeldahl
Available phosphorous	Brayl No.1
Exchangeable cations	Atomic Absorption Spectrophotometry
Heavy metals	Atomic Absorption Spectrophotometry
pH and Electrical conductivity	Digital glass electrode

Soil Physical Properties

- *Particle size analysis*

To obtain a complete separation of the soil sample into discrete particles and to facilitate the destruction of organic matter, 30% sodium hexametaphosphate solution was added as a dispersing agent. Homogeneity of the particles was then attained using a mixer. Readings were made with a standard Bouycous hydrometer at 40 seconds and 8 hours. The latter reading gave the concentration of clay, while the former yielded the combine concentration of both clay and silt (I.I.T.A Laboratory Manual, 1999).

The various particle grades (sand, silt and clay) and their percentage proportions, determined from the particle grain size analyses, were used to classify the sediments into textural composition using the triangular graph method (Holme and Mcintyx, 1972).

Soil Chemical Properties

Prior to the commencement of the laboratory analysis of the chemical properties, the soil samples were air-dried, sieved through a 2mm mesh and stored for use. Except for pH, the classifications used were those suggested by Sobulo and Adepetu (1987).

- *Organic Carbon*

The organic carbon content was determined titrimetrically using a mixture of the sample and acidified potassium dichromate. Ferrous ammonium sulphate was used as titrant with phenanthroline as indicator. Calculation of % organic matter was obtained by multiplying the % carbon by 1.724 (Jan Bammelen factor) based on the assumption that soil organic matter contains approximately 58% carbon.

- *Exchangeable Cations (Ca^{2+}, K^+, Mg^{2+}, Na^+)*

Exchangeable cations were extracted from the soil using 1N neutral ammonium acetate solution. Concentrations of the cations were determined using an Atomic Absorption Spectrophotometer (Varian Spectra AA-400 plus).

- *Anions (NO_3^-, SO_4^{2-}, PO_4^{3-}, Cl^-)*

20g of soil sample was added to 100ml of potassium chloride solution and the resulting mixture was shaken for about 1 hour to extract the anion contents. The resulting extracts were injected into a High Performance Liquid Chromatograph (HPLC) for the determination of the anion concentrations.

- *Soil pH*

Soil and deionized water in ratio 2:1 suspension was prepared and direct measurement of the pH was carried out using a glass electrode pH meter.

- *Electrical conductivity*

A mixture of soil: water in ratio 2:1 at 25^0C, was prepared from each soil sample and the electrical conductivity of the mixture was determined using an electronic conductivity meter.

- *Extractable Heavy Metals*

Extractable heavy metals in each soil sample were extracted using a 0.1N hydrochloric acid. The concentrations of the metals in the solutions were measured using an Atomic Absorption Spectrophotometer (Varian Spectra AA-400 plus).

Soil Microbiology

Soil samples were collected around the proposed project area for microbial analysis, observing all the relevant quality control procedures for microbial sampling and handling. The soil samples were collected into pre-labelled Mac Cartney bottles. The samples were then transported to the laboratory, ensuring that they were not contaminated. In the laboratory, the samples were subjected to series of microbial analyses, which included:

The soil and sediment samples were analyzed by weighing 1.0g of the samples into 10ml of sterile normal saline contained in 30ml dilution tubes and vortexed. While water samples were prepared by using 1.0mL in 9mL sterile normal saline contained in dilution tubes. Tenfold serial dilution of the samples was further carried out and was used for inoculation into various special selective media for enumeration of various types of bacteria.

Total Bacterial Count

Pour plate method was used for the enumeration of total bacteria in the sample, by inoculating into sterile Petri-dishes 1.0mL of the various dilutions (in duplicate), and were aseptically mixed with 15-18ml of sterile molten nutrient agar (45^{o}C), vortexes and allowed to solidify before incubation at 35^{o}C.

Coliform

Total and faecal coliform enumeration was done by using multiple tube fermentation technique and referencing to MPN table after incubation for the MPN values. McCkonkey Broth and Brilliant Green Bile Broth were used for total coliform count incubated at 37^{o}C for 48hours, while EC Broth was used for fecal coliform incubated in a water bath at 45^{o}C for 24hrs.

Salmonella and Shigella species, Vibrio spp & Pseudomonas spp

Salmonella and Shigella species were enumerated using surface spreading on specialized sterile Salmonella Shigella Agar. Vibrio species at the other hand were enumerated by plating out 0.1mL of the samples onto TCBS medium and incubated for 24hours at 37^{o}C.

Pseudomonas species was enumerated by plating 0.1ml of the sample onto sterile selective agar (Pseudomonas selective medium Oxoid), and incubated at 37^{o}C for 24 hour.

HUB and HUF

Hydrocarbon utilizing bacteria and fungi were enumerated using *vapor-phase-transfer* method on a solid mineral salt medium at pH 7 and 4 respectively for HUB and HUF, using Bonny Light Crude oil as the only carbon source.

Staphylococcus

Staphylococcus was enumerated by plating 0.1mL of the sample onto sterile solid Baird Parker Medium supplemented with egg yolk tellurite emulsion, and incubated at 35^{o}C for 24-48hrs.

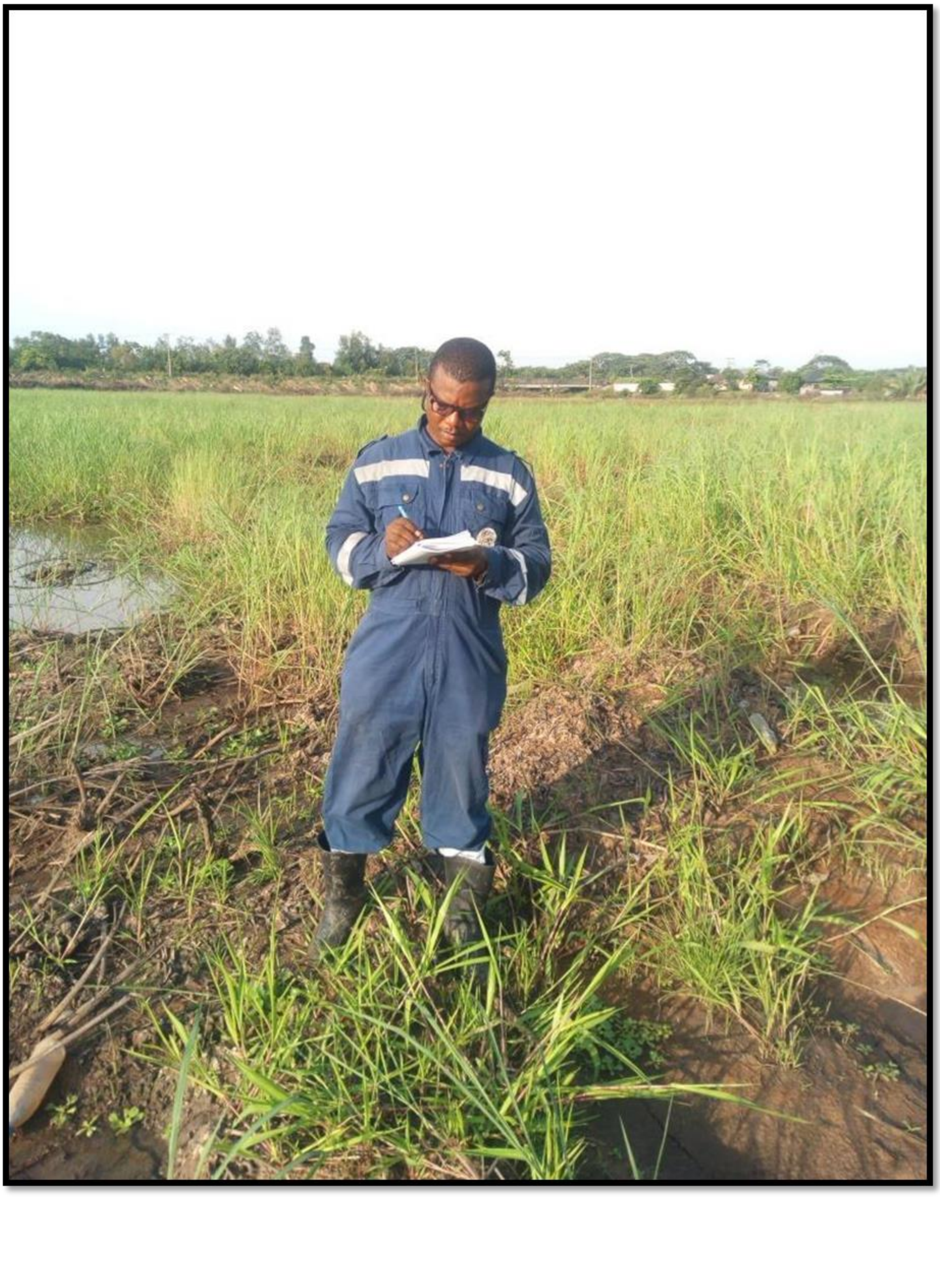
Further confirmation of the isolates (growth in various special media used) was carried out identification through by the conventional process: Staining using the Gram's staining technique to differentiate gram-positive microorganisms from gram-negative microorganisms was carried out. The pure bacterial cultures were subjected individually to various biochemical tests, which included oxidase, catalase, motility, nitrate reduction, urease production, gelatin liquefaction, arginine hydrolysis sugar fermentation and acid production. Individual bacterial strains were then identified based on their reactions on the above mentioned biochemical tests. Fungi identification was done by microscopic examination to determine the morphological characteristics of the isolates.

4.3.3 Vegetation Study

Prior to sampling a reconnaissance visit was undertaken to all areas (34,000square Meter and its environment) that are likely to be affected by the project activities and subsequent development. A reconnaissance tour of the entire area was to carefully examine the site characteristics so as to assist in designing the best strategy for field investigations. Based on the reconnaissance visit, the vegetation types of the study area were identified and photographs taken. For effective spatial coverage of the area, footpaths and transects were used for the sampling. All observations and sampling points were geo-referenced using hand held Global Positioning System (GPS) receivers while photographs of the major vegetation types were taken (Plate 4.3).

Species composition and density and habitat conditions were studied in detail using the Quadrat and Belt Transect Methods. Sampling was carried out along transects at each site. The quadrat for the determination of frequency and density of the species within a specific diagnosis sampling technique, 10m x 10 m quadrat at every 20-meter interval for a length of 100 meter was employed to provide maximum chance of encountering most of the species. The name and co-ordinates of each sampling point were recorded. All plants within each quadrat were systematically evaluated, identified to species level and the number of individuals of each species enumerated. Specimens of plant species that could not be readily identified on the field were collected and pressed in a plant press and taken to (University of Benin, Department of Life Science.) for proper identification.

Plate 4.1: Identification Vegetation Species



The number of strata in the vegetation was noted and the dominant species recorded. The height of the plants was measured with measuring tape and Haga altimeter. Where counting of individuals was not possible in situations where there are creeping plants, cover was measured according to Greig-smith (1983).

4.3.4 Socio-economic and Cultural Studies

The technique of study adopted in this survey comprise of the following procedures:

Firstly, is the conduct of preliminary investigations during which the extent of the intended area to be surveyed was determined and good rapports were established with the residents of the project area. The intentions of the researchers explained, the benefits therein for the host community were equally explained and group photographs taken with the Pupils as well. In each of the communities the number of questionnaire administered were as follows.

Ifie kporo-25 questionnaires Ijala - 45 questionnaires -15 questionnaires

Warri Market - 32 questionnaires.

Total 117

The questionnaires were administered randomly on the respondents in the area after the administration of the questions through the focal group discussion effort. Essentially, a total of 117 questionnaires administered and was based largely on the fact that the study area is contiguous in disposition or homogenous in characteristics. But, the variations in the number of questionnaires administered per community depended on the size of the population available for interactions during the interview processes. Following the homogenous nature of the population characteristics, the number of questionnaire administered may not really matter as population characteristic variance never existed conspicuously.

The adoption of random type of sampling premised basically on the fact that the residents are contiguous in orientation. That is, the residents generally have similar cultural background, religion, tribe, and language and belief system.

4.3.5 Public Health Assessment

Ethnographic research design was adopted for the study through stratified random sampling technique. The choice of stratified random sampling technique was informed by the observed dispersed settlements in the area of project influence. The dispersed settlements were characterized by differences in population size, quantity and quality of health institutions as well as health support services in the study area. The adoption of stratified random sampling, therefore, was inevitable in order to gauge the health status of the people as well as their disparities in opinions and attitudes regarding the impact of the proposed thermal plant on the health of the people that are likely to benefit from the project. Secondary data were collected from the following institutions: Data were obtained from 150 respondents from 3 villages, namely Ifie kporo, Ijala and (main project site). The instruments for data collection were mainly through consultation process, questionnaire and structured interview. Data was also collected through secondary sources including Primary Health Centre, Local Government office, Private Clinics and reviewed relevant literature.

All the study sites were visited by the researcher and his assistants to access baseline data in respect of the study's stated objectives. Visits were paid to the traditional rulers of the communities, health officials, local government authorities, religious and Community leaders. These provided information on knowledge, attitude, beliefs and practices related to disease prevention and health care utilization. These methods enhanced the validity of instruments used. They also increased the degree of reliability of data collected which might not have been so if only one technique had been used.

The health status of the communities in the project area was carried out and determined by means of baseline health data collected from below:

(i) Local health statistics from the PHC centre and clinics.

(ii) Consultation process with major stakeholders.

(iii) Field data in relation to :

- Water Supply.
- Waste Disposal.
- Refuse Disposal.
- Health Institutions
- Immunization status

4.3.6 Climate and Meteorological Study

The information presented in this report on the climate and meteorological components of the environment of the project area was collated from existing data on weather and climate from Nigerian Meteorological Agency (NIMET). Using information from these sources and the personal experience of the consultant on the weather and climate of the project area, comprehensive data on the various climatic elements were generated, which formed the basis for discussing the characteristics of weather and climate of the study area. No actual site data collection was undertaken for climate and meteorology in the course of this study.

The data compiled were analyzed and superimposed on the technical information on project construction and facility operation to distil out potential impacts.

4.3.7 Water Quality Sampling and Laboratory Analysis

While underground water samples were collected from existing boreholes around the study area, surface water samples were collected from surface water within the proposed project location (Warri River). Both samples were collected in clean PVC sample containers and sub sampled into appropriate sample containers for the various parameters analyses. Samples for physic-chemical and heavy metals analyses were collected in plastic containers while those for hydrocarbons and were collected in glass bottles. Samples for microbiological analyses were collected in 15ml McCartney sample containers.

Collected samples were properly labelled and stored in a thermos cooler and transported to the laboratory for analyses. As a precautionary measure, sample containers were rinsed with water from the sampling locations prior to sample collection. Water samples for heavy metals analyses were acidified with nitric acid (pH).

2) While those for hydrocarbons were acidified with sulphuric acid.

In-situ measurements of sensitive water parameters were taken using *Horiba U-10* water checker. The parameters measured *in-situ* includes pH, conductivity, salinity, dissolved oxygen, and temperature. The results of the *in-situ* parameters were crosschecked and compared with those from laboratory analyses. This is a quality control protocol for ensuring that reliable and accurate data were recorded. A summary of the laboratory methods used for the various water quality analyses is presented in table 4.3.

Table 4.3: Summary of Laboratory Methods for Water Analysis

Water Parameter	**Analytical Method**
Organics:	
Total Hydrocarbons (THC)	N-Hexane Extract using GC
Total Organic Carbon (TOC)	Dichromate Wet Oxidation (Walkley and Black, 1934)
Metals:	
Alkali Metals (Ca, Mg, Na and K)	Flame Photometry (Jone, 1988)
Other Metals: (Cr, Cu, Fe, Ni, V, Pb, Zn, Cd, Hg, and Mn)	Atomic Absorption Spectrophotometry (AAS)

Water Parameter	Analytical Method
Physico-chemistry:	
TDS/TSS	TDS/TSS meter (APHA 209C)
BOD5	Titrimetric (Winklers APHA 422)
TOC	Titrimetric, wet digestion (APHA 422)
Anions (SO_4^{2-}, NO_3^-, PO_4^{3-}, Cl^-)	Colorimetric, auto analyzer (ASTM 3867, APHA 427C)
Alkalinity	Titrimetric (APHA 427C)
Microbiology:	
Heterotrophic Bacteria	Plate count
Culturable Fungi	Plate count
Coliform Bacteria	Plate count, MPN (Crickshank, 1975)

Electrical Conductivity and pH

The electrical conductivity and pH of the water samples were determined with the aid of a Hanna meter (Model 7020). The calibration of the equipment was first carried out using standard potassium chloride solution after which the probe of the conductivity meter was inserted into sub-samples of the water to measure the pH and the electrical conductivity directly.

Turbidity

The turbidity of the water samples was determined using the spectrophotometric method. Here, the raw sample was poured into the

Spectrophotometer's cuvette and the reading taken using the appropriate wavelength. A blank reading of a freshly prepared distilled water was used to zero (calibrate) the Spectrophotometer. The turbidity value was thereafter read off from the Spectrophotometer screen.

Dissolved Oxygen (DO)

A Jenway hand-held DO meter was used to determine the dissolved oxygen content of the water samples in-situ. This DO meter consists of a 'Clark' type polarographic oxygen electrode and an oxygen meter. The reading displayed by the meter in mg/L (ppm) was recorded when the probe was dipped into the sample.

Biochemical Oxygen Demand (BOD)

For water with pH values of less than 6.5 and higher than 8.5, sufficient alkali or acid was added to bring the pH to acceptable range. The amount of acid or alkali was determined by neutralizing a separate portion of the sample to about pH 7.0 with a 1molar solution of alkali or acid, using an appropriate indicator (e.g. bromothymol blue), or pH meter. Known volume of acid or alkali was added to the sample for the BOD test. The sample was incubated in an air-proof BOD reagent bottles for five days at 25^{o}C. However, samples with pH values within 6.5 and 8.5 were incubated without pre-treatment with either alkali or acid. After the incubation period, the oxygen content of the sample was determined using the methods for dissolved oxygen.

Chemical Oxygen Demand (COD)

The test was performed by measuring the amount of oxidizing reagent (potassium dichromate or chromic acid) consumed during oxidation of organic matter present in the sample while titrating with Ferrous Ammonium Sulphate (APHA, 1985). This was mixed with 1g of powdered Mercuric Sulphate ($HgSO_4$) with 100ml of the sample contained in a conical flask after which 30ml of an oxidation mixture containing sulphuric acid (H_2SO_4), Silver Sulphate (Ag_2SO4) and Potassium Dichromate ($K_2Cr_2O_7$) (200ml H_2SO4, 1g Ag_2SO_4 and 100ml $K_2Cr_2O_7$) was added and heated in a water bath for 3-6 hours and allowed to cool.

The mixture was titrated using 0.25M Ferrous Ammonium Sulphate ($Fe(NH4)_2(SO_4)_2$) with 0.5% Diphenylamine as indicator (Golterman et al., 1978).

The color of the reaction hanged from turbid blue to brilliant green at the end point and the volume of the Ferrous Ammonium Sulphate used in the titration recorded. The same procedure was conducted for the blank, (distilled water). The COD of the sample in mg/l was then calculated using the formula:

$$X = \frac{Ct_t(V_{ab} - V_{as})}{V_s}$$

Where:

Ct = *Concentration of Titrant (Ferrous Ammonium Sulphate)*

Vab = *Volume of Titration of the Blank*

Vas = *Volume of Titration of the sample*

(Fe(NH4)2(SO4)2)

Vs = *Volume of water sample*

Total Suspended Solids (TSS)

The APHA 2540D test method was adopted using the glass fibre filter. The TSS content was calculated as follows:

$$\text{TSS (mg/l)} = \frac{(A - B)1000\ x\ 100}{Sample\ volume\ (ml)}$$

Where:

A = weight of filter paper + residue (mg) B = weight of filter paper (mg)

Total Dissolved Solids (TDS)

This was determined using Horiba Water Quality Equipment. The dissolved solids in the water sample was determined by inserting the probe of the equipment in the water sample collected in a specially designed cup, and the value of TDS in mg/L read off the Visual Display Unit of the equipment. This value summed with the value for the previous parameter (TSS) gave the Total Solid (TS) in the water sample.

Exchangeable Cations (Ca^{2+}, K^+, Mg^{2+}, Na^+):

Samples for exchangeable cations were extracted from the water samples using 1n neutral ammonium acetate solution. Concentrations of the cation extracts were determined using an atomic absorption spectrometer (spectra aa 400 plus Varian spectrometer).

Anions (NO_3^-, PO_4^{3-}, SO_4^{2-}, Cl^-):

The chloride was determined using the argentmetric method. Standard 0.0141N $AgNO_3$ (Silver nitrate) solution was used to titrate 50ml of the sample using 1ml of Potassium chromate as indicator. The color changes from orange to pink as the endpoint (APHA 4500 -Cl- B). Phosphate was determined as orthophosphate with ascorbic acid using Spectrophotometric procedure. The phenol disulphonic acid Spectophotometric method was used for the determination. Sulphate was determined by the turbid metric procedure. In each case, a standard calibration curve was prepared and the respective anions concentration read from the curve.

Extractable Heavy Metals:

Heavy metals in each water sample were digested using concentrated Nitric acid with a known volume (c. 10ml). The concentrations of the metals in the solutions were measured using an Atomic Absorption Spectrometer (Spectra AA 400 Plus Varian Spectrometer) after bringing the analyte into the acid solution by boiling for 15-20 minutes and cooling thereafter.

Total Hydrocarbon Content (THC):

The total hydrocarbon content of the water samples was determined by the chromatographic method. Specific volume of the sample was extracted with hexane and dichloromethane using a silica gel column. The hexane was used to extract for the aliphatic hydrocarbons while the dichloromethane was used to extract for the polycyclic aromatic hydrocarbons (PAH). The total hydrocarbon was then determined with the Agilent 4890 Gas Chromatograph (with Flame Ionization Detection) using the standard methods prescribed by Agilent Technologies.

Calibration of the Gas Chromatograph

Chloro-octadecane was used as the internal standard. Extract of each sample or standard mixture of known alkanes was spiked with a known amount of the internal standard and injected into the GC for both identification and quantification. The chromatograms after the analysis give the concentrations of both the alkanes and the internal standard and by this; routine recovery of the internal standard is maintained at greater than 90%.

Prior to getting to each sample points, a 60 micron plankton net was deployed for horizontal tow for about five minutes while the boat maintained low speed (about 0.7 knots). After five minutes of horizontal tow, samples collected were emptied into sample containers and fixed with 5% formaldehyde solution and stored in a cooler. While at the station and the boat stationary, 100micron plankton net was deployed for vertical tows for another five minutes. After the samples were collected, they were emptied into sample containers and fixed with were transported to the laboratory for identification and analyses.

Horizontal (tow) Plankton Sampling

4.4 QUALITY ASSURANCE METHODOLOGY

The quality assurance (QA) plan adopted for the entire EIA study covered sample collection, handling, laboratory analyses / data management and reporting. The procedure for the QA & QC is described below.

4.4.1 Sample Collection/Handling

Prior to mobilization to the proposed project site, sample containers were sterilized / washed using standard procedures and neatly packed. All field sampling and collection instruments were cleaned and re-calibrated after each use. Sample chain-of-custody forms were properly filled to indicate the sample names and locations, preservatives used, analysis required and date of sampling. This was used in the tracking of samples from the point of collection in the field to the laboratory where analyses were carried out.

4.4.2 Laboratory Analyses

QA/QC measures adopted for laboratory analyses were in accordance with FMEnv recommendations and standards. Other QA measures adopted in this study include:

- engagement of adequate competent personnel at all phases of the study;
- strict adherence to standard analytical operating procedures during analyses.
- use of calibrated equipment.
- peer review of the EIA output

4.5 ENVIRONMENTAL DATA ON THE PROJECT AREA

4.5.1 Climate and Meteorology

The climate of the South-south of Nigeria (including Warri**)** is driven by the seasonal oscillations of the Intertropical Discontinuity Zone (ITDZ) moving into the summer hemisphere. ITDZ separates two principally different air masses: Atlantic equatorial hot and humid tropical maritime air mass, and tropical warm and dry air mass of the Sahara desert. The north – south oscillation of ITDZ determines the seasonal variations in the weather and climatic conditions in Nigeria, where the two principal seasons are rainy and dry.

Temperature

Data were collected on the minimum, maximum and average monthly temperature characteristics of the project area (**Tables 4.4 & 4.5A; Figures 4.1A & 4.1B**). The average annual maximum temperatures ranged between 30.4^{o}C and 32.1^{o}C while the average annual minimum temperatures ranged between 22.8^{o}C and 24.8^{o}C. The average monthly maximum temperature ranges from 28.4^{o}C (August) to 33.7^{o}C (February) with a mean value of 31.6^{o}C while the average minimum temperature ranged from 22.8^{o}C (July) to 24.5^{o}C (March) with a mean value of 23.6^{o}C. Higher temperatures (32.6^{o}C – 33.7^{o}C) are recorded in the dry season (November – March).

Rainfall

The hydrological cycle depends fundamentally on the inter-relationship between the circulation of the ocean and the atmosphere. Water is withdrawn from the oceans into the atmosphere by the process of evaporation, which is dependent on factors such as air/sea temperatures, wind strength and humidity. Rainfall in the South-south of Nigeria is generally high, due to the relative proximity to the coast. Rain falls all through the year with the peak between June and October.

The average annual and monthly Rainfall values recorded over 20 years (1987 – 2007) are summarized respectively in **Tables 4.4 and 4.5A (Figures 4.1A & 4.1B).** The total annual rainfall at the project area ranged between 2,368.6mm in 2005 to 3,436.8 in 1995 with an average annual rainfall of 2,789.9mm while the average monthly rainfall ranged between 38.2mm (January) to 476.1mm (July) with an average monthly rainfall of 241.2mm. It is important to note that the rainfall pattern in this area is slightly different from what is obtainable in other high rainfall areas such as Lagos, Port Harcourt and Calabar, with a short break in August contrary to high rainfall of 319mm recorded in the area in August **(Table 4.5A)**. High rainfalls (216mm – 476.1mm) are recorded between April and October.

Relative Humidity (RH)

Overall, average humidity is higher than 50%, values lower than 50% are recorded during the dry season. Higher values are recorded in the early mornings than in the evening **(Table 4.5C; Figure 4.2C).** Relative Humidity is generally higher in the rainy season (morning: 85% - 88.7%; Afternoon: 74.2% - 83.5%) than in the dry season (morning: 80.8% - 82.2%; Afternoon: 57.2% - 68.6%), and in the mornings than in the evening. Typically, there is a direct correlation between rainfall and humidity, such that the lower humidity values coincide with the periods of low rainfall (December to March), while the higher values occur in the peak of the rains, between June and October. Overall, average humidity is higher than 70% in the project area for both morning and afternoon.

Table 4.4: Annual Temperature and Rainfall Values at the Project Area

	Average Max. Temp.	Average Min. Temp.	Average Annual Rainfall	Total Annual Rainfall
1987	31.9	23.3	257.8	2835.6
1988	31.4	23.8	225.7	2708.8
1989	31.4	23.4	212	2544.4
1990	31.5	23.9	294.7	2652.4
1991	31.4	24	254.2	3050.8
1992	31.5	23.3	266.7	3200.9
1993	32.1	23.7	274.7	3021.5
1994	31.9	23.4	233.1	2797.5
1995	32	23.6	286.4	3436.8
1996	31.6	23.8	226.4	2716.7
1997	31.5	23.3	240.5	2645.8
1998	31.6	24.8	207.7	2492.8
1999	31.3	23.5	249.6	2995.5
2000	31.6	23.5	224.1	2688.8
2001	31.7	23.7	199.2	2390.6
2002	31.6	23.7	246.95	2963.4
2003	32.1	24	232.8	2793.6
2004	31.5	23.4	293.5	3228.6
2005	32	23.2	197.4	2368.6
2006	31.4	23.3	201.9	2422.7
2007	30.4	22.8	239.2	2631.4

Source: Meteorological station Oshodi Lagos State

Table 4.5A: Average Monthly Minimum and Maximum Temperature at the Project Area

	Max.Temp. (ºC)	Min. Temp. (ºC)
January	32.8	22.9
February	33.7	24.2
March	33.4	24.5
April	32.8	24.2
May	32.0	23.9
June	30.5	23.5
July	28.8	23.0
August	28.4	23.1
September	30.0	23.2
October	31.2	23.4
November	32.7	24.2
December	32.6	23.2

Source: Meteorological station Oshodi Lagos State

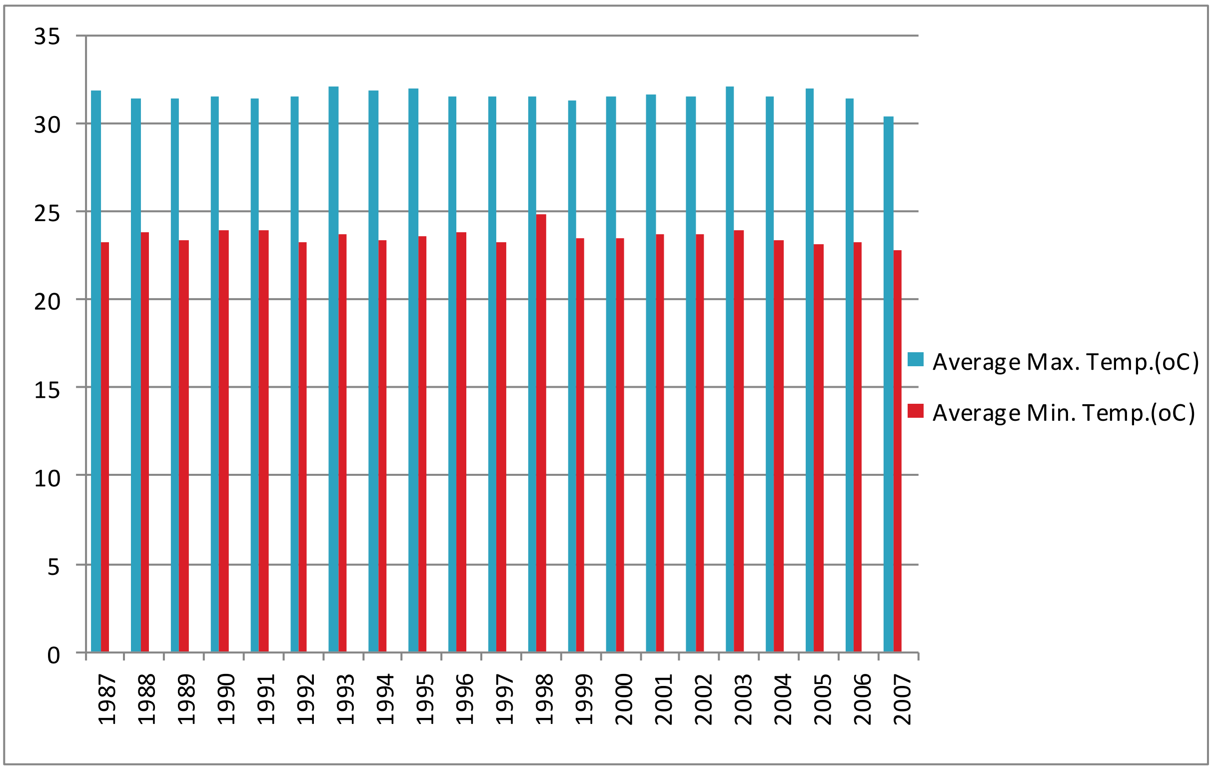


Figure 4.1A: Average Annual Minimum and Maximum Temperature at the project area

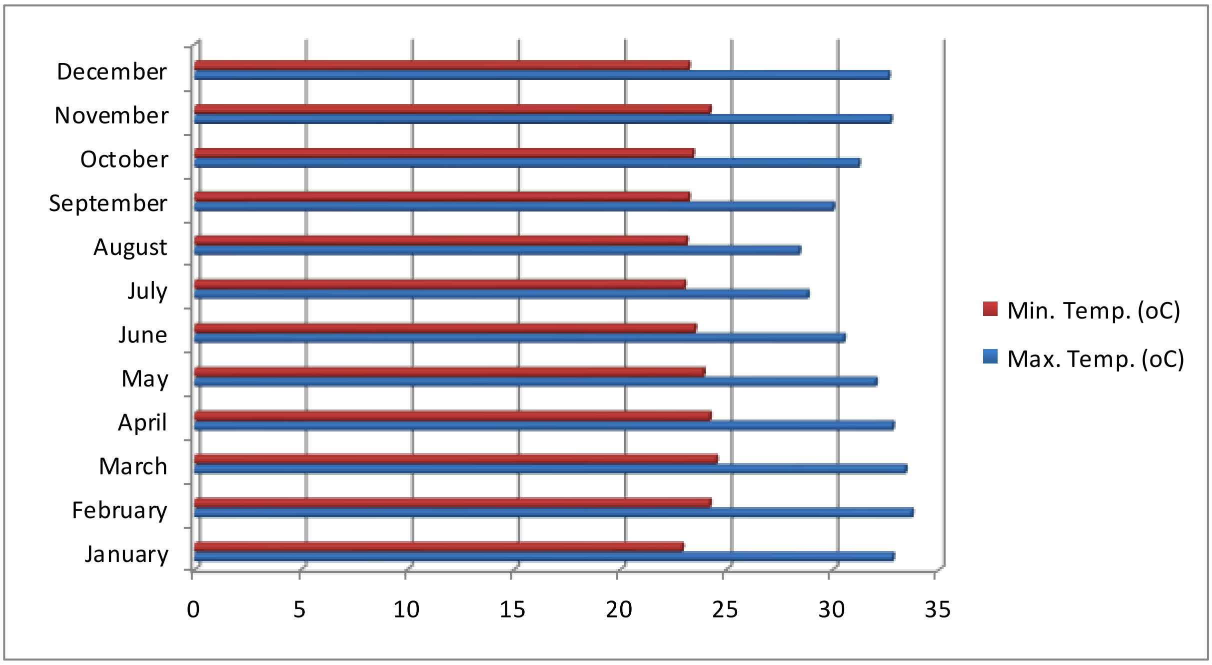


Figure 4.1B:Average Monthly Minimum and Maximum Temperature at the project area

Table 4.5B: Average Monthly Rainfall at the Project Area

	Average Rainfall (mm)
January	38.2
February	62.0
March	152.6
April	216.0
May	264.1
June	370.1
July	476.1
August	360.1
September	436.3
October	319.4
November	98.9
December	27.0

Source: Meteorological station Oshodi Lagos State

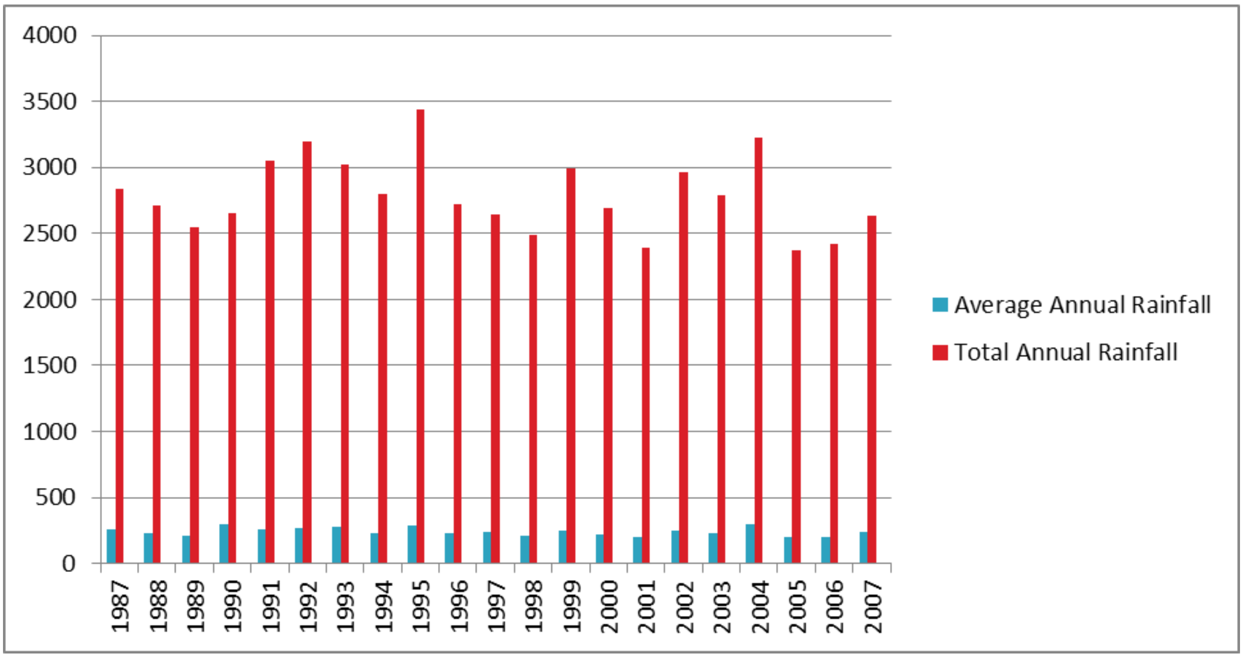


Figure 4.2A: Average Annual Rainfall at the project area

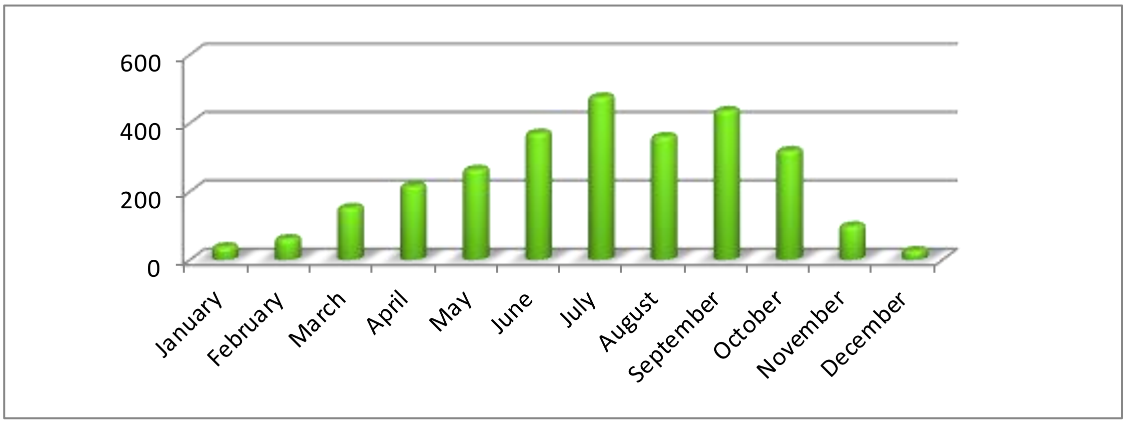


Figure 4.2B: Average Monthly Rainfall at the Project Area

Table 4.5C: Average Monthly Relative Humidity at the Project Area

	Rel. Humidity @09hrs (%)	Rel. Humidity @15hrs (%)
January	80.8	57.2
February	81.5	59.1
March	81	64.7
April	81.1	71.4
May	82.5	74.2
June	85.0	78.6
July	88.7	83.5
August	88.3	82.2
September	86.8	81.0
October	84.7	76.3
November	82.2	68.6
December	81.3	60.5

Source: Meteorological station Oshodi Lagos State

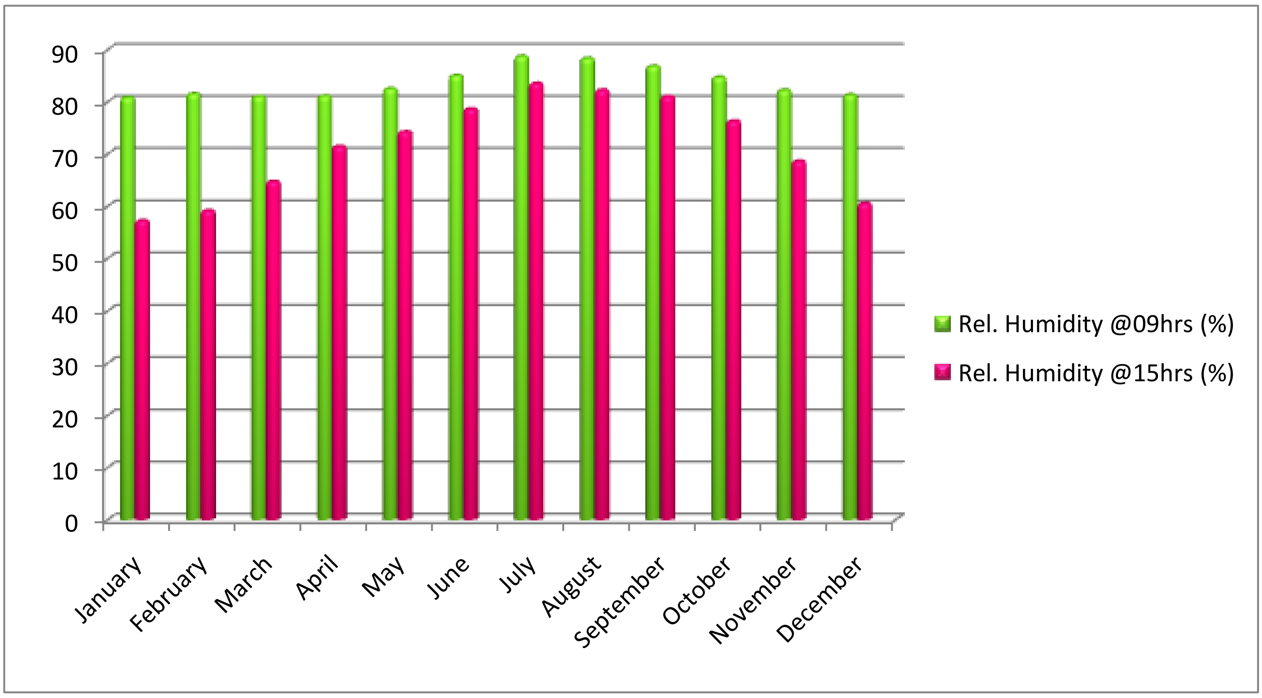


Figure 4.2C: Average Monthly Relative Humidity at the project area

Sunshine Hours

An average of just between 2.2 hours and 5.5 hours of bright sunlight were recorded on monthly basis within the project area, as shown in **Table 4.5D (Figure 4.2D).** An overall assessment of the sunshine hours reveal that the dullest months are during the peak of the rainy season in July/August while the brightest is in November/December at the onset of the foggy harmattan wind. The low sunshine hours in the region are associated with the thick cloud cover that prevails in this climatic belt for most of the year.

Table 4.5D: Average Monthly Sunshine Hours at the Project Area

	Sun Shine Hours
January	4.5
February	4.6
March	4.5
April	4.9
May	4.8
June	3.8
July	2.2
August	2.2
September	2.5
October	4.0
November	5.5
December	5.2

Source: Meteorological station Oshodi Lagos State

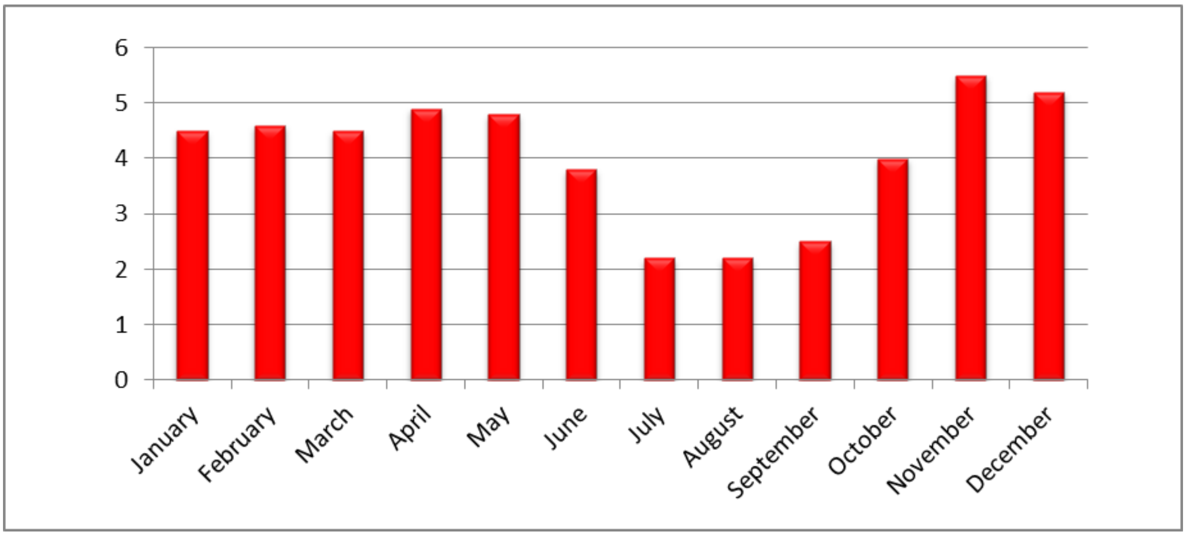


Figure 4.2D: Average Monthly Sunshine Hours at the project area

Wind Speed and Direction

The climatic conditions of the area are influenced by two wind systems related to a global passat system; south-westerly monsoon (SW) and the north-easterly (NE). The former (SW) is due to the influence of the Atlantic Ocean air mass, and reversed passat system of the southern hemisphere, while the latter (NE) arises from the passat system of the northern hemisphere blowing from the Sahara desert.

Wind speed ranges between 2.8m/s (November/January) and 3.5m/s (August/September) with an average value of 3.2m/s in the region over these periods **(Table 4.5E; Figure 4.2E).**

The SW monsoon winds, which predominate from April to August, have a speed range of 2.9m/s to 3.6m/s, but over the annual cycle, the overall mean is 3.2m/s, and this corresponds to light breeze on the Beaufort scale.

Table 4.5E: Average Monthly Wind Speed (m/s)

	Wind Speed (m/s)
January	2.8
February	3.2
March	3.4
April	3.6
May	2.9
June	3.2
July	3.2
August	3.5
September	3.5
October	3.1
November	2.8
December	3

Source: Meteorological station Oshodi Lagos State

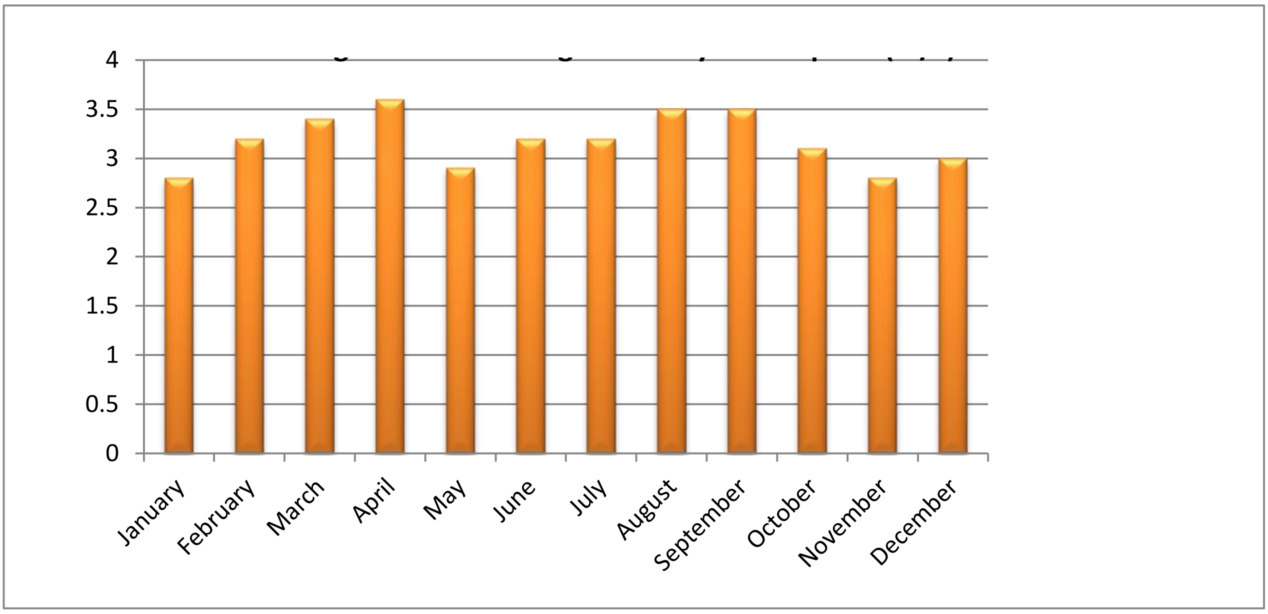


Figure 4.2E: Average Monthly Wind Speed (m/s)

Measured Meteorological Data

The study of the micro-meteorological condition of the area is important in describing microclimate of the area and in providing a basis for prediction of the impact of company's activities and future monitoring purposes. The measured climatic conditions within the project area carried out in the wet season (2010) and dry seasons (2013) respectively around Pinnacle and Blue fin facilities situated within the project area are recorded in **Table 4.6** and discussed below:

Temperature

The measured ambient temperature during the dry season ranged from 29.9^{o}C to 34.6^{o}C with a mean value of 32.6^{o}C while value recorded in the wet season complementary data ranged from 26.7^{o}C to 29.4^{o}C with a mean value of 27.8^{o}C. It is important to note that dry season measurements were carried out between 9.06am and 9.59pm while wet season measurements were carried out between 9.05am and 2.41pm.

Table 4.6: Measured Meteorological Data at the Proposed Project Area during the Dry and Wet Seasons

Sample Code	Parameter / Locations	Time (Hours)	Ambient Temperature (^{O}C)	Relative Humidity (%)	Wind Speed (m/s)	Wind Direction
Dry Season						
BE1	N05.53540°; E005.68651°	9.59	32.3	70.7	0.7	SW
BE2	N05.53542°; E005.68588°	9.55	32.6	69.8	1.3	E
BE3	N05.53598°; E005.68639°	9.52	31.9	72.4	0.8	SW
BE4	N05.53572°; E005.68560°	9.46	32.8	69.7	1.1	E
BE5	N05.53534°; E005.68546°	9.43	32.9	70.1	0.9	E
BE6	N05.53563°; E005.68526°	9.39	34.6	63.7	2.1	E
BE7	N05.53520°; E005.68519°	9.37	34.2	67.5	1.3	SW
BE8	N05.53455°; E005.68520°	9.33	33.6	69.4	0.5	E
BE9	N05.53496°; E005.68458°	9.21	30.8	70.8	1.2	SW
BE10	N05.53711°; E005.68659°	9.06	29.9	74.9	0.9	E
	Mean		**32.6**	**69.9**	**1.1**	
Wet Season						
PS1	N 05° 32’273”; E 005° 41’304”	1.52pm	27.6	81.9	5.2	SW
PS2	N 05° 32’236”; E 005° 41’208”	2.07pm	27,8	81.4	3.4	SW

PS3	N 05º 32'238"; E 005º 41'228"	2.28pm	27.1	82.1	7.3	SW
PS4	N 05º 32'228"; E 005º 41'233"	12.32pm	27.8	81.6	7.5	NE
PS5	N 05º 32'243"; E 005º 41'258"	12.11pm	27.6	82.1	11.2	SW
PS6	N 05º 32'235"; E 005º 41'310"	11.49am	28.7	71.7	6.4	SW
PS7	N 05º 32'211"; E 005º 41'205"	11.38am	27.4	81.4	13.6	SW
PS8	N 05º 32'178"; E 005º 41'213"	11.08am	27.8	81.3	8.5	W
PS9	N 05º 32'180"; E 005º 41'230"	11.21am	27.7	81.4	7.2	W
PS10	N 05º 32'181"; E 005º 41'320"	2.41pm	28.7	71.4	6.8	SW
PS11	N 05º 32'269"; E 005º 41'261"	1.17pm	29.4	70.1	7.3	NE
PS12	N 05º 32'425"; E 005º 41'203"	9.05am	26.7	90.1	8.8	NE
PS13	N 05º 32'394"; E 005º 41'526"	9.27am	26.9	86.2	2.7	NE
	Mean		**27.8**	**80.2**	**7.4**	

Source: ***EIA Field Survey of Pinnacle Proposed Tank Farm, October 2010 (Wet Season) and Dry Season Data from Bluefin Tank Farm EIA Study November 2013***

Relative Humidity

This is the amount of water vapor in the air compared to the maximum amount of water vapor, which that volume of air at the same temperature could carry. Saturated air has a relative humidity of 100%. The measured relative humidity values recorded at the project area is moderate/high and the values ranged from 63.7% to 74.9% (mean value of 69.9%) and 70.1% to 90.1% (mean value of 80.2%) respectively during the dry and wet seasons respectively.

Wind Direction and Speed

Wind is generally defined as the horizontal or near-horizontal movement of air caused by change in atmospheric pressure in which air normally moves from areas of high to low pressure. It helps determine the source and pathway of a pollutant. The prevailing wind directions in all the sampling locations during the dry season are South West and East while that of the wet season are South-West and North-East. The wind speed ranged from 0.5m/s to 2.1m/s (mean value of 1.1m/s) and 2.7m/s to 13.6m/s (mean value of 7.4m/s) respectively in the dry and wet seasons.

4.5.2 Land use Patterns

The land use features of the project area is dominated by agricultural (coastal fishing) grounds, mangrove forest resources, and built-up areas along the coast thus areas surrounding the Warri refinery as the main population centre. Mangrove swamp forest and vegetal land uses are found along the coastal settlements of Ife-Kporo, Ifie, Ifie –Tie, and Jalakporo.

The built-up areas have residential, educational, commercial, industrial (Warri refinery), transportation and religious infrastructures. The main populated centres close to the project area are Ubeji (Long. 5˚42' Lat. 5˚34'), Ekpan (Long. 5˚44' Lat. 5˚34'), Ogunu (Long. 5˚43' Lat. 5˚32'), Ejegba (Long. 5˚44' Lat. 5˚33'), towns and villages within the project area.

4.5.3 Geology/Hydrogeology

The project area lies within the Warri Refinery Jetty Complex and the basin within the larger Warri River drainage basin. The area is characterized by very low relief and level plains. The project area is located in the mangrove swamps which is one of three physical zones in the Niger Delta namely the coastal sandy ridges, the mangrove swamps and the fresh water zone. The mangrove swamps cover approximately 98% of the entire project area. The top soils are of three basic types namely blue- black mud soil, loamy soil and sandy soil.

A monitoring well was dug within the site for ground water study and the results are discussed under water quality**.**

From the lithology of the boreholes sunk within the project area, the area is underlined by 7.5m think of silty sandy clay which in turn underlain by 11.25m thick of silty sand and then underlain with fine to coarse sand to a termination of 20m depth. The Sand is slightly heterogeneous in colour. The moisture content of the soil ranges from 69.7% to 98%.

4.5.4 Vegetation

Introduction

Vegetation study is an important component of an environmental impact assessment study and as such, attention is usually given to particular attributes of the vegetation, which not only reflect the present state of the vegetation but can also serve as benchmarks to detect impacts (if any). These attributes include plant identification and characterization, vegetal composition and plant frequency, plant pathology and biomass productivity.

Vegetation serves some very useful functions that are crucial to the environment especially the biotic component and this include:

- Protection of the fragile soils from the erosive impacts of rains and wind.
- Maintenance of soil fertility through continuous nutrient recycling.
- Conservation of water resources through shading
- Preservation of water sheds.
- Regulation of air and soil temperatures.
- Moisture balance.
- Provision of habitat for countless terrestrial flora and fauna
- Purification of the environment through the carbon dioxide during photosynthesis and the release of oxygen for human and animal respiration.

Factors such as soil characteristics, climatic conditions as well as human activities (urbanization agriculture, bush burning etc), quite often, influence the floristic composition of an environment. Most times, extensive alteration of the natural vegetation structure of a given area is brought about more by human activities than any other factor.

Project Area Vegetation

The Proposed Project site is situated within the lowland mangrove forest belts of Nigeria. The major plants in the project site area include mangrove trees, very few oil palm (Elaeis genesis), very few raffia palm, black velvet tree (Dialium guineense). The weed species include Chromolaena adorate, Monophylum fluvum.

The mangrove swamp forest is seen along creeks of the coastal settlements in the tank farm project area where the water is brackish and affected by tides. Mangrove forest is well developed along the southeastern parts of the project site area facing the coast of the Warri River **(Plates 4.1 - 4.3).**

Mangrove trees possess long 'stilt roots' and these rootlets help to stabilize the trees in the loose, soft mud in which they grow. The most common species on the project site area is the *Rhizophora racemosa* (red mangrove).

Plate 4.2A: A Creek between IJala kporo and The Matrix Tank

Plate 4.2B: Mangrove Trees Dominating Other Plant

Farm Site- A Typical Drainage Feature of the Area Species at the Matrix Project Site area

Plate 4.2C: Mangrove ecotypes along the Warri River in the study area

4.5.5 Soil Studies

Introduction

Soil as a medium for food production or as a pedestal for engineering structures, plays significant roles in man's quest for sustainable development. It is a medium where micro/macro fauna and flora live and is made up of constituents that supply these and other living components of the environment, particularly higher plants with certain nutrients. As a consequence of food production and engineering infrastructural development on land, soil has been a receptor of detrimental and beneficial impacts.

In addition, alterations to the physio-chemical properties of soil, such as the one that occurs during the developmental phase of a project, can have positive or negative impacts on the micro/macro fauna and flora composition of the soil, thereby tilting the balance with significant impact.

Soil is therefore an important component of the ecosystem that serves as a footprint of impacts. Therefore, it is imperative that pre-project soil environmental conditions are one of the baselines upon which potential impacts of an activity is measured. Critical properties of soil whose baselines usually form the basis for impact assessment include:

- Particle grain size/composition
- Fertility indices
- Chemical composition
- Microbial composition etc.

The way these soil properties are impacted by a development project is a function of the project type, duration of project activities (construction and operation), type of machineries and equipment to be used, managerial competence of the project proponents and the susceptibility of the soil to pollution and degradation.

Results and Discussions

Soil profile study carried out from the project site identifies four levels/types of soil **(Table 4.7)** which are as follows:

Level 1= White smooth sand

Level 2= Brown muddy sand with plant parts

Level 3= Light brown muddy sand with plant parts

Level 4= Mud with lots of mangrove plant roots

The analysis results of these levels identified are summarized in **Table 4.8** while physio-chemical analysis results of top and bottom soil study within the project site area for the two seasons are summarized in **Tables 4.8A & 4.8B**. The soil analysis results are discussed as follows:

Table 4.7: Soil Analysis Results of Different Type of Soil Profile Identified in The Project Area

S/NO	Parameter	Levels Detected			
		1	2	3	4
1.	pH	7.25	7.42	7.36	7.14
2.	TOC (%)	0.63	2.51	2.22	4.72
3.	NO_3^- (mg/kg)	0.15	0.58	0.51	0.98
4.	PO_4^{3-}(mg/kg)	0.04	0.08	0.09	0.17
5.	SO_4^{2-}(mg/kg)	2.0	5.0	3.0	7.0
6.	THC (mg/kg)	ND	ND	ND	ND
7.	O&G (mg/kg)	0.02	0.07	0.04	0.06
8.	CN^- (mg/kg)	ND	ND	ND	ND
9.	Phenols (mg/kg)	ND	ND	ND	ND
10.	E.C ($nscm^{-1}$)	105.0	124.0	132.0	125.0
11.	Red Pot (mV)	38.2	37.4	38.0	42.0
12.	Ba (mg/kg)	ND	0.04	0.02	0.05
13.	cd (mg/kg)	ND	0.01	0.01	0.03
14.	Cr (mg/kg)	ND	ND	ND	ND
15.	Cu (mg/kg)	0.08	0.20	0.17	0.25
16.	Fe (mg/kg)	0.15	0.43	0.52	0.60
17.	Hg (mg/kg)	ND	ND	ND	ND
18.	Mn (mg/kg)	0.05	0.24	0.31	0.29
19.	Ni (mg/kg)	ND	ND	ND	ND
20.	Pb (mg/kg)	ND	0.02	0.02	0.05
21.	V (mg/kg)	ND	ND	ND	ND
22.	Zn (mg/kg)	1.48	2.54	1.98	3.18

Source: EIA Field Survey of Matrix Tank Farm, January 2009

Physical Properties

The soil study shows that the soil types within the project area are predominantly blue - black mud soil, loamy soil and sandy sand. Texture refers to the size and proportion of mineral particles (sand, silt, and clay) of which soil horizons are composed but does not refer to its organic matter or humus content. Soil texture dictates water-retention capacity and drainage properties of the soil, soil erosion as well as its ability to retain and absorb nutrients, which is a determinant of soil fertility and a key influence in soil productivity and management. Soil texture generally varies with depth, with the texture becoming more compact and less friable.

The particle size analysis (expressed as fractions of sand, silt and clay) showed that slit sized particles dominates samples collected at sampling points ME1- 3 while sand sized particles dominate samples collected at sampling points ME7-9 (Textural graph by Holme and Mcinx, 1972), making them muddy in most locations, loamy and sandy in very few locations.

Chemical Properties

The soil pH in the project area fall within the range specified for very acidic to distinctly acidic (see pH classes in **Table 4.9**) since the top soil for both seasons ranged between 4.78 and 5.91 while the sub surface soil ranged between 4.38 and 5.80. The average pH of the soil samples collected from the project area are within the optimal range for plant growth as shown in **Table 4.10.**

The values for soil organic matter ranged from 1.26% to 1.62% in the dry season while values recorded in the wet season samples ranged from 1.18% to 1.68%.

Table 4.8A: Physio-Chemical Analysis Results of Soil Samples Collected within the Project Site Area During the Dry Season

TYPES OF ANALYSES	ME 1 (TS)	ME 1 (SS)	ME 2 (TS)	ME 2 (SS)	ME 3 (TS)	ME 3 (SS)	ME 7 (TS)	ME 7 (SS)	ME 8 (TS)	ME 8 (SS)	ME 9 (TS)	ME 9 (SS)
pH	5.06	5.11	4.93	4.56	4.83	4.72	5.31	5.01	5.24	5.70	5.73	5.58
Sand %	0.31	2.06	1.25	1.32	2.21	2.64	76.31	88.40	52.62	53.64	73.17	69.22
Slit %	71.10	71.43	87.83	84.18	76.16	71.42	8.26	6.37	17.33	19.37	18.73	19.67
Clay %	28.59	27.51	10.92	14.50	21.63	25.94	15.43	5.23	30.05	26.99	8.69	11.11
Organic Matter %	1.32	1.26	1.53	1.41	1.62	1.45	1.38	1.27	1.35	1.31	1.53	1.31
Total Hydrocarbon (mg/kg)	51.306	3.513	14.831	7.426	58.152	3.057	24.742	4.270	14.251	11.318	11.742	5.833
METALS (mg/kg)												
Potassium	0.531	0.728	1.362	1.107	0.831	0.718	0.174	0.136	0.846	0.290	0.146	0.062
Sodium	8.337	14.516	6.163	11.528	12.614	17.403	10.105	7.625	6.420	6.172	12.480	4.173
Calcium	73.189	104.320	76.427	85.075	80.136	89.641	23.083	18.786	14.420	15.358	23.817	18.663
Magnesium	7.106	34.732	29.836	28.710	31.172	30.854	7.542	5.397	5.721	5.884	8.632	7.401
Iron	475.06	418.73	337.28	303.82	372.71	406.83	426.92	214.24	227.83	92.63	205.82	114.22
Nickel	0.126	0.102	0.153	0.116	0.162	0.137	0.109	0.062	0.142	0.082	0.176	0.142
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	1.072	0.732	0.842	0.086	0.538	0.423	0.318	0.114	0.193	0.078	0.248	0.114
Manganese	4.360	7.313	4.826	3.106	8.326	6.731	8.462	3.844	7.619	7.260	5.752	3.720
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.620	0.431	0.618	0.826	0.852	0.738	1.047	0.872	0.921	0.783	0.577	0.485
Copper	0.257	0.221	0.202	0.173	0.218	0.106	0.226	0.182	0.256	0.173	0.113	0.104

SOURCE: EIA Field Survey of Matrix Tank Farm, January 2009

NOTE: TS - Top Soil and SS – Sub Surface Soil

Table 4.8B: Physio-Chemical Analysis Results of Soil Samples Collected within the Project Site Area During the Wet Season

TYPES OF ANALYSES	ME 1 (TS)	ME 1 (SS)	ME 2 (TS)	ME 2 (SS)	ME 3 (TS)	ME 3 (SS)	ME 7 (TS)	ME 7 (SS)	ME 8 (TS)	ME 8 (SS)	ME 9 (TS)	ME 9 (SS)
pH	4.81	5.29	4.78	4.38	4.85	4.41	4.99	5.14	5.88	5.80	5.91	5.74
Sand %	0.14	1.25	0.81	1.62	1.79	3.68	70.97	88.58	49.58	53.27	72.42	58.11
Slit %	71.50	71.21	88.50	84.27	74.58	69.98	7.96	5.67	11.88	19.65	18.88	19.67
Clay %	28.36	27.53	10.69	14.11	23.63	26.34	21.08	5.75	38.54	27.08	8.69	12.22
Organic Matter %	1.68	1.59	1.60	1.30	1.52	1.36	1.26	1.18	1.31	1.28	1.47	1.26
Total Hydrocarbon (mg/kg)	74.596	4.770	17.578	7.611	80.644	3.498	44.853	5.126	17.544	15.519	13.895	7.930
METALS (mg/kg)												
Potassium	0.878	1.132	1.057	0.696	0.610	0.756	0.150	0.180	0.105	ND	0.024	ND
Sodium	11.560	23.494	7.464	17.239	10.058	25.704	10.138	6.838	6.768	7.178	14.816	2.714
Calcium	82.020	142.800	87.200	101.820	82.780	96.640	21.960	18.240	2.060	18.320	25.720	17.620
Magnesium	7.646	40.336	36.146	37.236	26.494	36.388	7.016	5.154	6.726	6.098	8.042	5.818
Iron	418.060	348.240	309.640	386.991	312.320	442.680	463.640	153.140	262.580	64.280	174.860	88.740
Nickel	0.463	0.514	0.422	0.368	0.283	0.413	0.565	0.034	0.257	0.036	0.344	0.150
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	0.704	0.896	0.675	ND	0.661	0.579	0.246	0.091	0.206	0.093	0.176	0.094
Manganese	3.360	14.800	4.260	2.080	8.160	7.960	8.100	3.380	6.360	7.880	5.300	0.480
Cadmium	0.023	ND	ND	ND	ND	ND	0.059	ND	ND	ND	ND	ND
Chromium	1.161	0.960	0.914	1.231	0.761	2.011	2.671	1.260	1.911	1.815	0.683	0.574
Copper	0.346	0.343	ND	0.192	0.215	0.117	0.143	0.103	0.277	0.148	ND	ND

SOURCE: EIA Field Survey of Matrix Tank Farm, September 2009

NOTE: TS - Top Soil and SS – Sub Surface Soil

Generally, organic carbon values were higher in the surface soils than in the sub-surface and this is normal, since much of the organic matter is formed in the surface soils where the decomposition of plant residues and soil organisms readily takes place. Studies previously carried out show the organic matter content of these soils range from low to medium **(Table 4.11).**

The Total Hydrocarbon content of dry and wet seasons samples respectively range from 3.057mg/kg to 51.306mg/kg and 3.498 to 74.596mg/kg respectively. Generally, the surface soils had higher TH content than sub-surface soils and this could imply that the Total Hydrocarbon in the soils is of anthropogenic, rather than natural sources.

The exchangeable bases (Ca^{2+}, K^{+}, Na^{+} and Mg^{2+}) are important components of the nutrient elements in soil and hence a strong determinant of soil fertility. Results obtained from the laboratory analysis (**Tables 4.8A & 4.8B**) and the application of the soil exchangeable classification in **Table 4.12** leads to the following conclusions; that the soils in the study area recorded high concentrations of the cations. These values imply that these soils are adequately equipped to provide the required level of nourishment for plants, and would therefore be suitable agricultural soils.

Heavy metal pollution is detrimental to soil fertility and other economic uses of land. When heavy metals are present beyond a particular threshold in soils, they may be absorbed by plants and this could, in turn lead to impaired growth and development.

From laboratory results of soil samples in the project area, only iron (Fe) was present in an appreciable level and the values recorded in the dry and wet seasons samples were in the range of 92.63 to 475.06mg/kg and 64.28 to 463.64mg/kg respectively.

These values are normal for tropical soils. It is important to note that cadmium was not detected in the dry season samples while lead was not detected in the both seasons samples. All the other metals were detected at levels that are adjudged normal in unpolluted soils. It is important to note that the heavy metal concentrations recorded at the sampling points generally are below naturally occurring Heavy Metal Concentrations and DPR set values for soil (**Table 4.13)**.

Table 4.9: Soil pH Classes

Range	Class
3.5 – 5.5	Very Acidic
5.5 – 6.0	Distinctly Acidic
6.0 – 7.0	Acidic
7.0	Neutral
7.0 – 7.5	Faintly Alkaline
7.5 – 8.0	Alkaline
8.0 – 8.5	Strongly Alkaline
8.5 – 9.0	Extremely Alkaline

Table 4.10: pH Limits for Optimal Plant Growth

pH Range	Class
<4.8	Low
4.8 – 9.5	Optimum
>9.5	High

Table 4.11: Organic Matter Classes

Organic Matter (%)	Class
<1.50	Low
1.50 – 2.50	Medium
>2.50	High

Table 4.12: Classes of Exchangeable Cations

	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)
Class				
Low	<0.15	<2.0	<0.5	<0.3
Medium	0.2 – 0.3	2.0 – 5.0	0.5 – 3.0	0.3 – 0.7
High	>0.3	>5.0	>3.0	>0.7

Table 4.13: Naturally Occurring Heavy Metal Concentrations in Soil and DPR Set Values For Soil and Sediment

Metals	Naturally Occurring Heavy Metal Concentrations/ Limits in Soil (mg/kg)	Soil and Sediment	
		DPR Target value (mg/kg)	**DPR Intervention value (mg/kg)**
Cadmium	0.03 - 0.3	0.8	12
Nickel	5 - 500	35	210
Lead	2 - 20	85	530
Zinc	10 - 50	140	720
Copper	-	36	190
Chromium	-	100	380

Soil Microbiology

In the soil microbiology analysis results recorded in **Table 4.14A**, the dry season sample contain THB count which varied from 1.63 x 10^7 cfu/g to 3.13 x 10^7 cfu/g, THF count of 4.0 x 10^4 cfu/g to 13.0 x 10^4 cfu/g and HUB count of 2.3 x 10^3 cfu/g to 11.2 x 10^3 cfu/g while the wet season samples contain THB count which varied from 1.13 x 10^7 cfu/g to 2.51 x 10^7 cfu/g, THF count of 2.0 x 10^4 cfu/g to 14.0 x 10^4 cfu/g and HUB count of 1.4 x 10^3 cfu/g to 13.1 x 10^3 cfu/g. Microorganism identified in all the samples for both seasons are as follows:

Bacteria	**Fungi**
Alkagenes	Candida
Acinetobacter	Geotrichum
Bacillus	Mucor
Corynebacteruim	Penicilium
Pseudomonas	Rhizopus
Micrococcus	Trichoderma
	Aspergillus

All bacteria present are notable hydrocarbon/petroleum oil utilizers. There was no significant difference in the distribution and total counts of microorganisms between top soils and sub soils. The percent HUB was less than 1.0% suggesting absence of chronic oil/hydrocarbon pollution.

Table 4.14A: Microbiological Analysis Results of Soil Samples collected at Matrix Energy Site during Wet and Dry Seasons

Sample Code	Soil Depth	Total Counts (cfu/g)				Dominant Species of Microorganisms
		Heterotrophic Bacteria x 10^7	Fungi x 10^4	HUB x 10^3	%HUB	
Dry Season Sampling Results						
ME 1	TS	3.13	13.0	9.50	0.030	Bacillus; Mucor; Candida; Geotrichum
	SS	2.32	11.0	3.00	0.013	Bacillus; Micrococcus; Aspergillus; Penicilium
ME 2	TS	2.86	10.0	2.40	0.008	Bacillus; Pseudomonas; Mucor
	SS	2.15	7.0	6.40	0.030	Bacillus; Flavobacterium; Aspergillus; Aspergillus
ME 3	TS	2.22	7.0	6.80	0.031	Bacillus; Rhizopus; Candida
	SS	1.22	4.0	2.30	0.019	Bacillus; Rhizopus, Penicillum, Aspergillus
ME 7	TS	2.78	8.0	4.70	0.017	Bacillus; Acinetobacter; Trichoderma, Penicillum; Aspergillus
	SS	1.63	7.0	9.30	0.057	Bacillus; Micrococcus; Aspergillus
ME 8	TS	2.62	9.0	11.20	0.043	Bacillus; Geotrichum; Aspergillus
	SS	2.06	6.0	8.60	0.042	Bacillus; Corynebacterium; Geotrichum; Aspergillus
ME 9	TS	2.30	7.0	6.20	0.027	Bacillus; Pseudomonas; Mucor; Aspergillus; Penicilium
	SS	2.10	8.0	8.20	0.039	Bacillus; Rhizopus; Aspergillus

Wet Seasons Sampling Results						
ME 1	TS	2.02	10.0	10.6	0.053	Bacillus; Mucor; Candida; Acinetobacter
	SS	1.79	14.0	2.10	0.012	Bacillus; Micrococcus; Aspergillus; Penicilium
ME 2	TS	2.19	9.0	1.50	0.70	Bacillus; Pseudomonas; Mucor; Geotrichum
	SS	1.97	5.0	7.20	0.037	Bacillus; Flavobacterium; Aspergillus
ME 3	TS	2.51	5.0	5.10	0.203	Bacillus; Corynebacterium; Rhizopus; Candida
	SS	1.46	3.0	1.40	0.096	Bacillus; Aeromonas, Rhizopus, Penicillum
ME 7	TS	2.13	6.0	2.50	0.012	Bacillus; Acinetobacter; Trichoderma, Penicillum
	SS	1.14	4.0	13.10	0.011	Bacillus; Micrococcus; Trichoderma; Aspergillus
ME 8	TS	2.07	6.0	9.40	0.045	Bacillus; Alkagenes; Geotrichum; Aspergillus
	SS	1.63	2.0	10.0	0.025	Bacillus; Corynebacterium; Geotrichum; Aspergillus
ME 9	TS	2.51	6.0	1.50	0.060	Bacillus; Pseudomonas; Mucor; Penicilium
	SS	1.13	10.0	7.50	0.067	Bacillus; Micrococcus, Rhizopus; Aspergillus

SOURCE: EIA Field Survey of Matrix Tank Farm, January & September 2009

4.5.6 Water Quality (Ground and Surface Water)

Ground Water

The physio-chemical analysis results of Ground water samples for both seasons collected within the project area were recorded in **Tables 4.14B**. The quality of the ground water sample was compared with that of World Health Organisation (WHO) maximum allowable level for drinking water quality.

Chemical Analysis

From the physio-chemical analysis results recorded in **Table 4.14B, t**he ground water samples collected in the wet and dry seasons satisfy WHO physico- chemical Standards for drinking water quality except for slightly high colour value (recorded in the dry season), objectionable odour and presence of TSS (8 – 12mg/L).

Microbiology Analysis

From the Microbiology results recorded in **Table 4.14B**, the ground water samples collected in both seasons are microbiologically unfit for drinking purposes due to high THB (162 – 174cfu/ml). Coliform, THF, HUB and HUF were not detected in both seasons' samples.

Discussion and Comments on Surface water

The physio-chemical and Microbiological analysis results of the surface water samples collected around the project site during the dry and wet seasons are summarized respectively in **Tables 4.15A and 4.15B**. The analysis results are discussed blow.

Physio-Chemical

The surface water samples collected in the two seasons have pH, DO, and TH values which range respectively from 6.97 to 7.50, 6.41 to 7.6mg/L and 2.354 to 4.18mg/L. Conductivity, COD and BOD Values range respectively from 637 to 688Uscm^{-1}, 40.8 to 53.4mg/L and 27.4 to 30.4mg/L). Nitrate and sulphate values are low while chloride values for both season samples range from 22.5 to 29.6mg/L.

The concentration of heavy metals analysed in the samples are relatively low and it is important to note that Nickel, lead and zinc are not detected in all the samples for both seasons.

Microbiology

From **Tables 4.15A & 4.15B,** the dry season sample contain THB count which varied from 1.56 x 10^7 cfu/ml to 1.74 x 10^7 cfu/ml, THF count of 2.0 x 10^4 cfu/ml to 4.0 x 10^4 cfu/ml, HUB count of 2.2 x 10^3 cfu/ml to 6.3 x 10^3 cfu/ml and HUF count of 3.6 x 10^1 cfu/ml to 4.2 x 10^1 cfu/ml while the wet season samples contain THB count which varied from 1.21 x 10^7 cfu/ml to 1.96 x 10^7 cfu/ml, THF count of 2.0 x 10^4 cfu/ml to 3.0 x 10^4 cfu/ml, HUB count of 1.5 x 10^3 cfu/ml to 7.2 x 10^3 cfu/ml and HUF count of 4.3 x 10^1 cfu/ml to 5.6 x 10^1 cfu/ml.

Oil degrading bacteria were *Bacillus, Corynebacterium and Pseudomonas*. There was significant presence of *Escherichia coli and Klebsiella*, bacteria which cause gastroenteritis, diarrhrea/dysentery and typhoid. There were no chronic petroleum/oil bacteria as their percent presence was less than 1.0%.

Table 4.14B: Physio-Chemical and Microbiological Analysis Results of Ground Water Sample Collected from the Project Site Area

S/N	PARAMETER	GW01 (Dry Season)	GW01 (Wet Season)
Physio-Chemical Results			
1.	pH	7.82	8.10
2.	Colour (Pt-Co)	**4.0**	2.0
3.	E.C. (Scm^{-1})	602.0	651.0
4.	Turbidity (FTU)	2.0	2.0
6.	Appearance	Not clear	Not clear
7.	Odour	**Objectionable**	**Objectionable**
8.	Temp (^{0}C)	26	26
9.	Cl^- (mg/L)	24.0	30.0
10.	COD (mg/L)	4.0	3.0
11.	BOD_5^{20} (mg/L)	2.0	3.0
12.	TSS (mg/L)	**12.0**	**8.0**
13.	TDS (mg/L)	300.0	324.0
14.	NO_3^-(mg/L))	0.63	0.85
15.	PO_4^{3-}(mg/L)	0.01	0.05
16.	$SO_4^{2—}$(mg/L)	4.0	5.0
17.	D.O (mg/L)	4.8	4.9
18.	NH_3 ((mg/L)	ND	ND
19.	S^{2-} (mg/L)	ND	ND
21.	Phenols (mg/L)	ND	ND
22.	Alkalinity (mg/L)	50.0	60.0
23.	CN^- (mg/L)	ND	ND

24.	THC (mg/L)	ND	ND
25.	Detergent (mg/L)	ND	ND
26.	Ba (mg/L)	ND	ND
27.	Cd (mg/L)	ND	0.002
28.	Cr (mg/L)	ND	ND
29.	Cu (mg/L)	0.06	0.12
30.	Fe (mg/L)	0.19	0.23
32.	Mn (mg/L)	0.03	0.02
33.	Ni (mg/L)	ND	ND
34.	Pb (mg/L)	ND	ND
35.	Zn (mg/L)	5.88	7.62
36.	V (mg/L)	ND	ND

Microbiology Results

37.	THB (CFU/ml)	162	174
38.	THF (CFU/ml)	Nil	Nil
39.	Coliform Count (cfu/ml)	Nil	Nil

Source: EIA Field Survey of Matrix Tank Farm, January & September 2009

Table 4.15A: Physio-Chemical and Microbiological Analysis Results of Surface Water Samples Collected around the Project Site Area during the Dry Season

PARAMETERS			
Temperature- Water (^oC) - Ambient (^oC)			
Appearance	Slightly Turbid	Slightly Turbid	Slightly Turbid
Colour (Pt-Co)			
Conductivity (Us/cm)			
pH			
Total Dissolved Solids (mg/L)			
Sulphate (mg/L)			
Chloride (mg/L)			
Nitrate (mg/L)			
Dissolved Oxygen (mg/L)			
Biochemical Oxygen Demand (mg/L)			
Chemical Oxygen Demand (mg/L)			

Potassium (mg/L)			
Sodium (mg/L)			
Calcium (mg/L)			
Magnesium (mg/L)			
Iron (mg/L)			
Nickel (mg/L)			
Lead (mg/L)			
Zinc (mg/L)			
Manganese (mg/L)			
Cadmium (mg/L)			
Chromium (mg/L)			
Copper (mg/L)			
Total Hydrocarbon (mg/L)			
MICROBIOLOGY			
Total Heterotrophic Bacteria (cfu/ml)		1.56×10^7	1.74×10^7

Total Heterotrophic Fungi (cfu/ml)		2.0×10^4	4.0×10^4
Hydrocarbon Utilizing Bacteria (cfu/ml)	6.3×10^3	2.2×10^3	2.8×10^3
Hydrocarbon Utilizing Fungi (cfu/ml)	4.2×10^1	4.0×10^1	3.6×10^1
Coliform (cfu/ml)	1.1×10^4	1.3×10^4	1.3×10^4
% Hydrocarbon Utilizing Bacteria	0.037	0.014	0.016
Dominant Species of Microorganism	*Bacillus, Aspergillius, Escheria coli, Rhizopus, Penicilium*	*Bacillus, Aspergillius, Escheria coli, Rhizopus, Klebsielia, Penicilium*	*Bacillus, Aspergillius, Rhizopus, Penicilium Geotricchum*

Source: EIA Field Survey of Matrix Tank Farm, January 2009

NOTE: ND – None Detectable (Below Instrument Detection Limit)

Table 4.15B: Physio-Chemical and Microbiological Analysis Results of Surface Water Samples Collected Around the Project Site Area during the Wet Season

PARAMETERS			
Temperature- Water (^oC) - Ambient (^oC)			
Appearance	Slightly Turbid	Slightly Turbid	Slightly Turbid
Colour (Pt-Co)			
Conductivity (Us/cm)			
pH			
Total Dissolved Solids (mg/L)			
Sulphate (mg/L)			
Chloride (mg/L)			
Nitrate (mg/L)			
Dissolved Oxygen (mg/L)			
Biochemical Oxygen Demand (mg/L)			

Chemical Oxygen Demand (mg/L)			
Potassium (mg/L)			
Sodium (mg/L)			
Calcium (mg/L)			
Magnesium (mg/L)			
Iron (mg/L)			
Nickel (mg/L)			
Lead (mg/L)			
Zinc (mg/L)			
Manganese (mg/L)			
Cadmium (mg/L)			
Chromium (mg/L)			
Copper (mg/L)			
Total Hydrocarbon (mg/L)			

MICROBIOLOGY			
Total Heterotrophic Bacteria (cfu/ml)		1.21×10^7	1.96×10^7
Total Heterotrophic Fungi (cfu/ml)		3.0×10^4	2.0×10^4
Hydrocarbon Utilizing Bacteria (cfu/ml)	7.20×10^3	1.50×10^3	2.50×10^3
Hydrocarbon Utilizing Fungi (cfu/ml)	5.6×10^1	5.1×10^1	4.3×10^1
Coliform (cfu/ml)	1.30×10^4	1.20×10^4	1.60×10^4
% Hydrocarbon Utilizing Bacteria	0.050	0.012	0.013
Dominant Species of Microorganism	*orynebacterium, Escheria coli, Rhizopus, Penicilium*	*Bacillus, Pseudomonas, Klebsielia, Penicilium, Aspergillius*	*Bacillus, Corynebacterium, E-colii, Rhizopus, Geotricchum*

Source: EIA Field Survey of Matrix Tank Farm, September 2009

NOTE: ND – None Detectable (Below Instrument Detection Limit)

4.5.7 Hydrobiology and Fishery

Plankton

In the dry and wet seasons, the zooplankton was predominant group **(Tables 4.16A & 4.16B)** forming about 56% of planktons collected. Phytoplankton identified at the sampling points for both seasons are *Coscinodiscus centralis, C.eccentricus, C.oculis iridis and* Thalassiothrix fraindelfi while the Zooplankton identified are *Sagitta englata, Oikopleura spp., Appendicularia spp., Copepoda clausii, Diaptomus spp* and *Nauplii larvae.*

There was no bloom or toxic species. The low phytoplankton numbers recorded in the wet season may be both due to grazing by zooplanktons and environmental stress.

Out of the phytoplankton species recorded, three belonged to the *centrals* and one *pennales* (diatoms).

Macrobenthic Fauna

Four major taxa of macrobenthic fauna identified in Warri river are as follow: Crustacea, Annelida, Polchaeta, Mollusca and Pisces **(Table 4.17).**

Fish study

Fish study was undertaken in the study area by direct sampling with hand net and interview of local communities in order to obtain information on species types found in the area. Based on the local and field account, fish species found in Warri river is summarized in **Table 4.18.**

4.5.8 Sediment Analysis

The summary of sediment grain size distribution, physio-chemistry and microbiology for both seasons are presented in **Tables 4.19A & 4.19B.** The results are discussed below:

Physio-chemical

The grain size of the sediment samples for both seasons are dominated by sand (98.66% to 99.27%) while the clay content range from 0.64% to 1.27%.

The pH of the sediments is acidic in nature (5.03 – 5.72). The organic matter contents of the sediments range from 0.73% **-** 0.96%; while the total hydrocarbon range from 36.418mg/kg – 903.963mg/kg.

The sediment samples in the project area contained relatively uniform low heavy metals concentrations for the individual elements analysed during both seasons except for iron. The high levels of iron recorded in the sediment samples (80.48 – 162.147mg/kg) may be as a result of high concentrations in the parent material which makes up the sedimentary basin of the project area.

It is important to note that the heavy metal concentrations recorded at the sampling points generally are below FMEnv/DPR recommended target and intervention values for micro pollutants for standard sediment **(Table 4.31).**

Microbiology

In the sediment microbiology analysis results recorded in **Tables 4.15A & 4.15B**, both season sample contain THB count which varied from 1.22 x 10^8

cfu/g to 1.84 x 10^8 cfu/g, THF count of 4.0 x 10^4 cfu/g to 10.0 x 10^4 cfu/g and HUB count of 4.7 x 10^3 cfu/g to 15.0 x 10^3 cfu/g.

Table 4.16A: Plankton Composition and Abundance in Warri River Mangrove Creek at Project Area during the Dry Season

PLANKTON				
Species/Major Taxa	**MEW1**	**MEW2**	**MEW3**	**Total**
Phytoplankton				
Coscinodiscus centralis	-	25	15	40
C.eccentricus	2	6	4	12
C.oculis iridis	-	10	3	13
Thalassiothrix fraindelfi	4	12	-	16
Sub-Total A	**6**	**53**	**22**	**81**
Zooplankton				
Sagitta englata	3	15	10	28
Oikopleura spp.	-	5	10	15
Mysis				
Copepoda clausii	5	10	7	22
Diaptomus spp	2	5	5	12
Nauplii larvae	-	5	5	10
Sub-total B	**10**	**45**	**47**	**102**
Total (A+B)	**16**	**98**	**69**	**183**

Source: EIA Field Survey of Matrix Tank Farm, January 2009

Table 4.16B: Plankton Composition and Abundance in Warri River Mangrove Creek at Project Area during the Wet Season

PLANKTON				
Species/Major Taxa	**MEW1**	**MEW2**	**MEW3**	**Total**
Phytoplankton				
Coscinodiscus centralis	3	5	3	11
C.eccentricus	6	3	5	14
C.oculis iridis	4	4	5	13
Thalassiothrix fraindelfi	-	6	9	15
Sub-Total A	**13**	**18**	**22**	**53**
Zooplankton				
Sagitta englata	5	3	3	11
Appendicularia spp.	4	5	8	17
Mysis				
Copepoda clausii	2	7	6	15
Diaptomus spp	3	5	5	13
Nauplii larvae	-	8	3	11
Sub-total B	**14**	**28**	**25**	**67**
Total (A+B)	**27**	**46**	**47**	**120**

Source: EIA Field Survey of Matrix Tank Farm, September 2009

Table 4.17: Macro benthic Fauna Present in the Warri River Mangrove Creek at the Project Area

SN	Major Taxa and Species	Common Name
1	**Crustacea**	
	a. Cirripedia: Balanus pallidus: Chthamalus dentatus	Acorn barnacles
	b.Crabs	
	Diogenidae: Clibanarius Africanus	Hermit crab
	Grapsidae: Sesarma huzardi	Purple mangrove crab
	Portunidae: Callinectus Amnicola	Flat swimming crab
	c.Shrimps/prawns	
	Penaeidae: Penaeus notalis	Pink Shrimp
	Palaemonidae: Nematopalaemon hastatus	Estuarine prawn
	Palaemonetes africanus	Creek shrimp
	Macrobrachium vollen-Hovenii	River prawn
2	**Annelida: Polychaeta**	
	Capitellidoe: Notomastus sp.	Polychate worm
	Glyceridae: Glycera capitala	Polychate worm
	Nereidae: Neanthes (= Nereis) siccina	Rag worm
	Orbiniidae: Scoloplos sp.	
3	**Mollusca**	Molluscs
	Gastropod snails	
	Melaniidae: Pachymelina aurita	Spiny Periwinkle
	Potamididae: Tympanotonus fuscatus	Smooth Periwinkle
	Bivalve	
	i. Ostreidae:Crassostrea gasar	Oyster
4	**Pisces**	Fishes
	Cichlidae: Tilapia guineensis; Sarotherodon melanothera	Tilapia
	Cynoglossidae: Cynoglossus senegalensis	Tongue sole
	Cynoglossidae: Aplocheilicthys spilauchena	Minnow
	Gobiidae: Bathygobius soporator; Youngeichthys thomasi	Gobiids

Source: EIA Field Survey of Matrix Tank Farm, September 2009

Table 4.18: Fish Fauna in the Warri River Mangrove Creeks at the Project Area

Family	Species	Common Name
A. Finfish		
Bagridae	Chrysichthys nigrodigitatus	Catfish
Cichlidae	Sarotherodon melanothera: Tilapia guineensis Tilapia mariae	Tilapia Tilapia
Clupeidae	Llisha Africana	Shad
Cynoglos	Cynoglossus senegalensis	Tongue sole
Cyprinodontidae	Aplocheilichthys spilauchena	Minnow
Ephippidae	Batanga sp. Eleotris viitata	Guppy
Elopidae	Elops lacerate	Ten pounder/Lady fish
Gobiidae	Bathygobius soporator, B. casamanous Youngischthys thomasi	Gobiids
Lutjanidae	Lutjanus dentatus; Lutjanus agennes	Brown snapper Red snapper
Monodactilidae	Psettias sebae	
Mugilidae	Liza falcipinis Mugil cephalus Liza grandisquamis	Sickle fin mullet Grey mullet Mullet
Polynemidae	Galeoides decadactylus Polynemus quadrifilis	African threadfin Shinny nose
Pomadasysidae	Brachydeuterus auritus Pomadasys jubeni	Big eye grunter Grunter
Sciaenidae	Pseudotolithus brachygnathus P. Senegalensis	Croaker Guinea croaker
Trichuridae	Trichurius lepturus	Silver fish
B. Shelfish		
Brachyura Gecarcinidae	Cardiosoma armatum	Red-blue crab
Ocypodidae	Uca tangeri	Fiddler crab
Portunidae	Callinectes amnicola	Flat edible crab
Shrimps/Prawns Palaemonidae	Macrobachium vollenbovenii Nematopalaemon hastatus Palaemonetes africanus	Brackish river crab Estuarine prawn Creek shrimp
Penaeidae	Penaeus notialis	Pink shrimp
Gastropod Mulluscs		
Littorinidae	Littorina anguilifera: L punctata	Periwinkles
Muricidae	Thais califera: Thais haemastoma	Whelks
Melanidae	Pachymelina aurita	Spiny periwinkle
Potamididae	Tympanotonus fuscatus	Smooth periwinkle
Bivalve Mollusc		
Ostreidae	Crassotrea gasar	Oyster

Source: EIA Field Survey of Matrix Tank Farm, September 2009

Table 4.19A: Physio-Chemical and Microbiological Analysis Results of Sediment Samples Collected from the Surface Water around the Project Site during the Dry Season

TYPES OF ANALYSES	**ME 1 SED**	**ME 1 SED**	**ME 2 SED**
pH	5.42	5.18	5.60
Sand %	99.18	99.04	99.10
Slit %	0.10	0.10	0.10
Clay %	0.72	0.86	0.80
Organic Matter %	0.73	0.78	0.82
Total Hydrocarbon (mg/kg)	611.271	92.005	36.418
METALS (mg/kg)			
Potassium	0.513	0.486	0.462
Sodium	3.731	6.840	4.183
Calcium	16.420	16.850	16.660
Magnesium	6.439	6.911	5.860
Iron	162.147	116.044	103.726
Nickel	0.131	0.175	0.162
Lead	0.08	0.07	0.07
Zinc	0.125	0.131	0.138
Manganese	6.418	6.432	5.042
Cadmium	ND	ND	ND
Chromium	1.620	1.610	1.270
Copper	0.063	0.031	0.046
MICROBIOLOGY			
Total Heterotrophic Bacteria (cfu/g)	1.53×10^8	1.46×10^8	1.32×10^8
Total Heterotrophic Fungi (cfu/g)	6.00×10^4	8.00×10^4	8.00×10^4
Hydrocarbon Utilizing Bacteria (cfu/g)	5.20×10^3	9.60×10^3	6.3×10^3
% Hydrocarbon Utilizing Bacteria	0.003	0.007	0.005
	Bacillus; Aeromonas; Flavobacterium, Aspergillus; Penicilium	Bacillus; Micrococcus; Geotrichum, Aspergillus	Bacillus; Pseudomonas; Aspergillus; Geotrichum; Penicilium

Source: EIA Field Survey of Matrix Tank Farm, January 2009

Table 4.19B: Physics-Chemical and Microbiological Analysis Results of Sediment Samples Collected from the Surface Water around the Project Site during the Wet Season

TYPES OF ANALYSES	ME 1 SED	ME 1 SED	ME 2 SED
pH	5.29	5.03	5.72
Sand %	99.27	98.66	98.66
Slit %	0.09	0.07	0.07
Clay %	0.64	1.27	1.27
Organic Matter %	0.94	0.93	0.96
Total Hydrocarbon (mg/kg)	903.963	80.131	24.925
METALS (mg/kg)			
Potassium	ND	0.440	0.367
Sodium	4.292	7.926	4.586
Calcium	16.720	18.320	15.420
Magnesium	5.584	7.248	4.820
Iron	103.640	94.200	80.480
Nickel	0.179	0.297	0.208
Lead	0.12	0.18	0.11
Zinc	0.115	0.118	0.127
Manganese	7.820	6.480	2.50
Cadmium	ND	ND	ND
Chromium	2.810	1.980	1.160
Copper	0.098	ND	ND
MICROBIOLOGY			
Total Heterotrophic Bacteria (cfu/g)	1.84×10^8	1.67×10^8	1.22×10^8
Total Heterotrophic Fungi (cfu/g)	4.00×10^4	10×10^4	8.00×10^4
Hydrocarbon Utilizing Bacteria (cfu/g)	4.70×10^3	15.00×10^3	4.50×10^3
% Hydrocarbon Utilizing Bacteria	0.003	0.009	0.004
	Bacillus; Aeromonas; Aspergillus; Penicilium	Bacillus; Micrococcus; Aspergillus	Bacillus; Pseudomonas; Aspergillus; Geotrichum; Penicilium

Source: EIA Field Survey of Matrix Tank Farm, September 2009

4.5.9 Air Quality and Noise Measurements

Air Quality Results and Discussions

Gaseous and particulate pollutants are emitted into the atmosphere from various sources. The emissions could affect the air quality of a region depending on the quality of substances emitted and the microclimate of the area, making the atmosphere the most vulnerable to the impacts of many actions.

The parameters investigated for air quality studies in the project area are: SO_2, NO_2, NO, CO, H_2S, Cl_2, THC and Suspended Particulate matter. The results obtained from the sampling points were compared with DPR and FMEnv air quality standards for environmental pollution control.

The results of the air quality for dry and wet season sampling within the project area are summarized in **Table 4.20.** Generally, the air quality parameters measured show concentrations that are within the DPR and Federal Ministry of Environment standard and guidelines (**Table 4.20**). The results are discussed as follow:

Nitrogen Oxides

The two oxides of nitrogen that are usually of primary concern in air pollution are nitrogen oxide (NO) and nitrogen dioxide (NO_2). NO and NO_2 were not detected in all the sampling points except at two points (inside generator house and welding shop area) where NO concentrations of 1-2ppm was recorded.

Generally, nitrogen oxides (NO_x) were below equipment detection limit (<0.01ppm) in all the sampling locations, which was found to be lower than 0.04 – 0.06ppm range specified by FMEnv.

NO_2 contributes to acid rain because it reacts with rainwater to form nitric acid, which in turn react with ammonia in the atmosphere to form a plant nutrient (ammonium nitrate). In human beings, NO_2 irritates the alveoli of the lungs. It also induces corrosion and rusting of materials including roofing sheets and textiles.

Carbon monoxide (CO)

Carbon monoxide is chemically inert, colourless, tasteless and odourless. The ambient concentration of carbon monoxide at the sampling locations ranged from 0.01ppm to 0.02ppm, which is within the FMEnv regulatory limits/standards of 10ppm.

The estimated atmospheric mean life of the gas is about two and half months. Carbon monoxide has little if any effect on property, vegetation and materials. However, carbon monoxide at high concentrations can seriously affect human aerobic metabolism, owing to its high affinity for haemoglobin, the component of the blood responsible for the transport of oxygen. The gas reduces the capability of haemoglobin to carry oxygen even at low concentrations.

Sulphur Oxides (SO_2)

SO_2 generally comes from a known source like combustion of coal or sulphur containing fuels and ores, pulp and paper mills and from non-ferrous, smelters and others (USEP, 1990).

Sulphur oxides were also below equipment detection limit (<0.01ppm) at all the sampling locations, which is lower than FMEnv limit of 0.1ppm.

Table 4.20: Air Quality and Noise Measurement within the proposed project area

Code	Temp.	NO_X (ppm)	SO_2 (ppm)	CO (ppm)	H_2S. (ppm)	SPM (ug/m^3)	VOC (ppm)	Noise Level dB (A)
Dry Season Sampling Results								
M1	29	<0.01	<0.01	0.02	<0.1	26.6	<1	67.3
M2	28	<0.01	0.01	0.02	<0.1	28.4	<1	42.3
M3	29	<0.01	<0.01	0.02	<0.1	22.8	<1	42.7
M4	31	<0.01	<0.01	0.02	<0.1	14.6	6	54.9
M5	29	<0.01	<0.01	0.02	<0.1	13.7	5	50.5
M6	30	<0.01	<0.01	0.02	<0.1	37.4	5	53.2
M7	31	<0.01	<0.01	0.02	<0.1	28.6	6	59.4
M8	29	<0.01	<0.01	0.02	<0.1	28.3	<1	55.7
M9	29	<0.01	<0.01	0.02	<0.1	13.4	6	62.4
Wet Season Sampling Results								
M1	24	<0.01	<0.01	0.02	<0.1	18.8	<1	61.4
M2	24	<0.01	<0.01	0.02	<0.1	16.0	<1	38.7
M3	24	<0.01	<0.01	0.02	<0.1	14.4	1	41.1
M4	24	<0.01	<0.01	0.02	<0.1	9.3	2	48.2
M5	24	<0.01	<0.01	0.02	<0.1	8.7	1	50.6
M6	25	<0.01	<0.01	0.02	<0.1	22.2	2	56.2
M7	24	<0.01	<0.01	0.02	<0.1	17.7	1	60.3
M8	26	<0.01	<0.01	0.01	<0.1	17.2	<1	53.6
M9	25	<0.01	<0.01	0.02	<0.1	6.9	1	61.6

Source: EIA Field Survey of Matrix Tank Farm, January & September 2009

Hydrogen Sulphide (H_2S)

Hydrogen sulphide or sour gas is a colourless gas with a specific gravity of 1.18. It is slightly less lethal than hydrogen cyanide and more lethal than chlorine. It has an odour of a rotten egg. It is a strong poison. H_2S was below equipment detection limit (<0.1ppm) in all the sampling locations. FMEnv did not set limit for H_2S.

Suspended Particulates Matter (SPM)

The concentration of SPM at the sampling locations within and around the project area for both seasons ranged from 6.9µg/m^3 to 37.4µg/m^3 for particle size of 10micron. All the sampling locations have SPM values lower than 60-90 µgm^{-3} and 250µg/m^3 recommended by DPR and FMEnv respectively.

At high concentrations, SPM poses health hazards to humans, particularly those susceptible to respiratory illness. As indicated in **Table 4.21**, the nature and extent of the ill effects that may be linked to SPM depends on the concentration and the presence of other atmospheric contaminants (notably sulphur oxides), and the duration of exposure. **Table 4.22** presents how the human respiratory system defends itself against the invasion of foreign substances, including SPM. The success or failure of the respiratory defense systems depends in part on the size of the SPM inhaled and the depth of their penetration into the respiratory tracts.

Noise Level Measurements and Discussions

The noise level measured at various locations within the project site is recorded in **Table 4.20.** The noise level recorded ranged from 38.7 to 67.3(dbA). Generally, the noise levels measured within the project site are below FMEnv standard of 90dB and DPR limit of 85dB.

Table 4.21: Health Effect of SPM

Concentration (ug/m^3)	**Accompanied by**	**Time**	**Effect**
750	715 $ug/m^3 SO_2$	24-h average	Considerable increase in illness
300	630 ug/m^3 SO_2	24-h average	Acute worsening of chronic bronchitis patients
250	250 ug/m^3 SO_2	24-h average	Increased absence of industrial workers
100 – 130	120 ug/m^3 SO_2	Annual mean	Children likely to experience increased incidence of respiratory disease
100	Sulphation rate above 30mg/cm3/mo	Annual geometric mean	Increased death rate for those over 50 likely
10-100	Sulphation rate above 30mg/cm3/mo	2-yrs geometric mean	Increased death rate for those over 50 to 69 years.

Table 4.22: SPM Size and Respiratory Defence Mechanism

SPM Size	Description	Mechanism
>10um	Coarse dust, fly ash (visible to the naked eye)	Filtered out by hairs at the front of the nose
2 - 10um	Fumes, dust smoke particles	Movement of cilia sweeps mucus upwards, carrying particles from windpipe to mouth, where they can be swallowed.
<2ump	Aerosols, fumes	Lymphocytes and phagocytes in the lung attack some submicron particles.

4.5.10 Socio-Economic and Health Studies

Introduction

The studies of concern in socio-economic studies include demographic pattern community structure, occupational structure, institutional presence, economic activities, transportation network, literacy level; community information on these aspects of the community was obtained from oral interviews with selected members of the community, questionnaires and review of related literature.

The proposed project site is located at Ifie kporo near AYM, Matrix, Bluefin and Pinnacle Oil facility as well as Warri Refinery Jetty.

Results and Discussions

The socioeconomic and health studies findings as documented in Matrix Energy EIA report of 2009 are presented as follows:

Marital Status

The majority of the respondents are married – 70.3%, while 29.7% are single. The divorce rate in the area appears insignificant (1.8%**).**

Age Distribution

The age distribution among the sampled respondents shows that they were largely middle-aged with 52% aged between 31-50 years. About 11% were 30 years and below; 30% were aged 52-70 years and 7% over 70 years.

Educational Attainment

The population is literate, as only 26% do not have some formal education; 33% have primary education, 39% have secondary education while 2% possess tertiary education.

Family Size

Family size, that is, the nuclear family, those married and their children, is large which is typical of Nigeria with 32% having 7-10 members; 12% with 11-15 members while 17% have 1-3 members. At both extremes in terms of size some 32% have 4-6 members; some 6% have over 15 members.

Religious Beliefs and Practices

Some 86% of the respondents claimed that they care Christians and only about 2% is Muslims. Traditional religious beliefs accounted for 13%. The people are thus predominantly Christians however, mixing of Christian belief with traditional beliefs and practices also occur.

Occupational Characteristics

The majority of those interviewed were farmers (68%) followed by traders/business (16%), civil service received 4%, fishing & gin distilling (9%) and industrial workers (3%). Thus there is high dependence on land and natural resources for survival which makes land and agricultural issues of critical consideration to these communities. The major stakeholders are therefore farmers and land owners within communities.

Yields from farming activities were said to be generally increasing by some 72% of respondents; only 18% said they were decreasing and some 10% said they were about the same; the land thus still appear fertile to sustain agriculture without fertilizers inputs, especially since the people generally practice fallow agriculture. The major crops grown in order of importance and recall include: cassava, yam, maize, melon, tomato, okra.

Income and Expenditure Characteristics

The income earnings by the people appear to be low with about 84% - earning under N71,000 per annum. The bulk of income realized is spent on food as recounted by 61% of the respondents followed by education 29% and medical care 11%; a smaller proportion (5%) mentioned household items and clothing. It would therefore appear that the people are living at the margin with the major preoccupation being basic survival especially how to provide food for the family.

Poverty and Unemployment

Unemployment is a major challenge in these communities. As much as 60% of those over 18 years in families interviewed do not have any form of employment in spite of the claims that a number of them have skills to be engaged. Some 43% of those interviewed have no savings and only 10% are able to save over N50,000 per annum.

Settlement and Housing

The Study area has a mixture of both traditional compounds and modern tenement and bungalow designs. Some 38% of the total respondents who own houses live in houses constructed of block with zinc roofing and 21% had mud houses with zinc roofing; 37% do not own houses. Cement plastered mud houses are common in the essentially rural settlements in Warri communities.

The housing style and design is largely in the form of traditional compound found in various towns and villages in the country. The primary unit of housing in project areas as in many other parts of Nigeria is the compound which varies from the simple rectangular buildings with rooms for lineage family members to more complex arrangement of a cluster or group of buildings around one or two large open spaces or courtyards. Majority of houses are of simple compounds with outhouse pit latrines and bathrooms usually covered with corrugated iron-sheets. The houses were usually common form.

Suffice it say that the compound and courtyard is an organic social that is the nucleus of family life and social intercourse including marriages, festivals, ancestral worship/rites/rituals, family meetings and children play ground/ moonlight stories.

<u>Communities Perceptions about the project</u>

The communities perceive that the project could have a beneficial effect on them in terms of employment opportunities (100%) and possible rental of houses during project period (4%). They do not anticipate much cultural/social impacts and noise nuisance from work machines and effects of wastes from the project site.

<u>Community Health Studies</u>

Disease Pattern in the Communities

The common diseases in the communities include malaria 75%, diarrhea diseases 41%, typhoid fever 18% and measles 9%.

Nutritional Status of Children Under Five Years

The dietary patterns of the communities consisted mainly of carbohydrates diet like cassava, rice, yam etc. the consumption of balanced diet limited by the income inflow into the households. The sources of proteins were fish, crayfish, beans etc.

Water Supply and Quality

The sources of water included: hand dug well, river and rain the communities do not treat their water before drinking.

Insect vectors and pests

The disease vectors and pests in the communities include cockroaches, rats, bedbugs, mosquitoes, sand flies, houseflies.

Sources of Waste and Disposal in Communities

The wastes generated in the study communities are from kitchen/domestic, human/animal, agricultural, commercial and trading activities **(Table 4.23).**

Wastes generated in the communities were disposed off in bushes and in some cases in designated open dumpsite. Kitchen and domestic waste were collected in baskets, old basins or buckets, nylon bags, which were kept near the kitchens or backyards and disposed when full.

Human fecal wastes were disposed off in pit latrines, water cisterns and the bush. There were no proper wastes recycling in the communities.

The overall level sanitation was observed to be good. The environment is swept and grasses cleared to ground level/packed and burnt.

Healthcare Facilities

The is no healthcare facilities in the community and the host community results to use of traditional medicine as well as travelling to Warri township as the case may be to consult public or private clinics/hospital.

Table 4.23: Types of Wastes Generated in the Communities

Waste Sources	Waste Types
Kitchen and domestic	Ashes, cassava peels, yam peels, food remains, rags, kitchen waste water, vegetable, fish and meat parts, coconut fruit barks, plates, polythene bags, plastic containers, sticks, wire gauze, paper, foot wears, deformed, Detergent containers.
Agricultural	Palm fronds, cassava tubers, sticks, palm kernel and coconut shells, sticks and baskets.
Commercial and trading	Papers and cartons, nylon bags, cans/tins, polythene bags, paper crates detergents packs, bottles, plastics
Human/Animal fecal waste	Excreta, Urine.

Source: EIA Field Survey of Matrix Tank Farm, September 2009

4.5.11 Air Quality Study

Air Quality Measurement Strategy

Sampling/measurement of atmospheric pollutants was carried out at designated seven sampling stations within the proposed project area. One of the sampling locations was created outside of the proposed project area to act as a control. The criteria for selecting the sampling sites, characteristics of the sampling sites (Table 4.24) and the air quality parameters measured are shown below:

- Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2)
- Carbon monoxide (CO)
- Total Volatile Organic Compounds (TVOC)
- Suspended Particulate Matter (SPM)

- Fine ($PM_{2.5}$) and Coarse (PM_{10}) Particles
- Hydrogen sulphide (H_2S)
- Noise

On site meteorological parameters measured include:

- Air Temperature
- Wind velocity and direction
- Relative humidity

Sampling Sites

The selection of the sampling sites was based on the following criteria;

- Accessibility
- Security of the operating staff and equipment
- Location of sensitive or vulnerable receptors relative to the location of the project.

The sampling sites and its characteristics are shown in Table 4.24.

Table 4.24: Sampling sites for air quality assessment

S/N	Site code	Coordinates	Elevation	Description
1.	EIA – AQ1	N05° 32.180’ E005° 41.388’	6m	By the jetty that is under construction, close to the project site.
2.	EIA – AQ2	N05° 32.266’ E005° 41.367’	8m	Project site
3.	EIA – AQ3	N05° 32.348’ E005° 41.316’	9m	Entrance gate to the project site.
4.	EIA – AQ4	N05° 32.333’ E005° 41.561’	15m	Ijala community – bordering the project area. A rural community
5.	EIA – AQ5	N05° 32.278’ E005° 41.617’	11m	Ijala community by NNPC fence.
6.	EIA – AQ6	N05° 32.260’ E005° 41.193’	9m	By Matrix gas, Aida energy, AYM Shafa farm tanks.
7.	EIA – AQ7	N05° 38.138’ E005° 46.288’	18m	Control site created off Warri – Sapele express way.

Methods of Sample Collection.

The ambient load of SPM, $PM_{2.5}$, PM_{10}, CO, NO_2, SO_2, H_2S, TVOC, Noise level and the meteorological parameters were surveyed in this study. Dry season air samples were collected in December 2019 and wet season samples in July 2020 at a height of about 1.5m above the ground level at each of the created sampling sites. For all of the pollution indicators, measurement was carried out using pre- calibrated hand- held meters which record in – situ levels of the parameters (Plate 4.3). The theoretical bases of the sampling approach are unique in each case and are discussed below:

Plate 4.3: Air sampling at the proposed project site

Noise level

A pre-calibrated BK Precision 732 sound level meter was used to measure the noise levels at all the sampling locations. The equipment measures noise level via a microphone probe that generates signals approximately proportional to located sound waves. Measurements were done by directing the probe towards the direction of the prevailing sound and the readings recorded from the digital meter in the decibel Db(A).

Suspended particulate matter (SPM), fine particulate matter ($PM_{2.5}$) and coarse particulate matter (PM_{10}).

Airborne suspended particulate matter (SPM) and the fine and coarse particulate matter concentrations were determined using Casella CEL 712 Micro dust sampler (Ukpebor et al. 2006, Mirmohammadi et al. 2016). It is capable of providing real time as well as gravimetric dust concentration. It has a sampling range of 0.001 mg/m^3 to 250 g/m^3. The sampling unit consists of a graphic display device attached to a probe. The probe works based on forward light scattering principles. Diffusion air passes through an inlet in the probe and particulate matter present in the air samples scatters a modulated laser light in the probe inlet. The amount of light scattering is correlated to the concentration of particulate matter present which is displayed on the screen. For the determination of the $PM_{2.5}$ and PM_{10} fractions, appropriate polyurethane filters were inserted in the instrument's probe to ensure the accurate determination of the dust size (Mirmohammadi et al. 2016).

Nitrogen dioxide (NO_2)

A portable Crowcon Gasman toxic gas detector (model 19849H) was employed in the measurement of NO_2 concentration. This hand- held meter houses a sensor that uses an electrochemical sensing element constructed from a sensing electrode, a reference electrode to produce electrons. A built in circuit amplifies the signal into a millivolt output. This NO_2 sampler has a detection range of 0 to 100 ppm, response time of 30 seconds and accuracy of ±1 ppm. At each of the sampling spot, NO_2 concentration was obtained by holding the sampler to a height of about 1.5 meters and readings recorded at stability. Readings were recorded every 30 minutes for 8 hours at each of the sampling location.

Sulphur dioxide (SO_2)

The ambient levels of SO_2 at the different sampling locations were obtained by using a hand – held meter Crowcon Gasman toxic gas detector (Model 19647H). This meter has an inbuilt sensor that uses electrochemical sensing element constructed from a sensing electrode, a reference electrode and a counter electrode. SO_2 gas diffusing into the sensor reacts with the special catalysed sensing electrode to produce electrons. A built – in circuit amplifies the signal into a millivolt output. This sampler has a response time of 20 seconds, accuracy of ±1 ppm and a detection range of 0 to 100 ppm. The ambient load of SO_2 at each of the sampling locations was obtained by holding the sampler to a height of about 1.5meters and readings recorded at stability. 8 hours sampling duration was observed at each site with readings recorded every half – hour.

Carbon monoxide (CO)

The CO concentrations were measured using a CO dosimeter (CEM CO – 180 Carbon monoxide meter). This sampler has a range from 0 to 1000ppm with a sensitivity of 1 ppm, an accuracy of ±5% and operating temperature from 0^oC

to 50^oC and operating relative humidity from 0 to 99%. It is equipped with a sensor which has an electrochemical sensing electrode and a counter electrode. The sensor has a permanent irreplaceable filter built inside the sensor to filter out trace concentrations of SO_2, NO_2 and most hydrocarbons. The CO being diffused into the sensor reacts with the special catalysed sensing electrode to produce electrons. A built in circuit amplifies the signals into a millivolt output which is displayed on a liquid crystal display (LCD) panel as CO concentration in ppm. The CO monitor was calibrated before deployment and during the monitoring campaign by ensuring that the zero and the span of the dosimeter were checked at regular intervals using zero air and a standard CO concentration. This sampling approach has been used by several authors (Wan-Kuen and Joan-Yeob 2006, Ukpebor et al. 2010) because of the following positive attributes; low cost, high accuracy and sensitivity, no special training sensing electrode to produce electrons. A built in circuit amplifies the signals into a millivolt output. This sampling unit has an operating range of 0 to 500 ppm and a relative humidity of 15 – 90%. The same sampling duration and height as observed for before usage, direct read – out, wide spatial coverage and non – dependence on electricity.

Wind speed

The wind speed was measured using LT Lutron – 8000 Anemometer. The anemometer reads the wind speed in meters per second (m/s).

Humidity

Hair hygrometer with a range of 0 – 100% was used in measuring the relative humidity.

Temperature

The prevailing temperature was measured a thermometer with a range of 0 – 100^{o}C.

4.5.12 Climate, Meteorology, Ambient Air Quality and Noise

Long term historical data from Nigeria Meteorological Agency (NIMET) and the data acquired during the fieldwork micro – climatic study were employed in characterizing the climate of the study area. The results of the Meteorological data, measured Air quality indicators and noise levels recorded during the full - scale (dry and wet season) EIA study are shown in Tables 4.25A – 4.26B.

Climate and Meteorology

The proposed project area is located within the equatorial belt that experiences rainfall for most part of the year. The climate typifies that of the humid tropics, characterized with tropical wet and semi-hot equatorial climate with high solar radiation. In addition to these are heavy precipitation, light winds, and low atmospheric pressure. This climate is governed by the prevailing (seasonal) wind, latitude, apparent movement of the sun across the tropics and relative stability of the Inter Tropical Discontinuity (ITD) in the area (Ojo, 1977). The two dominating air masses are the drier Tropical Continental from across the Sahara in the North and the humid Tropical Maritime from across the Atlantic

Ocean in the South. The Inter-Tropical Discontinuity (ITD) which separates them oscillates seasonally, but lies permanently north of the study area.

Ambient Air Temperature

As expected for a tropical climate, relatively high ambient atmospheric temperatures were measured during the sampling exercise in both dry and wet seasons. In the dry season a temperature range of 26.0^{o}C – 35.1^{o}C was obtained at the sampling stations with a mean of 30.8^{o}C at the control station (Table 4.25A). The maximum atmospheric temperature recorded at the sampling stations in the wet season was 32.60°C, while the minimum was 28.0°C (Table 4.25B). In a previous EIA study in the environment under assessment (Seplat, 2019), wet season mean atmospheric temperature of 29.7°C was reported. High atmospheric temperatures accelerate the formation of photochemical oxidants such as Peroxylacenitrate (PAN) and Troposphere ozone (O_3). The high ambient air temperature levels recorded in this study are typical of tropical environments (Ayoade, 2004). Due to the depletion of incoming solar radiation by greater cloud cover, temperature values are slightly lower during the wet season (Oguntoyibo, 1982).

Table 4.25A: Measured meteorological parameters at the project area in the dry season.

Parameters	Sampling stations			Control site		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean
Temperature (°C)	35.1	26.0	32.2	34.8	26.9	30.8
Humidity (%)	80.0	58.4	66.3	79.1	59.4	65.6
Wind speed (m/s)	3.7	0.1	1.7	2.8	0.1	1.3
Predominant wind direction	NE					

Table 4.25B: **Measured meteorological parameters at the project area in the wet season**

Parameters	Sampling stations			Control site		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean
Temperature (°C)	32.6	28.0	30.5	30.4	29.6	30.0
Humidity (%)	79.1	67.5	73.5	73.5	67.7	72.1
Wind speed (m/s)	2.8	0.1	1.3	2.0	0.7	1.1
Predominant wind direction	SW					

Wind Speed and Direction

The atmospheric concentrations and spatial distributions of air pollutants are influenced largely by the prevailing wind speed and direction. High wind velocities enhance the dilution and dispersion of the emitted pollutants. During this field exercise, low wind velocities were recorded all year round with a maximum of 3.7 m/s and a minimum of 0.1 m/s at the sampling stations in the dry season (Table 4.25A). In the wet season, the wind speed varied from 0.1 – 3.7 m/s at the sampling stations and a mean of 1.3 m/s at the control site (Table 4.25B). A mean wet season wind speed of 1.1m/s had recently been reported for the environment under assessment (Seplat, 2019). At all the created stations, the predominant wind direction was expectedly northeasterly in the dry season and southwesterly in the wet season.

The long-term wind distribution data retrieved and analyzed for the study area (2004 - 2010) shows that the wind blows generally from the South-westerly (SW/S/W) direction, calm periods are not frequently observed. Information on frequency distribution of wind speed and direction is important since it provides the basis for accurate estimation of the dispersion patterns of pollutants in the atmosphere.

The observation that South-westerly wind predominates in the wet season is in consonance with the climatic wind data for the area. Relatively weaker north-easterly wind has been observed at this region during the dry season. Wind directions were generally south-westerly and north-easterly (Figure 4.1).

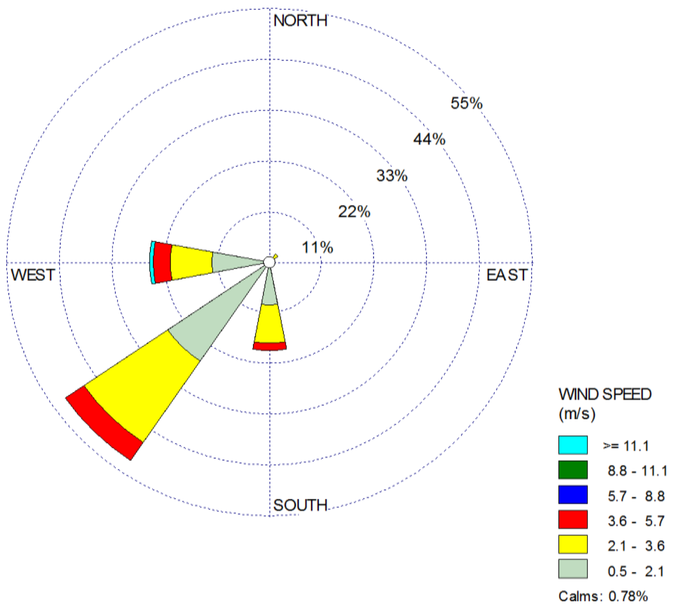


Figure 4.2F: **Wind Speed and Prevailing Direction in the Study Area (NIMET, 2015)**

Relative Humidity

This expresses the amount of the moisture content in the atmosphere. During this study, a relatively humid atmosphere was observed with a humidity range of 58.4 – 80.0% at the proposed project area in the dry season (Table 4.25A) and a range of 67.5 – 79.1% in the wet season (Table 4.25B). A wet season humidity range of 51.4 – 74.9% (Seplat, 2019), had been reported for the environment recently. A humid atmosphere enhances the wet deposition of the emitted pollutants from the atmosphere and might be partly responsible for the low concentrations of the gaseous air pollutants reported in this study.

Annual relative humidity average for the project area represented by data from Warri Synoptic Station (1991-2012) is presented in Figure 4.2F. The data shows that relative humidity values are high all year round at an average of 78.5%, which is typical of equatorial climate. Humidity values naturally exceed

85% during the rainy season under the influence of the moisture laden Tropical Maritime air mass. The daily variation of relative humidity is intricate. Usually it is highest in the morning and drops to a low value just by noon.

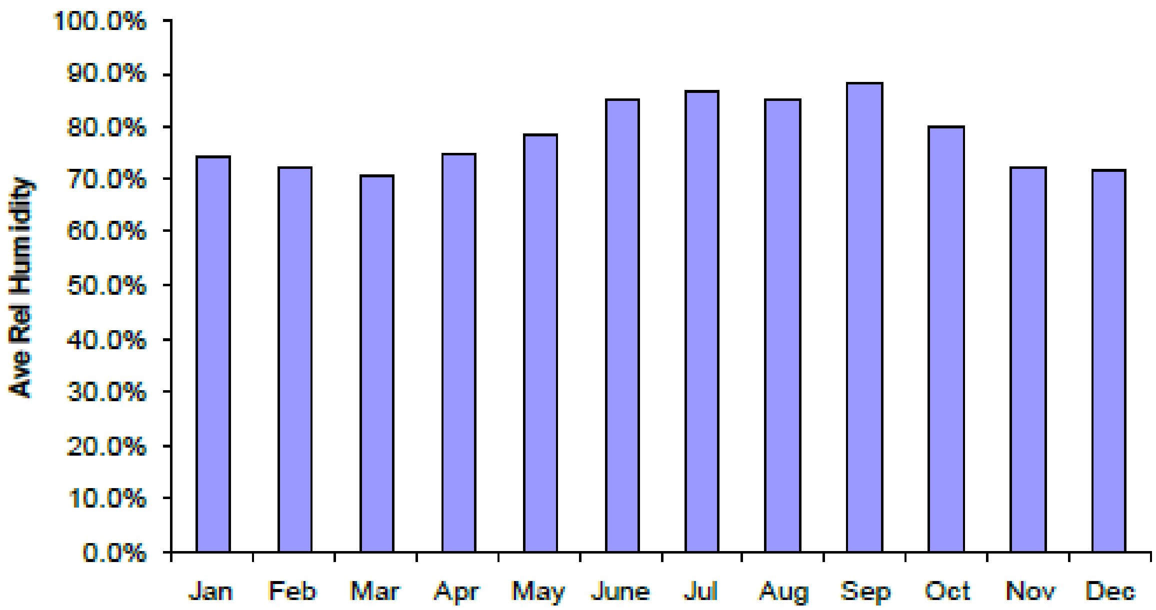


Figure 4.3A: **Average Relative Humidity for Warri Synoptic Station (1991-2012)**

Rainfall Pattern

At the Gulf of Guinea, rainfall is abundant all year-round without a marked dry season. At higher latitudes, precipitation decreases and is limited to a wet season of decreasing duration. Rainfall is experienced for about eight to ten months in the study area with peaks in July and September and lower amounts of rainfall from November to February. Data gathered from the area also shows that the mean annual rainfall often exceeds 2500mm. Available data from the Warri Meteorological Station, suggests a mean annual rainfall in excess of 2700mm for the region. The mean annual rainfall is above 2700mm due to the area’s location within the sphere of the Atlantic Ocean from which the southwest trade winds bring moisture laden air. The average monthly rainfall as recorded at the Warri Meteorological Station is presented in Figure 4.2B. The Figure shows that over 90% rainfall is recorded between the months of March and November. Rainfall in the area has a typical bimodal distribution which peaks in July, drops slightly in August, rises again in September and drops-off. It should be noted that rainfall is very important in air pollution studies because of its ability to cause wet deposition i.e., washing away pollutants from the atmosphere and depositing on land and water. Rains can create acid precursors in the air to form acid rain, which could be harmful to humans, plants, animals and the environment in general.

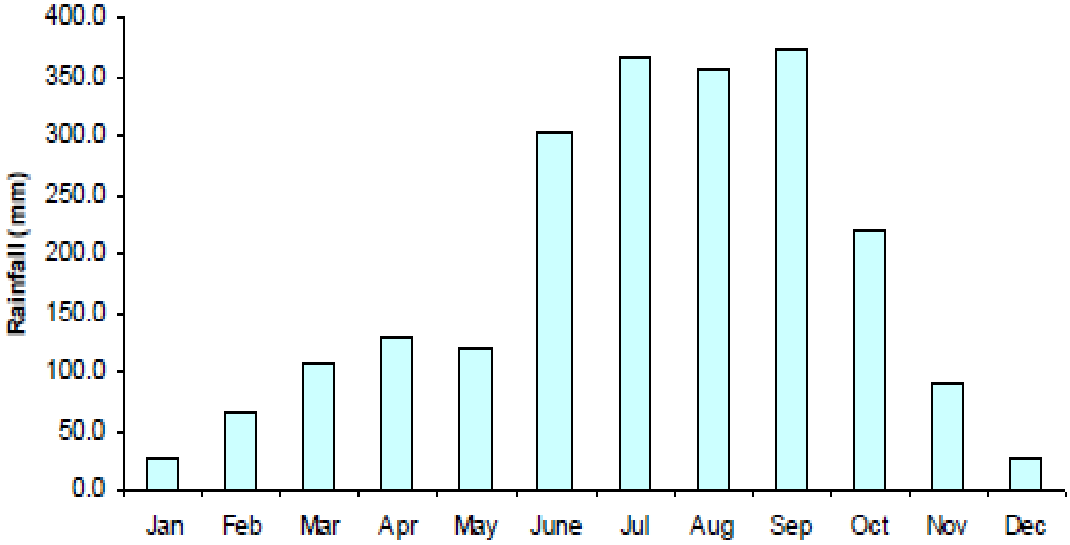


Figure 4.2B: **Average Monthly Rainfall distribution for Warri Synoptic - Station (1991-2012)**

Statistical Analysis

Many statistical tools were employed- Range, mean, standard deviation was used to describe the data while ANOVA was used to test for significant differences in the measured air quality parameters and their spatial distribution. The results of the statistical analyses are presented in appendix 1.

Air Quality Data Discussion

Suspended Particulate Matter (SPM): Airborne particles are regarded as criteria air pollutants because of their established deleterious health impacts in the literature (Manahan, 2017). Particulate air pollution is a mixture of solid, liquid or solid and liquid particles suspended in the air (Ukpebor et al., 2006). It is the most conspicuous form of air pollution in Nigeria (Akeredolu, 1989). Atmospheric particles inhaled through the respiratory tract may damage health, and exposure to particles in the atmosphere has been linked to a number of health effects including aggravated asthma and premature death from heart and lung disease (Manahan, 2017). In this study, relatively elevated concentrations of airborne particles were measured at the created sampling sites and control site in both seasons. In the dry season, SPM range of 38.8 – 84.0 µg/m^3 was measured at the sampling stations (Table 4.26A), with a mean of 37.2 µg/m^3 at the control station. Similar distributions were obtained in the wet season with averaged SPM levels of 40.2 µg/m^3 and 66.0 µg/m^3 (Table 4.26B) at the sampling and control stations respectively. At all the sampling sites (including the control), the FMEnv SPM regulatory limit of 250 µg/m^3, was complied with. Spatial variations in the measured SPM data, was found to be statistically significant ($p<0.05$) (Appendix 1) in both seasons. Furthermore, the dry season SPM concentrations were found to be statistically significantly higher ($p<0.05$) than the wet season data, though they were all within the national threshold limit.

Fine ($PM_{2.5}$) and Coarse (PM_{10}) Particulate Fractions: The health impacts of airborne particles in humans, depend on the particle size, concentration and composition (WHO 2003). Particle sizes of health concern are the $PM_{2.5}$ (particles with aerodynamic diameter <2.5 µm) and PM_{10} (particles with aerodynamic diameter between 2.5 and 10 µm). There are no national regulatory limits for these particle fractions (Tables 4.28 and 4.29). However, the WHO limits for $PM_{2.5}$ and PM_{10} are 25 µg/m^3 and 50 µg/m^3 respectively. During the dry season fieldwork, the baseline $PM_{2.5}$ concentration was found to vary from 19.6 – 24.6 µg/m^3, while PM_{10} concentration varied from 22.6 – 29.8 µg/m^3 (Table 4.26A). In the wet season, the mean concentrations of $PM_{2.5}$ and PM_{10} were 22.6 µg/m^3 and 24.6 µg/m^3 respectively (Table 4.26B). Quite remarkably, at all the created sampling and control site, the annual mean concentrations of $PM_{2.5}$ and PM_{10} were within the available WHO limits. Health impacts of elevated $PM_{2.5}$ and PM_{10} are cardiopulmonary diseases (Bauer et al., 2010; Thurston et al., 2016) in both short – and long term exposures scenarios. Just like the SPM, spatial variations in the fine and coarse fractions, were found to be statistically significant ($p< 0.05$) (Appendix 1). However, there were no temporal (seasonal) variations in the $PM_{2.5}$ and PM_{10} data.

Table 4.26A: Dry season measured Air Pollution indicators and noise levels during the EIA

Parameter	Sampling stations						Control station	DPR Limit	FMENV Limit
	EIA-AQ1	EIA-AQ2	EIA-AQ3	EIA-AQ4	EIA-AQ5	EIA-AQ6	EIA-AQ7		
SPM ($\mu g/m^3$)	52.8	54.4	84.0	38.8	42.0	76.0	37.2	NA	250
$PM_{2.5}$ ($\mu g/m^3$)	21.4	24.6	22.8	22.2	19.6	23.2	20.8	NA	NA
PM_{10} ($\mu g/m^3$)	22.6	23.6	29.0	28.2	24.8	29.8	25.6	NA	NA
NO_2 (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	50 **$\mu g/m^3$**	0.04- 0.06
SO_2 (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	125 **$\mu g/m^3$**	0.1
TVOC (µg/m3)	154.0	146.0	696.0	164.0	168.0	318.0	162.0	NA	160
CO (ppm)	1.4	1.6	1.8	1.4	1.6	1.0	1.4	9	10
H_2S (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NA	NA
Noise level (dB(A))	59.3	57.4	55.4	55.1	48.9	77.7	47.2	85	90

NA: Not available. 0.1 = detection limit for SO_2, NO_2 and H_2S samplers

Table 4.26B: Wet season measured Air Pollution indicators and noise levels during the EIA

Parameter	Sampling stations						Control station	DPR Limit	FMENV Limit
	EIA-AQ1	EIA-AQ2	EIA-AQ3	EIA-AQ4	EIA-AQ5	EIA-AQ6	EIA-AQ7		
SPM ($\mu g/m^3$)	35.2	79.0	17.8	40.8	26.8	41.6	66.0	NA	250
$PM_{2.5}$ ($\mu g/m^3$)	7.6	35.0	14.0	20.6	13.8	44.8	12.8	NA	NA
PM_{10} ($\mu g/m^3$)	10.2	38.2	14.4	20.6	14.4	50.2	13.2	NA	NA
NO_2 (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	50 $\mu g/m^3$	0.04- 0.06
SO_2 (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	125 $\mu g/m^3$	0.1
TVOC (µg/m3)	165.4	170.0	174.6	157.8	144.0	803.6	515.8	NA	160
CO (ppm)	1.4	1.4	1.0	1.2	1.4	1.8	1.2	9	10
H_2S (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NA	NA
Noise level (dB(A))	58.2	62.1	53.8	53.0	49.5	65.3	53.2	85	90

NA: Not available. 0.1 = detection limit for SO_2, NO_2 and H_2S samplers

Table 4.27: Summary of measured air pollutants and noise levels during the EIA

Parameter	Sampling stations				Annual mean	Control stations				Annual mean	DPR Limits	FMENV Limits
	Dry season		Wet season			Dry season		Wet Season				
	Range	Mean	Range	Mean		Range	Mean	Range	Mean			
SPM (µg/m^3)	38.8 – 84.0	54.0	17.8 – 79.0	40.2	49.1	37.2	37.2	66.0	66.0	51.6	NA	250
$PM_{2.5}$ (µg/m^3)	19.6 – 24.6	22.3	7.6 – 44.8	22.6	20.8	20.8	20.8	12.8	12.8	16.8	NA	NA
PM_{10} (µg/m^3)	22.6 – 29.8	26.3	10.2 – 38.2	24.6	25.5	25.6	25.6	13.2	13.2	19.4	NA	NA
SO_2 (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	125 **µg/m^3**	0.1
NO_2 (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	50 **µg/m^3**	0.04 – 0.06
TVOC (ppm)	146.0 -696.0	269.2	144.0 – 803.6	274.3	271.8	162.0	162.0	515.8	515.8	338.9	NA	160
CO (ppm)	1.0 – 1.8	1.5	1.0 – 1.8	1.4	1.5	<0.1	<0.1	0.21 – 0.28	0.24	0.12	9	10
H_2S (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NA	NA
Noise level (dB(A))	48.9 – 77.7	59.0	49.5 – 65.3	57.0	58.0	47.2	47.2	53.2	53.2	50.2	85	90

NA: Not available. 0.1 = detection limit for SO_2, NO_2 and H_2S samplers

Sulphur dioxide (SO_2): Sulphur dioxide is a respiratory irritant and one of the killer constituents of classical smog. It is also an acid rain forming gas. In this EIA, the baseline concentrations of SO_2 were below the equipment detection limit of 0.1 ppm and by implication, the FMEnv limit of 0.1 ppm at all the created sampling sites. Naturally, SO_2 is emitted from volcanic eruption, while 80% of all SO_2 emissions from anthropogenic sources come from coal combustion (UNEP 1983).

Nitrogen dioxide (NO_2): Nitrogen dioxide is one of the criteria air pollutants for assessing air quality. It is also the precursor gas for troposphere ozone formation which is a greenhouse gas. Furthermore, it leads to stratospheric ozone depletion (ozone hole) (Manahan 2017). The main anthropogenic source of NO_2 in the atmosphere is vehicular exhaust (Air Quality Fact Sheet 2005), and as expected therefore, NO_2 was not detected (concentration less than 0.1ppm the detection limit of the sampler) at any of the sites (Tables 4.3a and 4.3b) due to low traffic volume.

Carbon Monoxide (CO): Carbon monoxide is another criteria air pollutant. In the environmental parlance, CO is regarded as a “silent killer” because it is colourless, odourless, tasteless, but highly toxic (Ukpebor et al., 2010). Long – term (chronic) exposure to low levels of CO may produce heart disease and damage to the nervous system (Henry et al., 2006). In this fieldwork, relatively low concentrations of CO were measured with the same mean range of 1.0 – 1.8 ppm in both dry and wet seasons (Table 4.4). The FMEnv and WHO regulatory limits were perfectly complied with. Spatial and temporal variations in the CO data generated were statistically insignificant ($p>0.05$) (Appendix 1). The low CO level measured in this study is expected because CO is like NO_2; traffic related air pollutants. The CO data reported in our study are consistent with CO data captured previously in the project area (Seplat 2019).

Hydrogen Sulphide (H_2S): Hydrogen sulphide is a non – criteria air pollutant because its health impact is still in the realm of speculations. Consequently, H_2S has no national or international regulatory limits. However, it is routinely studied during EIAs due to its potential health challenges. The concentrations at which H_2S was present in the area under study were too low to be measured by the sampler which operated at a detection limit of 0.1 ppm (Tables 4.26A and 4.26B).

Total Volatile Organic Compounds (TVOC): Volatile organic compounds are compounds of carbon (both hydrocarbons and oxygenated organic compounds), sharing the same characteristic of high volatility. Currently there are more than 300 different kinds of VOCs that can be detected experimentally. The FMEnv threshold limit for VOC is 160 µg/m^3. At all the created sampling stations, inclusive of the control site, the above regulatory limit was violated in both dry and wet seasons (Tables 4.26A and 4.26B). The TVOC levels measured in this study ranged from 146.0 – 696.0 μg/m^3 at the sampling stations, with a mean of 162.0 μg/m^3 at the control site, in the dry season (Table 4.4). During the wet season fieldwork, the averaged VOC concentrations were 274.3 μg/m^3 and 515.8 μg/m^3 at the sampling and control stations respectively (Table 4.27). Statistically significant spatial variations ($p<0.05$) were observed in the VOCs distributions in the project area at both seasons, with locations (EIA – AQ3 and EIA – AQ6) close to the numerous farm tanks that adorn the area recording the highest levels. Fugitive hydrocarbon emissions from the numerous hydrocarbon tanks within the study area are responsible for the highly enriched VOC emissions in the environment under assessment. Seasonal variations in the obtained VOC data were statistically insignificant ($p>0.05$) (Appendix 1). Health effects from short-term exposure to VOCs include irritation of the eyes and respiratory tract, headaches, dizziness, visual disorders and nausea. Long-term exposure could lead to damage to liver, kidney and central nervous system (USEPA 2017).

Noise level: The baseline noise data measured in this study are shown in Tables 4.26A and 4.26B. A mean noise level range of 48.9 – 77.7 dB(A) was reported for the created sampling sites in the dry season and a variation of 49.5 – 65.3 dB(A) in the wet season (Table 4.27). A perfect compliance with the FMEnv and DPR occupational noise limits of 90 dB(A) and 85 dB(A) respectively and the WHO noise limit of 55 dB(A) for residential areas, was observed in this study. Independently, excessive noise increases risk of annoyance, cardiovascular disorders, and cognitive impairments and is a suspected risk factor for other mental health conditions such as anxiety and depression (WHO, 2011; Basner et al., 2013). Statistically significant spatial variations ($p<0.5$) were observed in the captured data, with the highest noise levels measured at the location (EIA – AQ6) created close to the farm tanks at both seasons. Insignificant temporal variations ($p>0.05$) were observed in the generated noise data.

Table 4.28: Nigeria Ambient Air Quality Standard

Pollutants	Time of Average	Limit
Particulates	Daily average of hourly values Hourly value	250µg/m^3 600*µg/m^3
SOx as SO_2	Daily average of hourly values Hourly value	0.01ppm (26µg/m^3) 0.1ppm (260µg/m^3)
NOx as NO_2	Daily average of hourly values (range)	0.04–0.06ppm (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	0.66ppm
Non-Methane hydrocarbon	Daily average of 3-hourly values	160µg/m^3

*Note: Concentration not to be exceeded for more than once a year. ***Source: FMEnv.*** 1991

Table 4.29: WHO Air Quality Guidelines

Pollutants	**Time- Weighted Average[a]**	**Average Time**
SO_2	500 300 100 - 150[b] 40 - 60[b]	10min 1h 24h 1yr
CO	30 10	1h 8h
NO_2	400 150	1h 24h
Total suspended particulates	150 - 230[b] 60 - 90[b]	24hr 1yr

Source: **SPDC 2001; [a]All concentrations in µg/m^3 except CO in mg/m^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).**

Table 4.31: DPR National Air Quality Guidelines for Maximum Exposure

POLLUTANT	1-Hour Mean ($\mu g/m^3$)	8-Hour Mean ($\mu g/m^3$)	Daily Average/ Mean ($\mu g/m^3$)	Annual ($\mu g/m^3$)
Carbon Monoxide*	3×10^4	1×10^4		
Sulphur Dioxide			125	60
Nitrogen Dioxide*	200			50
Lead				1.0
Ozone		120		

Source: EGASPIN, 2018; *Not to be exceeded

Table 4.31: Noise Exposure Limits for Nigeria

Duration Per day, hour	Permissible Exposure Limited dB(A)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Source: FEPA (1991)

4.5.13 Fish and Fisheries

Introduction

The industrialization, oil bunkering, oil exploration, technological advancements affects the water quality of the River bodies in the Niger Delta, including the Warri River which is the site for this Environmental Impact Assessment. This is due to the build-up of pollutants in these water bodies that adversely affect the fisheries resources (Aghoghovwia, 2008).

Materials and Methods

The study area was Warri River in Delta State within Latitude 5^{o} 24'-6^{o} 2N and Longitude 5^{o} 24'-6^{o} 2'E. Fishes were collected from fish sellers who bought from fisherfolks, who caught the fishes with nets such as long lines, fish traps, hollow cylinders and set hook and lines. The fish species were identified to species level using keys and descriptions of Boulenger, 1916; Holden and Reed, 1974; FAO Species Identification Sheets for Fishery Purposes (Fischer *et al.,* 1981); Powell (1982). The weights of the fish was measured to the nearest 0.1g using a Mculer E-200 Top loading balances and the lengths measured to 0.1cmusing a measuring board. Food and feeding habits was determined using frequency of occurrence method which is the number of times a particular food items occurred in the stomach is counted and expressed as a percentage of the total number of stomachs with food. The condition factor (CF) for the fish which is an index of the degree of fatness or wellbeing of species of fish. The CF is described by;

$$K(CF) = \frac{100W}{L^3}$$

Where W=weight (g)

L= standard length (cm)

Results and Discussion

Species Diversity of Warri River

Five fin species of fishes belonging to four families in the 1st season and Eight fin fishes belonging to Seven families in the 2nd season and four shell fish species belonging to two families were identified during this study for the dry and wet seasons respectively as shown in Tables 4.32A and 4.32B. The increasing pollution in the Niger Delta zones a result of industrialization and oil exploration etc. affects the aquatic communities including fishes. The number of fish species recorded in this study is very low when compared with 91 species earlier reported by Agada (1994), Okumagba (1987), Dibia (1989) and Aghoghovwia (2008). The reduction in the number of fish species and what appeared to be an extinction of some fish species may be an indication of community changes which result from habitat alteration. Fish species that cannot withstand environmental condition may die or migrate to elsewhere, while those that are hardy enough survives.

Table 4.32: Species Checklist in Warri River 1st Season (Dry Season)

Family	Species	Common Name	No	%No
Finfishes				
Bagridae	*Chrysichthysfuscatus* *C. nigrodigitatus*	Silver Catfish Silver Catfish	3 6	4.35 8.70
Cichlidae	*Tilapia mariae*	Black Mangrove Fish	3	4.35
Centropomidae	*Latesniloticus*	Niger/Nile Perch	2	2.90
Notopteridae	*Papyrocranusafer*	Feather back	1	1.45
Total			**15**	**21.74**
Shellfishes				
Palaemonidae	*Macrobrachiummacrobrachion* *M. vollenhovenii* *P. elegans*	Brackish water prawn Freshwater prawn Freshwater prawn	9 35 4	13.04 50.72 5.80
Portunidae	*Callinectespallidus*	Brackish water crab	6	8.70
Total			**54**	**78.26**
Grand Total			**69**	**100**

Table 4.33: Species Checklist in Warri River 2nd Season (Wet Season)

Family	Species	Common name	No	% No
Finfishes				
Bagridae	*Chrysichthysfurcatus*	Silver catfish	4	7.27
	Bagrusdocmacniger	Silver catfish	1	1.82
Cichlidae	*Oreochromisniloticus*	Nile Tilapia	3	5.45
Centropomidae	*Latesniloticus*	Niger/Nile perch	1	1.82
Cyprinidae	*Barbuscallipterus*	Barb	1	1.82
Distichodontidae	*Distichodusrostratus*	Distichodid/Grasseater	3	5.45
Mochokidae	*Synodontisvermiculatus*	Catfish	1	1.82
Pantodontidae	*Pantodonbucholzi*	Butterfly fish	2	3.64
Total			**16**	**29.09**
Shellfishes				
Palaemonidae	*Macrobrachiummacrobrachion*	Brackish water prawn	5	9.09
	M. vollenhovenii	Freshwater prawn	22	40
	Palaemonelegans	Freshwater prawn	6	10.91
Portunidae	*Callinectespallidus*	Brackish water crab	6	10.91
Total			**39**	**70.91**
Grand Total			**55**	**100**

Table 4.34A: Length-Weight Relationship Parameters of fishes from Warri River 1st Season (Dry)

	A	B	r^2	Total Length	Weight (g)
Fin fishes	-0.3045	1.91	0.3597	17.6-50cm	61-615
Prawns	-0.766	1.84	0.6045	8.0-11.2mm	9-28
Crab	0.6546	1.24	0.8016	10.5-12.5mm	78-100

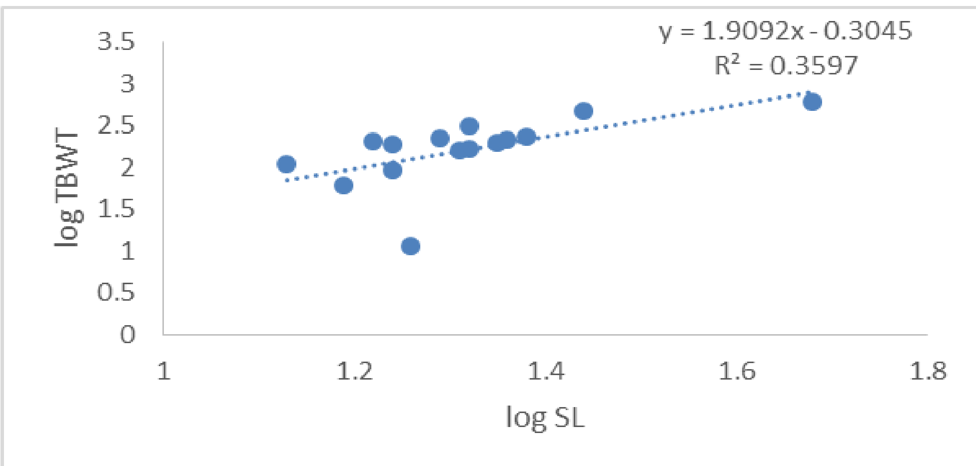


Figure 4.4A: Length and weight relationship of Fin fishes from Warri River 1st Season (Dry)

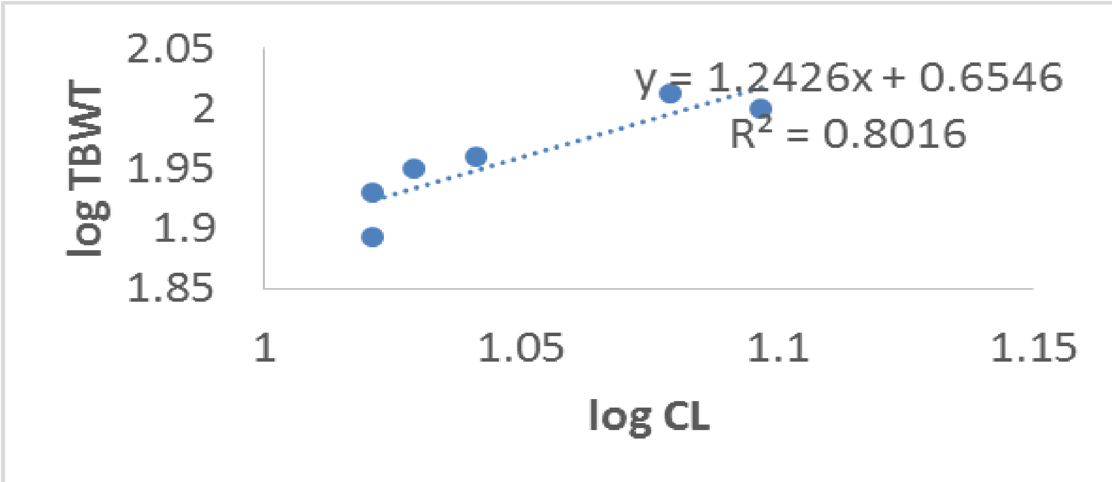


Figure 4.4B: Length and weight relationship of Crab (*Callinectespallidus*) from Warri River 1st Season (Dry)

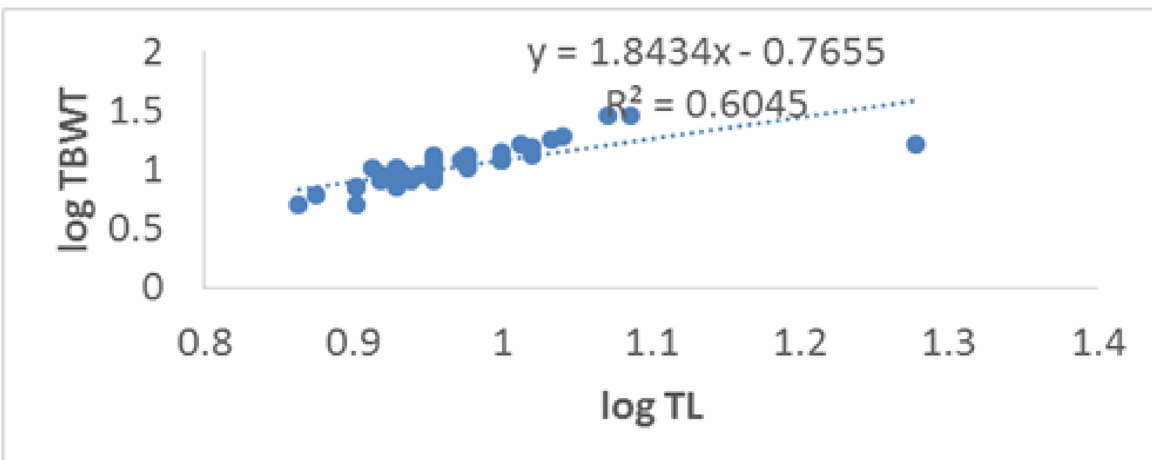


Figure 4.4C: Length and weight relationship of prawns from Warri River 1st Season (Dry)

Table 4.34B: Length-Weight Relationship Parameters of fishes from Warri River 2^{nd} Season (Wet)

	A	B	r^2	Total Length	Weight (g)
Fin fishes	-0.7561	2.36	0.6354	21-53.5cm	45-900
Crabs	-1.485	3.304	0.943	9.2-11.5mm	50-100
Prawns	-0.4502	3.38	0.920	5-10.55mm	78-100

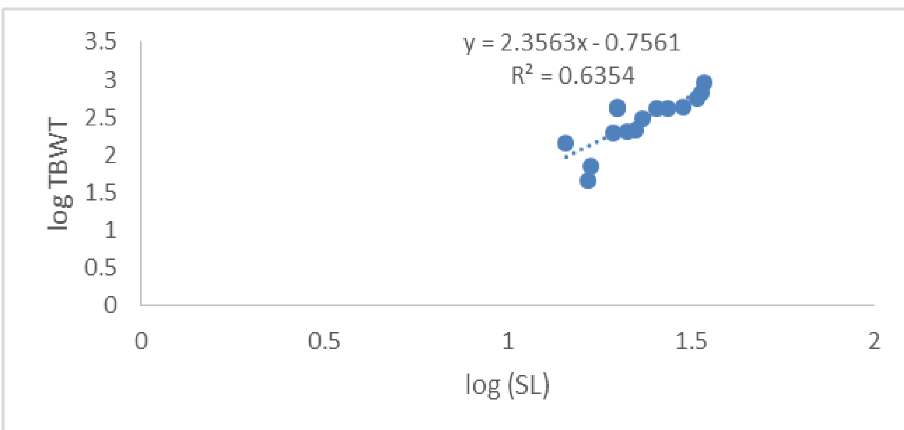


Figure 4.4E: Length and weight relationship of Fin fishes from Warri River 2^{nd} Season (Wet)

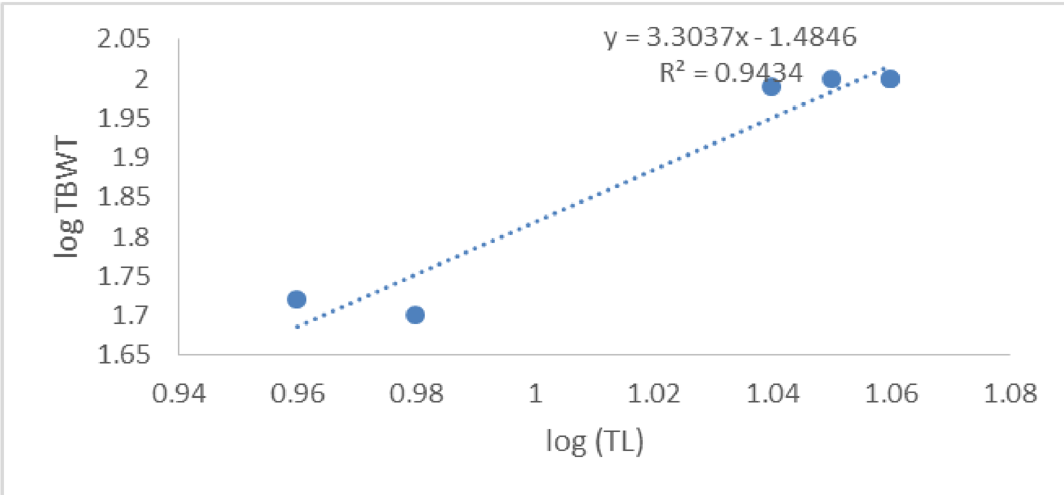


Figure 4.4E: Length and weight relationship of Crab (*Callinectespallidus*) from Warri River 2nd Season (Wet)

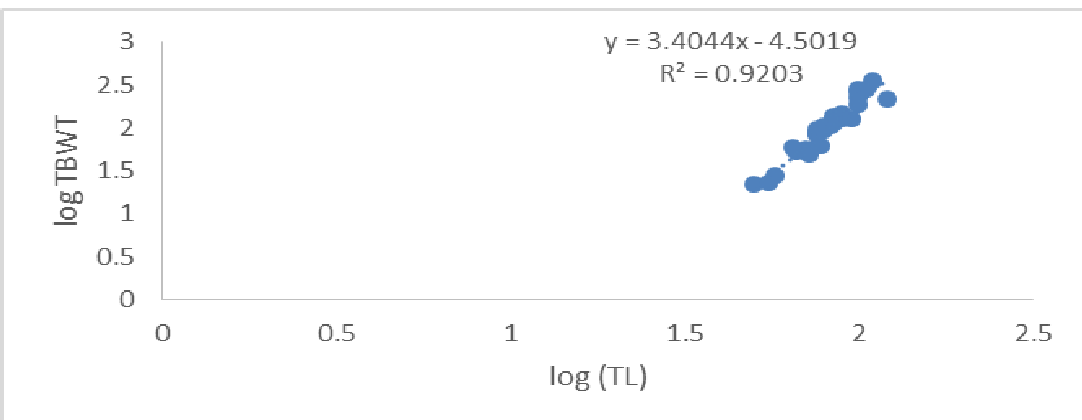


Figure 4.4F: Length and weight relationship of prawns from Warri River 2nd Season (Wet)

Table 4.35A: Condition Factor of the fish species from Warri River 1st Season (Dry)

Species	Condition Factor
Latesniloticus	3.14
Tilapia mariae	4.24
Chrysichthysfuscatus	2.28
Chrysichthysnigrodigitatus	1.83
Macrobrachiummacrobrachion	1.27
Macrobrachiumvollenhovenii	1.43
Palaemonelegans	1.80
Callinectespallidus	1.84

Table 4.35B: Condition Factor of the fish species from Warri River 2nd Season (Wet)

Species	**Condition Factor**
Chrysichthysfurcatus	1.77
Bagrusdocmacniger	1.76
Oreochromisniloticus	5.06
Latesniloticus	4.50
Barbuscallipterus	2.63
Distichodusrostratus	2.43
Synodontisvermiculatus	0.97
Pantodonbucholzi	1.89
Macrobrachiummacrobrachion	2.02
M. vollenhovenii	1.91
Palaemonelegans	2.64
Callinectespallidus	6.87

Table 4.36A: Food and Feeding Habits of Species Encountered in Warri River 1st Season (Dry)

Species	Food Items in stomach	Feeding Habits
Latesnilotius	Whole fish, fish parts e.g. Scales and fins	Carnivore
Tilapia mariae	Algae, detritus and higher plants and fish scales.	Mainly Plantivore
Chrysichthysfuscatus	Detritus, mud, algae, diptera and coleopteran larva.	Omnivore; Bottom feeder
Chrysichthysnigrodigitatus	Larvae of coleopteran, Trichoptera, nymphs of odonata, fish species, eggs, remains of crustaceans, bivalves, algae, seeds, fruits, detritus and sand.	Omnivore
Papyrocranusafer	Aquatic insects and terrestrial insects that falls into water.	Mesopredator
Macrobrachiumsp and P. elegans	Larvae, insects, detritus, molluscs, algae and crustaceans.	Omnivore
Callinectespallidus	Fishes, molluscs, higher plants, algae, sand grains and crustaceans.	Omnivore and an opportunistic feeder

Table 4.36B: Food and Feeding Habits of Species Encountered in Warri River 2nd Season (Wet)

Species	Food Items in Stomach	Feeding habits
Chrysichthysfurcatus	Algae coleopteran larva Mud and Detritus.	Omnivore and Bottom feeder
Bagrusdocmacniger	Mainly Fishes, prawns and insects.	Carnivore
Oreochromisniloticus	Algae, diatoms, insect larvae (chironomids), fish eggs, fry of fish and detritus.	Omnivore
Latesniloticus	Whole fish, fish parts e.g. Scales and fins	Piscivore
Barbuscallipterus	Zooplankton (mostly ostracods), insect larvae, terrestrial insects, detritus and sand grains.	Bottom feeder
Distichodusrostratus	Algae, diatoms, aquatic vegetation, mud and detritus.	Manly Herbivorous
Synodontisvermiculatus	Mainly detritus and insect larvae	Detritivore
Pantodonbucholzi	Mainly insects; plant materials	Insectivore
*Macrobrachium*sp and *P. elegans*	Larvae, insects, detritus, molluscs, algae and crustaceans.	Omnivore
Callinectespallidus	Fish parts, molluscs and crustaceans, plants, algae and sand grains.	Omnivore and opportunistic feeder

Figures 4.4A-4.4F and Tables 4.34A and 4.34B showed the length-weight relationships for fin fishes, crabs and prawns.

A significant linear relationship was established except for that of fin fishes in the 1st season. The value of correlation coefficient “r^2” for finfish was 0.64 for wet season; prawn were 0.60 and 0.92; crabs was 0.80 and 0.94 for dry and wet seasons respectively which showed very high positive correlation between the length and weight of these organisms. The growth pattern was negative allometric for most of the fishes except for the prawns and crabs in the wet season which showed positive allometric.

The observation of absolute isometric growth (b=3) in nature is occasional (Bagenal 1978; Bassey and Ricardo, 2003). Deviation from isometric growth is often observed in most aquatic organisms which changes shape as they grow (Thomas *et al.*, 2003). Except for *Synodontisvermiculatus*, the condition factor (Tables 3.5A and 3.5B) for all the species collected was higher than 1, which indicates the suitability of the environment for these species. The CF was also higher in the wet season than the dry season which could be attributed to availability of food in the wet season. Food and feeding habits of all the species encountered are enumerated in Tables 4.36A & 4.36B.

4.5.13 Vegetation Study

Dry and wet seasons vegetation (flora) study as part of Environmental impact assessment of SHAFA Energy depot LNG proposed site in Delta State was carried out to document the floristic composition, plants' diversity, health condition, habitat status and tissue analyses of the vegetation present in this field. Randomly sampled study sites were established where information about the vegetation were acquired following the methods outlined by Kershaw, 1977; Magurran, 1987; Sutherland, 1997; Bamidele and Akinnibosun, 2012. Vegetation found in10 m^2 quadrat samples at fourteen locations within the site and control point were identified to species level and documented using appropriate botanical literature such as (Keay, 1989; Lowe and Soladoye, 2000; Odugbemi, 2006; Hawthorne and Jongkind, 2006; Akinnibosun and Odiete, 2007; 2008; Akinnibosun and Omatsola, 2011; Deni, 2013; Aigbokhan, 2014 and Akobundu*et al.*, 2016).

The sampled field traverses freshwater swamp and partly upland/aquatic habitat. Aquatic macrophytes and few mangrove species were found in and around (control point) the field of study. There was the dominance of aquatic macrophytes such as *Sphenocleazeylanica, Eichhorniacrassipes, Alternantheramaritima* and the grass *Pennisetumpurpureum* with *Echinocloaobtusiflora* during dry season. Single strand of screwpine –*Pandanus candelabrum* and red mangrove – *Rhizophoraracemosa* was encountered at the site. There was a river at the edge of the proposed site of which Red mangrove trees were found. There was a nearby settlement close to the river by the bridge area. Succession took place in this aquatic environment between the dry season and wet (rainy) season. Some plants were no longer found during the raining season or have been suppressed/reduced in their dominance value.

Plants such as *Sphenocleazeylanica, Paspalumvaginatum, Adeniacissampeloides, Pandanus candelabrum, Paspalumscrobiculatum, Nymphaeamaculata, Scopariadulcis, Neptuniaoleracea, Rhynchelytrumrepens, Leersiahexandria* and *Schoenoplectussenegalensis* have been out-competed and no longer sighted. There was the dominance of *Echinocloaobtusiflora* and *Pennisetumpurpureum* .A total of one hundred and three (103) plants species were documented in the two seasons in the sampled field and control sites. A total of one hundred and three plant species were documented during both seasons (dry and wet). Seventy-eight (78) plant genera belonging to thirty seven (37) families, comprised of total of ninety three species (93) were documented during the dry season while Seventy (70) plant genera belonging to thirty four (34) families, comprised of total of eighty five species (85) were documented during the wet season in the sampled field (see Table 4.37).

There was no noticed symptom on the vegetation except for the partly yellowing of leaves of the screwpine (*Pandanus candelabrum*) in the dry season, this could be due to water logging causing anaerobic soil condition which area the single stranded plant was found. The screw pine could not be found in the wet season as the whole area have become overgrown and dominated by *Echinocloaobtusiflora* and *Pennisetumpurpureum*. There was no stratification of the vegetation at the project site except for the ground flora stratum (stratum E).Plates 4.4 – 4.35 showed some of the sampled location's vegetation in dry season and Plates 4.36 – 4.45 were taken in wet season.

Tissue analyses revealed the presence of heavy metals such as Zinc (Zn) in high quantity, low Lead (Pb) and very low quantity of Cadmium (Cd). Essential micronutrients such as Potassium (K) in appreciable quantity and Phosphorus (P) as Phosphate were reported but in very minute quantity to below detection limit (BDL) in some plant tissue at some sampled location. Table 4.37 showed the tissue analyses results.

Table 4.37: Plant Tissue Analyses for Heavy Metals Zn, Pb, Cd and Micronutrients P and K

Plant Sample Location/ Identity and Name	**Zn (mg/kg)**	**Pb (mg/kg)**	**Cd (mg/kg)**	**P (%)**	**K (mg/kg)**
AYM/VG 17(Control Site)*Ipomoeaaquatic*	17.069	1.356	<0.003	0.010	5.698
AYM/VG 17 (Control Site)*Sacciolepisafricana*	24.476	2.123	0.108	0.032	6.588
AYM/VG 03 *Sacciolepis*Africana	50.321	0.816	<0.003	1.968	6.713
AYM/VG 13 *Melastromastrumcapitatum*	39.774	0.907	<0.003	BDL	7.250
AYM/VG 15 *Alchorneacordifolia*	39.613	1.264	<0.003	1.156	6.114
AYM/VG 13 *Alchorneacordifolia*	26.006	1.062	0.021	0.377	7.016
AYM/VG 17 (Control Site)*Alchorneacordifolia*	54.185	1.731	0.067	3.615	7.432
AYM/VG 16 *Alchorneacordifolia*	46.134	1.559	0.097	0.025	5.521
AYM/VG 03 *Pennisetumpurpureum*	55.554	0.076	0.078	0.003	7.745
AYM/VG 06 *Pennisetumpurpureum*	29.468	2.017	0.133	BDL	6.724
AYM/VG 14 *Pennisetumpupureum*	34.379	1.704	0.042	BDL	5.713
AYM/VG 02 *Luduwigiaoctovalvis*	40.901	1.264	0.095	0.162	7.854
AYM/VG 02 *Heliotropumindicum*	25.362	2.106	0.410	0.001	7.901
AYM/VG 10 *Ludwigiadecurrens*	45.812	1.002	<0.003	0.483	6.750
AYM/VG 10 *Ipomoeaaquatic*	39.774	0.097	0.149	BDL	5.661
AYM/VG 10 *Eichhorniacrassipes*	20.933	1.954	0.047	0.064	5.651
AYM/VG 11 *Ipomoeaaquatic*	42.430	1.613	0.381	BDL	6.786
AYM/VG 09 *Pennisetumpurpureum*	25.684	2.116	<0.003	BDL	7.833
AYM/VG 02 *Sphenocleazeylanica*	43.638	1.821	0.032	BDL	7.432
AYM/VG 13 *Mariscusligularis*	29.065	2.170	0.167	BDL	6.849
AYM/VG 17 (Control Site)*Sphenocleazeylanica*	60.143	1.624	0.046	BDL	7.661

BDL= Below detection limit. (Zn = Zinc, Pb = Lead, Cd = Cadmium, P =Phosphorus, K = Potassium)

The vegetation was lush green in the wet season due to the abundance of rain for some months before the study took place. Succession was not unexpected as smaller plant were out-competed by larger fast growing grasses (Family: Poaceae), thereby leading to reduction in the number of family, genera (genus) and species encountered in the wet season.

Table 4.38A: Flora Composition/ Vegetation Diversity of Shafa LPG Site

S/No.	Botanical Name	Common Name	Family	Season	
				Dry	Wet
1	*Acroceraszizanoides*	Oat grass	Poaceae	+	–
2	*Adeniacissampeloides*	-	Passifloraceae	+	–
3	*Adenopusbreviflorus*	-	Cucurbitaceae	+	+
4	*Aeschynomeneindica*	-	Fabaceae	+	+
5	*Ageratum houstonianum*	Blue mink/ Blue billy goat weed	Asteraceae	+	+
6	*Alchorneacordifolia*	Christmas Bush	Euphorbiaceae	+	+
7	*Alternantheramaritima*	-	Amaranthaceae	+	+
8	*Andropogontectorum*	Giant BlueStem	Poaceae	+	+
9	*Anthocleistavogelii*	Cabbage Tree	Gentianaceae	+	+
10	*Aspiliaafricana*	Bush Marigold	Asteraceae	+	+
11	*Asystasiagangetica*	Chinese Violet	Acanthaceae	–	+
12	*Calopogoniummucunoides*	Calopo	Poaceae	+	+
13	*Carica papaya*	Pawpaw, Papaya	Caricaceae	+	+
14	*Cassia alata*	Candle drumstic	Fabaceae	+	+
15	*Centrosemapubescens*	Ccentro	Fabaceae	+	+
16	*Ceratopteristhalicthroides*	Water sprite, Water hornfern	Pteridaceae	+	+
17	*Chlorispilosa*	Fingergrass	Poaceae	+	–

S/No.	Botanical Name	Common Name	Family	Season	
				Dry	Wet
18	*Chromolaenaodorata*	Siamweed	Asteraceae	+	+
19	*Clerodendronsplendens*	Flaming Glory Bower	Lamiaceae	+	+
20	*Coccinialongicarpa*	-	Cucurbitaceae	–	+
21	*Commelinabenghalensis*	Wandering Jew, Spiderwort	Commelinaceae	+	+
22	*Commelinalagosensis*	Spreading dayflower	commelinaceae	+	+
23	*Croton hirtus*	Hairy Croton	Euphorbiaceae	+	+
24	*Cyathulaprostrate*	-	Amaranthaceae	+	+
25	*Cyperusdifformis*	Smallflower umbrella sedge	Cyperaceae	+	+
26	*Cyperushaspan*	Haspanflatsedge	Cyperaceae	+	+
27	*Cyperusiria*	Ricefieldflatsedge	Cyperaceae	+	+
28	*Cyperustuberosus*	Nutgrass	Cyperaceae	+	+
29	*Desmodiumramossissimum*	-	Fabaceae	–	+
30	*Desmodiumscopiurus*	Beggarweed	Fabaceae	+	+
31	*Digitariahorizontalis*	Digitgrasss	Poaceae	+	+
32	*Digitarianuda*	Crabgrass	Poaceae	+	+
33	*Dryopterisfilix-mas*	Male fern	Dryopteridaceae	+	+
34	*Echinocloaobtusiflora*	-	Poaceae	+	+
35	*Eichhorniacrassipes*	Water Hyacinth	Pontederiaceae	+	+
36	*Eleusineindica*	Goosegrass, Bullgrass	Poaceae	+	+
37	*Eleutheranthera ruderalis*	-	Asteraceae	–	+
38	*Emilia praetermissa*	Tasselflower	Asteraceae	+	+
39	*Euphorbia hyssopifolia*	Hyssop leaf, Sandmat	Euphorbiaceae	+	+
40	*Ficussur*	Fig Tree	Moraceae	+	+
41	*Fimbristylisferruginea*	West Indian fimbry, Rusty Sedge	Cyperaceae	+	+

42	*Fimbristylislittoralis*	Fimbry	Cyperaceae	+	+
43	*Fuirenaumbellate*	-	Cyperaceae	+	+
44	*Harunganamadagascariensis*	Dragon's-blood-tree	Clusiaceae	+	+
45	*Heliotropumindicum*	Indian Heliotrope, Cock's comb	Boraginaceae	+	–
46	*Hibiscus surattensis*	Bush Sorrel, Rosemallow	Malvaceae	–	+
47	*Hyptissuaveolens*	Bush tea, Wild spikenard	Lamiaceae	+	+
48	*Ipomoea aquatic*	Swamp morning-glory	Convolvulaceae	+	+
49	*Ipomoea involucrate*	Morning Glory	Convolvulaceae	–	+
50	*Ipomoea triloba*	-	Convolvulaceae	+	–
51	*Kyllingabulbosa*		Cyperaceae	–	+
52	*Lantana camara*	Wild sage, Curse of Barbados	Verbenaceae	+	+
53	*Leersiahexandra*	Razor grass	Poaceae	+	–
54	*Leptochloacaerulescens*	-	Poaceae	+	+
55	*Loudetiaarundinacea*	-	Poaceae	+	–
56	*Ludwigiadecurrens*	Water primrose	Onagraceae	+	+
57	*Ludwigiaoctovalvis*	Primerose-willow	Onagraceae	+	–
58	*Luffacylindrical*	Loofah, Loofah Gourd	Cucurbitaceae	+	+
59	*Machaereumlunatum*	Chinese earing	Fabaceae	+	+
60	*Mangiferaindica*	Mango	Anacardiaceae	+	+
61	*Mariscusligularis*	Sedge	Cyperaceae	+	+
62	*Mariscuslittoralis*	Sedge	Cyperaceae	+	+
63	*Melantherascandens*	-	Asteraceae	+	–
64	*Melastomastrumcapitatum*	-	Melastomataceae	+	+
65	*Mimosa pigra*	Giant sensitive plant	Fabaceae	+	+
66	*Mimosa pudica*	Sensitive plant	Fabaceae	+	+
67	*Musangacecropioides*	Corkwood,	Urticaceae	+	+

		Umbrrella tree			
68	*Naucleapobeguinea*	African Peach	Rubiaceae	+	+
69	*Neptuniaoleracea*	-	Fabaceae	+	–
70	*Nymphaea lotus*	Water Lily	Nymphaeaceae	+	+
71	*Nymphaeamaculate*	Water Lily	Nymphaeaceae	+	–
72	*Nypafruticans*	Nipa Palm	Arecaceae	+	+
73	*Pandanus candelabrum*	Screwpine	Pandanaceae	+	–
74	*Panicumbrevifolium*	Grass	Poaceae	+	+
75	*Panicumlaxum*	-	Poaceae	+	+
76	*Panicum maximum*	Guinea grass	Poaceae	–	+
77	*Panicumrepens*	-	Poaceae	–	+
78	*Panicumsubalbidum*	-	Poaceae	+	+
79	*Paspalumscrobiculatum*	Kodo millet, Ditch millet	Poaceae	+	–

Table 4.38B Contd.: Flora Composition/ Vegetation Diversity of AYM Shafa LNG Site				Season	
S/ No.	Botanical Name	Common Name	Family	Dry	Wet
80	*Paspalumvaginatum*	Ditch millet, Indian Paspalum	Poaceae	+	–
81	*Passiflorafoetida*	Passion flower	Passifloraceae	+	+
82	*Pennisetumpedicellatum*	Deenanath grass, feathery pennisetum	Poaceae	+	+
83	*Pennisetumpurpureum*	Elephant grass	Poaceae	+	+
84	*Phyllanthusniruri*var. *amarus*	Shatterstone, Stone breaker	Euphorbiaceae	+	+
85	*Physalisangulate*	Wildcape Gooseberry, Husk Tomato	Solanaceae	+	+
86	*Psidiumguajava*	Guava	Myrtaceae	+	+
87	*Rhizophoraracemosa*	Red Mangrove	Rhizophoraceae	+	+
88	*Rhynchelytrumrepens*	Blanketgrass, Natal grass	Poaceae	+	–
89	*Sacciolepisafricana*	-	Poaceae	+	+
90	*Schoenoplectussenegalensis*	-	Cyperaceae	+	–
91	*Scopariadulcis*	Sweet broomweed	Scrophulariaceae	+	–
92	*Sennaalata*	Ringworm bush, Candle bush	Fabaceae	+	+
93	*Sidaacuta*	Broomweed	Malvaceae	+	+
94	*Smilax anceps*	West African Sarsaparilla	Smilacaceae	+	+
95	*Solenostemonmonostachyus*	Monkey's potato	Lamiaceae	+	+
96	*Sphenocleazeylanica*	Wedgewort	Sphenocleaceae	+	–
97	*Spondiasmombin*	Hog Plum	Anacardiaceae	+	+
98	*Sporoboluspyramidalis*	Cat’s tailgrass,WestIndiesSmutgrass	Poaceae	+	+
99	*Tremaorientalis*	Pigeon wood	Ulmaceae	+	+
100	*Urenalobata*	Hibiscus bur, cadillo	Malvaceae	+	+
101	*Vernoniacinerea*	Little Ironweed	Asteraceae	+	+
102	*Vigna*sp.	Zombie-pea, wild cowpea	Fabaceae	–	+
103	*Zanthoxyllumzanthoxyloides*	Senegal prickly-ash, Spice-bark tree	Rutaceae	+	+

+indicates present, – indicates absent

Plate 4.4: ***Pennisetumpurpureum* (elephant grass) – a dominant species at the study sites at the fore ground and *Rhizophoraracemosa*(Red Mangrove at the Background) during dry Season**

Plate 4.5: Screwpine- *Pandanus candelabrum* with slight yellowing of leaves

Plate 4.6: Young Seedling of *Sphenocleazeylanica* (Wedgewort) One of the Dorminant Species during Dry Season

Plate 4.7: **Lush Green *Pennistumpurpureum* Elephant Grass and Seedling Of Sphenocleazeylanica During Dry Season**

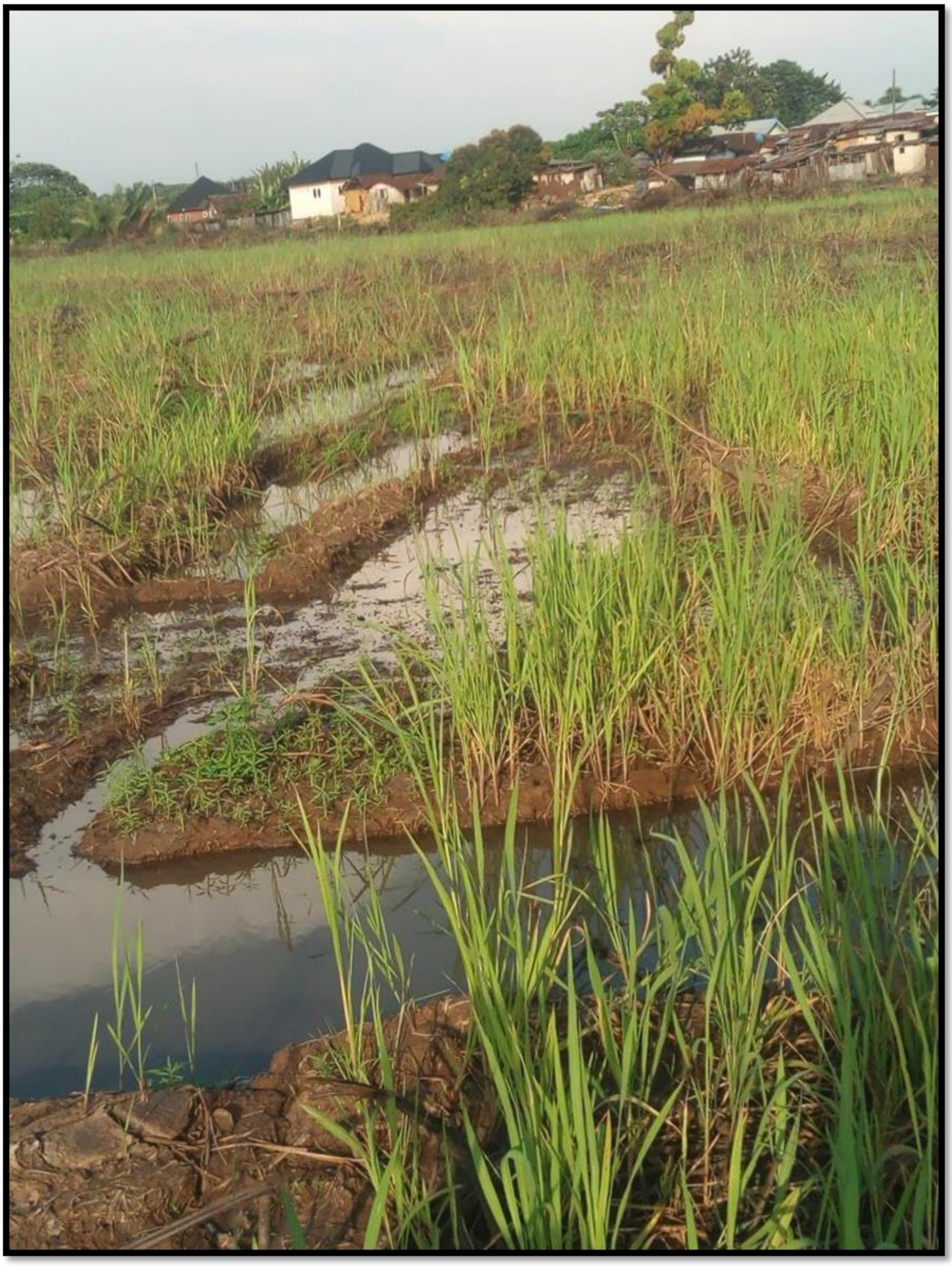


Plate 4.8: Vegetation Observed Towards Settlement Area During Dry Season

Plate 4.9: ***Eichhorniacrassipes*** **(Water Hyacinth) And Pennisetumpurpureum during Dry Season**

Plate 4.10: Collecting *Pennisetumpurpureum* Plant Sample for Tissue Analysis

Plate 4.11: Mixture Of Species – *Eichhorniacrassipes*, *Pennisetumpurpureum* And *Ludwigiadecurrens* With The River Bank At The Background Is Dry Season

Plate 4.12: Floating *eichhorniacrassipes* on water surface at the foreground and *pennisetumpurpureum* at the background during dry season

Plate 4.13: ***Paspalumvaginatum*** **(Ditch Millet/Indian Paspalum) At The Study Site During Dry Season**

Plate 4.14*: Ceratopteristhalicthroides* (Fern) During Dry Season

Plate 4.15: ***Mariscusligularis* (Sedge) During Dry Season**

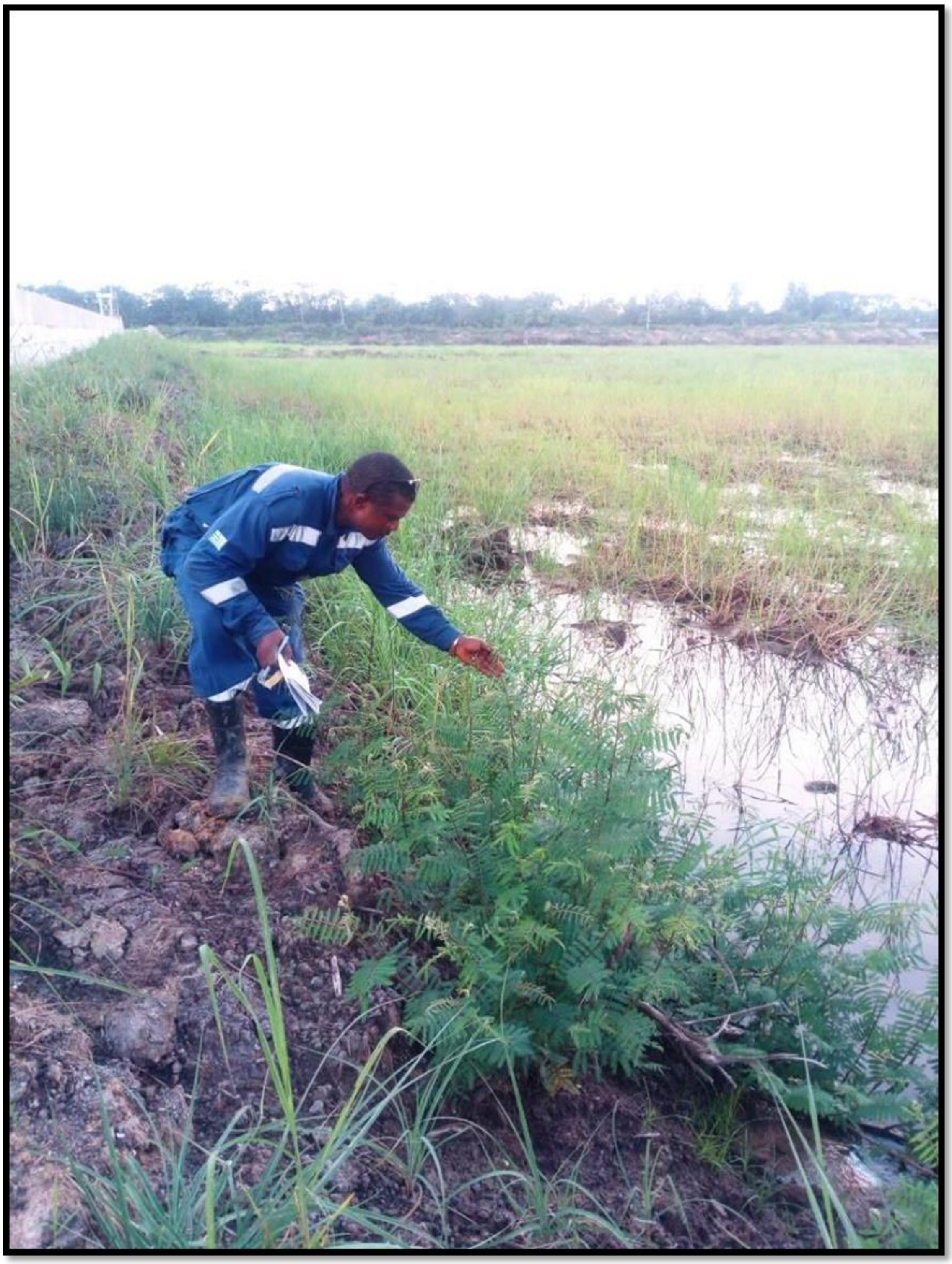


Plate 4.16: Identifying *Mimosa Pigra* (Giant Sensitive Plant) at the Study Site

Plate 4.17: Close view of *Mimosa pigra* (Giant sensitive plant) during dry season

Plate 4.18: Clustered Water Hyacinth- *Eichhorniacrassipes* during Dry Season

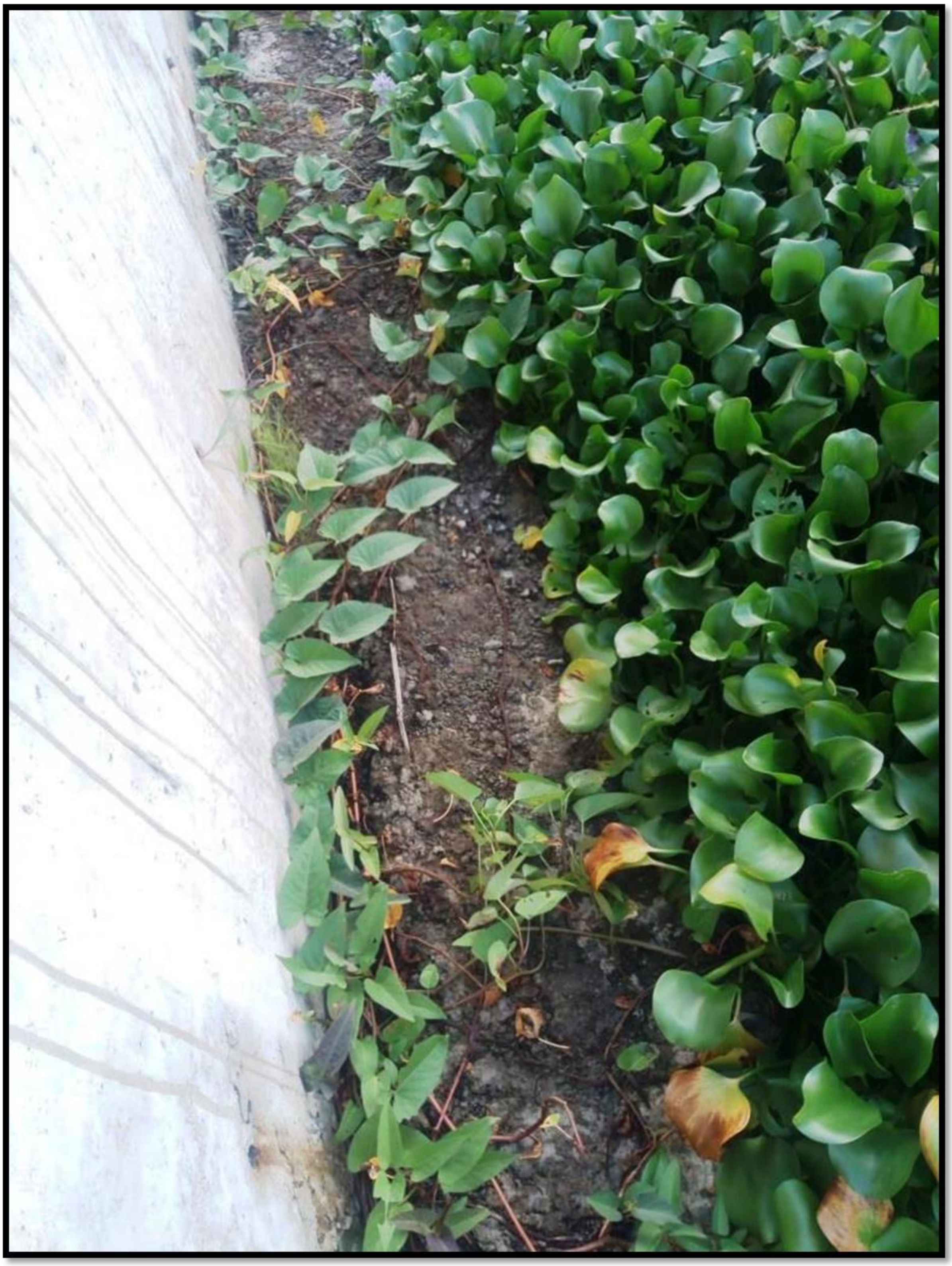


Plate 4.19: ***Ipomoea Aquatica* (Water Spinach) By The Perimeter Fence On The Left And Water Hyacinth- *Eichhorniacrassipes* On The Right During Dry Season**

Plate 4.20: Collecting *Alchorneacordifolia* Plant Sample for Tissue Analysis

Plate 4.21: Panoramic View of Part of the Sampled Location Showing Community at the Background during Dry Season

Plate 4.22: **Flowering Water Hyacinth- *Eichhorniacrassipes* at the Study Site during Dry Season**

Plate 4.23: ***Alternantheramaritima* with *Cyperusdifformis*at the Centre during Dry Season**

Plate 4.24: Passion Flower – *Passiflorafoetida* Entangle By *Mimosa Pigra* during Dry Season

Plate 4.25: ***Mariscusligularis*** **at the Extreme Top Right-Corner And *Chromolaenaodorat*** **(Siam Weed),** ***Panicumlaxum*** **And** ***Mimosa Pigra*** **At The Centre**

Plate 4.26: ***Panicumbrevifolium*** **(Grass) at the Upland Region of the Site during Dry Season**

Plate 4.27: ***Melastomastrumcapitatum*** **with some** ***chromolaenaodorata*** **and other grasses at the upland area of the study site**

Plate 4.28: Documenting Feathery Pennisetum – *Pennisetumpedicellatum* during Dry Season

Plate 4.29: Panoramic view of the proposed location from the upland area during dry season. The river with red mangrove (*rhizophora*racemosa) is at the far background

Plate 4.30: ***Ageratum Houstonianum at*** **the Top To The Centre, *Mariscusligularis* (A Sedge) At The Lower Right Corner And *Phyllanthusamarus* Centre Below**

Plate 4.31: Christmas Bush – *Alchorneacordifolia* with Heart-Shaped Leaves and the Grass *Pennisetumpedicellatum* at the Raised (Upland) Area of the Sampled Location during Dry Season

Plate 4.32: ***Adeniacisampeloides*** **Trailing on the Ground during Dry Season**

Plate 4.33: *Cassia Alata* at the Control Site during Dry Season

Plate 4.34: Mixture of *Dryopterisfilix-Mas* (Fern), Water Spinach - *Ipomoea Aquatica* – (Creeping Vine) and *Alchorneacordifolia*-Christmas Bush (At the Top) Found at the Control Point during Dry Season

Plate 4.35: Clockwise From Top Left Corner – (A)*Nypa Fruticans* (Nipa Palm) With *Echinochloa Obtusiflora* (B) Water Hyacinth- *Eichhornia Crassipes* On Water Surface And *Pennisetum Purpureum* By River Bank (D) *Aeschynomene Indica* Near The River Bank In Wet Season

Plate 4.36A,B,C,D: ***Echinochloa Obtusiflora*** **During Wet Season At The Proposed Site**

Plate 4.37: Vegetation Expert Documenting Flora Diversity During Wet Season

Plate 4.39: Clockwise From Top Left Corner (A) Soil Sampling Personnel Within The Field Of *Echinochloa Obtusiflora* And*aeschnomene Indica* (B) And (C) Mixture Of *Echinochloa Obtusiflora* And *Pennisetum Purpureum* Grasses (D) *Loudetia Arundinacea* And Other Plants During The Wet Season Study

Plate 4.40: Panoramic view of the sampled location near the river side showing (a)(b) (c)*echinochloa obtusiflora*and (d) *vigna* sp. Creeping near *pennisetum purpureum*

Plate 4.41: **Clockwise From Top Left Corner (A) & (B)Water Lotus – Nymphaea Maculata on Water Surface with Echinochloa Obtusiflora and Pennisetum Purpureum (C) Loofah – Luffa Cylindrica Creeping on the Wall and Floor with the Grass Echinochloa Obtusiflora (D) Aeschynomene Indica (With Yellow Flower) with Echinochloa Obtusifolia at the Background**

Plate 4.42: **Grasses, sedges and othe plants such as *luffa cylindrica, echinochloa obtusiflora, alternanthera maririma, mariscus ligularis,ipomoea aquatica, ludwigia decurrens* and *panicum maximum* during the wet seacon at the study site**

Plate 4.43: (A) Echinochloaobtusifolia (B) Alternantheramaritima, Aeschynomeneindica, Ludwigiadecurrens, Echinochloaobtusifolia (C) Mimosa Pigra And (D) Echinochloaobtusifoliaduring Wet Season

Plate 4.44: Panoramic View of the Study Field from the Main Road

Plate 4.45: Settlement by the River Bank and the Associated Vegetation In a Panoramic View

PLANKTON AND BENTHIC

METHODOLOGY

Study Sites

The Study was conducted within the banks of the Warri River at Ifiekporo, Warri South local government area of Delta State. Sampling was conducted in four sites which were randomly determined, with three of such sites (1, 2 and 3) strategically located less than 300m from a proposed Liquefied Natural Gas (LPG) tank farm and a control site (4) located about 4 kilometers from the tank farm. Aside all stations having signs of impacts from human activities like dredging and effluent discharge from refined crude products, stations 1, 2 and 3 were characterized by sharp sediments and experienced high tidal impact. However, the control station (Stations 4) which is slightly inland was highly silted, and had the presence of mangrove covers.

Plate 4.46: Tank farm sites with heavy pipes for transporting refined crude products

Sampling Techniques

Plankton net tapered with a pet vial at the bottom was used for collection of water samples with plankton. At each sampling point, water samples were collected around the shores of the river and on the open water surface. Samples collected were transferred to collecting bottles and preserved in 10% formalin.

Benthos collection was achieved using a D-frame sampling net. Benthos was sampled using a kick sampling method. This was done by sampling against water current after substrate and vegetation have been disturbed. Organisms were collected by handpicking and drag netting with samples placed in 10% formalin for storage and laboratory analysis.

RESULTS

In the phytoplankton sampled, diatoms, dinoflagellates, cynobacteria and Chlorophyta (green algae) species were identified. The diatoms were more dominant with 13 genera (59.1%) followed by *Chlorophyta* 5(22.7%) and cynobacteria with 3(13.6%) each. In terms of genus, the *Nitzchia* sp. was more dominant followed by *Gyrosigma sp.*

Table 4.39A: Phytoplankton recorded across the sampling sites dry season

Organism	**Station**			
Phytoplankton	**1**	**2**	**3**	**4 (Ctrl)**
Diatom				
Pseudonitzchia sp	1	3	0	2
Navicula sp	3	3	2	4
Asterionella sp	6	4	0	5
Coscinodiscus sp	4	2	0	2
Eunotia sp	1	3	0	0
Nitzchia sigmoidea	9	14	1	12
Stephanopyxis sp	2	1	1	3
Thalassiosira sp	4	5	2	4
Melosira sp	*0*	*3*	*0*	*0*
Gyrosigma sp	*6*	*7*	*1*	*6*
Frustulia sp	*1*	*2*	*0*	*0*
Synedra sp	*3*	*3*	*0*	*1*
Rhizosolenia sp	*4*	*7*	*0*	*6*
Dinoflagellates				
Prorocentrum sp	2	1	1	1
Chlorophyta				
Phacus sp	**1**	**0**	**0**	**1**
Spirogyra sp	*4*	*3*	*0*	*4*
Actinastrum sp	*2*	*0*	*0*	*0*
Desmidium sp	*1*	*4*	*0*	*2*
Skeletonema sp	*1*	*4*	*0*	*0*
Cynobacteria				
Trichodesmium sp	1	1	0	3
Nostoc sp	*0*	*1*	*0*	*0*
Osciliatoria sp	*2*	*1*	*0*	*2*
Total no. 22				

Plankton abundance in dry season were well represented across stations by the following taxa, Diatoms, Dinoflagellates, Cyanobacteria, Chlorophyta, Crustacea, Copepod, Rotifer, Protozoa, Titinida and Decapoda (Table 4.39A). While stations 2 were completely represented by all the taxa, stations 3 was represented by only four taxa (Diatoms, Dinoflagellates, Crustacea and Decapoda), with stations 1 and 4 (control) each represented by nine taxa. However, across all stations diatoms were the more abundant taxa, with the highest abundance well observed for stations 2, while stations 3 had the lowest abundance. Decapoda and copepod showed a slight increase across stations with stations 1 having the highest abundance and stations 3 the lowest abundance (Figure 4.5A).

In dry season, stations 2 had the highest phytoplankton abundance, slightly followed by stations 4 and then stations 1. Stations 3 accounted for the lowest abundance of phytoplankton in the dry season. Zooplankton abundance showed that stations 1 had the highest abundance, followed by stations 2 and stations 4, while the lowest zooplankton abundance was observed for stations 3 in dry season. However there was a comparative difference in the abundance of both plankton groups across stations in dry season. Aside stations 3 all other stations showed a high abundance of Phytoplankton than zooplankton (Figure 4.5C).

Table 4.39B: Zooplankton recorded across the sampling sites in dry season

Organism	**Station**			
Zooplankton	1	2	3	4 (Ctrl)
Cladocera	2	1	1	2
Tintinnid	-	1	-	-
Copepoda	6	5	1	6
Rotifera	1	2	-	2
Protozoa	-	1	-	-
Nemertinea	-	1	-	1
Polychaete worms,	2	-	-	-
Fish egg	4	6	-	3
Isopods	-	1	-	-
Decapoda	8	4	2	4
Total	23	22	4	18

Plankton abundance in wet season revealed that Phytoplankton had the highest abundance in stations 4, slightly followed by stations 2 and 1, with the lowest abundance observed in stations 3. The abundance of Zooplankton showed a decreasing trend form stations 4 to stations 1, with peak abundance recorded in stations 4 while stations 1 recorded that lowest abundance. Comparatively, plankton abundance in wet season showed a significant difference among the groups across the various stations, as phytoplankton was more abundant than zooplankton across all stations (Figure 4.5D).

Taxa abundance of plankton in wet season showed Diatom and Chlorophyta as the taxa with the highest abundance across all stations. However, the trend in abundance in the above two groups showed that stations 4 with the highest, followed by stations 2 and 1, while stations 3 had the lowest abundance. Furthermore, only stations 4 recorded the presence of the Isopod taxa in wet season, while Dinoflagellates were completely absent in stations 2 and 3 (Figure 4.5C).

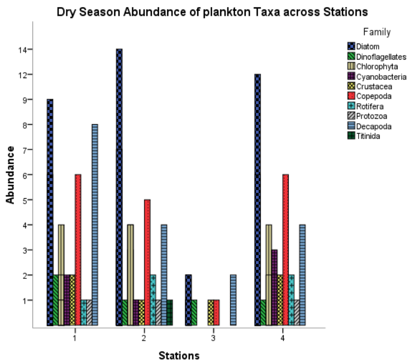


Figure 4.5A: Dry season abundance of plankton Taxa

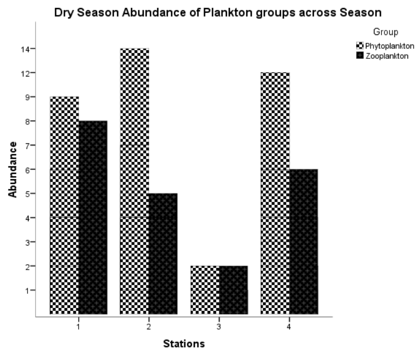


Figure 4.5C: Dry season abundance of plankton groups

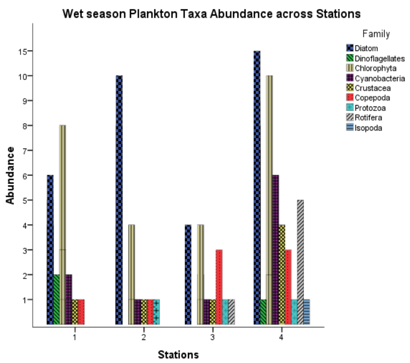


Figure 4.5B: Wet season abundance of Plankton Taxa

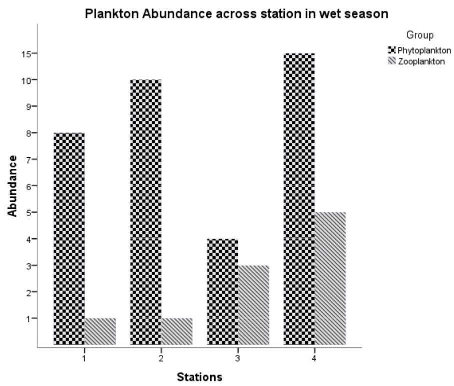


Figure 4.5D: Wet season abundance of Plankton groups

Diversity Indices for Benthos

Seasonal diversity for Benthos was generally low across all stations. Species diversity (using Shannon diversity index) showed stations 1 and 2 were lower than stations 3 and 4 in dry season. However in wet season, stations 1 had the lowest diversity in Benthos species, while the trend gradually increased from stations 4 to stations 2 (Table 4.40A).

Species richness (**H_{max}**) across stations was high for dry season than wet season. In dry season, Stations 1 and 2 were observed to have high richness than stations 3 and 4. However, the trend was different across stations in wet season as stations 2 recorded the highest richness in benthic species, followed closely by stations 1, while stations 3 and 4 recorded the lowest richness in species. Furthermore, wet season showed a complete evenness across stations when compared to dry season. Evenness was higher in stations 3 and 4 than stations 1 and 2 in wet season while in dry season, species evenness was high for stations 3 and 4 than stations 1 and 2 (Table 4.40A).

Table 4.40A: Seasonal Diversity indices for Benthos across stations

Season	**Dry Season**			**Wet Season**		
Indices / **Site**	**H'**	**H_{max}**	**E**	**H'**	**H_{max}**	**E**
1	0.27	2.55	0.10	0.24	1.61	0.15
2	0.26	2.45	0.11	0.32	2.08	0.16

3	0.35	2.07	0.16	0.31	1.09	0.29
4	0.35	2.07	0.16	0.25	1.09	0.23

H' = Shannon diversity index; $\mathbf{H_{max}}$ = Species Richness; **E** = Evenness

<u>Diversity indices for Plankton</u>

<u>Diversity indices for zooplankton</u>

Results of Zooplankton diversity showed that stations 1 and 2 had high species diversity in dry season than wet season. There was relatively slight difference in this trend in stations 2 as wet season diversity was greater than dry season diversity for that station. In stations 4 the dry season diversity in zooplankton was higher that wet season diversity. Across stations, stations 1, 2 and 4 similarity in species diversity, which was higher than stations 3 in dry season. Results of wet season zooplankton diversity showed that stations 1 and 2 had no species diversity, while stations 4 had the highest diversity, followed by stations 3 (Table 4.40B).

Zooplankton richness across station showed stations 2 to be highest in dry season while stations 1 were lowest. However, stations 4 had the highest richness while stations 1 had the lowest richness in wet season. Furthermore, species Evenness was high in dry season than wet season for zooplankton. This trend across stations revealed that there was a complete evenness in stations 4 when compared to other stations in dry season, while in wet season, stations 1 and 2 recorded no evenness as complete evenness in zooplankton species was recorded stations 4 and subsequently stations 3 (Table 4.40B).

Table 4.40B: Seasonal Diversity indices for Zooplankton across stations

Season	**Dry Season**			**Wet Season**		
Indices / **Site**	**H'**	**H_{max}**	**E**	**H'**	**H_{max}**	**E**
1	0.35	1.60	0.22	0.00	0.69	0.00
2	0.36	1.79	0.20	0.00	1.09	0.00
3	0.21	1.09	0.19	0.27	1.37	0.19
4	0.37	1.61	0.23	0.36	1.61	0.22

H' = Shannon diversity index; **H_{max}** = Species Richness; **E** = Evenness

Diversity indices for Phytoplankton

Diversity results of phytoplankton observed across stations showed that stations 1 had a high diversity followed by stations 4 and then stations 2 when compared to stations 3 which recorded the lowest diversity for dry season. Wet season results revealed a gradual decrease in diversity from stations 1 to 4, with stations 1 having the highest Phytoplankton diversity and stations 4 recording the lowest values for diversity in wet season. Comparatively, phytoplankton diversity was slightly high in wet season than dry season (Table 4.40C).

Wet season had a higher Phytoplankton richness than dry season. Similar richness was observed across stations 1 and 2 which were highest across all stations in dry and wet season. Species evenness was higher in wet season than dry season. Further observation in wet season revealed similar evenness in stations 1, 2 and 3. In dry season, stations 2 recorded a low evenness while station 4 recorded a high evenness across the stations (Table 4.40C).

Table 4.40C: Seasonal Diversity indices for Phytoplankton across stations

Season	**Dry Season**			**Wet Season**		
Indices / **Site**	**H'**	**H_{max}**	**E**	**H'**	**H_{max}**	**E**
1	0.38	2.99	0.12	0.37	2.83	0.13
2	0.35	2.99	0.11	0.36	2.83	0.13
3	0.21	1.79	0.12	0.34	2.56	0.13
4	0.36	2.77	0.13	0.32	2.94	0.11

H' = Shannon diversity index; **H_{max}** = Species Richness; **E** = Evenness

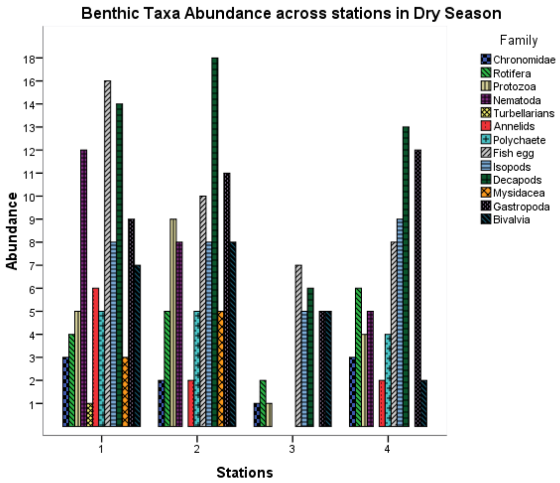
Benthos Distribution

Distribution of benthic taxa showed a relatively high abundance across stations in dry season. Among the thirteen taxa recorded, stations 1 showed complete taxa representation, followed by stations 2 with twelve taxa, stations 4 with 11 taxa while stations 3 had only eight taxa. Decapoda was the most abundant taxa with distributions recorded in stations 2 and 4. However, fish eggs were the most abundant group in stations 1 and 3, while Chironomidae, Tuberllaria and

Protozoa were the groups with the lowest abundance across the stations in dry season (Figure 4.6A).

Dry season species abundance across the stations showed that species of the genus Cardiosoma was highly abundant in stations 2 and 4. However, this was not the case in other stations which recorded other species. Fish eggs were the most abundant in stations 1 and 3 followed by Cardiosoma, Nematodes and clams. The species with the lowest abundance was recorded in stations 3 and 1, and constituted Euglena, midge larvae and Tuberllarians (Figure 4.6B).

Wet Season abundance of benthic taxa showed station 2 was represented by seven taxa and stations 4 (Control station) by six taxa. Stations 1 was represented by four taxa while stations 3 had the lowest taxa represented by three families. Across stations, the Decapoda (Cardiosoma) taxa had the highest abundance in stations 4 and followed by Bivalvia (Clam) in stations 2. Furthermore, wet season sampling found the emergence of the Odonata (dragonfly larvae) taxa in stations 2 and one of the least abundance across stations (Fig 4.6C).



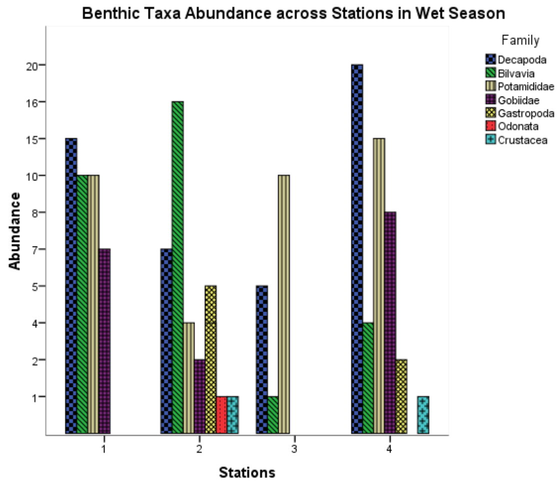
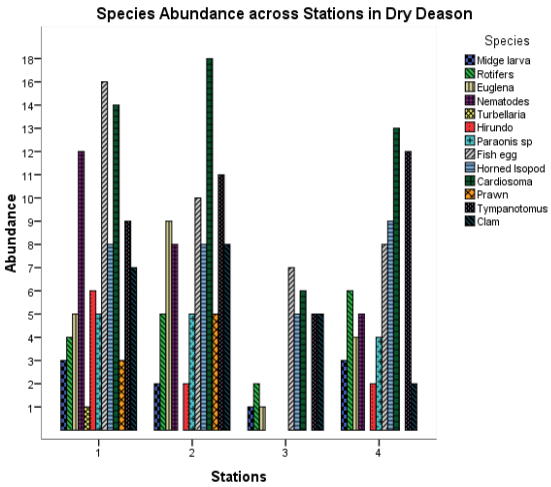


Figure 4.6A: Dry season Abundance of Benthic Taxa **Figure 4.6B: Wet season Abundance of Benthic Taxa**



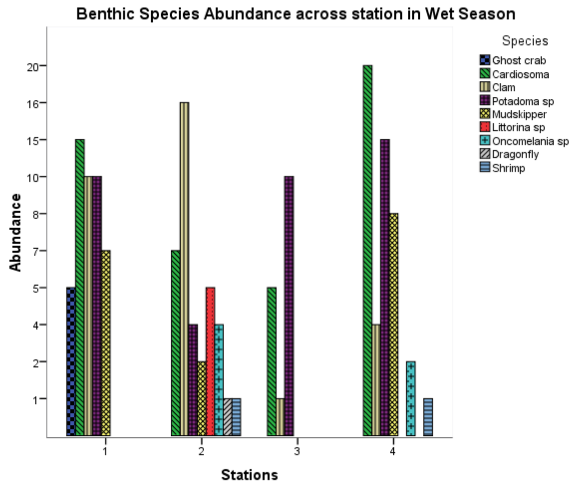


Figure 4.6C: Dry season Abundance of Benthic species **Figure 4.6D: Wet Season abundance of benthic species**

Benthos abundance showed a variation across stations in both seasons (Dry and wet seasons). While benthos abundance was high in dry season in stations 1 and 2, the reverse was the case in Stations 3 which showed high benthos abundance for wet season than dry season. Furthermore, Stations 4 which was the control station showed a remarkable difference in seasonal abundance with Wet season showing a very high abundance of benthos than dry season (Figure 4.6E).

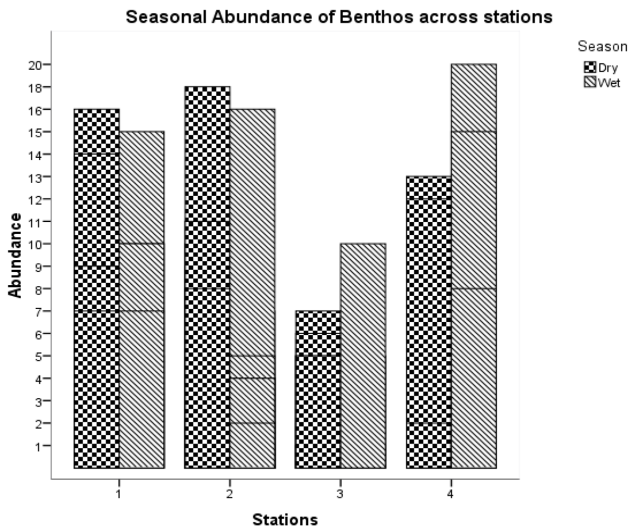


Figure 4.6E: Seasonal abundance of Benthos across stations

DISCUSSIONS AND RECOMMENDATIONS

The relatively low abundance of plankton and benthos observed for this study is an indication of the level of human activities taking place within the various sites samples across the banks of the Warri River. There was a remarkable difference in seasonal distribution of species as more species were recorded in the wet season than dry season. The study subjectively concludes that this difference may be as a result of the change in the level of concentration of pollutants that accompanies the season, as there is the possibility of a decreased concentration of pollutants in the wet season because of frequent rainfall when compared to dry season when there is low or no rainfall.

Furthermore, the low abundance of the taxa Chlorophyta is also an indication of the sites being contaminated by oil particles or droplets. These surface droplets may reduce light intensity which is a limiting factor for organisms in these taxa.

However, one of the most promising findings of this study was the discovery of a dragonfly larva in wet season. When compared to other highly tolerant organisms such Crabs and Periwinkles, dragonfly larvae would hardly withstand the level of pollution found in these areas. With a discovery of the larvae in wet season, it thus connotes the potentials of the water body and its catchment areas to regain its health if proper measures are put in place to mitigate the level of pollution and destruction cause by human activities, especially the operating oil farms within the banks of the Warri River.

<u>Pictures of Organisms found during sampling</u>

Plate 4.47: *Gyrosigma Sp* (Phytoplankton) **Plate 4.48: Copepoda (*Calanoida)* – Zooplankton**

Plate 4.49: Odonata (Dragonfly larvae) **Plate 4.50: Gastropoda (*Tympanotomus sp)***

Plate 4.51: Decapoda (*Cardisoma sp)* **Plate 4.52: Decapoda (Ghost crab)**

Plate 4.53: Gastrpoda (*Littorina sp*) **Plate 4.54: Gastropoda (*Oncomelania sp*)**

Plate 4.55: *Skeletonema sp.*- (Phytoplankton) **Plate 4.56: Crustacea (Shrimp)**

4.5.15 Soil Quality Study

Introduction

For projects such as the proposed Gas plant impacts on the soil may occur at various stages of the project. This study is thus important for the sustenance of the quality of the environment to ensure that activities to be undertaken such as construction of the LPG plant is carried out in such a way to minimize the potential impact on the soil.

The project site which is along Ifie kporo community is presently a fallow land entirely covered with various forms of vegetation.

Results and Discussion

The properties of soil within the study are discussed in the following subsections.

Soil Physio-Chemical Characteristics

pH

Soil pH is a measure of the acidity or alkalinity of soil. A pH of 7 is neutral, a pH below 7 is acidic or sour, and a pH above 7 is alkaline. The pH value of soil affects the quality of plant growth because it directly affects nutrient availability in the soil.

From the laboratory analysis result (Table 4.), the pH of the top soil for the (dry season) ranged from 4.60 to 7.30, with a mean value of 5.95, while the bottom soil samples ranged from pH of 4.70 to 7.20 with a mean value of 5.92.

TABLE 4.41A: pH, Conductivity and Total Organic carbon of the Soil within the project Area. Dry season

SAMPLE ID	pH		EC		%TOC	
	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM
Ss1	7.30	7.20	460	426	0.86	0.59
Ss2	5.20	5.10	990	1175	0.78	0.47
Ss3	4.80	4.70	808	545	0.74	0.66
Ss4	4.60	4.70	874	988	0.43	0.31
SS Control	4.60	4.80	1254	1159	0.47	0.27
MIN	4.60	4.70	460	426	0.43	0.27
Max	7.30	7.20	1254	1175	0.86	0.66
Mean	5.95	5.92	857	800	0.640	0.46

Source: Clairgold.2020

While for the second season top soil has 5.10 to 6.83 with mean 5.97 and bottom soil 4.69 to 6.74 and mean 5.72.

By the classification system of Udo, 1986 (Table 4.41B), the soil is distinctly acidic in nature. This relatively low pH may have long term corrosive effects on buried infrastructures such as cables. However, this is unlikely as the cables will be coated with relevant anti corrosion materials.

Table 4.42. Soil pH classes

Ph	
4.5—5.5	Very Acidic
5.5-6.0	Distinctly Acidic
6.0-7.0	Acidic
7.0	Neutral
7.0-7.5	Faintly Alkaline
7.5-8.0	Alkaline
8.0-8.5	Strongly Alkaline
8.5-9.0	Extremely Alkaline

.

Electrical conductivity

The electrical conductivity (EC) of soil-water mixture is a measure of the concentration of salts in the soil.

All soils contain some salts, which are essential for plant growth. However, excess salts may hinder the growth of some plant species and corrode buried materials. The electrical conductivity measurement reveals the amount of cations or anions (salts) in solution; the greater the amount of anions or cations, the greater the electrical conductivity of the soil.

The electrical conductivity of topsoil within the proposed project area ranged between460 and 1254µS/cm with a mean value of 857µS/cm while it ranged between 426 and 1175µS/cm with a mean value of800µS/cm for the bottom-soil and for second season on table 4; it ranges from top soil 451 to 915µS/cm With mean value of 684.5 and bottom soil ranges from 371 to 1096µS/cm with mean of 733.5µS/cm.

Total Organic Carbon

A wide variety of organic carbon forms are present in soils and range from freshly deposited litter (e.g. leaves, twigs, branches) to highly decomposed forms such as humus. They are a product of decomposition of plants and animals and/or through anthropogenic activities in the environment. Organic carbon influences some soil characteristics including colour, nutrient holding capacity (cation and anion exchange capacity), nutrient turnover and stability, which in turn influences water relations, aeration and workability.

The total organic carbon of top soils collected for analyses ranged between 0.43% and 0.86% with a mean value of 0.64%, while those of the Bottom soils ranged from 027% to 0.66% with a mean value of 0.46% (Table 4.). For the second season topsoil ranges from 0.62to 1.87% and bottom soil 0.47 to 1.17% with mean value of 1.24 and 0.82 respectively.

According to Udo, 1986 as shown that the dry season fall's within the low category class and second season within Medium.

Table 4.43 Organic Carbon

<0.87	Low
0.87-1.43	Medium
>1.45	High

Source Udo: 1986

Particle Size Distribution

The result of particle size distribution of the soil in the proposed project area is shown in table 4. Textural analyses of the soil within the proposed project area showed a predominance of sand particles.

Table 4.44A: Particle Size Distribution of Soil within the Project Area (Dry Season)

Sample ID	1mm VCS	0.5mm CS	0.25mm MS	0.106mm FS	<0.106mm VSF	Total sand	Total Slit	Total Clay	TEXTURE
SS1(0-15cm)top	0.00	0.00	2.06	8.63	1.31	12	57	31	Silt clay loam
SSi(15-30cm)Bottom	0.00	0.00	0.00	9.04	0.96	10	46	44	Silty clay
SS2(0-15cm)top	0.00	0.00	0.00	8.37	0.24	15	66	19	Silty loam
SS2-15cm) 30)Bottom	0.00	0.00	6.42	4.06	0.53	5	79	16	Silty Loam
SS3(0-15cm)top	0.00	0.00	0.00	7.61	0.64	8	72	20	Silty Loam
SS3(15cm-30)Bottom	0.00	0.00	0.00	6.11	0.89	7	61	32	Silt clay loam
SS4(0cm-15cm)top	0.00	0.00	0.74	11.50	1.77	14	47	39	Silt clay loam
SS415-30cm)Bottom	0.00	0.00	0.00	8.75	1.25	10	55	35	Silt clay loam
SS Control(15-30cm)top	0.00	2.74	14.38	10.48	5.40	33	54	13	Loam
SScontrol(15-30cm)Bottom	0.00	1.85	16.54	20.55	2.06	41	41	18	Loam

VCS-- Very coarse Sand Ms---Medium sand

FS--- Fine Sand   VFS ---Very fine Sand   CS--- Coarse Sand

TABLE 4.44B: PARTICLE SIZE DISTRIBUTION OF SOIL WITHIN THE PROJECT AREA (WET SEASON)

SAMPLE NAME	*1mm* VCS	*0.5mm* CS	*0.25mm* MS	*0.106mm* FS	*<0.106mm* VFS	% TOTAL SAND	% TOTAL SILT	% TOTAL CLAY	TEXTURE
SS1 Top (0-15cm)	0.00	0.00	0.00	15.67	0.39	16	60	24	SLITY LOAM
SS1 Bottom (15-30cm)	0.00	0.00	0.00	2.93	0.33	3	52	45	SLITY CLAY
SS2 Top (0-15cm)	0.00	1.95	15.37	9.52	5.16	32	43	25	LOAM
SS2 Bottom (15-30cm)	0.00	0.00	0.50	30.98	0.40	32	39	29	CLAY LOAM
SS3 Top (0-15cm)	0.00	0.00	0.31	23.08	0.42	24	36	40	CLAY LOAM
SS3 Bottom (15-30cm)	0.00	0.00	1.15	27.20	2.65	31	31	38	CLAY LOAM
SS4 Top (0-15cm)	0.00	0.00	0.00	3.65	0.35	4	62	34	SILT CLAY LOAM
SS4 Bottom (15-30cm)	0.00	0.00	1.32	10.26	0.42	12	60	28	SILT CLAY LOAM
SS Control Top (0-15cm)	0.00	14.21	61.71	7.81	0.38	84	7	9	LOAMY SAND
SS Control Bottom (15-30cm)	0.00	14.29	64.29	8.29	0.29	87	10	3	LOAMY SAND

VCS = Very Coarse Sand
CS = Coarse Sand
MS = Medium Sand
FS = Fine Sand
VFS = Very Fine Sand

In the top soil, sand particles ranged between 12.0% and 33.0 % with a mean value of 22.5%. Silt ranged between 47.0% and 72.0% with a mean value of 59.5% while clay particles ranged between 13.0 % and 39.0 % with a mean value of 26.5%. The bottom soils gave the following result; sand particles content ranged between 5.0% and 41.0 % with a mean value of 23.0 %; silt particles ranged between 41.0% and 79.0 % with a mean value of 60.0 %, while clay particles ranged between 16.0% and 44.0% with a mean value of 30.0%.and for the second season sand particles ranges from 4 to 84% with mean of 44% and bottom soil 3 to 87% with mean value of 45%,silt ranges from 7 to 62% top soil and bottom 10 to 60% with mean value of 34.5 and 35% respectively. While clay particles ranges from 9 to 40% top soil and 3 to 45 bottom soil with 24.5 and 24.0% mean values respectively. From the tables the soil is silt, Clay and loam in texture.

Soil Exchangeable Cation

Table 4.45A: Cation content in the soil of the proposed project area. (1st season)

Sample ID	Ca^{2}+		Mg2+		Na+		K+	
	Mg/Kg							
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
SS1	0.97	1.24	1.85	2.05	0.67	0.87	0.42	0.32
SS2	2.05	1.78	1.48	1.95	0.52	0.33	0.45	0.41
SS3	1.88	1.30	1.50	1.94	1.00	0.63	0.21	0.55
SS4	1.86	2.58	1.04	1.84	0.50	0.56	0.40	0.67
SSControl	2.00	1.22	1.36	2.14	1.03	0.60	0.68	0.85
Min	0.97	1.22	1.04	1.84	0.52	0.33	0.21	0.32
Max	2.05	2.58	1.85	2.14	1.03	0.87	0.68	0.85
Mean	1.51	1.90	1.45	1.99	0.76	0.65	0.45	0.58

Table 4.45B: Cation content in the soil of the proposed project area. (2ND Season)

Cations:												
Na	meq/100g	ASTM D4191	0.85	1.28	2.24	0.34	0.49	0.32	0.84	0.75	0.80	0.86
K	meq/100g	ASTM D4191	0.67	0.89	1.64	0.95	0.54	0.26	0.87	0.99	0.52	0.40
Ca	meq/100g	ASTM D511	3.95	4.14	4.88	2.64	2.13	4.42	4.89	3.22	2.48	3.61
Mg	meq/100g	ASTM D511	3.44	2.86	2.94	1.42	1.85	1.08	1.62	2.05	1.24	2.42

Calcium

A higher concentration of calcium was recorded in the bottom soil relative to the topsoil. While the top soil recorded a mean value of 1,51mg/kg, the bottom soil recorded 1.90mg/kg.for the second season mean values were 3.01mg/kg and 3.02 Mg/kg according to Sobulo and Adepetu, 1987 (Table 4.31), the calcium ion concentration in the project area is in the low and medium concentration range.

Table 4.46: Class Standard for Cation

Class	K+	Ca2+	Mg2+	Na+
Low	<0.15	<2.0	<.0.5	<0.3
Medium	0.2-0.3	2.0-5.0	0.5-3.0	0.3-0.7
High	>0.3	>0.5	>3.0	>0.7

Sobulo and Adepetu 1987

Magnesium

Like calcium, higher magnesium concentration was recorded in the bottom soil relative to the topsoil. Magnesium ions ranged between 1.04 and 1.85mg/kg with a mean value of 1.45mg/kg, while a range of between1.84mg/kg and 2.14mg/kg with a mean value of 1.99mg/kg was recorded in the bottom soil and for second season mean values are 2.34 mg/kg and 1.97mg/kg. According to Sobulo and Adepetu, 1987, the magnesium ion in the soil samples of the project area ranked as medium in abundance

Sodium

The concentration of sodium in the top soil profile ranged between 0.52 and 1.03 mg/kg with a mean value of 0.76mg.kg while bottom soil ranged between 0.33 and 0.87mg/kg with a mean value of 0.65mg/kg and for second season the mean values where 1.22mg/kg and 1.30mg/kg From the result, Sodium concentration was higher in the top soil than in the bottom soil. According to the classification criteria of Sobulo and Adepetu, 1987 (Table 4.31), the sodium ion concentration in the project area is in the medium concentration range in the dry season and above the limit in the wet season.

Potassium

The concentration of potassium in the study area was lower in the top soil than the sub-soil. The concentration of potassium in the top soil ranged between 0.088 and 0.276 mg/kg with a mean value of 0.1mg/kg, while subsoil ranged from 0.068 to 1.158mg/kg with a mean value of 0.3mg/kg. for second season 1.08 and 0.62mg/kg According to Sobulo and Adepetu, 1987 (Table 4.31), the potassium ion concentration in the project area ranges between low and medium in first season and above limit in wet season.

Soil Anions

Nitrate

The concentration of nitrate ions in the top soil of the project area ranged between4.76 and 7.03mg/kg and a mean of concentration of 5.89mg/kg. The bottom soil compared favourably with a range of between 3.61mg/kg and 6.92 mg/kg with a mean value of 5.26mg/kg for the second season it mean value for the top soil and bottom were 3.58mg/kg and 2.99mg/kg respectively.

Sulphate

The concentration of sulphate in the top soil ranged between 36.70 and 108.13mg/kg with a mean value of 72.42mg/kg while the sub soil ranged between 43.29mg/kg and 79.01mg/kg with a mean value of 61.15mg/kg and for the second season it compared favorably with mean values of 67.35mg/kg and 66.53mg/kg

Phosphate

The concentration of phosphate ions in the top soil samples analyzed ranged between 0.74mg/kg and 3.94mg/kg with a mean value of 2.34mg/kg while those of the bottom soil ranged between 1.34mg/kg and3.00mg/kg with a mean value of 2.17mg/kg also for second season mean values of 2.67mg/kg and 2.59 were obtained.

Chloride

Chloride is known to combine with other prevalent cations to degrade both concrete and polyethylene coated materials and as such has negative impact on the structural integrity of such materials.

Chloride concentrations ranged between 85,08 and 173.71mg/kg with a mean value of 129.3mg/kg in the top soil, while the bottom soil recorded values which ranged between77.99 to 219.79mg/kg with a mean value of 148.89mg/kg and for the second season means of 194.94mg/kg and 144.97 mg/kg were obtained respectively.

Heavy metal Concentrations

The study of heavy metals within the soil of the project area becomes paramount in view of the potential impacts they could elicit on buried cables and other equipment. Heavy-metal can react with other chemicals in the soil; accumulate under certain circumstances, for example, in metal components of diverse equipment and could lead to violent explosions.

Some of them are dangerous to health or to the environment (e.g. mercury, cadmium, lead, chromium), some may cause corrosion (e.g. zinc, lead), and some are harmful when present at certain concentration in the environment or absorbed by plants and animals or in contact with underground equipment like buried steel pipes. The result of the heavy metal in the soil from the project area is shown in Tables 4.45A and 4.45B.

Table 4.47A: Heavy metal concentration in the proposed project Area (1st season)

Sample ID	Cu		Fe		Ni		Zn	
	Mg/Kg							
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
SS1	2.48	3.08	543.92	487.02	1.28	2.00	7.59	10.10
SS2	1.76	1.96	646.11	432.2	1.58	1.63	13.45	12.26
Ss3	3.03	2.71	753.62	586.38	3.33	2.75	8.47	9.00
SS4	4.44	2.18	600.3	611.49	4.20	1.74	11.38	12.46
SS Control	3.85	3.40	704.27	684.12	2.05	1.45	13.27	8.38
Min	1.76	1.96	543.92	432.2	1.28	1.45	7.59	8.38
Max	4.44	3.40	753.62	684.12	4.20	2.75	13.45	12.26
Mean	3.10	2.68	648.7	558.1	2.74	2.10	10.52	10.32

Table 4.47A:Heavy metal Concentration in the proposed Area. (Dry season)

Sample ID	Pb		Mn		Cd	Cr		
	Mg/Kg							
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
SS1	1.28	1.64	10.53	8.86	0.13	0.09	3.27	4.05
SS2	2.58	0.93	7.49	11.32	<0.001	<0.001	2.09	1.84
Ss3	0.86	2.23	11.32	8.75	0.10	0.15	2.31	1.94
SS4	1.85	2.01	13.44	7.39	0.32	0.28	2.00	4.50
SS Control	1.50	0.95	12.47	9.90	<0.001	<0.001	2.00	1.84
Min	1.28	0.93	7.49	7.39	<0.001	<0.001	2.00	1.84
Max	2.58	2.23	13.44	11.32	0.32	0.28	3.88	4.50
Mean	1.93	1.58	9.51	9.35	0.16	0.14	2.94	3.17

Table 4.47B: Heavy metal Concentration in the proposed Area. Wet season

Heavy Metals:												
Cu	mg/kg	USEPA 7000B	4.82	2.17	2.03	1.28	4.28	6.00	2.67	3.16	2.56	2.15
Fe	mg/kg	USEPA 7000B	355.60	526.00	2213.00	1998.50	558.65	471.10	379.20	226.05	432.25	417.55
Ni	mg/kg	USEPA 7000B	0.86	1.02	3.84	2.40	2.80	4.26	0.73	1.15	1.57	1.26
Zn	mg/kg	USEPA 7000B	9.37	5.97	14.36	13.11	7.32	8.61	4.17	4.80	5.50	2.86
Pb	mg/kg	USEPA 7000B	2.05	1.26	1.67	2.01	2.30	1.64	3.85	3.96	0.97	1.10
Mn	mg/kg	USEPA 7000B	10.35	14.05	27.05	24.83	13.85	12.15	11.02	9.39	13.11	10.98
Cd	mg/kg	USEPA 7000B	1.00	0.55	0.35	0.20	0.65	0.60	<0.001	0.15	0.20	<0.001
Cr	mg/kg	USEPA 7000B	2.05	2.65	1.81	3.02	3.11	2.89	3.78	3.52	1.47	1.06
Ba	mg/kg	USEPA 7000B	0.85	0.50	0.62	0.88	1.24	1.05	1.01	1.57	0.66	0.41
V	mg/kg	USEPA 7000B	0.13	<0.001	<0.001	<0.001	0.05	0.09	<0.001	<0.001	<0.001	<0.001
Hg	mg/kg	USEPA 7473	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

The Heavy metal concentration in the top soil and bottom soil samples collected from project area recorded the following levels of concentrations for dry and wet season: Cadmium ranged between <0.001 and 0.32mg/kg with a mean value of 0.16mg/kg for top soil, while the bottom soil ranged between <0.001 and 0.28mg/kg with a mean concentration of 0.014mg/kg for dry season while wet season ranges from <0.001 to 1.00 and <0.001 to 0.60 with average mean of 0,5 and 0.30 mg/kg respectively.

Copper was between 1.76 and 4.44mg/kg in top(dry season,) 2.03 and 4.82 mg/kg (wet season) and 1.96 and 3.40 mg/kg (dry Season) 61.28 to 6.00mg/kg (wet Season)in bottom soil levels.

Iron, ranged between 543.92mg/kg and 753.62mg/kg with a mean value of 648.7mg/kg (dry season) 355.0 to 2213.0mg/kg with mean of 1284.3mg/kg(wet season) for top soil while the bottom soil ranged between 432.2 and 684.12mg/kg with a mean value of 558.1mg/kg.(dry season)226.05 to 1998.5mg/kg with 1,112.5mg/kg mean .

Nickel, ranged between 1.28 and 4.20mg/kg with a mean value of 2.74mg/kg(dry season)0.86mg/kg to 3.84mg/kg with mean value of 2.35mg/kg (wet Season) for top soil, while bottom soil ranged between1.45 and 2.75mg/kg with a mean value of 2.10mg/kg(Dry season) and 1.02 to 4.26mg/kg with mean value of 2.64mg/kg..

Lead in the top soil ranged between1.28 and 0.93mg/kg with a mean value of1.90mg/kg,(dry season)0.97 to 3.85mg/kg with mean of 2.89mg/kg (wet season) while the bottom soil ranged between 0.93 and 2.23mg/kg with a mean value of1.58mg/kg(dry Season). 1.10 to 3.96mg/kg with mean value of 2.53mg/kg, Zinc concentration in the top soil ranged between 7.59 and 13.49mg/kg with a mean value of 10.52mg/kg, (dry season) 4.17 to 14.36mg/kg with mean value 9.26mg/kg (Wet season) while bottom soil ranged between 8.38 and 12.26mg/kg with a mean value of 10.32.mg/kg (dry season) 2.86 to 13.11mg/kg with 7.98mg/kg (wet season).

The concentration of Manganese in topsoil is between 7.49 and bottom soil 7.39 mg/kg mean value for (dry season) 10.35 to 27.05mg/kg with mean of 18.7mg/kg and 10.98 to 24.83mg/kg with 23.399mg/kg.

Chromium ranged between 2.00 and 3.88mg/kg (dry season) 1.47 to 3.78mg/kg with mean value of 2.12mg/kg in the topsoil; and 1.84 and 4.50mg/kg(wet Season) 1.06mg/kg to 3.52mg/kg with 2.29mg/kg in the bottom soil.

The heavy metal concentration detected in the soil samples were within the corresponding naturally occurring heavy metal concentrations in soils as reported by Allen *et al.* (1974) in Table 4.

Table 4.48: (Naturally occurring Heavy metals)

Metals	Limits(Mg/kg)
Cadmium	0.03-0.3
Nickel	5-500
Lead	2-20
Zinc	10-50

Source Allen et al (1974)

Total Hydrocarbon

The total Petroleum hydrocarbon concentration of the project area ranged between 2.175 and 7.63mg/kg with a mean value of 4.65mg/kg for top soil, while a range of between 1.65mg/kg and 5.05mg/kg with a mean value of 3.35mg/kg was recorded for bottom soil while Benzene, Toluene, Ethyl benzene and Xylene where below detectable limit (dry season).Total petroleum hydrocarbon concentration ranges from 0.943 to 5.743mg/kg with mean value of 3.343mg/kg (Top soil) and 1.215 to 5.839mg/kg with mean value of 3.527mg/kg (wet season.) while Benzene, Toluene Ethyl benzene and Xylene where below detectable limit.

Table for (Dry Season)

Wet Season

Organics:												
TPH	mg/kg	USEPA 8015	5.317	2.027	3.058	2.421	5.743	5.839	2.489	2.423	0.943	1.215
PAH (total of 16 components)	mg/kg	USEPA 8270	0.150	0.210	0.080	0.110	0.300	0.240	0.120	0.040	<0.001	<0.001
Benzene	mg/kg		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Toluene	mg/kg	USEPA 8260	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ethylbenzene	mg/kg		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Xylene	mg/kg		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Soil Microbiology

The results of microbial counts in both top and bottom collected in the project area are presented in Tables 4.49A and 4.49B.

Sample ID top

	THB	THF	SRB	HUB	HUF
SS1	7.3x10	5.20x10	Nil	1.2x10	0.7x10
SS2	6.2x10	6.1x10	Nil	2.2x10	1.8x10
SS3	9.7x10	7.6x10	Nil	1.2x10	0.6x10
SS4	10.3x10	7.4x10	Nil	0.8x10	0.3x10
SScontrol	9.0x10	5.8x10	Nil	1.1x10	Nil
Min	6.2x10	5.2x10	nil	0.8x10	0.3x10
Max	10.3x10	7.6x10	Nil	2.2x10	1.8x10
Mean	8.25x10	6.4x10	Nil	1.5x10	1.05x10

Table 4.49A: Microbial count in Bottom (Dry season)

	THB	THF	SRB	HUB	HUF
SS1	8.2x10	6.1x10	Nil	0.8x10	Nil
SS2	5.1x10	3.7x10	Nil	1.0x10	0.7x10
SS3	6.2x10	8.1x10	Nil	2.0x10	1.0x10
SS4	7.6x10	4.7x10	Nil	0.2x10	Nil
SScontrol	6.4x10	6.0x10	Nil	0.6x10	Nil
Min	5.1x10	3.7x10	Nil	0.2x10	Nil
Max	8.2x10	8.1x10	Nil	2.0x10	1.0x10
Mean	6.65x10	5.9x10	Nil	1.1x10	0.5x10

Table 4.49A: Microbial count in Top (Wet Season)

Microbiological Test:												
THB	(cfu/g)	Pour Plate	8.2×10^4	6.3×10^4	7.2×10^4	5.9×10^4	9.2×10^4	8.3×10^4	9.2×10^4	7.0×10^4	7.6×10^4	4.3×10^4
THF	(cfu/g)	Pour Plate	4.3×10^3	3.7×10^3	3.2×10^3	2.9×10^3	8.0×10^3	6.8×10^3	7.0×10^3	6.6×10^3	4.8×10^3	3.9×10^3
HUB	(cfu/g)	Vapour Phase Transfer	1.0×10^2	0.5×10^2	1.2×10^2	1.0×10^2	1.4×10^2	1.7×10^2	1.0×10^2	1.1×10^2	0.9×10^2	0.7×10^2
HUF	(cfu/g)	Vapour Phase Transfer	0.5×10^2	0.2×10^2	0.4×10^2	0.8×10^2	1.0×10^2	0.7×10^2	0.4×10^2	0.7×10^2	0.3×10^2	0.5×10^2
SRB	(cfu/g)	Plate Count	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

From the table (dry Season), while the concentration of Hydrocarbon Utilizing Bacteria recorded a mean count of 1.5x104cfu/g in top soil of the study area, a lower mean value of 1.1x104cfu/g was recorded in the bottom soil. On the other hand, a higher mean count of 1.05x103cfu/g was recorded in the top soil for Hydrocarbon Utilizing Fungi relative to a lower mean count of 0.5x102cfu/g in the bottom soil. For wet season THB records 8.2x10 and 5.60cfu mean values, THF mean values 5.6X10 and 4.8cfu, HUB records 0.95 cfu and 1.1cfu and HUF records 0.65cfu and 0.5cfu.

Bacteria isolates identified in the soil where staphylococcus, spp, Bacillus spp pseudomonas spp, Enterobacter Spp and fungi isolated species present in all top and bottom soil sample were Mucor Spp, Aspergillus Spp and Penicillium Spp in all the season.

4.5.16 Water Quality Study

Surface Water

The Physio-chemical properties of waters collected from various surface water sampling points within the study area during the dry season sampling are presented in Table 4.50A

Parameters	Unit	Standard Test Method	Surface water Upstream	Surface water Midstream	Surface Water Downstream	Surface Water Control 1	Surface Water Control 2
Physiochemical:							
pH		APHA 4500-H^+	6.00	6.60	5.70	6.70	6.70
Electrical Conductivity	µS/cm	APHA 2510B	111	108	102	95	102
TDS	mg/L	APHA 2540C	61.05	59.40	56.10	52.25	56.10
Temperature	^0C	APHA 2550B	32.2	32.8	31.8	31.8	31.8
Colour	Pt-Co	APHA 2120B	12	14	10	4	6
TSS	mg/L	APHA 2540D	1.5	1.2	0.9	0.2	0.3
Nitrite	mg/L	APHA 4500-NO_2	0.045	0.059	0.048	0.042	0.055
DO	mg/L	APHA 4500-O-G	5.8	5.6	6.0	2.3	2.9
Turbidity	NTU	APHA 2130B	6.8	7.2	5.5	2.4	2.5
BOD_5	mg/L	APHA 5210B	5.40	5.10	4.80	2.70	2.40
COD	mg/L	APHA 5220D	18.13	19.20	14.00	10.67	11.04
THC	mg/L	ASTM D3921	0.26	0.15	0.37	<0.01	<0.01
Oil & Grease	mg/L	ASTM D3921	0.47	0.36	0.59	<0.01	<0.01
Ammonium	mg/L	APHA 4500 NH_3C	0.538	0.674	0.648	0.522	0.808
Salinity as Chloride	mg/L	APHA 4500-Cl-B	38.59	34.68	30.12	28.70	30.29
Nitrate	mg/L	APHA 4500E	0.58	0.66	0.55	0.53	0.57
Phosphate	mg/L	APHA 4500P-E	0.706	0.11	0.086	0.072	0.08
Sulphate	mg/L	APHA 4500 SO_4^{2-}	7.982	9.304	8.222	8.823	8.462
Alkalinity	mg/L as $CaCO_3$	APHA 2320B	24	24	24	24	28
Silica	mg/L	APHA 4500-SiO_2-C	<0.01	<0.01	<0.01	<0.01	<0.01

SURFACE WATER RESULTS (Wet season) in Table 4.50B

Coordinates			**5^0 32′ 11" N 5^0 41′ 25" E**	**5^0 32′ 7" N 5^0 41′ 21" E**	**5^0 32′ 1" N 5^0 41′ 27" E**	**5^0 32′ 1" N 5^0 41′ 41" E**	**5^0 31′ 50" N 5^0 41′ 57" E**
Parameters	**Unit**	**Standard Test Method**	**Surface water Upstream**	**Surface water Midstream**	**Surface Water Downstream**	**Surface Water Control 1**	**Surface Water Control 2**
Physiochemical:							
pH		APHA 4500-H^+	7.24	7.18	6.97	6.93	6.82
Electrical Conductivity	µS/cm	APHA 2510B	81	82	87	78	80
TDS	mg/L	APHA 2540C	45.40	45.90	48.70	44.00	44.80
Temperature	^{0}C	APHA 2550B	26.3	26.2	26.2	26.5	26.3
Colour	Pt-Co	APHA 2120B	9	11	10	3	5
TSS	mg/L	APHA 2540D	1.8	1.6	1.2	0.6	0.4
Nitrite	mg/L	APHA 4500-NO_2	0.132	0.088	0.122	0.080	0.108
DO	mg/L	APHA 4500-O-G	6.9	6.7	6.8	6.7	6.9
Turbidity	NTU	APHA 2130B	4.2	3.6	3.9	1.8	1.6
BOD_5	mg/L	APHA 5210B	6.6	7.2	7.5	4.2	4.8
COD	mg/L	APHA 5220D	16.80	17.07	14.93	11.73	7.47
THC	mg/L	ASTM D3921	0.49	0.61	0.28	<0.01	<0.01
Oil & Grease	mg/L	ASTM D3921	0.66	0.82	0.34	<0.01	<0.01
Ammonium	mg/L	APHA 4500 NH_3C	0.12	0.10	0.08	0.05	0.06
Salinity as Chloride	mg/L	APHA 4500-Cl-B	14.00	14.50	14.89	13.79	12.00
Nitrate	mg/L	APHA 4500E	0.34	0.29	0.23	0.15	0.20
Phosphate	mg/L	APHA 4500P-E	0.23	0.22	0.15	0.27	0.23
Sulphate	mg/L	APHA 4500 SO_4^{2-}	6.86	9.36	8.79	7.43	8.34
Alkalinity	mg/L as $CaCO_3$	APHA 2320B	18	18	22	22	20
Silica	mg/L	APHA 4500-SiO_2-C	<0.01	<0.01	<0.01	<0.01	<0.01

Physio-Chemical Characteristics

pH values ranged between 5.20 and 6.70 with an average value of 6.20 and 7.03 for wet season. These values range near acidic and faintly alkaline in both season. Temperature values had a mean value of 32.3C and 26.4 ^{0}c for dry and wet season and a range from 31.8.0oC to 32.8oC. and 26.2 to 26.5 ^{0}c

Conductivity and TDS values ranged between 95µS/Cm and 111µS/Cm, 78.0µS/cm and 87.0µS/cm dry season and wet season respectively and 52.25.0ppm and 61.05.0ppm, 44.0 ppm and 45.90ppm respectively.

Total Suspended Solids ranged from 0.2mg/L and1.5mg/L, 0.4mg/Land 1.8mg/L with an average value of 0.85mg/L and 1.1mg/L The range of values recorded for alkalinity was very large, ranging from 24mg/L to 28mg/L and with a mean value of 26mg/L.(dry season)18 mg/L to 22mg/L with mean value of 1.1mg/L.

DO values ranged between 2.3mg/L and 6.0mg/L ,6.7mg/L and 6.9mg/L dry and wet season respectively, with an average value of 4.15mg/L and 6,8mg/L This reveals that the water body in the project area can sustain life forms.

BOD is a measure of the amount of oxygen required to oxidize almost all the organic matter present in the water by aerobic microbial decomposition to a stable inorganic form.

BOD is a pointer to the level of pollution in the water.

The BOD in this instance is low with an average value of 3.90mg/L. This can be attributed to the absence of high levels of contaminating organic materials in the water bodies. Usually, when organic matter level is high in water, it stimulates microbial activity and the microbes, in turn, require copious amounts of dissolved oxygen (DO) for respiratory activities. This translates to lower available DO and commensurately increased BOD. The DO in the study area was above the minimum range generally required to optimally sustain a thriving aquatic life.

According to Peavy *et al*. (1985) cited by Prodec-Fugro, (1998) a DO value of 4mg/L and above is required by most aquatic organisms to thrive fully. This average value also falls within regulatory (DPR) limit of 4.0ppm-5.0ppm.

On the other hand, COD is an indirect measurement used to indicate the amount of oxygen consumed by organic compounds in water. The test is conducted using boiling acid potassium dichromate solution, with the result of an oxygen equivalent required to oxidize the organic matter in a water sample that is susceptible to oxidation under the conditions of the test.

COD in these samples ranged between 10.67mg/L and 19.20.0mg/L, with average of 15.94g/L (dry season) for wet season 7.47mg/L and 17.07mg/L with mean value 12.27mg/L The source of this observed COD cannot be adduced to a particular cause, as it does not relate correspondingly with values of BOD, it is not impossible for it to be due to organic influents from decomposing dead plant matter.

The level, with acceptable DO level, does not impact living organism thriving in the available water.

Turbidity values recorded ranged from 2.4NTU to 7.20NTU with a mean of 4.8NTU. (Dry Season) while for wet season 1.6 NTU to 4.2 NTU and mean of 2.9NTU.

Anions and Exchangeable Cations

The concentrations of exchangeable cation and anions in the study area are presented in the Table 4.51A From the table, the concentration of sulphate and chloride accounted for the larger part of the anion content with sulphate being in the range of 7.98mg/L and 9.304mg/L with an average of 8.64mg/L,(dry Season) while chloride falls within the range of 28.70mg/L and 38.59mg/L with a mean value of 33.64mg/L. Phosphate ranged between 0.08mg/L and0.706mg/L with an average of0.39mg/L. while for wet season sulphate is recorded within 6.86 mg/L to 9.36mg/With average mean value of 8.16mg/L.

All the anions fell below regulatory limits of the DPR and FMEnv

Table 4.51A Cation in surface water. Dry Season

Cations:							
Na	mg/L	APHA 3500-Na	16.66	18.37	15.50	13.28	17.11
K	mg/L	APHA 3500-K	0.48	1.24	0.71	0.52	1.00
Ca	mg/L	APHA 3500-Ca-B	7.92	6.06	8.37	4.02	6.84
Mg	mg/L	APHA 3500-Mg-B	3.01	2.57	3.20	1.45	2.24

Table 4.51B Cation in surface water. Wet Season

Cations:							
Na	mg/L	APHA 3500-Na	4.18	7.01	4.46	4.47	10.26
K	mg/L	APHA 3500-K	0.86	1.19	0.94	0.87	1.12
Ca	mg/L	APHA 3500-Ca-B	6.54	6.72	3.18	2.79	4.78
Mg	mg/L	APHA 3500-Mg-B	2.19	2.24	1.08	0.88	1.28

Cations concentrations on the other hand were calcium metal, which ranged between 4.02mg/L and 8.37mg/L with an average value of 6.18mg/L. and 2.79mg/L and 6.72mg/L with mean value of 4.75 mg/L respectively.

The range of values recorded for magnesium was between1.45mg/L and 3.01mg/L, with a mean vaule 6.72mg/L and 0.88mg/L to 2.24 mg/L with mean of 1.56mg/L respectively.. Sodium and Potassium concentrations were between 13.28mg/L and 18.37mg/L, 4.18mg/L and 10.26mg/L for both season and 0.48mg/L and 1.24mg/L. 0.86mg/L and 1.18mg/L respectively.

Hydrocarbon

Total Hydrocarbon Content (HTC) is measured of the hydrocarbon pressure in a medium such as water, sediment or soil. It represents the summation of both the biogenic (from natural/biological source) and petrogenic (from petroleum source) hydrocarbons in a sampled environment or medium.

Table 4.52A and 4.52B summarizes the results of the analysis for Total petroleum hydrocarbons in the water of the study area. TPH concentration in the study area ranged between<0.001mg/L and 0.177mg/L with an average value of 0.088mg/L. in the dry season and <0.001 to 0.425mg/L PAH, Benzene, Toluene, Ethyl benzene and Xylene were <0.001, these values are below DPR limit of 10mg/L for I surface both for the two season.

Table 4.52A: Hydrocarbon (Dry season)

Organics:							
TPH	mg/L	USEPA 8015	0.102	<0.001	0.177	<0.001	<0.001
PAH	mg/L	USEPA 8270	<0.001	<0.001	<0.001	<0.001	<0.001
Benzene	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Toluene	mg/L	USEPA 8260	<0.001	<0.001	<0.001	<0.001	<0.001
Ethylbenzene	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Xylene	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001

Table 4.52B: Hydrocarbon (Wet season)

Organics:							
TPH	mg/L	USEPA 8015	0.385	0.425	0.194	<0.001	<0.001
PAH	mg/L	USEPA 8270	<0.001	<0.001	<0.001	<0.001	<0.001
Benzene	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Toluene	mg/L	USEPA 8260	<0.001	<0.001	<0.001	<0.001	<0.001
Ethylbenzene	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Xylene	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001

Heavy Metals

The result of the heavy metals analysis carried out is presented in Table 4.53A

The concentrations of heavy metals recorded in the study area were generally low. Cadmium (Cd) recorded a range between less than the detection limit of the measuring equipment (<0.002mg/L) and 0.055mg/L with an average value of 0.044mg/L. (dry season) and for the wet season it recorded <0.001 to 0.043mg/L with average value of 0.0215mg/L. Copper and Iron ranged between less than the detection limit of the measuring equipment and 0.822mg/L and 0.071mg/L respectively. While for wet season copper is less detection limit, iron arranges from 0.078 to 0.543mg/L with mean value of 0.310mg/L.

Table 4.54A: Heavy metals concentration in surface water of the proposed project Area. (Dry Season)

Heavy Metals:							
Cu	mg/L	APHA 3111B	0.053	0.040	0.023	0.020	0.014
Fe	mg/L	APHA 3111B	0.274	0.185	0.473	0.103	0.088
Ni	mg/L	APHA 3111B	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/L	APHA 3111B	0.085	0.101	0.048	0.050	0.021
Pb	mg/L	APHA 3111B	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	mg/L	APHA 3111B	0.021	0.053	0.016	<0.001	<0.001
Cd	mg/L	APHA 3111B	<0.001	<0.001	<0.001	<0.001	<0.001
Cr	mg/L	APHA 3111B	0.060	<0.001	0.048	<0.001	<0.001
Ba	mg/L	APHA 3111B	<0.001	<0.001	<0.001	<0.001	<0.001
V	mg/L	APHA 3111B	<0.001	<0.001	<0.001	<0.001	<0.001
Hg	mg/L	APHA 3111D	<0.001	<0.001	<0.001	<0.001	<0.001

Table 4.53B: Heavy metals concentration in surface water of the proposed project Area. (Wet Season)

Heavy Metals:							
Cu	mg/L	APHA 3111B	<0.001	0.016	0.011	<0.001	<0.001
Fe	mg/L	APHA 3111B	0.244	0.740	0.543	0.098	0.078
Ni	mg/L	APHA 3111B	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/L	APHA 3111B	<0.001	0.088	0.038	0.044	0.093
Pb	mg/L	APHA 3111B	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	mg/L	APHA 3111B	0.512	0.808	0.830	0.032	0.045
Cd	mg/L	APHA 3111B	<0.001	0.007	<0.001	0.043	0.022
Cr	mg/L	APHA 3111B	0.021	<0.001	<0.001	<0.001	<0.001
Ba	mg/L	APHA 3111B	<0.001	<0.001	<0.001	<0.001	<0.001
V	mg/L	APHA 3111B	<0.001	<0.001	<0.001	<0.001	<0.001
Hg	mg/L	APHA 3111D	<0.001	<0.001	<0.001	<0.001	<0.001

Zinc recorded values that ranged from less than the detection limit of 0.021mg/L and 0.085mg/L. Nickel (Ni) also recorded values of between <0.001mg/L and <0.001mg/L with a mean value of <0005mg/L. The concentration of Lead varied widely from less than 0.01mg/L which is less the detection limit of the measuring equipment and 3.00mg/L. while for wet season Zinc recorded values ranged from less than the detection limit and 0.093mg/L, Nickel (Ni) , lead (Pb) also recorded values below detected limit.

The high values recorded for some locations cannot be readily adduced to any source. Most of the heavy metal values however fell within regulatory limits of both the DPR and FMEnv.

Surface Water Microbiology

The result of microbial counts in surface water samples collected in the project area is presented in Table 4.54A (Dry Season)

Microbiological Test:							
THB	cfu/ml	APHA 9215B	4.3×10^4	5.7×10^4	6.8×10^4	7.2×10^4	3.0×10^4
THF	cfu/ml	APHA 9215B	3.2×10^3	4.0×10^3	3.7×10^3	5.8×10^3	1.0×10^3
HUB	cfu/ml	APHA 9215B	2.3×10^2	4.1×10^2	1.9×10^2	3.0×10^2	Nil
HUF	cfu/ml	APHA 9215B	1.0×10^1	Nil	0.7×10^1	Nil	Nil
SRB	cfu/ml	Plate Count	Nil	Nil	Nil	Nil	Nil
Feacaloliform	MPN/100ml	APHA 9221C	26	28	14	6	8

The result of microbial counts in surface water samples collected in the project area is presented in Table 4.54B (Wet Season)

Microbiological Test:							
THB	cfu/ml	APHA 9215B	5.2×10^4	5.9×10^4	6.3×10^4	8.1×10^4	7.6×10^4
THF	cfu/ml	APHA 9215B	4.7×10^3	3.8×10^3	4.5×10^3	5.7×10^3	6.2×10^3
HUB	cfu/ml	APHA 9215B	2.1×10^2	3.3×10^2	2.0×10^2	Nil	Nil
HUF	cfu/ml	APHA 9215B	1.2×10^1	2.1×10^1	1.0×10^1	Nil	Nil
SRB	cfu/ml	Plate Count	Nil	Nil	Nil	Nil	Nil
Feacal Coliform	MPN/100ml	APHA 9221C	42	52	40	20	10

From the table, the following is the summary of the microbial analysis of the surface water in the project area:

Faecal coli form was recorded in all locations sampled around the project area with an average load of 17,0x10^4MPN/100ml. for dry season and 31.0x10^4 MPN/100ml for wet season.

Hydrocarbon utilizing bacteria ranged between 0 and 4.1x10^3cfu/ml with an average of 2.05x10^3cfu/ml,(dry season) 0 and 3.3cfu for the wet season while hydrocarbon utilizing fungi recorded relatively lower load of between 0 and 1.0x10 cfu/ml with an average load of 0.5cfu/ml.

Also 0 and 2.1x10^4 cfu with average load of 1.05 X10^4.

Bacteria identified in surface water in all the sample were Bacillus Spp, staphylococcus spp, Peseudomonas spp, Enter bacteria spp ,E.coli and fungi identified are Penicillum spp ,Aspergillus Spp For the two season.

Underground Water

Physio-chemical properties of water samples collected from underground sources within the study area are presented in Table 4. 55A (dry season)

Coordinates					
Parameters	**Unit**	**Standard Test Method**	**SHAFA ENERGY GW 1**	**SHAFA ENERGY GW 2**	**SHAFA ENERGY GW Control 1**
Physiochemical:					
pH		APHA 4500-H^+	7.4	6.40	4.80
Electrical Conductivity	µS/cm	APHA 2510B	940	988	311
TDS	mg/L	APHA 2540C	520.12	553.06	171.05
Temperature	^{0}C	APHA 2550B	33.4	33.4	31.8
Colour	Pt-Co	APHA 2120B	2	1	1
TSS	mg/L	APHA 2540D	<0.1	<0.1	<0.1
Nitrite	mg/L	APHA 4500-NO_2	0.026	0.030	<0.001
DO	mg/L	APHA 4500-O-G	7.0	6.9	7.2
Turbidity	NTU	APHA 2130B	0.5	0.4	<0.1
BOD_5	mg/L	APHA 5210B	3.9	3.3	2.1
COD	mg/L	APHA 5220D	16.00	12.80	8.53
THC	mg/L	ASTM D3921	<0.01	<0.01	<0.01
Oil & Grease	mg/L	ASTM D3921	<0.01	<0.01	<0.01
Ammonium	mg/L	APHA 4500 NH_3C	0.48	0.66	0.10
Salinity as Chloride	mg/L	APHA 4500-Cl-B	194.94	184.94	42.99
Nitrate	mg/L	APHA 4500E	1.71	1.54	0.35
Phosphate	mg/L	APHA 4500P-E	0.06	0.05	0.02
Sulphate	mg/L	APHA 4500 SO_4^{2-}	21.44	17.00	3.30
Alkalinity	mg/L as $CaCO_3$	APHA 2320B	29	25	6
Silica	mg/L	APHA 4500-SiO_2-C	<0.01	<0.01	<0.01

Physio-chemical properties of water samples collected from underground sources within the study area are presented in Table 4.55B (Wet season)

Coordinates			**5^0 32′ 12.7"N 5^0 41′ 21"E**	**5^0 32′ 14"N 5^0 41′ 9"E**	**5^0 34′ 8"N 5^0 44′ 38"E**
Parameters	**Unit**	**Standard Test Method**	**SHAFA ENERGY GW 1**	**SHAFA ENERGY GW 2**	**SHAFA ENERGY GW Control**
Physiochemical:					
pH		APHA 4500-H^+	6.52	6.73	6.92
Electrical Conductivity	µS/cm	APHA 2510B	770	750	110
TDS	mg/L	APHA 2540C	431.00	420.00	61.60
Temperature	^{0}C	APHA 2550B	26.1	26.1	26.3
Colour	Pt-Co	APHA 2120B	3	1	1
TSS	mg/L	APHA 2540D	<0.1	<0.1	<0.1
Nitrite	mg/L	APHA 4500-NO_2	<0.001	<0.001	<0.001
DO	mg/L	APHA 4500-O-G	6.1	5.9	6.3
Turbidity	NTU	APHA 2130B	0.4	0.3	<0.1
BOD_5	mg/L	APHA 5210B	6.0	4.8	2.4
COD	mg/L	APHA 5220D	14.93	11.73	7.47
THC	mg/L	ASTM D3921	<0.01	<0.01	<0.01
Oil & Grease	mg/L	ASTM D3921	<0.01	<0.01	<0.01
Ammonium	mg/L	APHA 4500 NH_3C	0.26	0.31	0.18
Salinity as Chloride	mg/L	APHA 4500-Cl-B	96.97	83.64	16.00
Nitrate	mg/L	APHA 4500E	0.46	0.50	0.41
Phosphate	mg/L	APHA 4500P-E	1.35	1.02	<0.01
Sulphate	mg/L	APHA 4500 SO_4^{2-}	20.64	20.18	2.16
Alkalinity	mg/L as $CaCO_3$	APHA 2320B	23	32	12
Silica	mg/L	APHA 4500-SiO_2-C	<0.01	<0.01	<0.01

Physio-Chemical Characteristics

pH values were constant at 6.10 for the three underground water samples collected. This value is near neutral. The wet season carried out in july 2010 recorded a pH range of between 6.52 and 6.92 and mean of 6.72near neutral. Temperature values ranged between 31.8oC and 33.4oC with a mean value of 32.6oC. For wet season 26.1 and 26.3^0 c Conductivity and TDS values ranged between 311µS/Cm and 988µS/Cm and 171ppm and 553.06ppm respectively for dry season, for wet season. Total Suspended Solids ranged from 61.6 mg/L and 420.0mg/L, with an average value of 240.8mg/L.

The range of values recorded for alkalinity was very large, ranging from 6.0mg/L to 29.0mg/L with a mean value of17.5mg/L while for the second season 12.0mg/Land 32.0mg/L with mean value of 22.0mg/L.

DO values ranged between 6.9 mg/L and 7.2mg/L respectively, with an average value of 7.05mg/Land for wet season 5.90mg/L and 6.3mg/L with average value of 6.1 mg/L

This reveals that the water body in the project area can sustain life forms.

BOD

The BOD in ground water was low with an average value of 20.50mg/L and 6.10 for dry and wet season respectively. This can be attributed to the absence of high levels of contaminating organic materials in the water. The DO in the underground water was above the minimum range generally required to optimally sustain a thriving aquatic life.

According to Peavey *et al*. (1985) cited by Prodec-Fugro, (1998) a DO value of 4mg/L and above is required by most aquatic organisms to thrive fully. This average value also falls within regulatory (DPR) limit of 4.0ppm-5.0ppm on the other hand, COD is an indirect measurement.

COD in these samples ranged between 8.53.0mg/L and 16.0mg/L, with average of 12.26mg/L and wet season with 7.47mg/L and 14.93mg/L acceptable DO level, does not impact living organism thriving in the available water. Turbidity values recorded ranged from <0.1 NTU to 0.5NTU with a mean of 0.25NTU then for wet season it ranges from <0.1NTU to 0.7 NTU with mean value of 0.35NTU.

Anions and Exchangeable Cations

The concentrations of exchangeable cations and anions in the groundwater of the study area are presented in Table 4.51A From the table, the concentration of sulphate and chloride accounted for the larger part of the anion content with sulphate being in the range of 3..30mg/L and 21.44mg/L with an average of 12.37mg/L, for wet season it recorded 2.16 mg/L and 20.64mg/L with mean value of 11.40mg/L while chloride falls within the range of 42.99mg/L and 194.99mg/L with a mean value of 118.96mg/L. and for wet season it ranges from 16.0 to 96.97mg/L with mean vale of 56.48mg/l. Phosphate ranged between 0.02mg/L and 0.06mg/L with an average of 0.04mg/L. and for wet season it ranges <0.01 and 1.35mg/L. All the anions fell below regulatory limits of the DPR and FMEnv.

Table 4.56A: Cation in Underground Water of the Project Area (Dry Season)

Cations:					
Na	mg/L	APHA 3500-Na	105.95	90.44	30.30
K	mg/L	APHA 3500-K	4.40	3.92	0.88
Ca	mg/L	APHA 3500-Ca-B	29.64	26.02	7.07
Mg	mg/L	APHA 3500-Mg-B	10.77	8.83	2.54

Table 4.56B: Cation in Underground Water of the Project Area (Wet Season)

Cations:					
Na	mg/L	APHA 3500-Na	54.62	76.03	6.38
K	mg/L	APHA 3500-K	6.48	7.21	0.66
Ca	mg/L	APHA 3500-Ca-B	32.97	30.56	2.40
Mg	mg/L	APHA 3500-Mg-B	11.26	10.94	0.61

Cations concentrations on the other hand were highest with sodium metal, which ranged between 30.30mg/L and 105.95mg/L with an average value of 68.12mg/L. The range of values recorded for magnesium was between 2.54mg/L and 10.77mg/L, with a mean value of 6.65mg/L. or wet season sodium ranges from 6.38mg/L to 76.03mg/L with mean value of 41.20mg/L, Magnesium obtained ranges from0.64mg/L to 11.26mg/L with mean value of 5.95mg/L, calcium ranges from 2.40mg/L to 35.37mg/L with mean of 17.6mg/L

Hydrocarbons

Total Hydrocarbon Content (THC) is a measure of the hydrocarbon presence in a medium such as water, sediment or soil. It represents the summation of both the biogenic (from natural/biological source) and petrogenic (from petroleum source) hydrocarbons in a sampled environment or medium.

Table 4 57ASummarizes the results of the analysis for hydrocarbons in the under groundwater of the study area. THC concentration in groundwater ranged between <0.001mg/L and <0.001mg/L with an average value of <0.001mg/L. These values are below DPR limit of 10mg/L for inland waters for the two season.

Table 4.57A: (Hydrocarbon Concentration of Underground water samples 1st season

Organics:					
TPH	mg/L	USEPA 8015	<0.001	<0.001	<0.001
PAH	mg/L	USEPA 8270	<0.001	<0.001	<0.001
Benzene	mg/L		<0.001	<0.001	<0.001
Toluene	mg/L	USEPA 8260	<0.001	<0.001	<0.001
Ethylbenzene	mg/L		<0.001	<0.001	<0.001
Xylene	mg/L		<0.001	<0.001	<0.001

Table 4.57B: Hydrocarbon Concentration of Underground water samples 2nd season

Organics:					
TPH	mg/L	USEPA 8015	<0.001	<0.001	<0.001
PAH	mg/L	USEPA 8270	<0.001	<0.001	<0.001
Benzene	mg/L	USEPA 8260	<0.001	<0.001	<0.001
Toluene	mg/L		<0.001	<0.001	<0.001
Ethylbenzene	mg/L		<0.001	<0.001	<0.001
Xylene	mg/L		<0.001	<0.001	<0.001

Heavy Metals

The result of the heavy metals analysis carried out is presented in Table 4.. The concentrations of heavy metals recorded in the groundwater were generally low. Cadmium (Cd) recorded a range between less than the detection limit of the measuring equipment (<0.002mg/L) and 0.029mg/L. Copper ranged between <0.001mg/L and 0.02mg/L with an average value of 0.001mg/L.

Table 4.58A: Heavy Metal concentration in underground water 1st season

Heavy Metals:					
Cu	mg/L	APHA 3111B	<0.001	0.02	<0.001
Fe	mg/L	APHA 3111B	0.07	0.04	0.01
Ni	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Zn	mg/L	APHA 3111B	0.03	0.05	<0.001
Pb	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Mn	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Cd	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Cr	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Ba	mg/L	APHA 3111B	<0.001	<0.001	<0.001
V	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Hg	mg/L	APHA 3111D	<0.001	<0.001	<0.001

Table 4.58B: Heavy Metal concentration in underground water 2nd season

Heavy Metals:					
Cu	mg/L	APHA 3111B	0.01	0.02	<0.001
Fe	mg/L	APHA 3111B	0.08	0.02	0.01
Ni	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Zn	mg/L	APHA 3111B	0.06	0.13	0.11
Pb	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Mn	mg/L	APHA 3111B	0.05	0.08	0.03
Cd	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Cr	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Ba	mg/L	APHA 3111B	<0.001	<0.001	<0.001
V	mg/L	APHA 3111B	<0.001	<0.001	<0.001
Hg	mg/L	APHA 3111D	<0.001	<0.001	<0.001

Iron were between 0.01 and 0.07mg/L and Manganese were undetected in the samples, as the values obtained from analysis were both below the detection limit of the measuring equipment. Zinc recorded values that ranged from <0.001mg/L to 0.05mg/L. Nickel (Ni) also recorded values of between <0.001mg/L and <0.001mg/L with a mean value of 0.0005mg/L.

All the heavy metal values fell within regulatory limits of both the DPR and FMEnv. These low heavy metal values compared favorably with the July 2020 study as follows:

Manganese ranged between <0.003ppm and <0.001ppm (mean, 0.08ppm).

Iron ranged from 0.01ppm to 0.08ppm (mean, 0.04ppm)

Zinc recorded an average of 0.011ppm

The concentration of Chromium, Cadmium and Lead were below the detection limit of the measuring equipment used.

Underground Water Microbiology

Table 4.59A: The result of microbial counts in underground water samples collected in the project area is presented in (Dry season)

Microbiological Test:					
THB	cfu/ml	APHA 9215B	0.8×10^3	0.5×10^3	Nil
THF	cfu/ml	APHA 9215B	Nil	Nil	Nil
HUB	cfu/ml	APHA 9215B	Nil	Nil	Nil
HUF	cfu/ml	APHA 9215B	Nil	Nil	Nil
SRB	cfu/ml	Plate Count	Nil	Nil	Nil
Feacal Coliform	MPN/100ml	APHA 9221C	Nil	Nil	Nil

Table 4.59B: The result of microbial counts in underground water samples collected in the project area is presented in (Wet season)

Microbiological Test:					
THB	cfu/ml	APHA 9215B	3.2×10^3	2.0×10^3	0.7×10^3
THF	cfu/ml	APHA 9215B	1.5×10^2	1.0×10^2	Nil
HUB	cfu/ml	APHA 9215B	Nil	Nil	Nil
HUF	cfu/ml	APHA 9215B	Nil	Nil	Nil
SRB	cfu/ml	Plate Count	Nil	Nil	Nil
Feacal Coliform	MPN/100ml	APHA 9221C	32	20	Nil

From the tables, Feacal coliform species recorded relatively low concentration with an average load of Nil MPN/100ml. While hydrocarbon utilizing bacteria was not detected in all the underground water sources sampled with an average load of Nil, hydrocarbon utilizing fungi was not detected in any of the locations. The only microbe isolated in underground water was Bacillus spp. For the two season.

4.5.17 Sediment Study

The physiochemical properties of sediments collected from various sampling points within the study area during the dry season sampling are presented in 1st season

Table 4.60A: Physiochemical Properties of Sediment in the Project Area

Coordinates			**5^0 32′ 11" N 5^0 41′ 25" E**	**5^0 32′ 7" N 5^0 41′ 21" E**	**5^0 32′ 1" N 5^0 41′ 27" E**	**5^0 32′ 1" N 5^0 41′ 41" E**	**5^0 31′ 50" N 5^0 41′ 57" E**
Parameters	**Unit**	**Standard Test Method**	**Sediment Upstream**	**Sediment Midstream**	**Sediment Downstream**	**Sediment Control 1**	**Sediment Control 2**
Physiochemical							
pH		ASTM D4972	7.30	5.60	5.70	5.10	5.40
Electrical Conductivity	µs/cm	USEPA 9050A	626	618	427	696	371
Chloride	mg/kg	ASTM D512	95.72	102.81	88.63	92.17	67.36
Sulphate	mg/kg	ASTM D516	37.25	32.30	39.45	31.21	28.46
TOC	311%	Walkley Black	1.05	1.21	1.13	0.94	0.90
Phosphate	mg/kg	ASTM D515	2.05	1.20	1.25	1.83	2.52
Ammonium	mg/kg	ASTM D3867	2.85	2.74	3.00	2.15	2.10
Nitrate	mg/kg	ASTM D3867	3.59	5.44	4.51	4.04	3.16
Nitrite	mg/kg	ASTM D3867	0.23	0.15	0.27	0.22	0.18
THC	mg/kg	ASTM D3921	4.17	3.90	5.72	2.50	2.81
Oil & Grease	mg/kg	ASTM D3921	8.21	7.05	9.33	4.72	4.40

Table 4.60B The physiochemical properties of sediments collected from various sampling points within the study area during the dry season sampling are presented in 2nd season

Coordinates			**5^0 32′ 11" N 5^0 41′ 25" E**	**5^0 32′ 7" N 5^0 41′ 21" E**	**5^0 32′ 1" N 5^0 41′ 27" E**	**5^0 32′ 1" N 5^0 41′ 41" E**	**5^0 31′ 50" N 5^0 41′ 57" E**
Parameters	**Unit**	**Standard Test Method**	**Sediment Upstream**	**Sediment Midstream**	**Sediment Downstream**	**Sediment Control 1**	**Sediment Control 2**
Physiochemical							
pH		ASTM D4972	4.07	4.74	4.60	3.44	4.69
Electrical Conductivity	μs/cm	USEPA 9050A	966	1014	2685	1030	2010
Chloride	mg/kg	ASTM D512	301.33	318.05	478.58	443.13	460.85
Sulphate	mg/kg	ASTM D516	136.09	255.20	268.28	236.31	188.35
TOC	%	Walkley Black	2.34	1.95	2.42	2.15	2.26
Phosphate	mg/kg	ASTM D515	1.86	2.04	1.54	1.24	1.42
Ammonium	mg/kg	ASTM D3867	2.22	2.09	2.10	1.65	1.98
Nitrate	mg/kg	ASTM D3867	5.22	4.78	5.08	4.97	5.06
Nitrite	mg/kg	ASTM D3867	0.26	0.20	0.21	0.18	0.21
THC	mg/kg	ASTM D3921	8.36	13.73	5.67	<0.01	<0.01
Oil & Grease	mg/kg	ASTM D3921	13.23	20.35	7.56	<0.01	<0.01

Physiochemical Properties

pH values ranged from 5.10 to 7.30 with a mean value of 6.20,for dry and wet season are the same indicating varying degrees of acidity. Electrical conductivity ranged from 317 to 696µS/cm, with a mean of 533.5µS/cm. for wet season it ranges from 371µS/cm to 696µS/cm with mean value of 533.5µ.

The status of nutrient elements in sediments is a crucial index for measuring the fertility and productivity of a marine ecosystem. Total Organic Carbon ranged between 0.90 and 1.21%, with an average concentration of 1.06%, for wet season 1.90 % and 2.42% with mean value of 1.01% which is indicative of low fertility. Average composition of textural classes of sediment indicated the predominance of sand-sized particles.

Anions and Cations in Sediments

Table 4.61A presents the concentration of anions and cations in sediments of the project area. The highest concentration of all the anions was sulphate with a mean value of 32.85mg/kg and 33.95mg/kg for both season, Phosphate recorded the least average concentration of1.86mg/kg, while Chloride and Nitrate recorded average values of 84.58mg/kg and 4.30mg/kg respectively. For wet season Phosphate records1.24mg/kg to 2.04mg/kg, while chloride and nitrate recorded 85.08mg/kg and 5.00mg/kg respectively.

The relatively chloride concentrations are expected considering the relative freshness of the surface water environment and these correlated very well with the Na+ values recorded.

Table 4.61A: Concentration of Anions and Cations in Sediment of the Project Area 1ST season

Cations:							
Na	meq/100g	ASTM D4191	0.60	0.42	0.31	0.67	0.51
K	meq/100g	ASTM D4191	0.21	0.33	0.50	0.45	0.27
Ca	meq/100g	ASTM D511	1.06	2.14	1.58	1.86	1.90
Mg	meq/100g	ASTM D511	3.27	2.14	3.68	1.20	1.54

Table 4.61B: Concentration of Anions and Cations in Sediment of the Project Area 2nd season

Cations:							
Na	meq/100g	ASTM D4191	1.01	3.36	3.33	0.97	2.35
K	meq/100g	ASTM D4191	0.35	0.61	1.03	1.11	0.48
Ca	meq/100g	ASTM D511	1.38	3.00	2.10	2.05	3.14
Mg	meq/100g	ASTM D511	2.49	4.02	4.72	3.17	2.85

The concentrations of cations (Ca2+, Mg2+, Na+ and K+) were presented as follows (Table 4.49).

The concentration of cations is presented below.

Calcium ranged from1.06 to 2.14mg/kg (mean, 2.10mg/kg).

Magnesium ranged from 1.20 to 3.68mg/kg (mean, 2,44mg/kg).

Sodium, ranged from 0.31 to 0.67mg/kg (mean, 0.49mg/kg)

Potassium, ranged from 0.21 to 0.50mg/kg (mean, 0.355mg/kg).

For wet season:

Calcium ranged from2.05 to 3.14mg/kg (mean, 2.59mg/kg).

Magnesium ranged from 2.49 to 4.72mg/kg (mean, 4.60mg/kg).

Sodium, ranged from 0.97 to 2.35mg/kg (mean, 1.66mg/kg)

Potassium, ranged from 0.35 to 1.11mg/kg (mean, 0.73mg/kg

From the results, it could be concluded that the exchange complex of sediments in the study area is dominated by magnesium, followed by calcium, sodium and potassium respectively.

Heavy Metals and Hydrocarbon Concentrations

Heavy metal concentrations in sediments are useful indicators of the source or cause of river pollution, as relatively high heavy metal content in sediments depicts a polluted environment. All the heavy metals (Cd, Cu, Fe, Ni, Pb, Zn, Cr and Mn) analyzed for in the sediment samples were present in varying levels of concentrations as shown in Table 4.62.

Table 4.62A: Heavy Metals and Hydrocarbon Concentration in Sediment of the Project Area (Dry Season)

Heavy Metals:							
Cu	mg/kg	USEPA 7000B	4.21	4.70	5.01	3.21	3.00
Fe	mg/kg	USEPA 7000B	646.84	650.32	684.53	537.28	690.07
Ni	mg/kg	USEPA 7000B	1.26	1.47	1.64	0.96	1.02
Zn	mg/kg	USEPA 7000B	6.90	7.03	6.95	7.74	8.04
Pb	mg/kg	USEPA 7000B	2.11	1.75	1.84	1.35	0.88
Mn	mg/kg	USEPA 7000B	8.47	8.08	9.84	5.63	7.01
Cd	mg/kg	USEPA 7000B	0.17	0.21	0.16	<0.001	0.09
Cr	mg/kg	USEPA 7000B	1.31	1.47	2.02	0.42	1.05
Ba	mg/kg	USEPA 7000B	1.06	1.58	0.97	1.00	<0.001
V	mg/kg	USEPA 7000B	0.07	<0.001	0.10	0.04	<0.001
Hg	mg/kg	USEPA 7473	<0.001	<0.001	<0.001	<0.001	<0.001

Table 4.62B: Heavy Metals and Hydrocarbon Concentration in Sediment of the Project Area (Wet Season)

Heavy Metals:							
Cu	mg/kg	USEPA 7000B	3.69	3.84	4.00	3.73	2.36
Fe	mg/kg	USEPA 7000B	2949.00	2600.50	2045.00	1973.10	1759.00
Ni	mg/kg	USEPA 7000B	3.00	3.12	3.98	1.27	0.85
Zn	mg/kg	USEPA 7000B	21.76	68.52	54.60	28.03	53.88
Pb	mg/kg	USEPA 7000B	4.26	3.95	4.12	1.10	1.20
Mn	mg/kg	USEPA 7000B	15.20	21.00	25.50	14.50	23.50
Cd	mg/kg	USEPA 7000B	0.80	4.35	3.45	0.23	0.31
Cr	mg/kg	USEPA 7000B	2.10	1.95	1.60	1.63	2.17
Ba	mg/kg	USEPA 7000B	1.90	2.00	1.83	2.10	1.68
V	mg/kg	USEPA 7000B	<0.001	<0.001	<0.001	<0.001	<0.001
Hg	mg/kg	USEPA 7473	<0.001	<0.001	<0.001	<0.001	<0.001

With a mean value of 1.53mg/L, Chromium (Cr) recorded concentration among the metals analyzed, while, manganese (Mn) concentration were (7.05mg/kg). Other metals were detected at varying concentrations as follows.

Cadmium ranged from <0.001 to 0.21mg/kg (mean, 0.01mg/kg).

Copper ranged from 3.00 to 5.01mg/kg (mean, 4.005mg/kg).

Iron ranged from 537.28 to 690.07mg/kg (mean, 613.6mg/kg).

Nickel ranged from 1.02 to 1.64mg/kg (mean, 1.33mg/kg).

Lead ranged from 0.88 to 2.11mg/kg (mean, 1.49mg/kg).

Zinc ranged from 6.90 to 8.04mg/kg (mean, 7.47mg/kg).

For wet season:

With a mean value of 1.88mg/L, Chromium (Cr) recorded concentration among the metals analyzed, while, manganese (Mn) concentration were (20.00mg/kg). Other metals were detected at varying concentrations as follows.

Cadmium ranged from 0.311 to 4.35mg/kg (mean, 3.33mg/kg).

Copper ranged from2.36 to 4.00mg/kg (mean, 3.18mg/kg).

Iron ranged from 1759.0 to 2949.0mg/kg (mean, 2354.0mg/kg).

Nickel ranged from 1.27 to 3.98mg/kg (mean, 2.62mg/kg).

Lead ranged from 1.10 to 4.26mg/kg (mean, 2.68mg/kg).

Zinc ranged from 21.76 to68.52mg/kg (mean, 45.14mg/kg).

Total hydrocarbons were relatively high and ranged from 1.478 to 3.286mg/kg (mean 2.382mg/kg) and wet season <0.001 and 11.316mg/kg. This concentration may be as a result of the relatively low volume of hydrocarbon sources, which could result to fugitive hydrocarbon contribution within the study area.

In conclusion, going by the laboratory results and the respective parameters, which are relatively low in concentrations, it is obvious that the sediments in the project area have not experienced significant pollution fingerprints.

Table 4.63A: Hydrocarbon (Dry Season)

Organics:							
TPH	mg/kg	USEPA 8015	3.185	2.185	3.286	1.478	1.532
PAH (total of 16 components)	mg/kg	USEPA 8270	0.150	0.060	0.110	<0.001	0.040
Benzene	mg/kg	USEPA 8260	<0.001	<0.001	<0.001	<0.001	<0.001
Toluene	mg/kg		<0.001	<0.001	<0.001	<0.001	<0.001
Ethylbenzene	mg/kg		<0.001	<0.001	<0.001	<0.001	<0.001
Xylene	mg/kg		<0.001	<0.001	<0.001	<0.001	<0.001

Table 4.63B: Hydrocarbon (Wet Season)

TPH	mg/kg	USEPA 8015	6.674	11.316	3.286	<0.001	<0.001
PAH (total of 16 components)	mg/kg	USEPA 8270	0.110	0.050	0.040	<0.001	<0.001
Benzene	mg/kg	USEPA 8260	<0.001	<0.001	<0.001	<0.001	<0.001
Toluene	mg/kg		<0.001	<0.001	<0.001	<0.001	<0.001
Ethylbenzene	mg/kg		<0.001	<0.001	<0.001	<0.001	<0.001
Xylene	mg/kg		<0.001	<0.001	<0.001	<0.001	<0.001

Sediment Microbiology

Table 4.64A: Microbial Counts in Sediment Samples around the Project Area (Dry season)

Microbiological Test:							
THB	(cfu/g)	Pour Plate	8.7×10^4	6.3×10^4	7.2×10^4	8.4×10^4	5.2×10^4
THF	(cfu/g)	Pour Plate	5.3×10^3	4.2×10^3	5.1×10^3	4.3×10^3	2.8×10^3
HUB	(cfu/g)	Vapour Phase Transfer	2.0×10^2	3.6×10^2	2.8×10^2	3.5×10^2	2.0×10^2
HUF	(cfu/g)	Vapour Phase Transfer	1.0×10^2	0.5×10^2	1.7×10^2	1.0×10^2	0.2×10^2
SRB	(cfu/g)	Plate Count	Nil	Nil	Nil	Nil	Nil

The result of microbial counts in sediment samples collected in the project area is presented in. Table 4.64B (Wet season)

Microbiological Test:							
THB	(cfu/g)	Pour Plate	6.2×10^4	5.7×10^4	8.1×10^4	7.0×10^4	6.5×10^4
THF	(cfu/g)	Pour Plate	4.3×10^3	5.1×10^3	6.0×10^3	4.7×10^3	3.0×10^3
HUB	(cfu/g)	Vapour PhaseTransfer	1.8×10^2	2.6×10^2	2.0×10^2	2.5×10^2	2.0×10^2
HUF	(cfu/g)	Vapour Phase Transfer	1.2×10^2	0.9×10^2	1.0×10^2	1.2×10^2	0.7×10^2
SRB	(cfu/g)	Plate Count	Nil	Nil	Nil	Nil	Nil

From the table, the following is the summary of the microbial analysis of the sediment in the project area:

Hydrocarbon utilizing bacteria ranged between $2.0x10^3$ and $3.60x10^4$cfu/g with an average of $2.80x10^4$cfu/g, while hydrocarbon utilizing fungi recorded relatively lower load of between0.2 and 1.7cfu/g with an average load of 0.85cfu/g. for the wet season HUB ranges from 2.0x10 to $3.5x10^4$ and mean value of 2.75 cfu, HUF ranges 0.2x10 to 1.7 $x10^4$ cfu, THB $5.4x10^4$ to$8.7x10^4$,,THF 5.3 $x10^4$ to $8.1x10^4$.

The few isolated microbial species in sediment samples in the project area include, *pseudomonas spp*, Baclius spp and Enterobacter spp. Other fungi species such as Mucor spp.candida spp, Aspergillus spp and penicillium spp *were* not isolated in any of the sediment samples.

4.5.18 Socioeconomic Study

The socio-economic facilities in an area enhance the quality of life of any community of people. Such socio-economic infrastructures comprise of roads, education, houses, water, electricity, health facilities, markets, banking facilities among others. These vital ingredients of life often influence the behavioral pattern of people with themselves and even to others as well. Further, the quality of these socioeconomic infrastructures can be greatly enhanced with the presence of well-articulated power project capable of propelling different types of economic activities. Thus, the decision to embark on this power project in the study area will certainly serves as a means of fulfilling the yearnings and aspirations of the respondents in the study area as it will positively impact on the quality of their livelihoods and appreciation of life in a good perspective as well.

Lee and Wood (1995), defined consultation as the process of asking for information about the environmental implications of projects subject to Impact Assessment (IA) process, from designated bodies, organizations or persons with environmental responsibilities or interests. From the foregoing definition, it is clear that consultation must have a wide variety of scope in different countries. It is also clear that provisions and practices relating to consultation, and particularly to public participation, must be strongly influenced by the culture, the educational level and the political consciousness in the jurisdiction concerned.

Consultation is an important element of this socio-economic assessment and an integral component of any environmental study. This is because appropriate and adequate consultations will ensure smooth project implementation and guarantee economic and commercial sustainability of any project. It involves information dissemination and interaction/dialogues with identified stakeholders (including communities within the project vicinity).

Interaction with people and eliciting feedback allows the affected populations to influence the decision-making process by raising issues that should be considered in project of sign; mitigation; monitoring and management plans; and the analysis of alternatives. The overall result would be the optimization of the potentials of the operation of the facility/project and maximization of its benefits. They key objectives of consultation on the exercise are to:

- ensure that the community and all stakeholders are well informed on the operation of the facility;
- provide a framework for improving the understanding of the potential impacts of the facility on the ecological, social and health environment;
- identify alternative sites or designs, and mitigation measures, in order to improve environmental and social soundness;
- identify contentious issues in the operation of the facility;
- establish transparent procedures for carrying out the activities of the Tank farm;
- and create accountability and a sense of local ownership of the facility thus minimizing community conflicts and project delays that may result thereof.

Benefits of Consultation

Regardless of regulatory and other requirements for consultations, it may also offer a number of other benefits, which are enough reasons for undertaking it. These benefits are outlined below.

- Obtaining regulatory approval: statutory requirement for the continued operation of the facility.
- By taking the advice and views of local community into account at the operation of the facility.
- Consultation can help to avoid errors, delays, the need for mitigation and remedial measures which may be expensive or less effective when implemented at a later stage.

- Defining the scope of EER.
- Gaining the trust and co-operation of local community.
- Every consultation helps the proponent of the facility to understand needs, concerns and values and prevents misconceptions arising from poor communication.
- Consultation can also be a powerful means of improving the relationship in existing operations.
- Identifying opportunities and partnerships.
- Improving economic performance.
- Improve corporate reputation.
- Increased project success.
- Promoting sustainability of the project.
- Increasing accountability.

Levels of Consultation

In this study the following levels of consultation was carried out:

(i) Primary Stakeholders

The primary impact stakeholder in this project is the host community which is directly affected by the existing facility, the local government area responsible for the welfare of the affected community, Youth Vanguards, and project owners.

(ii) Secondary Stakeholders

The secondary-impact stakeholders are those not directly affected by the project, but who may have an influence, interest or expertise to offer. These include non-governmental organizations (NGOs), regulatory authorities (FMEnv, DSMEnv, and DPR).

(iii) Community Based Organizations (CBOs)

This level of consultations involves interested groups such as community based organizations (CBOs), community based associations (CDAs), naturalists and affected groups or other people who may in any way be directly or indirectly affected by the project, participated in the assessment.

Study Design

The socio-economic survey of the project was designed with the cardinal aim of extracting information from the community people within the project area. The study design includes literature research, identification of sample populations, administration of questionnaires and conducting interviews in the affected community. Households were randomly sampled for even and appropriate representation. Generally, the study was broken into three components involving field survey data collation and analysis, and reporting.

Target Population

The target population was essentially indigenes of the community aged above 15 years. The age was carefully chosen to capture the groups that would be most directly impacted upon and also most active, physically, socially, economically and health wise. Generally, the target groups are:

- Paramount rulers and members the council of chiefs.
- Youth associations
- Women associations

- Other community based organizations
- Economic subgroups like hunters, farmers, traders etc.
- The community development union or committee (CDC)
- Individuals/household

Data Sources

Information on the socio-economic and health profiles of the community was obtained from both primary and secondary sources. The primary sources of data included the following.

- Questionnaires administered on households
- Focused group interview (FGI) held in the various communities
- Interview with individuals during the field survey
- Observation made by EIA team during field survey

Beside coordinated interviews with key informants of the various communities which include, paramount rulers/chiefs in council community elder/leaders of thought as well as the CDC and youth leadership in the communities' household questionnaires were also administered in the communities. Sampling of between (5) five to (10) ten households were randomly selected from the target population in the community. Secondary sources of data included published-documents, such as publications of the National population commission, Federal Office of Statistics (FOS), Federal Ministry of Health, Academic publications. All appropriately referenced.

Demographic Characteristics

Population Size

Warri south LGA has an area of 633 km² and a population of 303,417 at the 2006 census. Ifie-kporo community falls within the Warri south local government area. The population of the community is not known as there are no current source data that captures the population of ifie-kporo but can be projected within the population of warri south LGA. The population of Warri south LGA was projected to 2016, to be 429,600 from the 2006 population census.

Age and Marital Distribution

Age composition of the sampled respondents showed a predominantly young to middle age groups with over 90% aged between 21-50 years, while 8.6% are below 20 years (Table 4.65). The sample may also have been somewhat tilted in favour of younger population. Given the young age bracket of the respondents, majority are single – 57.1%, 2.0% are separated, 40% are married and only one person or 2.9% is widowed (Table 3.14). The pattern shows a youthful population. The preponderance of unmarried may also have to do with critical unemployment picture and general economic downturn.

Table 4.65: Age Composition

*Age groups	Percentage
10 – 20	10.6
21 – 30	39.7
31 – 40	23.6
41 – 50	19.1
51 – 60	3.0
61 – 70	2.7
70 +	1.3

Source: Field work, 2019

Table 4.66: Marital Status of Respondents

Marital Status	Percentage
Single	53.1
Married	42.0
Divorced/Separated	2.5
Widow/Widower	2.4

Source: Field work, 2019

Family Size

The family type in the study area I mainly nuclear family. Those married and their children, is modest given the proportion of single respondents with 68.5% having 1-6 members; 17.1% with 7-10 members while 14% have 11-15 members. FGD had estimated household size at 6-8 persons on the average. The gulf may be as result of the number of single respondents.

In view of the unmarried category in the sample, births are low with 65.7% of the family interviewed recording no birth in the last one year while some 25.7% percent of the families had one birth in the last one year; 5.7% registered two births and 2.9% four births. In terms mortality, 80% had no deaths in the last one year; 8% each had one and two deaths while 2.9% had four deaths. This seems to point to a modest pattern of population growth which may be typical of a relatively well educated urban community.

Settlement and Housing

The settlement pattern is dense and compact and dominated by traditional compound housing built with blocks and mud as well as modern rooming and bungalows; roofing is mainly with corrugated iron sheets. The study area has a mixture of both traditional compounds and modern tenement and flat/bungalow designs (Plate 3.6). Some 42.3% of the respondents do not own a house with the community. Being a rapidly transforming community there are more block and zinc constructed houses than zinc/mud types; thatch/mud houses are few although cement-plastered mud houses are common.

Plate 4.57: Linear settlement pattern and housing types in the study area

Socio- Cultural Characteristics

Traditional Governance

In spite of the modern formal pattern of administration in Nigeria, the local structure and political administration of the community is basically traditional (Figure 4.5). The Warri South local government council is administered politically by a People Democratic Party (PDP) lead government. The traditional government is structured into hierarchies. The study areas is Itsekiri territory and speak Itsekiri language. However, for day-to-day running of the community, the following administrative structure functions.

The paramount ruler is the head of traditional administration in the community. He is assisted in the day-to-day administration of the community by the chairman and members of the community development committee. In short, the paramount ruler, the council of chiefs, in conjunction with community development committee, CDC, the Women Association and the youth group who are headed by chairman/chairperson respectively take decisions on behalf of the entire community. For meaningful dialogue and consultation on issue concerning any aspect of the community life, the above organogram of authority is strictly adhered to.

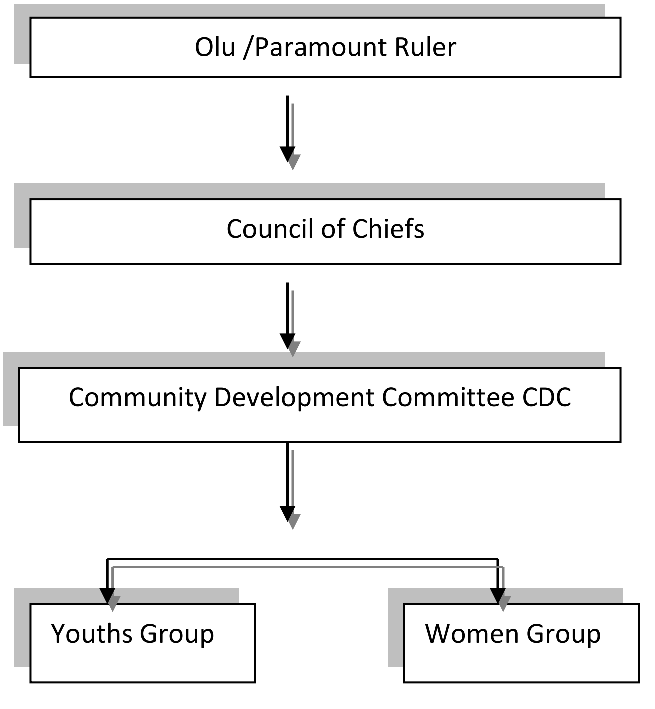


Figure 4.7: Traditional structure of governance in the study area

Historical Perspective of the Community

Ifie-kporo town is located in Delta state, southern Nigeria. The community shares landmass with Ijala, itsekiri's ancestral heartbeat location of where Itsekiri first king Ginuwa settled in the late fourties. The administrative headquarters of is located in Warri town. They are traditionally fishermen and traders. The Itsekiri were among the first in the region to make contact with Portuguese traders. These interactions in the 16th century led the Itsekiri to become primarily Roman Catholic. The Itsekiri monarchy has continued to the present day, with the coronation of Ogiame Atuwatse II in 1987.

The Itsekiris traditionally lived in a society that was governed by a monarchy (the Olu) and council of chiefs who form the nobility or aristocracy. Itsekiri society itself was organised along the lines of an upper class made up of the royal family and the aristocracy – the 'Oloyes and Olareajas' these were mainly drawn from noble houses including the Royal Houses and the Houses of Olgbotsere (Prime Minister or king maker) and Iyatsere (defence minister). The middle class or Omajaja were free-born Itsekiris or burghers. As a result of the institution of slavery and the slave trade there was a third class 'Oton-Eru' or those descended from the slave class whose ancestors had come from elsewhere and settled in Itsekiri land as indentured or slave labourers. In modern day Itsekiri society the slave class no longer exists as all are considered free-born.

Traditionally, Itsekiri men wear a long sleeved shirt called a Kemeje, tie a George wrapper around their waist and wear a cap with a feather stuck to it. The women wear a blouse and also tie a George wrapper around their waist. They wear colorful head gears known as Nes (scarf) or coral beads. Itsekiris are also famed for their traditional fishing skills, melodious songs, gracefully fluid traditional dances and colourful masquerades and boat regattas.

Historically, the Itsekiris are said to have migrated from the great Ife Kingdom.

Cultural Festivals

These were many and varied in the community. They were usually associated with the seasons, economic activities like fishing, yam cultivation, the worship of certain deities and memorials. Celebrations are usually marked with masquerade and traditional dances, boat regatta, merry making and feasting. There are also rituals and rites, which are usually associated with them, especially the fishing festival. Visitors were welcome to observe and sometimes participate in some of these festivals. However, there are places where some restrictions are imposed on movement and participation by visitors and women. Participation in some of the festivals was restricted to adherents of and worshippers of certain deities. Some of these festivals were also marked with sacrifices and ritual cleansing of the community.

Religion

Before the introduction of Christianity in the 16th century, like many other African groups, the Itsekiris largely followed a traditional form of religion known as Ebura-tsitse (based on ancestral worship) which has become embedded in modern day traditional Itsekiri culture. Today, about 94.3% claimed that they are Christians while only 5.7% claimed traditional religion. The dominant form of western Christianity in Itsekiri land for centuries, only a minority of Itsekiris are Roman Catholics whilst the majority are Protestants notably Baptist and Anglican.

Land Ownership

Land has diverse forms of ownership. Land is owned by at community, family and individual levels and could be transferred through the community, family inheritance and individual sales. Size of land holding is generally small mostly under hectare. Land values in the community are increasingly liberal especially with increasing demand for land away from the already congested surrounding cities (urban area).

Community Stability and Conflict

Intra- and inter- community conflicts were said to be generally common and family conflicts are not common. Only 10% of responses referred to inter-family disputes as a social problem. Land dispute received 14% response and youth unrest 24%; the most significant social problem is that of unemployment which was cited in 30% of responses (Table 4.67).

Table 4.67: Perceived Major Social Problems

Social Problems	Percentage
Youth Unrest	30.0
Land Disputes	14.0
Chieftaincy Problems	5.0
Inter-village Conflicts	5.0
Inter-Family Conflicts	10.0
Unemployment	30.0
Others (no response)	6.0

Source: Field work, 2019

There are minor conflicts over landholdings and traditional titles but these are not any way serious. Issues about family inheritance are generally peacefully resolved. The community has a system of conflict settlement in which the Leaders/Chieftaincy of Thought plays a major role. The committee is responsible for settling issues pertaining to land, marriages and family problems brought to its attention and the decisions are usually well respected and accepted by parties. Crime is generally low in the community as people live harmoniously together. However, where criminal cases arise these are referred to the police.

Social Organization and Institutions

In terms of community administrative structure, the Ogiame Atuwatse II is the paramount traditional ruler of all Itsekiris. There is the Chairman of Community, who is normally elected for tenure of two years and can be renewed for another one term. This is followed by the First Vice-President and Second Vice-President, usually reserved for a woman (these are all elected positions). There is an Elders Council to which chiefs belong which is an advisory body on community issues and traditional matters. Community power seems to rest on the Chairman and his executive members and officials that have day to day oversight functions in the community. There is also a Youth Chairman and Assistant Youth Chairman. There is a community town hall where most community meetings are held (Plate 4.58).

Plate 4.58: Ifie Community Town Hall.

Marriages and Customs

There are intra- and inter-ethnic marriages; and non-indigenes own houses within the community. Marriages are conducted largely under Itsekiri traditional laws and customs while weddings take place in churches. Polygamy was common in the past but appears to be on the decrease with the penetration of Christian values and economic pressures which limits the capacity to cater for children.

In Itsekiris, bride price/dowry payment is regarded highly while inheritance is patrilineal. Marriage is a valued socio-cultural norm and practice among the Itsekiri in all lands. But like in the days past when parents decided when a child is up/ripe for marriage and who a child should marry, today, since everybody is in township, the churches have taken over the task and, ‘’there is no particular specified age for marriage, it varies from community to community and is controlled by their occupation which is fishing. ‘’Anybody who is up to occupation age needs a helping hand and is therefore, qualified to marry; whether man or woman’’. A marriage is announced with an assortment of drinks up to the actual marriage itself. Marriage introduction/inquiry’ processes literally corresponds with ‘’knocking on the door by the suitor and opening of the door by the family of the bride. For those still living in the rural villages, dissolution of contracted marriages is through the local heads who summon the couple; attempts are made towards settlement and if such fails, the marriage is then dissolved with the one summoning (wishing for end of marriage or complainant) buying the drinks.

Youths

Focus Group Discussions (FGDs) revealed that youths are in good relation with elders and the issue of youth unrest is minimal. Drug and alcohol were not regarded as problems in the community. The community has a good pool of both skilled and unskilled persons. In spite of the stated harmony within the community, the constant reference to youth unemployment makes it a potentially explosive issue. Youths are worried about the scale of unemployment and its potential to generate unrest and disaffection because of the severe limits it places on their future prospects. The community youths are not against the operation of the Tank Farm as since it can lead to some form of employment.

Women

Women are largely traders, fisher women and farmers. There is increasing land access by women in the community through inheritance or direct purchases. Women also have reasonable access to properties following the death of a father or through processes of sharing of properties of the deceased. They suffer no adverse widowhood rights or denials of property rights. Women in FGD however presented the increasing pressure on them as a result of growing family responsibilities, the challenge of child upbringing thrust on them as a result of chronic unemployment of husbands, adult males and youths with no livelihoods means. This implies increased demand on women to source for additional livelihood opportunities for family survival. This brings with physical strains and social pressures which are unhealthy for women. Women in order to improve livelihood chances will appreciate credit schemes.

Economic Characteristics

Market

The community has one market on the bank of the river for the marketing of goods and services (Plate 3.8). It is a periodic market that operates on a 7-day cycle which is rather long in relation to the typical rural marketing system of 4 or 5-day cycle. This might be reflective of the smallness of the community in the time past and the rings of other periodic markets with which it has been associated over time serving as outlets for the marketing of products.

Plate 4.59: Ifie-kporo Market

Occupation and Income Characteristics

The major occupational activities identified in FGD in order of significance are: trading/business, farming and fishing. Men are more involved in trading and fishing and women in trading and farming. Fishing is generally on the decline. There are generally also occupational combination activities within the community. Table 3.16 however shows the occupational distribution of those interviewed with majority – 40.5% describing themselves as trader and business people and another 20% are industrial workers and 8.2%% as civil servants while 30.7% are either students or unemployed.

Table 4.68: Occupational Characteristics

Major Occupational Groups	Percentage
Farming	11.5
Fishing	29.3
Civil Servant	8.2
Trading	19.4
Business	20
Industrial Worker	17.1
Others (Students or unemployed)	5.0

While farming is on the decline, those engaged in farming from FGD session do so at the periphery of the settlement and within open lands around compounds. Land availability is on the decline for farming and people are moving to other non-farming activities. The period of fallow from discussion is about three years although some pointed to emergence of more or less continuous cropping. Some fifteen years or so ago, the period of fallow was much longer being in the range of 5-7 years but with population increase and scarcity of land it is now much more reduced. From the interview, about 43% said yields from land were on the decline and attributed the declining yields to mass oil exploitation which renders soil infertile and as well as the non-application of fertilizers to boost yields. The major crops grown in order of importance include: cassava, plantain, maize, yam, okra, leafy vegetables, okro and pepper.

Fishing is another declining occupational activity from FGD account. Fish catch is generally on the decline and yields are smaller with decreasing returns to fishermen and with sales hardly exceeding N500 per fishing trip which is carried out on a couple of days in a week. Fish ponds are emerging in the community and represent a growing source of income for investors. Income generated from occupational activities is said to be low being as an estimated ₦100,000 – ₦ 150,000 per month for a few in the high income bracket; while the vast majority are said to earn ₦3,000 - ₦7,000 per month. Income is said not to have risen significantly over the last ten years.

Table 3.17 shows the income characteristics of those interviewed. The population could be described as poor with the predominant proportion – 51.4% - earning under ₦50,000 per annum while 20% earn between ₦51,000 – ₦100,000 per annum. The bulk of income realized is spent on food (Table 4.70) as recounted by 45% of the respondents followed by education - 36.3%, clothing - 6.0% and medical and household items - 1.9% each. It would appear therefore that the people are living at the margin with the major preoccupation being basic survival especially how to provide food for the family and education for children.

Table 4.69: Annual Income Characteristics

Income Range in Naira	Percentage
0 – 50,000	51.4
51,000 – 100,000	20.0
101,000 – 150,000	11.0
151,000 – 200,000	9.0
201,000 – 250,000	8.6
251,000 – 300,000	-
301,000 – 350,000	-
351,000 – 400,000	
401,000 – 450,000	-
No Response	-

Table 4.70: Major Areas in which Income is spent

Expenditure Sector	Percentage Making Reference
Food Items	45
Household items	2.9
Clothing	6
Education of Children	36.3
Medical Care	2.9
No Response	6.3

Poverty and unemployment are rife within the community and people expressed the view that much of it could be alleviated if industries were established. The absence of micro-credit facilities is seen as a major constraint to the growth of economic activities and to grow income. The people stated that the lack of regular power supply was also adversely affecting social and economic activities.

Poverty and Unemployment: Unemployment is a major challenge in the community. As much as 71.4% of those over 18 years in families interviewed do not have any form of employment in spite of the claims that a number of them have skills to be engaged. Some 43% of those interviewed have no savings and only 12% are able to save over ₦50,000 per annum. Only small proportion own persons own motorized boats.

Potential for Tourism: There is great potential for tourism in the community owning to the presence of falcorp mangrove park (Plates 3.10).

Plate 4.66: Falcorp Mangrove Park

State of Infrastructural Facilities

Educational Status/Facilities: The population is very literate, as there was none amongst those interviewed that was without formal education; 5.7% have primary education, 48.6% have secondary education while as much as 45.7% possess tertiary education. Again this may reflect the younger segment of the population that was interviewed but reveals clearly an enlightened and educated community.

The community has government-owned primary and secondary schools. In addition there are a host of private schools at both primary and secondary levels.

Plate 4.61: Government Owned Secondary School Facility in Ifie-Kporo

Plate 4.62: Government Owned Primary School Facility in Ifie-Kporo

Access to Water: The major sources water for respondents include, in order of importance: Ifie-Kporo river, – 45%; pipe-borne water (50.8%), and rainwater (1.5%) (Plate 4.63). The community stated firmly that the river water was drinkable and can be used for cooking because of the low level of pollution.

Table 4.63: Major Sources of Water

Electricity: The community is connected to the national grid (Plate 4.64), however the national problem of erratic power supply is of concern in the community.

Plate 4.64: Presence of Electricity in the Community

Transportation

Transportation of personnel goods and services within the study area has greatly affected the development of the area because of the perennial damage on the only access road to the community caused by spilled crude oil from oil transporting trucks, continuous plying of the road by heavy duty trucks and poor maintenance. Many roads within the community are in good condition and free of oil spills. There’s usually a grid lock of petroleum transporting trucks at the entrance point to the community connecting from Ubegi, notwithstanding, traffic is moderately free as community youths engage in traffic control to ease the flow of trucks and cars.

Plate 4.65: Means of Transportation in the Study Area

Tele-Communication and Postal Services

With regard to the availability of telephone facility in the area, the study revealed that NITEL lines were not present. However, GSM networks of MTN, GLO and Airtel are available in the community.

Leisure and Recreational Facilities

Most of the respondents claimed there were no recreational facilities in their community. 72% of respondents said they stayed indoors while 15% visit friends and 13% go to beer parlors, **Figure 4.6**. However, it was observed during the study, that the community is fairly endowed with recreational and leisure facilities such as leisure park, town hall, open spaces (playgrounds), attached to schools and churches.

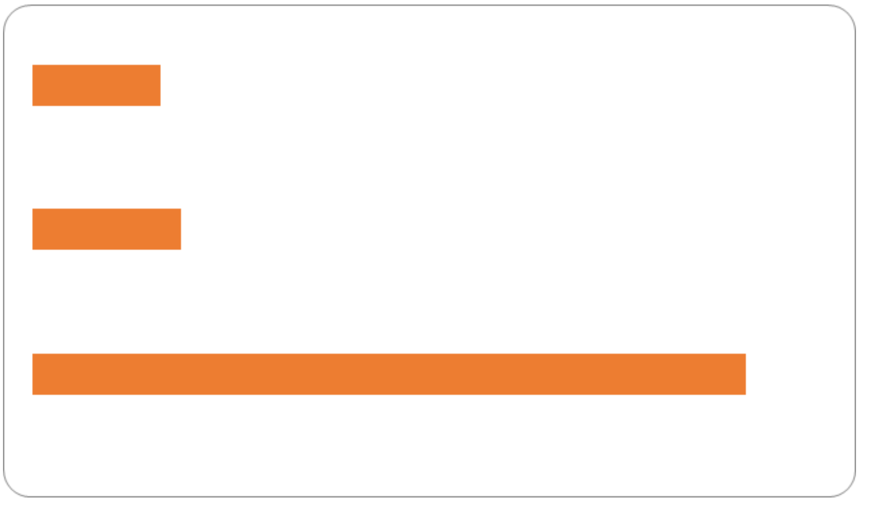


Figure 4.8: Recreational activities of respondents after work

Plate 4.66: Falcorp leisure park Ifie-Kporo.

Environmental Problems: Flooding and coastal erosion, environmental pollution from spilled crude by transporting trucks, air pollution from heavy duty trucks exhausts and burning crude, (Table 3.19) are the major environmental problems of the community although household wastes from observation as in most Nigerian urban areas are poorly managed.

Table 4.71: Major Environmental Problems

Environmental Problems	No.	Percentage
Flooding	32	55.2
Coastal Erosion	11	18.9
Water and land pollution	11	18.9
Deforestation	3	5.2
Others	2	5.2
No idea	1	1.7

Source: Field work, 2019

Health Studies

The results of the major findings in the health survey aspect of this of the study including analysis and interpretation where necessary are presented as:

Health Facilities: There is a health center in the Community (Plate 3.16). The health center is equipped to be able to treat minor ailments and conduct deliveries. Patronage, according to the Nurses is high, due to the presence of resident doctors.

Some expectant mothers (15%) prefer to deliver at home supervised by Traditional birth attendants. Some persons prefer to go to private clinics and patent medicine stores in the community when ill. Twenty percent (25%) of the respondents also patronize traditional medical practitioners.

Plate: 4.67: Health center at Ifie-Kporo community

Care Seeking Attitudes

The care seeking attitude of the respondents showed that 10% attend private clinics when they need medicare. 25% go to traditional healers, while 10% depend on prayers/church. Another 35% used patent medicine dealers while 20% used the health center facility in the community.

At the health center, drugs would be prescribed and dispensed in full dosages and so are bound to cost more than the few tablets purchased at the patent medicine stalls. On immunization 5 of the 6 women (83%) admitted immunizing their children against the six childhood killer diseases.

Major Illness Episodes in the Study Area

Malaria was obviously the commonest illness in the community and also the commonest cause of death among infants and under-fives. Diarrhea diseases closely followed this.

Table 4.72: Common Illness Episodes in the Last One Year

ILLNESS	FREQUENCY (%)
Malaria	35.0
Diarrhea Diseases	33.0
Respiratory tract infections	18.0
Arthritis	6.0
Dermatitis	4.0
Measles	3.0
Others	1.0
Total	**100.0**

Source: Field Work, 2013

Birth Rate

From available records in the Health center, averages of 8 women are seen in the Antenatal section per week, while 6 of them deliver there in a month.

Fuel and Light Sources

Figure 4.9 reveal that fuel wood and kerosene respectively, remain the most popular materials utilized as fuel and light sources in the surveyed households. This is consistent with literature (Onokerhoraye, 2001).

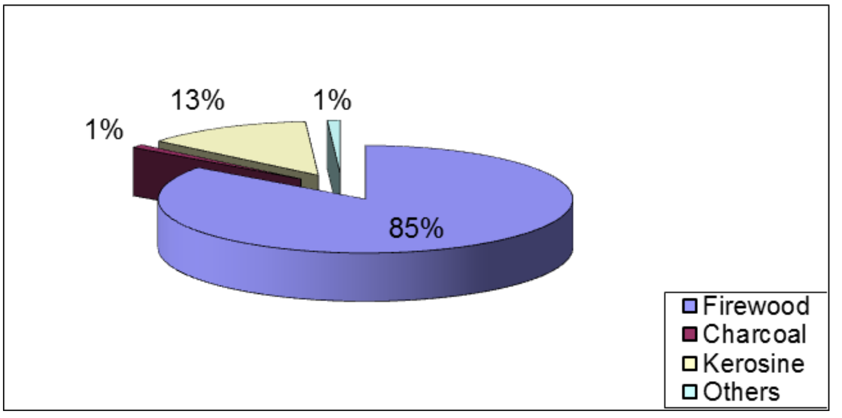


Figure 4.9: Sources of Fuel in the Study Area.

Mortality Rate

As in most of the developing world, children and women constituted the vulnerable group with respect to morbidity and mortality. Infant mortality rate is generally regarded as the best indicator of the health status of any community**.** Infant, Under-five and Maternal mortality rates in the community are in Table 4.73. The rates obtained from the community were comparable to the National values.

Table 4.73: Mortality Rates in the Community

Rate (per 1000)	**National data (2003)**	**Ifie-Kporo**
Infant mortality rate	100	32
Under-five mortality rate	201	49
Maternal mortality rate	10	7

Source: National Health Survey (2003) and Field Work, 2013

Sanitary status of households

From observation made, about 5% of the households were very clean, 28% had clean sanitation status; 46% were fairly clean and 20.8% poor level of cleanliness. Most of the houses 60.6% were mud/thatch; 26.7% mud/zinc while cement/zinc were 12.7% (See Figure 4.9B). There was an average of 4 people per room in most of the households visited.

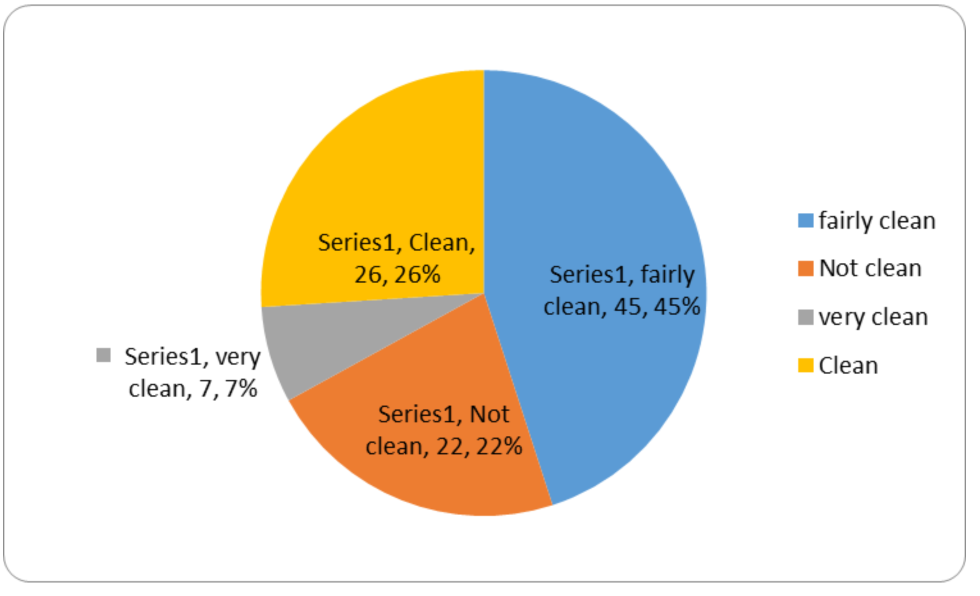


Figure 4.9B: Sanitary State of Households in the Studied Community

Waste Management: Wastes in the communities are generated from farming domestic, commercial, human and animal activities (**Table 4.74).** In the community, Wastes generated are generally disposed indiscriminately. The wastes are later disposed in open land and bushes. The major refuse disposal methods were open burning, open dumping, burying and dumping into pits, which could be covered later or left uncovered.

Table 4.74: Sources of wastes

Source	Type
Human & animal faeces	Excreta, urine
Domestic	Food remains, paper, polythene bags, animal remains (bones, feathers etc), battery, cartons, bottles, rags etc.
Furring activities	Processed food remains; palm leaves & fronds. Cutlass & hoe blade, etc.

Lifestyle: The effect of people's lifestyle on their health cannot be underrated. Indulgence of people in alcohol consumption, cigarette smoking, drug and substance abuse and patronage of commercial sex workers in the communities was investigated. High-level alcohol and tobacco consumption was observed and admitted in the community visited, but the presence of commercial sex workers was denied.

It is a known fact that chronic alcohol consumption and smoking are known etiological factors for liver and lung diseases respectively.

Fish and Fisheries

Exploitation of fish resources in the study area is largely by artisan fishers. These fishers operate in dugout wooden canoes measuring 7-12m in length and 0.4-1.9m in width. The boats are hand-paddled and movement is occasionally complimented by the use of sail. Two fishers usually operate each boat.

Fishing gears are largely made of long setlines, circling nets and seine nets of different mesh sizes varying between ½”, 1”, 1½”, 2”, 2½ and 3” (1.0mm to 5.0mm). Gears measure 6-12m in length and 2-4 meters in width (Plate 4.68).

Plate 4.68: Fishing Gears in the Project Area

Nets are manually operated. They are set and allowed to stay for up to one hour before they are removed with the catch. When the net is set and before it is removed another net is also set. Catch rates are seasonally dependent and varied between 15-120 kg/day in the dry season.

The fish species identified in the landings of these fishers and their relative abundance in both the dry and wet season are as presented in Table 4.75.

Table 4.75: Species Composition of Fishes within Koko River

FAMILY	SPECIES	COMMON	ABUNDANCE	
Family Belonidae	*Strongylura senegalensis*		1	
Family Tetradintidae	*Ephippion guttifer* (Bennet,		2	
	Lagocephalus laevigatus		1	
Family Megalopidae	*Tarpon atlantica*	Tarpon	1	
Family Pristidae	*Pristis pristis*	Saw fish	1	
Family Ephippidae	*Chaetodipterus goreensis*		2	
Family Clupeidae	*Ethmalosa fimbriata*	Bonga	3	
	Sardinella maderensis (Lowe,	Sardine	2	
	Sardinella aurita (Lowe,	Sardine	2	
Family Mugilidae	*Liza falcipinnis*[Val,1836]	Mullet	2	
(Mullets)	*Liza grandisquamis* [Val,	,	3	
	Mugil bananensis [Pellegrin,	,	2	
	Mugil curema Val, 1836	,	3	
Family Sphyraenidae	*Sphyraena guachancho*	Barracudas	3	
Family Polynemidae	*Galeoides decadatylus*	Threadfins	1	
	Pentanemus quinquarius	Shiny nose	2	
	Polydactylus quadrafilis		2	
Family Eleotridae	*Butis koilomatodon* [Bleeker,	Sleepers	1	
Family Elopidae	*Dormitator pleurops* [Boul,	Lady Fish	3	-
Family Trichuridae	*Trichuris lepturis* Linn, 1758		2	-

Key to Abundance Rating: 1 = Rare; 2 = Low abundance; 3 = Abundant; and 4 = Very Abundant.

CHAPTER FIVE

POTENTIAL ENVIRONMENTAL IMPACT

5.1 INTRODUCTION

Potential Impact Assessment

General

Impact assessment is required for all major public and private projects that might significantly affect the quality of the environment. It is intended to provide reasoned predictions of the possible consequences of policy decisions and thus, to permit wiser choices among alternative courses of action.

In pursuance of its policy on the environment and in compliance with relevant national and international laws and conventions, acceptable industry standards, SHAFA has embarked on this impact assessment prior to the commencement of the project. The study is intended to predict, identify, interpret and communicate the impacts of the various phases of the project on the environment. This Chapter however evaluates the potential impacts of the various project activities of the proposed LPG Plant on the environment.

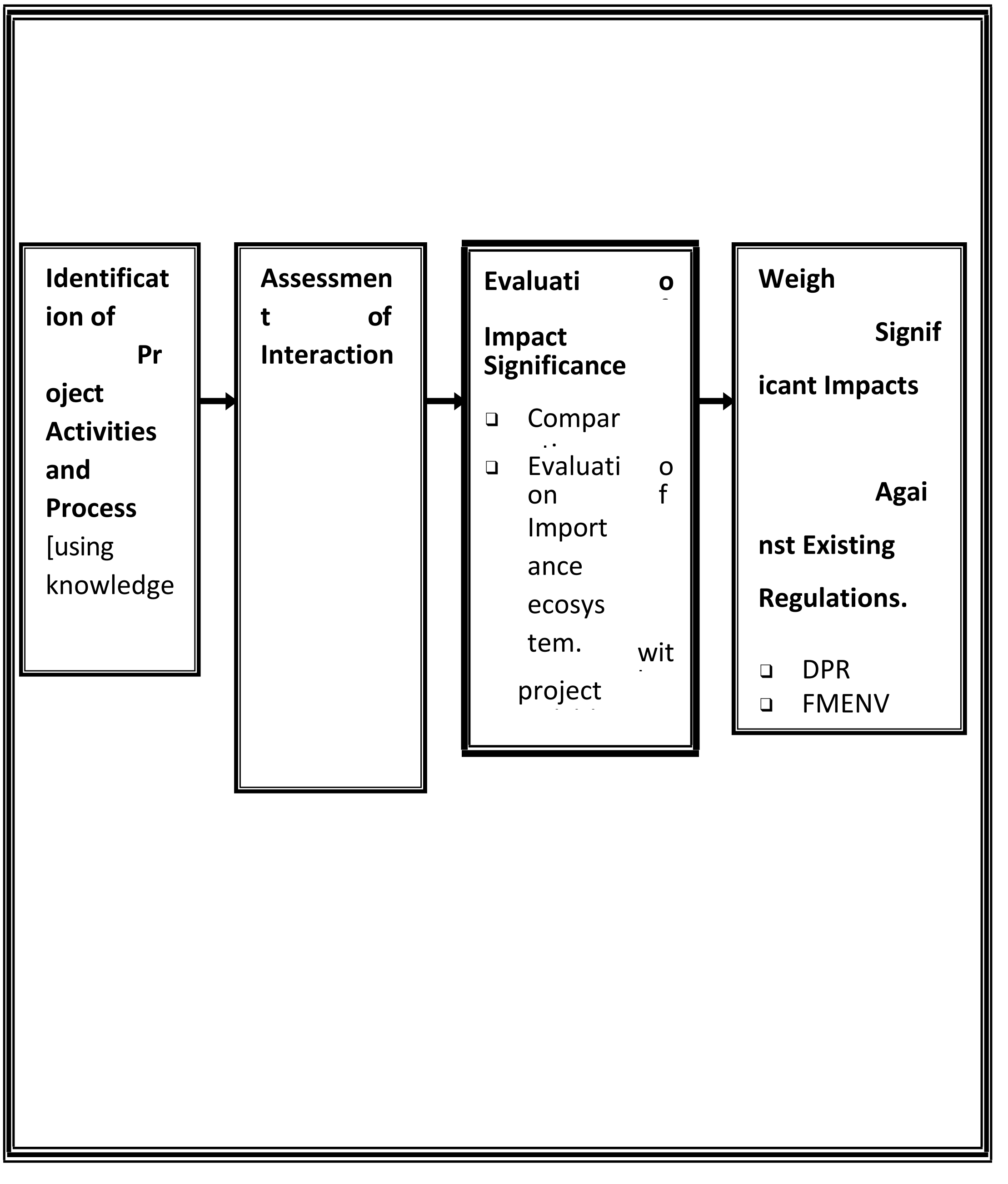
Principles of Impact Prediction and Evaluation

Whatever the impact and whatever specific technique is used to analyses it, prediction and evaluation should be based on a sound methodological framework, which covers;

- Overall prediction and evaluation process
- Choice of prediction technique
- Criteria for evaluating significance

The design of mitigation measures

- Direct impacts, long range impacts and uncertainty



5.2 IMPACT ASSESSMENT METHODOLOGY

There are several approaches and techniques developed for evaluating potential impacts of any project on the environment. Some of which were developed in the early 1970s and lean heavily upon approaches used in other spheres of environmental management (Wathern, 1986). The Overlays techniques (McHarg, 1968); Leopold matrix (Leopold *et al.*, 1971); Battelle Environmental Evaluation System (Dee *et al.*, 1973) and Peterson Matrix (Peterson *et al.*, 1974) are among the most widely used methods employed for impact assessment.

5.2.1 The Overlay Technique

The overlay technique uses a series of transparencies to identify, predict, assign relative significance to, and communicates impacts in a geographical area. In this method, the study area is sub-divided into convenient geographical units, based on uniformly spaced grid points, topographic features or differing land uses. Within each unit, the assessor collects information on environmental factors, through aerial photography, topography, land inventory maps, field observations, public meetings and discussions. The concerns are assembled into a set of factors, and used to draw a regional map. By a series of overlays the land-use suitability, action compatibility, and engineering feasibility are evaluated visually, in order that the best combination may be identified.

5.2.2 Leopold Matrix

Leopold *et al* (1971) were the first to suggest the use of a matrix method for impact assessment. This method is useful as it reflects the fact that impacts result from interaction of development activities and the environment. Thus, Leopold Matrix is a comprehensive checklist designed for the assessment of impacts associated with almost any type of construction project. One hundred possible project actions are listed on one axis, eighty-eight human and natural environmental elements on the other. The Leopold matrix is also used to present the results of an appraisal. Numbers representing magnitude and significance, expressed on a 10-point scale, are included in each cell indicating where a likely impact is anticipated. Positive and negative impacts are identified with “+” or “-” sign, respectively.

5.2.3 Battelle Environmental Evaluation System

The Battelle Environmental Evaluation system involves the separation of human concerns into four categories namely, ecology, physical/chemical, aesthetics and socio-economics. The method translates the state of individual environmental parameters into arbitrary, environmental quality indices all expressed in the same scale. For each component, the Battelle system develops an index of environmental quality, normalized to a scale ranging from 0 to 1, using a value-function method. Each impact indicator is given as the difference in environmental quality between the states with and those without actions. Environmental quality scores are multiplied by the appropriate weightings and added to give a total score of environmental quality for each option under consideration.

5.2.4 Peterson Matrix

Peterson Matrix is a modified version of Leopold matrix, adopted for the screening and scoping exercise of this project. This matrix relies directly on the multiplication properties of matrices. An ordinal scale is used to evaluate individual impacts by a team of assessors, and separate matrix layers are produced for physical and human impacts. The matrices are also multiplied to find the effect of the casual elements on human environment while the resulting product is weighed according to the significance of the human impact.

Screening and Scoping of the Potential Impacts

It has become necessary to undertake an early and open process for determining the scope of issues to be addressed and for identifying the significant issues relating to a proposed action.

It is important that the effective screening of actions takes place in all environmental assessment systems. Without it, unnecessarily large numbers of actions would be assessed and some actions with significant adverse impacts may be overlooked. The determination of whether or not an environmental assessment is to be prepared for a particular action should hinge upon the likely significance of its environmental impacts. Lee, (2000), identified two broad approaches to the identification of such action and they includes:

- The compilation of list of actions, accompanying thresholds and criteria (which may include locational characteristics) to help in determining which actions should be assessed, and
- The establishment of a procedure (which may include the preparation of

a preliminary or intermediate environmental assessment report) for the case by case (Discretionary) determination of which actions should be assessed.

To undertake this process, an assessment of the environmental impacts of action should be made. For this project, the likely significant potential impacts of the proposed development project on the ecosystem of Ifie community are derived from the following:

- Knowledge of the project activities, equipment types and layout of the project facilities;
- The status of the baseline of the environment;
- Findings of other EIA studies on similar projects;
- Experience on similar projects and
- Series of expert group discussions and meetings.

The criteria applied for predicting the impacts for this project on the environment were:

Magnitude -- probable severity.

Prevalence -- likely extent of the impact.

Duration and frequency -- intermittent, short term, long-term.

Risk -- probability of serious effects.

Importance -- value attached to the undisturbed project environment.

The screening of the project activities indicate that construction of tanks, pilling, Piping, transportation of materials to site during construction phase, presence of infrastructure during operational phase pose a threat to the biotic and abiotic components. Most of the adverse effect will come from construction phase involving the pilling, welding, dredging, and laying of pipes.

These impacts are expected to be short-term and shall cease with the completion of the construction phase. Impacts from operational phase are expected to be long-term.

The social components are expected to have beneficial impacts like the recruitment of labor force, which will increase income and inject a sizeable amount of cash into the Nigerian economy.

The main environmental components that shall be significantly impacted are water quality, ecology, fisheries, wildlife fauna, health and safety of host communities and workers. The impact indicators are defined and adopted so as to identify potential environmental impacts. Impact indicators are the easily observable environmental components, which readily indicate changes. The impact indicators used for this study are presented in **Table 6.1**

Table 5.1: Environmental components and potential impact indicators

Environmental components	**Impact Indicators**
Climate	Temperature, Rainfall, Relative Humidity
Air Quality	Particulate, NO_x, SO_x, CO_2, CO, VOC
Soil	Soil type and structure, physio-chemical and microbiological characteristic
Surface water Characteristics	Dissolved and suspended Solids; Turbidity, Eutrophication and Toxicity
Ecology / Hydrobiology	Species diversity, Abundance, Productivity, Yield.
Sediment Characteristics	pH, Heavy metal concentration,

The scoping of potential impacts involves identifications of interactions between project activities and environmental impact indicators. This stage of the impact assessment process simply qualifies impacts as beneficial or as adverse. Ranking of the potential impacts at this stage is done on a scale of 1 to 5 and the interpretations are as follows:

1 = Very low impact (insignificant)

2 = Low impact (insignificant)

3 = Moderate impact (significant) 4 = High impact (significant) 5 = Very high impact (significant)

The ranking, relative to recovery period was as follow:

Transient	→	A few hours to somedays
Short-term	→	6months,
Medium-term	→	6 – 12months
Long-term	→	>12months
Very long/Permanent	→	5years

A checklist of key project activities and description of the potential and associated impacts identified for the various activities is presented in **Table 5.2**.

Table 5.2: Potential and Associated Impact Identification Checklist

PROJECT ACTIVITY	GENERAL DESCRIPTION OF IMPACTS	NATURE OF IMPACTS			
		Adverse	**Beneficial**	Short-term	Long-term
Mobilization and other logistic demands	Interference with other public and private water transport activities and alternative.				
	Physical disturbance of Warri by the jetty dredging equipment.				
	Emission of atmospheric pollutants from exhausts.				
	Reduction in aesthetic and recreational value of welding, pilling sites.				
	Pollution of surface water by anti-fouling chemicals used to coat metal surface to discourage growth of algae and corrosion.				
Site Preparation Dredging	Increased turbidity of surface water, dislodging of aquatic organisms and disruption of fish spawning.				
Unintentional discharges	Increase in biological and chemical toxicity of surface water from discharged chemicals, wastes and materials including spent mud, oily wastewater, sewage, cooling water and additives etc.				

	Pollution of surface water from spilled hydrocarbons that may occur as a result of sabotage, valves blow-outs, pipeline ruptures, etc.				
	Destruction of benthic flora and fauna by unintentional dumping of waste materials				
Employment of locals as skilled and/or unskilled labour. Discharge of , sewage, Other wastes, gaseous emission and noise	Increased income and livelihood				
	Localized increase in baseline concentrations of surface water physic-chemical parameters from routine discharge of , chemicals, treated sewage, deck drainage, etc.				
	Localised dumping of welding in the Warri River.				

PROJECT ACTIVITY	GENERAL DESCRIPTION OF IMPACTS	NATURE OF IMPACTS		
		Adverse	Beneficial	Long-term
Operations	Localized increase in ambient concentrations of air pollutants from the exhausts of fuel combustion engines and gas testing fumes.			
	Possible collision of boats during operation.			
	Noise (on-site) from the use of operations engines and motors.			
	Increased national revenue from oil and gas exploitation			
	Employment of locals and consequent increase in business activities in the area			
	Community Development Programmes			
Oil spills	Oiling of surface water. This will reduce light penetration and thus overall productivity of the ecosystem.			
	Oiling of surface water can also reduce dissolved oxygen levels and cause oxygen starvation and death of aquatic organisms			
	Spilled oil may emulsify and eventually dissolve into surface water to increase its toxicity. This may lead to the death of the less resistant/adaptable aquatic organisms and dominance of the more resistance ones.			
Decommissioning and abandonment	Collision of boats with abandoned materials.			
	Permanent obstruction of Warri River with permanent structures such as steel material.			
	Hydrocarbon leak from abandoned pipes and valves.			

5.3 POTENTIAL IMPACT EVALUATION

The purpose for this evaluation is to assign relative significance to the predicted impacts associated with this project and to also determine the priority order in which the potential impacts are to be avoided or mitigated. This involves the computation of the potential impact of the project activities on the recipient environment.

The first step is to determine the magnitude of impact and thereafter evaluate the importance of the impact relative to its ecological and social values. The evaluation of the degree of alteration to natural conditions due to the project activities were carried out using a modified Leopold and Peterson matrices that permits scaling and direct transformation of impact magnitude and importance into potential impact significance (Peterson *et al.*, 1974); **(See Table 5.3)**.

The significance of impacts is linked to the following elements;

- Effect of project action on wildlife
- Ecosystem sensitivity, biodiversity and carrying capacity
- Viability of local species population
- Rare and endangered species
- Duration
- Demand on transport
- Recreational values of the prospect

In this method, project activities are assigned to columns, while environmental components and characteristics are indicated in rows in the matrices. Then the project activities are interacted with the environmental components and characteristics using mathematically weighted values for each activity with respect to the environmental components and characteristics. The mathematical weighting was done based on the magnitude and importance of potential impacts of the project activity on the environment. Where possible, quantification of impacts has been undertaken. In some cases, systems of weighting together the quantitative scoring of rankings of various effects have been adopted, but there is no general consensus as to the relative values.

The value assigned to each cell in the matrices is in the form "x (y)": where "x" denotes the magnitude and "y" the importance of the impact. Positive (+) and negative (-) signs were used to represent beneficial and adverse impacts respectively. The effect of any particular activity across all environmental components and characteristics are assigned columns, while the potential impacts of all project activities on a particular environmental component or characteristic are assigned to rows. A quantitative evaluation of the impacts of the SHAFA Energy LPG Plant project on the environment is shown in **Table 5.3**.

5.3.1 Summary of Potential Impact Evaluation

The evaluation of the impact of the SHAFA Energy LPG Plant project activities on the various environmental components is presented in **Table 5.3**. The proposed project activities, which could adversely impact the environment of the project area, are, transportation of equipment and materials, construction, (Pipe laying, trenching, backfilling, hydro testing, dredging, etc.), and abandonment.

The adverse environmental impacts, which are likely to occur mostly at the construction phase (site preparation/Pilling) of the SHAFA LPG plant project, shall be short- term. Consequently, these adverse impacts will be localized and transient.

However, mitigation measures have been proffered, to eliminate or reduce these impacts to tolerable levels. Overall, the beneficial impact from the SHAFA Energy Plant project shall be long-term. These beneficial impacts will result from increased business activities in the area, employment for skilled and unskilled laborers and community development activities.

Table 5.3: Impact Evaluation Matrix for SHAFA LPG PROJECT

Project Activities **Environmental Component (x)**	**Aggregate Rating of Ecological Components (y)**	Site Mobilization/ other logistic needs	Construction and Installation/Flow line laying	Dredging	Drilling	Wastes disposal	Operations / Maintenance	Materials Transport	Accidental spill & Leaks	Gaseous Emission/Flares	Demobilization
Air Quality											
Particulates Acid gases (SO_x, NO_x, NH_3) CO_x VOC											
Surface water Quality											
Turbidity and solids Temperature Oil and Grease Biochemical Parameters											
Groundwater Quality											
Turbidity and solids Oil and Grease Biochemical Parameters											

Aquatic Ecology											
Diversity & abundance Productivity Catch and Yield											
Vegetation/ Terrestrial Ecology											
Diversity & abundance Forest Resources Habitat Productivity											
Soils/Land use											
Soil fertility / Productivity Soil Erosion Land take											
Sediment Characteristics											
Physio-chemistry Productivity											
Noise/Vibration											
On-site Off-site											

5.3.2 Detailed Description of Potential Impacts

Crane Mobilization

The pilling campaign will involve several movements in the course of the pilling project. There shall also be the need for spread mooring with chain, standard wire cable and anchor for each leg of the crane. These operations and activities are likely to have the following impacts:

- Discharges and emissions
- River disturbance and interference due to anchoring and movement;
- Fisheries interaction; and
- Boat navigation interaction.

The process of mobilization and movement of construction materials to site shall exert stress on the river resulting in the suspension of sediments. This could lead to destruction of habitats/communities of benthic organisms. Pipes positioning shall also cause disturbance to water-bed through increase in suspended solids, smothering/burial of fauna. However, this impact is considered insignificant, as recovery time is usually short.

The physical presence of the pipes and other facilities may be an obstacle to fishing and navigational routes within the area. Nevertheless, this impact is not significant because of the relatively small area these facilities will occupy.

Piling

The primary sources of impact associated with the piping operations are related to Noise, vibration of the earth crust, waste disposal. Thus in the course of this project, the following category of Noise, vibration, and other potential release may affect the environment, this includes:

- Noise of Pilling operation
- Vibration
- sewage system
- Accidental releases (such as diesel fuel)

Sewage and Sanitary Wastes

This includes all sanitary waste and grey-water that is water from showers sinks, garbage disposal, etc. This waste will be treated in the sanitary sewage treatment unit before disposal. This is particularly important since the depot construction phase of the project will require about 50 men on site.

Accidental Oil Spill

Accidental oil spills could have serious economic impact on coastal activities and direct health impact on the host communities. In most cases such damage is temporary and is caused primarily by the physical properties of oil creating nuisance and hazardous conditions. The impact on aquatic life is compounded by toxicity and tainting effects resulting from the chemical composition of oil, as well as by the diversity and variability of biological systems and their sensitivity to oil pollution. The effects of oil spills on fish larvae are even more pronounced when dispersants are used. In addition, gas contamination of the water from which phytoplankton derives nutrients will adversely affect the rate of primary production.

Impact due to Dredging

Dredging activities during the proposed project will result in the following impacts:

- ❖ Changes in water quality viz higher turbidity, reduced light penetration, stress on photosynthetic algae including other light sensitive organisms.
- ❖ Noise of dredging operations.
- ❖ Offensive smell from dredged spoils.
- ❖ Loss of biodiversity.
- ❖ Vibrations.
- ❖ Prevention of fish migrating to spawning grounds.
- ❖ Destruction of spawning grounds by the removal of habits.
- ❖ Possible release of locked up nutrients by the agitation and overflow of dredged spoil.
- ❖ Possibility of subsoil failure.
- ❖ Possible depletion of local fish communities.
- ❖ River bank draws down i.e. movement of materials riverwards due to removal of sediments.

Impact due to Pipe Installation:

Pipe will be laid across the River-bed resulting in localized bed disturbance. Such disturbances may take the form of loss of benthic organisms through smothering or burial, interference with fishing activities, navigational impacts, suspended solids, anchor damage to the creek-bed, etc. The precise width of sediment disruption is unclear and varies according to the type of substrate and depth of water.

Gaseous Emissions

Atmospheric or gaseous emissions anticipated during the project will emanate from fuel powered boats, electrical generators, vented gases (during testing), gases from and fugitive emissions, e.g., leaks from components such as valves and connectors. The emissions are dependent upon the fuel use of boats, generators, etc.

Impact on Fishing

Commercial Fishing:

The presence of utility boats on the river during transportation of equipment and materials would obstruct the movement of fishing boats. In addition, the high turbidity of the surface waters that is likely to result during drilling and other construction activities would reduce dissolved oxygen, which is crucial for fish yield. This is likely to have limited temporary interference with commercial fishing activities in the area. There may also be limited temporary interference from periodic visits to the check the pipes.

Impact due to valve, pipes blow-out:

Pipe blow out is one potential impact of pilling and piping operations that must certainly be avoided because such an occurrence, which results in the sudden release of pressure, could be devastating. Pipes, valves blowouts or explosions are associated with geological formations that are characterized by abnormal formation pressure. Oil, saline water, and volatile organic compounds (VOC) could be emitted into the atmosphere. The subsequent explosion could emit dangerous gases into the air, as well as oil and chemicals into the swamp environment, which could also contaminate soil and sediments.

Impact on Ambient Air Quality

Construction activities particularly earthworks; increased traffic; and the use of cement, asphalt, and other building materials will produce excessive airborne dust and toxic asphalt fumes, causing a major impact on air quality within the project area. There will also be gaseous emissions like sulphur dioxide, nitrogen oxides, hydrocarbon, particulates, carbon monoxide etc. from heavy vehicles. Impact on air quality during construction phase is temporary and site specific. It is therefore unlikely that significant effects will occur. To minimize the dust impact, construction fields and major access roads and haul roads should be watered on a set schedule, particularly in the dry season. During operation, background concentrations of TSP and CO may exceed the recommended DPR/FMEnv standard. The vehicle emissions and fugitive dust emissions from the expressway will add to the problem. There will be increase in traffic volume as well as vehicle type. These impacts may have adverse impact on flora and fauna in forest along the project route. During operations, criteria pollutants such as PM, SO_2, NOX, CO, PM, VOCs, H_2S, Benzene, naphthalene, ammonia etc. have great potentials of being released into the environment.

These may arise from:

a. Exhaust gases from the combustion of duels to generate power, heat and steam
b. Flue gas
c. Venting and flaring
d. Fugitive emission

There is also a potential for the release of VOCs during operational activities (filling, withdrawal, additive blending, loading/unloading, tank cleaning and degassing operations. Breathing losses and standing losses from bulk storage tanks.

Noise

Noise impacts are expected to increase during construction due to the use of construction machinery and earth-moving equipment. This problem can be reduced by proper mitigation measures. Further, construction phase noise is short-term. The extent of noise during operation depends upon traffic flow, road condition, speed of vehicle, use of horn etc. The increased vehicular traffic will have increased noise levels. These increased noise levels will have adverse effect on population, noise sensitive receptors residing along project routes. The wild life present in forests along project routes may also be impacted. During operations, noise levels from power turbines and plants will be significant for a long term.

Water Resources

Major sources of potential water pollution were identified as increased soil erosion during construction, which may cause water pollution with sedimentation; wastewater pollution caused by large construction sites, pollution caused by surface runoff and service area wastewater. Wastewater and hazardous materials (fuel, oil, acids, caustics, etc.) may drain into streams and drainage areas, causing pollution to surface water or groundwater during construction. This is particularly true for construction campsites and staging areas where workers, construction equipment, and building materials are most concentrated.

Perturbation in river bed may increase suspended solids resulting in turbidity. Rainwater washes out atmospheric pollutants, picks up roadway deposits, and runs off into rivers thus increasing pollutant concentration. The impact on water quality from construction activities will be short-term. Implementation of recommended mitigation measure will greatly reduce the likely impact. During operation impact will be due to accidental spill of chemicals / fuel oil at road side or close to water bodies.

During operations there will be potential for pollution of the Warri River from spilled refined petroleum products. Storm water may wash stored petroleum products into the river. Catastrophic failure of storage tanks may also lead to pollution of the river.

Process waste water arising from:

- Tank Bottom draining
- Tanker vehicle washing
- Vapor Recovery processes
- Contaminated storm water runoff
- Leaks and spills

Process waste oily “sour” water arising from distillation, fluid catalytic cracking and catalytic reforming processes will also be aspects that may potentially lead to impact of ground water contamination and surface water pollution, especially the Benin River.

Soil Erosion

Road rehabilitation/construction will intensify the effects of natural soil erosion due to vegetation removal, soil disturbance, and exposure of bare soil surface. The most severe problems will be associated with embankment construction in the plain area, road sections with heavy cuts and fills, borrow and spoil sites, as well as bridge and culvert construction sites, particularly on rainy days. If recommended mitigation measures are taken, the erosion loss could be significantly reduced.

Safety

Hazardous Materials, Fire & Explosion potentials of operating this refinery will be potentially high without mitigation measures put in place. Risk of fire and explosions due to the flammable and combustible nature of petroleum products will potentially exist especially during pre-commissioning and operations. Risk of leaks and accidental releases from equipment, tanks, pipes etc. during loading and unloading (handling) will also potentially threaten soil, ground water and surface water.

Construction accidents and injuries are potentially bad events that may arise. Road tanker trucks accidents are also potential accidents that may occur if necessary steps are not taken towards road safety and journey management.

Security

Potential Risks of fuel farms or gas storage areas being targeted for criminal or terrorists attack. Potential Loss and injury to human life. The proposed project may lead to community issues and might create community divide amongst the youth population and factions as has been experience in other Niger Delta Areas and Projects.

Wastes

LPG plant produces noticeable amounts of solid wastes. The largest amount of solid wastes originate from cracking, coke production, sludge production and treatment (sludge deriving from cleaning tanks), water and oil separators and effluent treatment system. Waste generated will cut across various waste type and stream including both hazardous and nonhazardous. Hazardous wastes produced include:

i. Tank bottom sludge composed of water residual product, sand, scale rust, inorganic slats and additives

ii. Sludge from oil/water separations systems

iii. Spill cleanup material

iv. Contaminated equipment and protective clothing

This forebodes Risk of site contamination from hazardous waste and Risk of contamination to water bodies.

Socioeconomic Impacts

The Project will have significant beneficial impacts on both urban and rural economy in the project area. The greatest beneficiaries from a monetary standpoint will be the business entrepreneurs, and fuels users, who will experience greater efficiency, and greater availability to their demands for petroleum products. From a numerical standpoint, the largest group of beneficiaries will be farmers, who will have improved access to markets and cheaper transport costs for their commercial produce. Farmers and their families will also benefit from expanded opportunities for seasonal employment elsewhere to earn supplemental incomes. Rural village level enterprises will also prosper, promoting local economic growth. The planned LPG depot and White product tank farm facility will generate significant employment opportunities in the area during construction.

Possible adverse social impacts of the project will be temporary displacement of project affected persons along the corridor. Other impacts are disruption of electrical facilities, health risk of workers, local population and road users, possible transmission of STDs and HIV/AIDS due to the influx of site workers to that region. Heavy duty vehicles and machinery movement during construction may cause traffic along the roads and might give rise to accidents. The traffic will be temporary and limited to the construction areas. During operations phase, the plying of the road by tanker trucks might also give rise to accidents. The potential for this will be for the entire life of the project.

Impact on Biological Resources

Flora and Fauna

During road construction, the vegetation along the project corridor will be destroyed, and the local ecosystem changed. In addition, the destruction and fragmentation effect of the road construction may diminish the habitats for some of the animal species, so that there may not be enough roosting places any more for them to survive. Construction workers may hunt animals and fell trees for cooking. There are no endangered species encountered along the project corridor. Appropriate mitigation measure will reduce impact on wildlife and vegetation.

5.3.3 Beneficial Impacts

The execution of the field development plan activities will provide employment opportunities for unemployed Nigerians. The number of persons to be employed shall however, depend on the work force needed and the proportion of the work activities. Provision of employment during the project execution will have additional benefit augmenting household incomes and thus improving living standards. This will bring about associated financial benefits to SHAFA Energy Ltd and Nigeria.

5.4 RISK ASSESSMENT

Risk assessment according to Wathern (1986) stresses formal quantification of probability and uncertainty. Thus a study that provides quantitative measures of risk levels, where risk refers to the possibility of uncertain, adverse consequences, most fundamental estimates of possible health and other consequences. A risk assessment typically includes a determination of the types of hazard posed, together with estimates of probability of their occurrence. It also includes the population at risk of exposure and the ensuing adverse consequences (Conservation Foundation1984).

Table 5.4: HSE Risk Matrix

Consequence					Probability				
					A	B	C	D	E
Severity	**People**	**Assets**	**Environment**	**Reputation**	**Never heard of incident in industry**	**Incident has occurred in oil industry**	**Incident has occurred in SHAFA**	**Happens several times per year in**	**Happens several times per year in SHAFA**
0	No injury	No damage	No effect	No impact					
1	Slight Injury	Slight damage	Slight effect	Slight impact		**Low**			
2	Minor Injury	Minor damage	Minor effect	Limited impact		**Risk**			
3	Major Injury	Localised damage	Localised effect	Considerable impact			**Medium**		
4	Single Fatality	Major damage	Major effect	National impact			**Risk**	**High**	
5	Multiple Fatalities	Extensive damage	Massive effect	International impact				**Risk**	

5.4.1 Project Risk Management

In order to continuously address the risks associated with this project a risk register was set up and routinely updated. Risk events affecting all aspects of the project were Identified i.e., Pipes, pilings, facilities, communities, commerce, organization and politics is recommended that the register is kept alive throughout the project implementation phase.

CHAPTER SIX

MITIGATION MEASURES

6.1 Introduction

The acceptability and/or suitability of a project is premised on several considerations, among which is the reduction of negative environmental and social impacts to tolerable levels. Impact significance reduction is usually achieved by introducing mitigation/amelioration measures to cater for the negative impacts identified. This section presents a summary of those measures that are deemed adequate to achieve this objective as well as the residual impacts that will remain after the implementation of these mitigation measures. For ease of comprehension, the mitigation measures are presented based on the various impacts identified. It should be noted that no mitigation measures are necessary for positive impacts and as such they are not discussed in this section.

6.2 Mitigation Measures

Mitigation measures are options that can be used to either completely eliminate or minimize identified negative impacts of a development project. The traditional approach to design and operations is to ensure compliance with the applicable safety codes and standards during design. However, compliance with regulations, codes and standards may not be sufficient to achieve an appropriate level of Health Safety and Environmental (HSE) performance in design. Design codes are generic and applicable to facilities in a number of geographical areas that face a wide range of technical challenges unique to the project. The design of the proposed Alausa Power Project is based on the best-practices of international codes.

The HSE objective with respect to the design and implementation plan is to implement all cost effective measures to reduce the risk and effects from major hazards including accidents. The approach has been to use this as a goal rather than a prescriptive objective that cannot be achieved without following a documented process of identification, assessment, reduction and continuous monitoring.

Thus the steps taken in the HSE process for the project included the following:

- Design based on Codes, Standards and Regulations.
- Improved design based on Quantitative Risk Assessment (Air emission and noise dispersion modelling in Appendices 5.1 and 5.2) and Environmental Impact Assessment
- Improved design from human factors evaluation

The hierarchical order of importance of these HSE design elements is illustrated in Figure 6.1

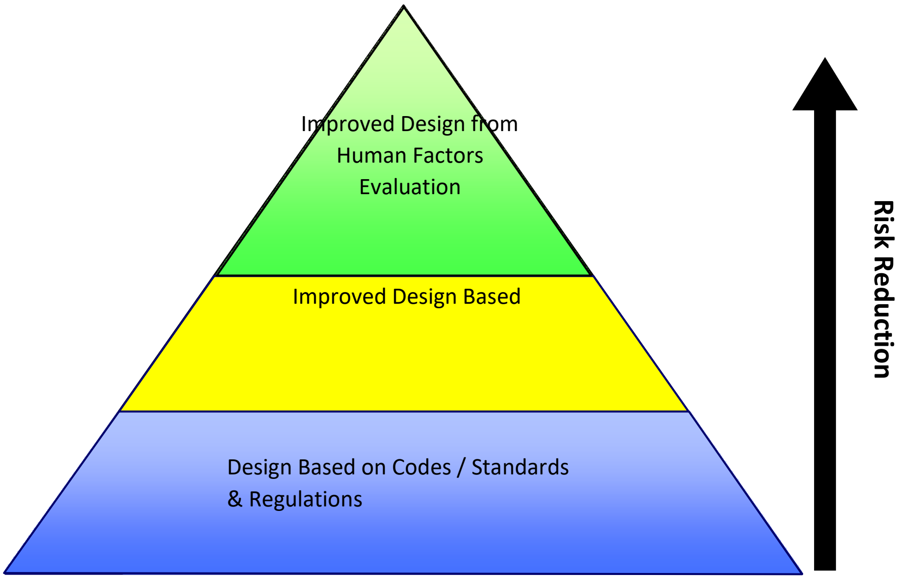


Figure 6.1: Risk Based Design Strategy

6.2.1 Mitigation Measures Built into Project Design

The description of the proposed power plant has been discussed extensively in chapter three of this report. The component of the project include the setting-up of generators, transmission cables, installation of switch panels, laying of the gas pipeline that will supply natural gas fuel to the generators, etc. Based on this, certain safety devices have been integrated into the system for robust system control and management of integrity. Some of the safety mitigation measures built into the project design includes the following:

- Pressure Reducing and Metering Station (PRMS)
- Slam shut valve.
- Voltage control measures
- Fire prevention and curtailment equipment.

Pressure Reducing and Metering Station (PRMS)

PRMS shall be installed at SHAFA premises to regulate the incoming gas pressure and ensure that the desired pressure is supplied. By design, the PRMS has also been incorporated with adequate isolation valves to enhance safety, maintenance and operational flexibility. In addition, it is also equipped with a filter for removing solid particles and liquid droplets, pressure regulators with built-in slam shut valves to disconnect the system in case of high pressure or any abnormal situation.

In addition to these safety hardware's are the safe vent system, which vents and purges the system; relief valves, which routinely vent out gases in case of increased pressure; fire prevention system; gas detector, fire extinguisher and alarm system. All these are to ensure adequate safety in the entire pipeline design.

Slam Shut Valve

This is a component of the central (source) PRMS and it is expected to automatically shut down the upstream system so that the operating pressure of the downstream system does not in anyway, exceed the required pressure. This limiting pressure is the maximum allowable operating pressure (MAOP), to enhance system integrity and optimum performance.

Voltage Control Regulators

Voltage regulators shall be installed throughout the entire system to regulate the quantity of voltage that is transmitted. In some circumstances, it has been identified that irregular voltage are transmitted through the transmission lines and the essence of the regulation is to maintain the desired voltage transmitted within the system.

Fire Prevention and Curtailment Equipment

Another important safety feature that has been built into the project is the curtailment of accidental fires. The proposed project's safety procedures have taken into considerations accidental fires due to gas pipeline leakages, sparks, etc. To prevent the incidence of accidental fires along the pipeline, the aforementioned safety precautionary devices such as slam shut valves etc. have been incorporated and in addition, SHAFA has made adequate provision for the installation of fire extinguishers at strategic locations within the power plant and around the equipment area.

6.3 SUMMARY ASSESSMENT OF IMPACTS AND MITIGATION

Other mitigation measures recommended for potential environmental and social impacts associated with this project are summarized in Tables 6.1 and 6.2 respectively.

Table 6.1: Recommended Mitigation Measures for Negative Environmental Impacts Associated with the LPG Project

Activity/Source of Impact/Issue	Potential Negative Impact	Mitigation Measures
PRE-CONSTRUCTION		
Clearing and Site Preparation.	• Clearing and site preparation may lead to emission of particulate matter (dust) into the ambient air. Thereby deteriorating the air condition of the area. This is especially if this activity is carried out during the dry season;	• This activity will be for a very short duration and is therefore expected to be of minor impact. However, SHAFA will ensure that contractor on site is advised to sprinkle water on the construction site prior to clearing, especially where this activity is carried out in the dry season;
	• The introduction of fill materials such as laterite and gravel for the road construction activities could lead to contamination of the soil and groundwater of the area, especially if the fill materials are contaminated;	• Where fill materials will be required, SHAFA will ensure that fill materials are sought around the project area or area with similar constituents. In addition, SHAFA will ensure that fill materials are free from possible contamination;
	• The clearing of vegetation from the site may lead to vegetation loss and subsequent exposure of the soil surface to agents of denudation (Rain and wind);	• SHAFA will ensure that only required portion of the project area is cleared;

Activity/Source of Impact/Issue	Potential Negative Impact	Mitigation Measures
	Potential increase of ambient noise around the plant location.	• This activity will be carried out during the day. In addition, appropriate noise safety gears such as ear muffs will be provided for the construction workers.
Installation of engines	Potential waste generation among workers due to indiscriminate disposal of food wrappers and containers.	• EPC shall provide adequate waste bins at strategic location within the construction sites. The wastes shall be regularly carted away by accredited waste manager for safe disposal in the State accredited dump site.
Backfilling	Backfilling during the dry season may increase Total Suspended Particulate (TSP) in the air.	• EPC engineer shall be mandated to sprinkle water on construction site prior to backfilling to minimize total suspended particulate especially if this activity is carried out in dry season;
	• Potential erosion especially if the backfilling is not properly reinforced;	• Backfilling shall be adequately done and compacted to avoid loose soil structure, which may engender soil erosion;

	Potential introduction of foreign materials to the soil during backfilling may alter the ecology around the backfilled portions;	Excavated soil shall be kept beside the dug portion and used for backfilling. i.e. as much as possible and where necessary, same soil shall also be used for backfilling;
	Improper disposal of human and domestic waste generated during construction may lead to bad odour thereby deteriorating the ambient air quality.	EPC contractor shall provide mobile toilets throughout the construction phase of the project. In addition, waste bins shall be provided around the construction site.
Vehicular/Traffic Movement	Potential increase in soil erosion due to continuous loosening of soil as a result of increased movement of vehicles	Movement of vehicles shall be restricted to compacted and properly reinforced portions.
Emission from Stationary Equipment and Vehicular Movement	• Potential increase in noxious gases concentration in the ambient air from the exhaust of the stationary equipment and supply vehicles. Emissions of CO_2 and CO are potential contributors to climate change; NO_X and SO_2 contribute to acid rain, while NO_X impacts on the ozone layer.	• SHAFA shall make it mandatory for the contractor to comply with FMEnv emission standards for CO, NO_X, and SO_X for stationary equipment; SHAFA shall ensure that project vehicles are serviced and

Activity/Source of Impact/Issue	Potential Negative Impact	Mitigation Measures
	• Potential deterioration of ambient air quality especially around the project area due to increase of particulate matter from movement of construction vehicles; • Potential increase in ambient noise around the project area;	Maintained appropriately. Particularly, equipment exhaust must be in perfect order. This will ensure that project vehicles perform optimally and noise is minimized; • EPC contractor shall provide appropriate ear muffs to construction workers and the use shall be strictly enforced by the HSE supervisor on site; • EPC contractor shall ensure that project vehicles are serviced and maintained appropriately. Particularly, equipment exhaust must be in perfect order. This will ensure optimum performance of project vehicles and minimal noise.
Wastes Generation. Various waste materials are always generated in most construction site. In most cases, proper	• Foul odour from decomposing wastes may deteriorate ambient air quality.	• EPC contractor shall provide waste bins and mobile toilets, which shall be daily collected into a central dump site;

disposal of these wastes pose some problems, especially if appropriate mitigation are not put in place.		• Adequate enlightenment shall be given to construction workers on effective waste disposal; • Wastes shall be collected in covered waste bins and shall be appropriately carted away and disposed off early enough before decomposition; • EPC contractor shall be mandated to enforce its waste management policy.
Hydro testing of the pipeline	• Indiscriminate discharge of the hydro test fluid could lead to acute toxicity of aquatic organisms, low dissolved oxygen levels in the immediate surrounds of the discharge.	• The quality of chemicals injected shall be ascertained. • The discharge shall be treated to acceptable FMEnv limit before discharge. • Release of hydro test fluid shall be above the surface of the receiving water to enhance re-oxygenation of the effluent prior to entering the water body.

Activity/Source of Impact/Issue	Potential Negative Impact	Mitigation Measures
OPERATION/MAINTENANCE		
Gas supply to the plant	• Potential gas leakage during operation may foul ambient air quality. Although natural gas is generally accepted as clean gas, in case of low engine performance, certain level of GHG could be emitted. Potential supply of wet gas and accumulation of condensate could damage the gas turbines. • Potential accumulation of condensates and its indiscriminate disposal could pose danger to the environment such as contamination of soil, surface and ground water bodies.	• Standard safety apparatuses shall be put in place to forestall gas pipe leakage. • The engines shall be properly and promptly maintained in line with the manufacturer's specification in order to maintain the engine in a tip-top condition. • SHAFA shall install at the inlet point, gas treatment facilities such as heaters and scrubbers to knock off possible wet gas and condensates. • Collected condensates shall be containerized for proper disposal by DPR accredited condensate handler.

Power generation and evacuation	Potential electric shock and electrocution in the event of human error or circuit leakage in any part of the facility;	• SHAFA shall implement its operational safety guidelines during the operational phase of the project. In addition, the facility shall be provided with all relevant safety facilities in line with international best practices;
	Potential Electromagnetic Interference to household electronic devices and digital devices in the control room.	• SHAFA shall provide all its operational personnel with relevant and appropriate safety gadgets such as hand gloves, well insulated tools and enforce strict compliance; • SHAFA shall ensure the implementation of 1996 versions of IEEE Standard 1050 Instrumentation and Control (I&C) equipment grounding methods in its facility.
	• Vibration impacts from the engines could impact on the land physical (geological) characteristics.	• The engines are equipped with installation materials that ensure that vibration effects from the engines are not transferred to the earth.
	• Noise from the operating turbines could impair hearing of turbine operation staff as well as nearby communities.	• Turbines shall be equipped with noise reducing materials. Noise dispersion of the proposed plant has been modeled (see appendix 5.2).

Activity/Source of Impact/Issue	Potential Negative Impact	Mitigation Measures
	• Gaseous emissions from the turbine exhaust could impair ambient air quality, thereby leading to health challenges such as bronchitis and other respiratory disorder.	• SHAFA will ensure that the maintenance schedule of the power plant is strictly adhered to. • SHAFA shall carry out regular monitoring of gaseous emissions to ensure compliance with FMEnv regulatory standards. • Possible air emission dispersion from the exhaust of the proposed plant has been modelled (see appendix 5.1 for model report)
Routine maintenance and Pipeline/RoW surveillance	• Potential indiscriminate dumping of spent lube oil may alter the physicochemical characteristics of the soil or water;	• Spent lube oils shall be collected in well protected containers and disposed by accredited spent lube oil managers.
	• Potential solid waste generation from spare part package, used engine parts and accessories etc.	• Used parts and accessories shall be collected in provided waste containers within the facility for proper disposal;
		• SHAFA shall ensure that the maintenance engineer duly adhere to the waste management plan and policy of the company.

Wastes and emission generation	• Air emissions from engines may have potential health effects on workers. However, this is not likely as gas fired engine is generally known to emit cleaner air than any other fuel;	•Gaseous emission will be minimal and is not likely to pose any health hazard as natural gas is known to be one of the cleanest available fuels.
	• Potential global warming due to increased CO2 emission from the continuous running of the engines.	• Nigeria is one of the lowest world emitters of CO2. Therefore, the contribution of the proposed plant may have little or no impact on the ozone layer.
	• Sanitary wastes generated within the plant facility may pose danger to both surface and aquifer if not adequately treated before discharge/disposal.	• Sanitary wastes shall be contained in underground septic tanks.
System Cooling	• Indiscriminate discharge of the cooling water on available surface water (warri Riverr) without adequate treatment could lead to contamination and death of aquatic organisms.	• Cooling water shall be treated FMEnv regulatory standards and best international standard before use and discharge.

Activity/Source of Impact/Issue	Potential Negative Impact	Mitigation Measures
	• Depending on the chloride content of the water used for cooling, important metallic parts of the engines could rust faster thus subjecting the engines to mechanical fault.	
DECOMMISSIONING		
Dismantling of Structures	• Dismantling of structures may engender increase in solid waste;	• International standards and best practices for dismantling or closure of such project will be applied;
		• SHAFA shall dispose appropriately all waste generated during this phase of the project by engaging the services of an accredited waste manager;
		• Steel materials may be sold to steel recycling companies such as nearby steel company.
	• Potential increase in noise around the project area;	• SHAFA shall develop a closure plan into the overall project implementation program. Such closure plans shall be able to offset all associated negative impacts with closuresL and decommissioning of projects;
	• Potential alteration of the soil structure especially at locations where facilities are fixed to the ground;	
	• In the event that this activity is carried out in the dry season, there may be increase in particulate matter, which lead to temporary deterioration in ambient air quality around the project area;	• This activity shall be of very short duration. Therefore impact of particulate emission will be minimal;

	• Potential gaseous emission from taili pipes of machines and vehicles carrying out the dismantling exercise.	• SHAFA shall ensure that all dismantling machines and vehicles and machine are duly serviced to reduce possible emission.
Site Restoration	• In the event that the site is not adequately reinstated, there may be soil erosion and flooding;	• Erosion prone areas shall be properly reinforced and compacted to avoid possible impact of erosion;
	• Improper site reinstatement may also engender alteration of soil structure;	• SHAFA shall ensure proper and environmentally friendly restoration of site;
	• Potential increase in TSP and gaseous emissions from machines and vehicles used for site restoration, especially if this activity is carried out in the dry season.	Where this activity is carried out during the dry season and there is increase in dust, SHAFA shall ensure that the site restoration engineer sprinkle water on the ground surface to reduce dust;
		• SHAFA shall develop a closure plan into the overall project implementation program. Such closure plans shall be able to offset all associated negative impacts with closures and decommissioning of projects.

Summary

In summary, the mitigation measures recommended in this section may not be exhaustive. However, they are considered adequate to effectively ameliorate or in some cases, eliminate the negative impacts that may attend this project. From the assessment undertaken, if the measures are applied, all minor and moderate negative impacts will be reduced significantly and will leave, in most cases, negligible and minor residual impacts. However, for accidental occurrences such as fire outbreak and electrocution, the residual impact would still remain major, given the costly and sometimes irreversible effect of it occurrence. A summary of this scenario is presented in Figure 6.2. In order to verify these assertions, and to ensure that the measures are effective, it is necessary to have in place a sound and cost-effective environmental management plan (EMP), presented in the next section of this report.

Figure 6.2: Residual Impacts after Application of Mitigation Measures

		Sources of Potential Impact																				
		Pre-Construction				Construction									Operation					Closure		
		Land Acquisition	Design	Site Clearing and Preparation	Mobilization of Equipment to	Excavation	Laying of Cables and Pipes	Preparation and concreting of	Installation of Turbine engines	Backfilling	Vehicular/Traffic Movement	Emission from Stationary	Emission from Vehicular	Wastes Generation	Natural gas supply	Power generation and	Routine Maintenance	Wastes and Emissions	System Cooling	Dismantling of Structures	Waste Management	Site Restoration
Environmental		***Vegetation***																				
		Surface water Quality																				
		Groundwater Quality																				
		Soil fauna																				
		Air Quality																				

		Noise																					
		Soil Structure																					
		Wildlife																					
		Population Characteristics																					
		Influx of Temporary workers																					
		Population Change																					
		Livelihoods																					
		Loss of Land																					
		Loss of Business/income																					
		Local employment																					
		Physical Properties (Houses etc)																					
		Erosion/Flooding																					
		Sexually Transmitted Diseases/AIDS																					
	Human/Social	*Socio/cultural institutions*																					

		Religious Institutions (Archaeology etc)																					
		Formal (govt.) institutions																					
		Community infrastructure																					
		Water Supply																					
		• Health																					
		• Recreation																					
		• Roads																					
		• Educational Institutions (Schools)																					
		Conflicts																					
		• Interest Group Activities																					
		Disturbance																					
		• Youth unrest due to unemployment																					
		• Communal clashes due to																					

		differences in youth employment																					
		Accident																					
		• Explosion/Fire																					
		• Electric Shock/Electrocution																					

Positive Impact		Negligible/No Impact		Minor Impact		Moderate Impact		Major Impact

CHAPTER SEVEN

ENVIRONMENTAL MANAGEMENT PLAN

7.1 INTRODUCTION

Environmental Management Plan (EMP) is the essential component of an EIA that provides the assurance that the mitigation measures developed for reducing the effects of adverse associated and potential impacts to as low as reasonably practicable (ALARP) as well as those proposed for enhancing beneficial impacts are implemented and maintained throughout the project lifecycle. The EMP for the proposed LPG Project, which outlines the strategies for managing hazards, associated and potential impacts and their effects on the environment, is presented in this chapter.

7.2 OBJECTIVES OF THE EMP

The objectives of this EMP are:

- To demonstrate that a systematic procedure, which ensures all project activities are executed in compliance with applicable legislations and SHAFA policies on Health, Safety, Environment, Security and Community Relations have been established for the project;

- To show that mitigation measures for all impacts have been established and shall be maintained throughout the project life cycle, so that impact risk levels will remain ALARP;

- To demonstrate that emergency response measures will be in place. This will ensure that adequate responses in case of emergency have been established for the project; and

- To set out the structure that will ensure compliance to the EMP by SHAFA and its contractors.

7.3 MANAGEMENT ORGANIZATION

SHAFA shall retain the primary responsibility of ensuring that environmental Commitments are met throughout the life cycle of this project. The company shall establish a schedule for responsibility and training on matters relating to the environment. Environmental issues shall be a line responsibility for which all levels of personnel are accountable. Top management shall ensure that all environmental considerations are integrated into project execution. The Environment Unit of SHAFA shall offer expert advice on protection measures and shall assist to monitor performance.

SHAFA shall appoint an Environmental Monitoring Team (EMT) to ensure effective implementation of the recommendations of the EIA and its management plan. This team shall be made up of representatives of the project team, HSE and other Departments. The project HSE Team Leader shall additionally provide leadership to the EMT. However, final environmental responsibility lies with the Project Manager. The EMT shall liaise at a predetermined interval with contractors, engineers, quality assurance officers, supervisors and relevant SHAFA departments on all environmental matters. The HSE Team Leader within the project, assisted by the EMT shall be the focal point for all environmental matters relating to detailed design and monitoring of construction, operation, and handover of facilities to the operating and maintenance teams. The EM Team shall verify the effectiveness of the EMP implementation in liaison with Regulators and other stakeholders as appropriate.

Notwithstanding, all action parties within the project team shall demonstrate compliance directly from their line through to the proposed power Project manager.

In this way, SHAFA shall take responsibility for all environmental matters and ensure that the Engineering, Procurement and Construction (EPC) and Operations and Maintenance (O&M) contractors comply with all applicable environmental laws, regulations and policies as they apply to this power project. In principle, the EPC Contractor shall be responsible for implementing those aspects of the EIA recommendations that pertain to the engineering, procurement and construction phase of the project. Similarly, the O&M contractor(s) shall be responsible for the implementation of the recommendations of those aspects of the EIA recommendations that are relevant to the operations and maintenance phases of the project.

The EPC and O&M contractors shall be required to submit, for approval, their proposal to manage HSE inherent in their contract execution. The EM Team through the HSE- Team Leader will operate in an advisory capacity in all matters; the approval responsibility lies with the Project Manager.

Use and Maintenance of the EMP

The EMP shall remain a dynamic working tool and will be owned by the proposed LPG plant project team. SHAFA HSE Manager is, however, the custodian of the document and may exercise auditing role to verify compliance by the project. The EMP shall be updated and revised periodically, throughout the project's life span to incorporate improved technologies, better environmental regulations, management systems, guidelines and policies. Constructive suggestions by users (contractors, management, line and operating personnel) shall be assessed by the EM Team and integrated into the EMP.

7.4 REGULATORY COMPLIANCE

All environment-related regulations as they apply to Power Project have been documented and described in this EIA. SHAFA management shall ensure compliance with these regulations throughout the project's lifecycle in line with measures inherent in the Engineering Project Management Guide (EPMG).

7.5 DETAILED DESIGN GUIDELINES

Health, Safety and Environmental (HSE) Premises that cover the minimum performance standards for HSE critical elements to be applied to the design of the gas plant will be established as part of the Front-End Engineering Design (FEED) phase of the GAS LPG project. These standards and criteria are meant to ensure that the design of the LPG Plant is in line with currently accepted HSE principles and policies as they apply to this project. In particular, the HSE

Premises will steer the design towards the goal of preventing/minimizing injuries, ill health, and damage to assets and the (natural and social) environment, to avoid/eliminate liabilities in the future. In the design of the power project, efficient use of natural resources and energy sources as a requirement will be taken into account to conserve and protect resource of the environment through prevention/minimization of discharges that have adverse effects on the environment.

The HSE Premises shall be flexible enough to permit refinements and extensions arising from formal HSE deliverables that are likely to be produced during successive project development phases. The driving force for the design will be the reduction of risks to people, assets, reputation and the environment in compliance with the principle of As Low as Reasonably Practicable (ALARP). Any residual risks/effects after the application of the ALARP principle shall be managed through continuous improvement of the design of the station.

7.6 TRANSPORT OPERATIONS

The project shall manage all transportation operations in line with the following guidelines in order to forestall accidents/incidents.

Pre-mobilization of Vehicles

All vehicles to be used for transportation of equipment, materials and personnel shall be pre- mobilized. The pre-mobilization shall be conducted to confirm that the vehicles are fit for purpose and that the driver of the vehicles as well as their assistant(s) has the necessary competencies needed for the journey. It shall also be confirmed during the pre-mobilization exercise that a job hazard analysis (JHA) has been conducted for the trip and that all recommended precautions (mitigation measures) have been adopted.

Journey Management Plan

In liaison with the HSE Team Leader, the contractors for this project shall manage their day-to- day transportation needs within a framework of controls that ensures compliance with SHAFA's standards. Journey management shall include the following:

- Planning takes place before travelling;
- Distances travelled are minimized;
- Unnecessary journeys are avoided;
- Transport tasks are combined, e.g. unused cargo space and empty seats;
- Right vehicle and driver for the job are selected; and
- The safest times and routes are selected.

7.7 PREVENTION OF ACCIDENTS/INCIDENTS

Prevention of workplace accidents and incidents during the proposed project shall be achieved using the JHA tool and written work instructions (WIs).Consequently, the HSE Team Leader shall arrange for JHA to be conducted for all HSE critical activities. Written and explicit work instructions from such activities shall be developed.

Compliance to regulatory standards, operations/maintenance codes and specifications as well as HSE guidelines shall form the basis for the execution of the proposed project. However, emergency situations could still occur as a result of equipment failure, weather, negligence and/or sabotage. Consequently, a contingency plan shall be developed as back up to other containment systems put in place to handle such occurrences. As a minimum, the contingency plans that shall apply to both SHAFA and contractors, shall address the following emergency situations:

- Fires and Explosions;
- Electrocution
- Serious injury or illness;
- Uncontrolled gas leaks and hydrocarbons/chemical spills;
- Weather related disasters; and
- Land vehicle mishaps.

The HSE Team Leader shall ensure that adequate security arrangements are put in place. Such plan shall have inputs from host communities. The team shall also identify, evaluate and manage the risks to personnel and property arising from malicious practices, crime, civil disorder or armed conflict.

The security activities shall be co-coordinated from a common viewpoint by all stakeholders and be in line with SHAFA's security guidelines. In addition, each contractor shall be required to prepare a project security plan and community involvement strategy and submit to SHAFA for a review and approval. As part of the Environmental Management Plan and with the approval of the proposed

LPG Project Manager, the HSE Team Leader shall organize security workshops to identify, evaluate and recommend contingency plans for all security risks associated with the Power project.

7.8 TRAINING AND AWARENESS

In order to assure competence and awareness amongst EPC as well as O&M staff and contractors, the project management shall establish, maintain and operate a training and awareness programme on health, safety and environmental issues. A great deal of attention shall be devoted to the locals in the contractors' teams. The training shall include accident emergency practices, basic First Aid, the use of Personnel Protective Equipment etc. Environmental Induction Course and subsequent refresher course relating to the project shall be organized for all work forces. The objective of the courses would be to develop environmental awareness and sensitivity amongst the personnel. The training and awareness programme shall be reviewed periodically by top management and shall include but not limited to the following aspects:

- HSE induction course,
- Emergency response drill,
- Community interaction and relations management,
- Basic First aid for all and more in depth training for selected personnel, (numbers as required by SHAFA's policy),
- Defensive driving,
- Permit to Work System, and
- HSE on site

Certificates of attendance shall be issued to successful participants. SHAFA shall also conduct HSE awareness campaigns for the host communities and general public with the aim of sensitizing them to the potential impacts and hazards associated with its operations and the appropriate response to accidents/incidents. The public awareness campaigns shall be conducted periodically and the proceedings documented for subsequent audit.

7.9 MAINTENANCE PROGRAMME

The maintenance officer to be employed by the contractors for the project shall develop a comprehensive maintenance programme. The maintenance schedule contained in the programme shall be designed in line with manufacturer's specifications for each of the equipment. A maintenance logbook shall also be operated and it shall be regularly checked by the HSE Team Leader. In addition, the maintenance status (last and next service dates) shall be displayed at appropriate and clearly visible points on each equipment and machine.

7.10 CONSTRUCTION GUIDELINES

7.10.1 Site Preparation/Clearance

Site preparation/clearance works shall be carried out within defined perimeters and only when necessary. The maximum permissible time lapse between site clearing and initiation of construction operations shall be reduced to the barest minimum necessary to permit safe operations. Areas cleared in excess of operational requirements shall be reinstated with indigenous topsoil and vegetation.

During construction, acquired land not used shall be fenced off and left fallow until use for the land is required. As an additional measure to mitigate reduction in biodiversity, approved clearing of land for construction activities shall commence from the road into the bushes. This is to give any animals present in the area to be cleared the opportunity to move away.

7.10.2 Use of Public Rights of Way

All transportation and construction works shall be executed in such a manner that will ensure that interference with the use of public highways and access roads is minimal. However, if operational safety demands that public highways or roads be blocked, then SHAFA's LPG Project Manager may approve such action only when temporary traffic control and diversion arrangements have been provided.

Dumping or storage of litter/debris, tools and equipment in public or private highways and roads shall be prohibited. The proponent shall develop highway and road clearing strategies to ensure that public roads and highways are kept clear, safe and passable.

7.10.3 Archaeological/Heritage Sites

Contractors and all SHAFA personnel working at the sites shall preserve the cultural heritage of the host communities by clearly demarcating and avoiding all known existing sites of heritage or cultural value. If there is need to relocate any such site, definite agreements shall be reached between members of the affected community and SHAFA prior to relocation. Interestingly, no site of heritage or cultural value was discovered in the proposed project site.

7.10.4 Health and Safety of Workers

Throughout the project development Hazards and Effects Management Process (HEMP) shall be applied and shall consist of identifying, assessing and controlling hazards, and putting in place measures to recover from the consequences of hazards if the controls fail.

Operations at all work sites shall be subject to regulatory, industry and SHAFA HSE policies and guidelines. All SHAFA and contractor staff shall be well informed and trained on the HSE policies and guidelines. All facilities shall also be designed to enhance safety planning and activities to be executed within the confines of relevant legislation and stakeholders' interests.

SHAFA shall provide adequate health services as well as site first aid services for its workforce. The first aid services shall be extended to visiting personnel and casual workers. All construction activities shall be properly managed through careful planning and the application of relevant HSE policies including the following:

- Use of Permit to Work (PTW);
- Job Hazard Analysis and toolbox meetings;
- Appropriate use of PPE in designated hazard areas;
- Prohibition of alcohol during work hours and at work sites and facilities;
- Prohibition of use of petrol engines for operations;
- Regular emergency drills;
- Prohibition of smoking in fire hazard areas.

7.10.5 Emergency Response

The following equipment shall be provided as minimum requirements for emergency response action.

- Safety showers at locations in the plant where accidental spillage of chemicals could occur. Supply shall be taken from the firewater system;
- Self-contained (storage type) eye wash units shall be provided at battery rooms;
- Safety signs and notices shall be provided throughout the plant in accordance with SHAFA requirements and industry best available standards;
- Hot surfaces (>70-^{0}C) likely to be accessible by personnel, shall be lagged or caged;
- A general alarm system shall be provided, capable of giving an audible alarm in all areas of the plant and visual display in areas of high background noise;
- Two sets of personnel breathing apparatus shall be provided in control building to allow rescue activities to be performed in smoke conditions.
- Safety mats shall be provided in areas where there is the possibility of electrocution;
- Emergency response procedures shall be put in place for snakebites, electrocution, road traffic accidents, medevac/medial rescue and gas leaks.

7.10.6 Pollution Control

i) Air Pollution

In operating equipment, SHAFA shall utilize all practical methods and devices available to control, prevent and otherwise minimize atmospheric emissions or the discharge of air contaminants. Good engine efficiency of equipment and vehicles shall be maintained. Indiscriminate burning of materials resulting from clearance of trees, bushes and combustible materials shall not be permitted. Measurements of air pollutants to determine the air quality in the communities around the project area shall be undertaken as part of the monitoring exercise.

ii) Water and Soil Pollution

a) Waste waters: Pollution of surface water by project-related waste including wastewater shall be prevented by proper management practices. Contaminated or potentially contaminated plant area run-offs shall be collected and treated by the proponent to meet regulatory requirements before discharge.

b) Soil: SHAFA shall ensure that all construction activities are performed by methods that will prevent pollution of the soil media by accidental spills of contaminants, debris, and other objectionable pollutants. In the event of a significant spill, relevant spill control measures shall be applied and contaminated soil shall be cleaned as appropriate. Regular checks shall be conducted on equipment to minimize minor lube oil and combustible leaks from engines.

iii) Noise Pollution

SHAFA shall comply with all requirements for noise control and with regulatory standards. For example, SHAFA shall ensure that contractor plans activities such that regulatory limits are not exceeded at the nearest communities especially at nights. All equipment shall be maintained at optimal working conditions and recommended work practices shall be employed to minimize noise. Night operations shall be avoided except when absolutely necessary. In such instances, adequate measures shall be taken to reduce the noise involved and keep working hours to a minimum. Earmuffs shall be provided for all workers and any other person present in the vicinity of high noise generating equipment or operations.

7.10.7 Waste Management Guidelines

The handling, storage and disposal of all wastes that will be generated during the life of the project shall be in accordance with SHAFA's approved waste management guidelines. These guidelines shall be binding on all staff and contractors involved in the proposed project with respect to the:

- Emission or release of pollutants, exhaust and/or fugitive gases.
- Discharge or spill of effluent into surface water, rivers, streams, swamp or land.
- Discharge of solid wastes (including domestic waste) into surface water, streams or land.
- Generation of noise and vibration.

A detailed waste management plan shall be developed for the wastes generated during the site preparation and construction activities. This waste management plan shall be subject to approval by the regulatory authorities prior to implementation. In the design of this plan the focus shall be on possible optimal recycling and reuse of materials.

i) Waste Handling

For proper handling and disposal, wastes shall be well defined at source and the definition transmitted along with the waste to the final disposal points. The proponent shall define and document all wastes generated in the course of work. Basic information that must be provided, as a minimum, for adequate definition of wastes include:

- Waste type identification
- Proper waste categorization
- Waste segregation information
- Recommended Management practices.

ii) Waste Minimization

Waste minimization implies reduction to the greatest extent possible of the volume or toxicity of waste materials. The four principles of waste minimization process: recycle, reduce, reuse and recover shall be adopted as applicable.

Opportunities to achieve significant waste volume reductions during the proposed project are functions of activity level, age, depreciation and maintenance level of facilities and operating equipment. A large proportion of excavated materials shall be used for landscaping or other remedial works on site.

iii) Waste Segregation

For effective implementation of appropriate wastes disposal methods, it is important that wastes be segregated, preferably at source into clearly designated (colour coded) bins at strategic locations. It is the responsibility of the contractors, during their operations to provide enough clearly marked bins at strategic locations to ensure proper segregation. Particular attention shall be given to work areas where a variety of wastes are generated such as in kitchens and residential areas.

Table 7.1: The Different Colour Codes For The Waste Bins Are:

Waste Type	**Colour Code**
Kitchen	**Green**
Glass	**Blue**
Plastic	**Brown**
General (non-useable	**Black**
Medical	**Yellow**
Toner/inks	**While**

For medical wastes (hazardous & non-hazardous) shall further be segregation into colour coded bags for easy management.

iv) Waste Disposal

All waste, except excavated soil and rock, shall be cleared regularly from the site and disposed off at designated areas and facilities owned by the Delta State Ministry of Environment. Instructions on material safety handling sheet shall be strictly adhered to and shall form basis for the disposal of wastes related to such products. Wastes in transit shall be accompanied and tracked by consignment notes. The waste consignment notes shall contain the following information as a minimum:

- Date of dispatch;
- Description of waste;
- Waste quantity/container type;
- Consignee/driver name and means of transportation; and
- Confirmation of actual disposal (time and date).

In addition, mobile toilets shall be provided at strategic locations within the construction site. These toilets shall be regularly carted away and disposed by Delta State Ministry of Environment accredited waste management consultant.

7.10.8 Prevention of Erosion

During construction, SHAFA shall all trenches and properly backfilled and reinstated. Where necessary, SHAFA shall ensure that surface water flow on land or swamp areas are controlled and if necessary channeled into temporary discharge pits. Such pits shall be located, designed and constructed in a manner that will minimize the potential threat of erosion. Muddy water and surface runoff from work sites shall be drained into suitable silt traps before discharge into Niger River and the adjoining streams. The silt trap shall be of adequate size and regularly de- silted. Excessive site clearing shall be avoided and exposed surfaces shall be re-vegetated as soon as practicable to minimize erosion.

For environmental accountability and sustainability, the areas that are prone to degradation around the Power Station where erosion has been noticed shall be reconstructed if necessary. Proper channels for the flow of run-off water into Niger River shall be constructed where required. These are aimed at preventing further erosion of land behind the power plant.

7.11 OPERATIONAL GUIDELINES

As part of the development of the project, a set of minimum standards and guidelines shall be developed and agreed upon by the project managers. This is the HSE Premises document. These include numerical limits (e.g. for noise, air emissions) as well as commitment to certain policies, systems and actions. The relevant sections and commitments from the project HSE Premises document shall be translated to contractual requirements of the contractor(s).

It is known that in some cases when power plant is operating at below approximately 50-70% rated capacity, NOx emissions rise significantly because the Dry Low NOx (DLN) burner system cannot operate at these lower loads and the burners switch (automatically as determined by the manufacturer) to a different mode. For this reason, a manual of permitted operations (MOPO) shall be developed and implemented for the project. This (MOPO) shall establish:

- ➢ The limits within which the plant will be allowed to operate and
- ➢ The required level of supervisory intervention when operating outside the optimal design envelope.

Other than during start-up and rectification of system upset periods, the facilities shall be operated in compliance with project environmental standards.

To assist in maintaining the technical integrity of the facilities, a well-defined maintenance management system, which shall be approved by the HSE Team Leader, shall be used to ensure compliance with SHAFA's maintenance policies. The maintenance system shall include plans and procedures for:

Normal maintenance (routine and breakdown maintenance performed by the

- various disciplines);
- Preventive maintenance (activities carried out at pre-determined intervals);
- Predictive maintenance (as initiated by facility condition monitoring and assessment);
- Inspection (in accordance with a pre-defined programme and based on statutory and company requirements);
- Production and maintenance personnel shall be properly selected and trained to ensure safe and effective job performance. Ongoing competence training shall be undertaken.

Inspections shall be carried out to comply with statutory and company requirements and shall be based on “Risk Avoidance” rather than “Risk Management”. The principle of risk-based inspection shall be adopted. Routine maintenance and inspection activities shall also be carried out for all project facilities and on-line condition based performance monitoring shall be applied.

7.11.1 Operational Wastes and Disposal Methods

Solid Wastes

Provision shall be made for the proper storage and subsequent disposal of all sludge/solid/sewage wastes generated at the facilities in accordance with FMEnv, SHAFA and Delta State Ministry of Environment waste management guidelines. In addition, organic wastes, generated during construction shall be collected, segregated and transported to an approved disposal facility. No dumping of wastes in streams or rivers or on land shall be permitted. All operational solid wastes shall be segregated prior to disposal and concrete arrangement shall be worked out with the Delta State Ministry of Environment to use their waste dump facilities for the disposal.

Liquid Wastes

In the LPG plant, water from Warri River shall be used to cool the condensers in the cooling towers and re-circulated. The amount required to compensate for evaporation and blow-down losses is designed to be of the order of 750 tonnes per hour. This makeup water is extracted from Bore hole. The intake works shall be located in compliance with applicable consent conditions.

In order to minimize environmental impacts and prevent direct recirculation of warm water from the blow down discharges, optimum locations for cooling water intake works have been determined and used water wash effluents which shall be collected in a holding tank located within each LPG tanks constitute the water use of the LPG Plant.

A coherent policy for the discharge of all site water in accordance with all environmental and process requirements shall be adapted in designing the discharge of water from the plant. The discharge pipeline shall be capable of discharging the total combined wastewater from the site. This total combined wastewater shall include all process water subject to contamination. For this power plant, these shall be treated to acceptable FMEnv limit and combined into a single discharge into Warri River.

The cooling tower blow down shall also be discharged into Warri River via a suitably sized two- sump neutralization pit. The appropriate location for the outfall shall take into account all relevant environmental restrictions. The waste water shall be channeled to the Warri River through a network of pipeline systems and this waste water must be treated to meet FMEnv's regulatory limit for discharge before releasing into the Warri River.

Gaseous Wastes

Provisions shall be made in the facilities design to permit upgrade of equipment in order to reduce emissions and discharges as new technologies emerge. Facilities for in-situ measurement of emissions and discharge levels shall also be provided where practicable.

7.11.2 Noise Minimization Guidelines

Noise and vibration generated by facilities and equipment shall meet the ergonomic requirements of SHAFA and other National and International Standards, Codes of Practice and Statutory Regulations. Where noise level exceeds the stipulated limits, it shall be treated as nuisance and the contractor concerned shall put in place adequate mitigation measures to ensure that the situation is properly addressed. All personnel working for a long period in high noise area such as the engine rooms shall be required to use earmuffs at all times. Permanent warning signs shall be posted at the boundaries of these restricted areas.

7.12 SITE INSPECTION PROCEDURES

The EM Team and representatives of regulatory bodies throughout the project life shall carry out regular inspection of sites and facilities. The main objective of such inspections shall be to assess compliance level with mitigation measures and recommendations of the EIA. When the HSE Team Leader requests such inspection, the site shall therefore be made accessible to such inspectors upon authentication of identity to:

- Examine and inspect all equipment that could cause pollution;
- Collect samples of any atmospheric emissions, effluent discharges or solid waste deposition for analyses and interpretation;
- Examine all construction and operation logbooks for environmentally related issues.

After each inspection, the Team shall compile a site inspection report detailing the:

- Specific facilities or areas inspected,
- Details of project activities, and
- Highlights of any observed non-compliance/persistent negligence.

In case of non-compliance the O&M contractor shall be requested to take appropriate measures. The inspection procedure shall be repeated after implementation.

7.13 AUDIT PROGRAMME

Environmental audit shall be periodically conducted at the project site during operation. The audit process shall be used to assure that the equipment used for the operations of the power station meet the requirements and specification outlined in the EIA and also to assess its environmental performance during this phase of the project. This will ensure that environmental protection and management procedures are being enforced.

7.13.1 Objectives

In implementing the audit programme, facilities on the plant perceived as having high environmental risks shall be thoroughly investigated. The audit programme shall:

- Examine compliance with regulatory requirements;
- Examine line management systems, plant operations, monitoring practices etc.;

- Identify current and potential environmental problems especially during the various phases of the project.
- Assure implementation of recommended practices and procedures; and
- Make recommendation for the improvement of the management system of the LPG plant operation.

After every audit exercise, the environmental auditor shall produce an Environmental Audit Report (EAR), which shall be submitted to SHAFA and the plant-operating Manager as well as the Federal Ministry of Environment who is the apex regulatory body on environmental matters in Nigeria. This regulatory and facility audit shall be conducted three years after the commencement of operations of the power plant.

7.14 MANAGING STAKEHOLDER PERCEPTIONS

Public interest is expected to be high. The project will have impacts on the surrounding communities through disturbance during construction and operation (e.g. noise, traffic, dust, emissions etc) and through the influx of workforce. Effective and realistic measures have been put in place to mitigate these impacts.

Nevertheless, stakeholder perceptions are bound to persist. These perceptions include:

- damage to structures due to vibration
- increase in hearing impairment due to increase in noise

This project shall manage these perceptions by employing and sustaining dialogue as well as involvement of the communities and other stakeholders in all phases of the project. In particular,

- The proponent shall ensure that the O&M Engineers(s) fully involve stakeholder communities in the environmental monitoring and management plan for this project.
- Use exhaust gas emissions monitoring and other test results as evidence of good environmental practice and performance.

7.15 EMP AND COMMUNITY DEVELOPMENT

The Environmental Management Team (EMT) shall ensure that this EMP does not conflict with the community development programmes of government authorities, NGOs and other agencies of the proposed Power Project area. The EMT shall integrate the Community Development/Assistance aspects of this development project with the community development programmes of external bodies such as the Delta State Ministry for Women Affairs and Social Development.

7.16 MONITORING PLAN

The environmental aspects to be monitored are: Air quality, Noise level, vegetation, effluent (wastewater) quality, and receiving body of water, underground water quality, soil characteristics and solid waste management. The attributes, parameters and phase of monitoring are summarized in Tables 7.2 and 7.3.

Table 7.2: Environmental and Social Parameters and Frequency of Monitoring during Construction

Environmental Attribute	Monitored Parameter	Measuring Frequency	Responsible Party
Air Quality	Emissions (CO, NO_X, SO_X, VOC) from construction vehicles and machines as well as dusts from construction surface.	Weekly	SHAFA HSE
Noise	Noise Level (dBA)	Weekly	SHAFA HSE
Soil Quality	pH, TOC, Heavy metals, THC	Quarterly	SHAFA HSE
Receiving water body (Ofunene and R. Niger)	Temperature, pH, TSS, DO, BOD_5, Heavy Metals, hydrocarbon, conductivity, turbidity, and Coliform,	Every week within the first month after discharge	SHAFA HSE
Ground water	Hydrocarbon, Heavy metals, conductivity	Biannually	SHAFA HSE
Solid Waste	Indiscriminate disposal of construction wastes, equipment packaging materials, plastics, sanitary and office wastes.	Monthly	SHAFA HSE
Vegetation	Loss of plants and crops	Only required portion will be cleared per time.	SHAFA EPC and HSE
Wildlife	Loss of wildlife	Only required portion will be cleared per time. Clearing will be gradual to	SHAFA EPC and HSE

Environmental Attribute	Monitored Parameter	Measuring Frequency	Responsible Party
		Ensure movement of animal resources to the nearby bush.	
Community Consultation	Discussion of issues that borders on the health of project and community.	Regularly and all through project life cycle	SHAFA Community relations department.
Land	Loss of land	Ensure proper settlement of compensation before construction	SHAFA Energy
Traffic	Free movement of traffic	Daily	SHAFA EPC

Table 7.3: Environmental and Social Parameters and Frequency of Monitoring during Operation

Environmental Attribute	Monitored Parameter	Measuring Frequency	Responsible Party
Air Quality	Particulate, CO, NO_X, SO_X, VOC, NH_3 and H_2S	Weekly	SHAFA HSE
Noise	Noise Level (dBA)	Weekly	SHAFA HSE
Soil Quality	pH, TOC, Heavy metals, THC	Quarterly	SHAFA HSE
Effluent (hydrotest fluid, cooling/diminera lized water)	Residual Chlorine, temperature, pH, TSS, DO, BOD_5, Heavy Metals, hydrocarbon, conductivity, turbidity, and Coliform,	Before discharge	SHAFA HSE
Receiving water body (warri River)	Temperature, residual Chlorine, pH, TSS, DO, BOD_5, Heavy Metals, hydrocarbon, conductivity, turbidity, and Coliform,	Every week within the first month	SHAFA HSE
Ground water	Hydrocarbon, Heavy metals, conductivity	Biannually	SHAFA HSE
Solid Waste	Indiscriminate disposal of construction wastes, equipment packaging materials, plastics, sanitary and office wastes.	Monthly	SHAFA HSE
Vegetation	Loss of plants and crops	Ensure no further loss of vegetation and supervise revegetation.	SHAFA EPC and HSE
Soil Erosion	Soil degradation	Monthly	SHAFA EPC and HSE
Exhaust heat Emission and Vibration	Heat emission (with a continuous discharge of heat in excess of 500^oC, all efforts will be made to ensure it's kept to the barest minimum).	Daily	SHAFA HSE
Electromagnetic Interference	Electromagnetic radiation	Daily	SHAFA EPC HSE
Community Consultation	Discussion of issues that borders on the health of project and community.	Regularly and all through project life cycle	SHAFA Community relations department.
Community	Influx of workers and people will	Build	SHAFA Energy

Environmental Attribute	Monitored Parameter	Measuring Frequency	Responsible Party
Infrastructures	put pressure on the very limited and nonfunctional infrastructures	accommodation and provide infrastructure	
Roads	Pot holes and drainage	Quarterly	SHAFA Community relations
Community conflict	Equity in employment opportunity among the host communities	Liaise with community leaders for employment opportunities	SHAFA Energy
CSR	Provision and maintenance	Regular functionality	SHAFA Energy

Air Quality and Noise Level

Air quality study carried out revealed that TSP and noise levels within the study area were low relative to the Federal Ministry of Environment ambient air quality standards. However, with the indicative emission from the proposed project presented in Table 7.4, it is expedient to monitor the mentioned parameters in order to detect negative deviations from the conditions documented in this report as well as ensure that the emissions from the turbines have not significantly impacted the environment especially the communities around the proposed project. The monitoring of the air quality and noise level shall be carried out around the plant facility during operation and project area during construction.

Table 7.4: Air Quality & Noise Level Carried out

Parameter	Unit	OCGT (~300MWe)
Flue gas temperature	oC	550
Total flue gas volume	m^3/sec	2282
Flue gas analysis		
CO_2	Kg/sec	53.7
Total flue gas volume	Nm^3/sec	831.4
NOx emission	mg/Nm^3	50
NOx emission	g/sec	41.5
CO emission	mg/Nm^3	100
CO emission (Nm^3 are at 15% oxygen dry 273K, 1atm	g/sec	83.1
Stack height	m	30

Soil Quality

The analysis of soil of the study area carried out during this EIA indicated that the effects of this project on soil, as an environmental attribute, are limited. However, some impacts may result in places where excavation will be carried out. As stated in chapter 5 of this report, a number of impacts may result from excavation and backfilling especially as it relates to possible introduction of foreign materials and alteration of native soil composition. In addition, during engine maintenance, indiscriminate dumping of spent lube oils on the environment, may negatively affect soil fauna as well as chemical constituents of the soil. It is therefore expedient for the proponent to ensure that soil quality monitoring is carried out, so as to detect early, any negative project impact on soils of the area. The sampling locations for soil monitoring activities shall be around the power plant facility.

Effluent

Effluent materials such as hydrotest fluid and cooling/dimeralised water shall be monitored or treated to FMEnv acceptable standard before discharge into the receiving water body. Because the temperature of these discharges may have increased as well as contained various contaminants, it is imperative that at each time they are generated, they will be subjected to treatment to acceptable and tolerable level prior to release into the environment.

Receiving Water body

For the purpose of this project, the receiving surface water bodies are the River Niger and Ofunene stream, which is about 25m from the proposed project site. Like the effluents, the receiving water bodies shall be monitored after each discharge to ascertain that the environment has not been contaminated by the discharged effluents.

Ground Water Quality

Project impacts on ground water may not occur over long periods. Although the activities of the proposed project have little potential of contaminating groundwater, the chances are not totally eliminated considering use of liquid substances like lube oil, transformer oil etc. Monitoring of groundwater quality around the project area as prescribed in Table 7.2 is very necessary considering the public health implications associated with contamination of ground water with toxic substances. During monitoring, the physico-chemical properties of water shall be checked, especially heavy metals to ensure compliance to FMEnv standards.

Wastes Management

Periodic on-site assessment of the waste management practices within the site, during pre- construction, construction and operation of the power plant shall be conducted to ensure that best waste management practices are upheld. Existing management practices shall be assessed during monitoring. Waste management records shall be assessed by the monitoring team to ensure compliance. The schedule for waste management monitoring is presented in table 7.2.

CHAPTER EIGHT

REMEDIATION PLANS AFTER DECOMMISSIONING

8.1 INTRODUCTION

This chapter presents the plans that have been put in place by SHAFA to recover and/or restore the project site to its original state after the project's life cycle.

Remediation plans after decommissioning requires a sound understanding of all the environmental components of the project on the ecosystem during its lifespan. It is therefore a best-practice requirement to take this component into cognizance even at the conceptualization of the project.

After decommissioning, there are various restoration options as it relates to the environment where the project once existed. These options include:

- Remediation to pre-project state or condition.
- Partial remediation.
- Remediation to acceptable alternative condition.
- No remediation.

For the proposed project, SHAFA proposes to adopt a combination of partial remediation and remediation to acceptable state.

8.2 DECOMMISSIONING ACTIVITIES

The major activities that will be carried out during the decommissioning phase include:

1. Dismantling and removal of turbines and other ancillary equipment.
2. Excavation, dismantling and removal of all underground cables, water pipes and other power transmission facilities.
3. Removal of all structures including plant house, administrative office buildings etc.

The recommended remediation measures are expected to mitigate the possible resultant negative impacts of this decommissioning phase on the environment. The likely impacts include:

- Physical disturbance arising from equipment removal techniques.
- Soil erosion resulting from improper reinstatement of excavated portions and buried structures.
- Increased particulate emission (dust) especially if this activity is carried out in the dry season.
- Hazards and accidents associated with decommissioning activities.
- Waste management challenges.
- Loss of jobs and income

8.3 SITE REMEDIATION

The remediation measures depend on the environmental/social characterization of the project area as well as the predicted potential and associated impacts. However the following measures shall be planned for implementation after de-commissioning/closure.

- ➢ All equipment and debris shall be removed from the environment and disposed off in an environmentally friendly manner. The mode of disposal of these shall include the following:
- ° Turbines shall be decoupled and sold off as spared parts to auto-mechanical artisans, scrap buyers or steel industries.
- ° Gas pipes shall be sold to steel making industries or for other commercial uses.
- ° Excess laterite from excavated portions shall be used to fill other failed portions around the project area or sold off as inputs in the building industry.

Plant debris shall be cut into pieces and carted away by KSMENV waste management consultant or used as organic manure.

- ° Administrative buildings shall be leased out or used for other purposes.
- ➢ Reinstatement of all excavated routes to their original status to minimize negative impacts.
- ➢ Grading of site to its original topography to prevent erosion.
- ➢ Good waste management plan shall be put in place.
- ➢ Appropriate pension schemes shall be put in place for project workers for their up keep after the project is closed or decommissioned.

CHAPTER NINE

CONCLUSION AND RECOMMENDATIONS

9.1 CONCLUSION

Given the detailed description of baseline environmental characteristics of the proposed project area and the impact assessment, mitigations and EMP that has been presented in earlier sections of this EIA report, it is therefore concluded that:

- The technology, equipment and facilities that is proposed to be employed in the open cycle gas LPG project is one of the cheapest best available and environmentally friendly technology, which has been used by a number of developers in Nigeria;
- The comprehensive effluent and waste water treatment plants incorporated into the design of the LPG Plant system will ensure the complete treatment of effluent to regulatory requirements before discharging into the Niger River.
- Apart from the buffer zone that shall be created in between the Gas Plant and the other buildings, the engine rooms shall be adequately sound proofed to reduce noise in the office environment.
- The project will be attended with a number of positive impacts such as employment opportunities, increased power supply and utilization, reduced cost of production, increase in income etc.
- A number of negative impacts have also been identified to be associated with the projects. Such impacts include potential pollution

of ambient air, water and soil, soil erosion, electrocution, increase in noise, pressure on limited infrastructures, potential proliferation of STDs, potential drop out of school for quick income especially during construction etc. However, the mitigation measures recommended for this project if judiciously implemented will reduce some of the significant negative impacts to minor and negligible.

- The project will ensure more efficient utilization of natural gas, much of which is currently flared. Consequently leading to reduction in health and environmental challenges associated with gas flaring.
- The ultimate success of this project and full actualization of improved power supply to stakeholders around the project area and Nigeria in general is partly dependent on the desire to protect the power and gas supply facilities from possible vandals.

9.2 RECOMMENDATIONS

SHAFA has shown strong commitment to implementing this project in an environmentally friendly manner that will reduce associated negative impacts. The already existing good relationship with the host communities and the best available technology the proponent is poised to deploy will no doubt enhance the successful implementation of the proposed power project. Given the aforementioned, it is therefore recommended that:

- All project activities from the planning, construction to operational phases are carried out under the overall monitoring of the relevant environmental regulatory agencies.

- SHAFA ensures its strict adherence to all specifications and standards for design and construction, mitigation measures and recommended EMP in its implementation of this project.
- SHAFA maintains continuous consultations with all relevant stakeholders including the host communities.
- Mitigation measures prescribed in the report should be strictly followed by the proponent and all its contractors, while complying with regulatory guidelines and standards throughout the implementation of the proposed project.
- SHAFA should strictly implement and enforce all safety programs mentioned in this report especially as it relates to workers at all phases of the proposed project.
- Continuous implementation and improvement of the emergency response procedures should be strictly adhered to throughout the life cycle of the proposed project.

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Appendix 1

Table 1

	SPM				
	Mean	Min	Max	F	p
AQ1	44.00±10.09	30	58	3.946	0.002
AQ2	66.70±19.78	47	110		
AQ3	50.90±35.69	12	93		
AQ4	29.10±12.11	12	46		
AQ5	34.40±11.66	15	54		
AQ6	58.80±26.42	33	110		
Control	51.60±18.54	24	79		

Table 1 show that there is significant spatial variation in SPM. Further analysis reveals that locations 1, 4 and 5 are the sites that have significant lower SPM than the control site, while the other sites didn't show any significant difference with the control site.

Table 2:

	PM2.5				
	Mean	Minimum	Maximum	F	p
AQ1	14.50±8.89	6	29	5.187	0.000
AQ2	29.80±15.98	12	73		
AQ3	18.40±4.70	13	24		
AQ4	21.40±2.46	15	24		
AQ5	16.70±3.13	13	21		
AQ6	33.40±17.75	22	67		
Control	16.80±4.42	11	23		

Table 2 shows that there is significant spatial variation in PM2.5. Further analysis reveals that locations 2 and 6 are the sites that have significant higher PM2.5 than the control site, while the other sites didn't show any significant difference with the control site.

	PM10				
	Mean	Minimum	Maximum	F	p
AQ1	16.40±8.57	7	30	5.145	0.000
AQ2	30.90±18.16	12	80		
AQ3	21.70±7.80	13	31		
AQ4	24.40±4.65	15	29		
AQ5	19.60±5.58	14	27		
AQ6	40.00±18.86	24	70		
Control	19.40±6.72	11	27		

Table 3 shows that there is significant spatial variation in PM_{10}. Further analysis reveals that locations 2 and 6 are the sites that have significant higher PM_{10} than the control site, while the other sites didn't show any significant difference with the control site.

	CO				
	Mean	Minimum	Maximum	F	p
AQ1	1.40±0.70	0	2	0.148	0.989
AQ2	1.50±0.71	0	2		
AQ3	1.40±0.84	0	3		
AQ4	1.30±0.67	0	2		
AQ5	1.50±0.53	1	2		
AQ6	1.40±0.70	0	2		
Control	1.30±0.48	1	2		

Table 4 shows that there is no significant spatial variation in CO.

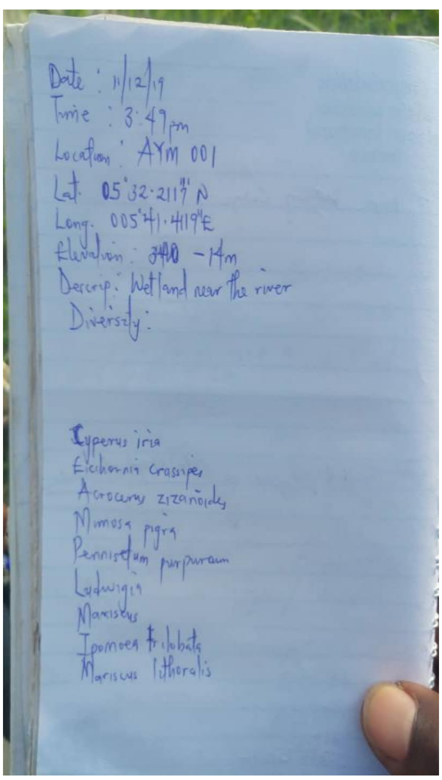
	VOC				
	Mean	Minimum	Maximum	F	p
AQ1	159.70±17.66	120	182	10.712	0.000
AQ2	158.00±21.11	120	180		
AQ3	435.30±278.39	136	770		
AQ4	160.90±14.43	140	180		
AQ5	156.00±18.38	120	180		
AQ6	560.80±257.72	310	875		
Control	338.90±186.69	150	521		

Table 5 shows that there is significant spatial variation in VOC. Further analysis reveals that locations 1,2, 4 and 5 are the sites that have significant lower VOC than the control site, site 6 has significant higher VOC than the control site, while the other sites didn't show any significant difference with the control site.

	Noise				
	Mean	Minimum	Maximum	F	p
AQ1	58.76±2.57	55.5	65.1	32.681	0.000
AQ2	59.73±2.98	54.5	63.7		
AQ3	54.57±3.42	49.3	60.3		
AQ4	54.04±4.62	44.6	61.6		
AQ5	49.23±3.13	45.7	57.0		
AQ6	71.49±6.69	63.3	78.9		
Control	50.18±4.37	44.9	58.9		

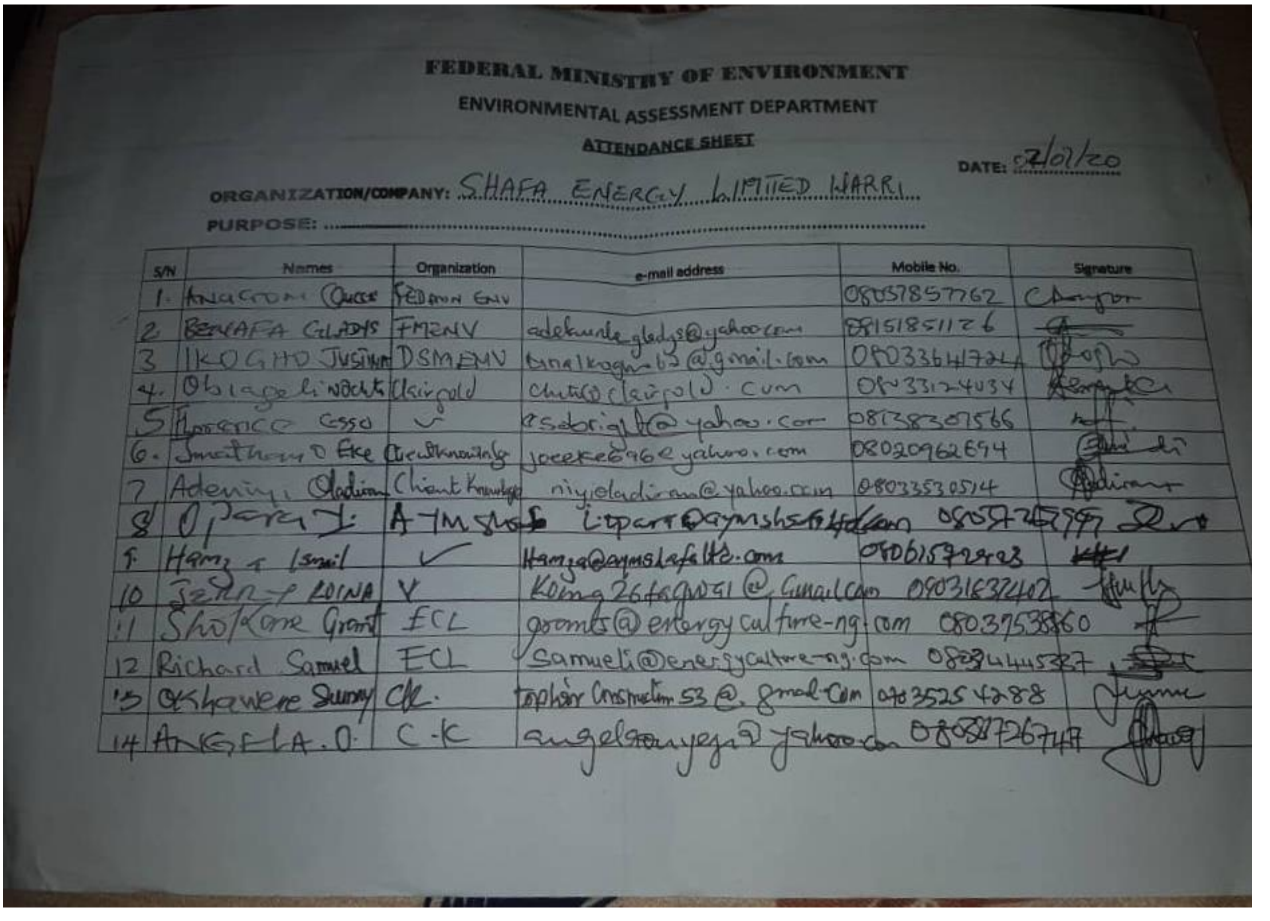
Table 6 shows that there is significant spatial variation in Noise. Further analysis reveals that locations 1, 2, 3 and 4 are the sites that have significant higher Noise than the control site, site 6 has significantly higher Noise than control site, while the other sites didn't show any significant difference with the control site.

FIRST SEASON DATA GATHERING (DECEMBER 1ST -3RD 2019)


Date : 11/12/19
Time : 3:49pm
Location : AYM 001
Lat. 05°32.211" N
Long. 005°41.419"E
Elevation : ~~340~~ -14m
Descrip. : Wetland near the river
Diversity :
Cyperus iria
Eichornia crassipes
Acroceras zizanioides
Mimosa pigra
Pennisetum purpuraum
Ludwigia
Mariscus
Ipomoea trilobata
Mariscus lithoralis

<u>**SECOND SEASON DATA GATHERING (JULY 16TH -19TH 2020)**</u>

Attendance for Second Season



FEDERAL MINISTRY OF ENVIRONMENT

ENVIRONMENTAL ASSESSMENT DEPARTMENT

ATTENDANCE SHEET

DATE: 27/02/20

ORGANIZATION/COMPANY: SHAFA ENERGY LIMITED WARRI

PURPOSE:

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