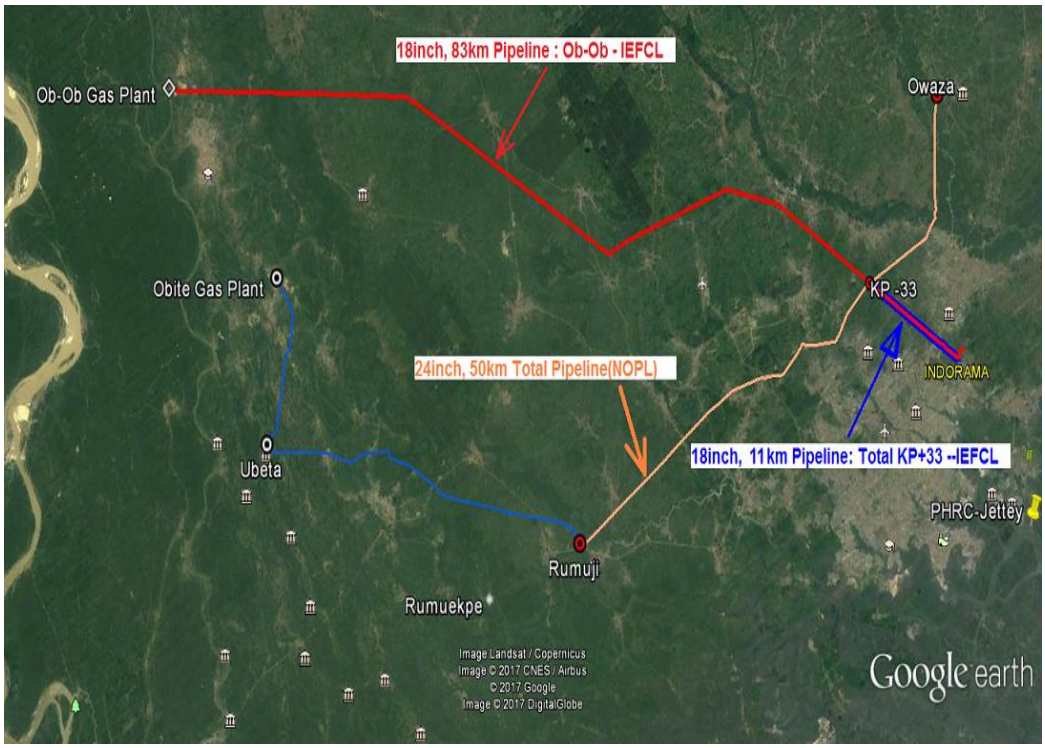
TOTAL E&P NIGERIA LIMITED

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) REPORT FOR THE PROPOSED NOPL-INDORAMA GAS SUPPLY TIE-IN POINT PROJECT



Submitted by:
TOTAL EXPLORATION AND PRODUCTION NIGERIA (TEPNG)

DRAFT REPORT

JULY 2020

This draft EIA report for the **"ENVIRONMENTAL IMPACT ASSESSMENT OF NOPL-INDORAMA GAS SUPPLY TIE-IN PROJECT"** was prepared by Delta Systematics Limited for Total Exploration & Production Nigeria Limited. All confidentialities are maintained.

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List of Abbreviations and Acronyms

%	Percentage
µg/l	Microgram per litre
µg/m^3	Microgram per Cubic Meter
µM	Micro Meter
AIDS	Acquire Immune Deficiency Syndrome
ASME	American Society of Mechanical Engineering
ASTM	American Society for Testing and Materials International
BAT	Best Available Techniques
BCF	Billion Cubic Feet
BOD	Biochemical Oxygen Demand
CDC	Community Development Committee
CEIA	Cumulative Environmental Impact Assessment
CHEW	Community Health Workers
CITES	Convention on International Trade in Endangered Species of Fauna and Flora
CNS	Central Nervous System
CO	Carbon-Monoxide
COD	Chemical Oxygen Demand
COHB	Carboxyl – Haemoglobin
COx,	Carbon Oxides
CxHy	Hydrocarbon
DAF	Dissolved Air flocculation
dB	Decibel
DO	Dissolved Oxygen
DPR	Department of Petroleum Resources
Dr	Doctor
DSL	Delta Systematics Ltd
EA	Environment Assessment
EAR	Environmental Audit report
EBA	Environmental Baseline Assessment
EC	Electrical Conductivity
EER	Environmental Evaluation Report
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EP	Equator Principles
EPC	Engineering, Procurement & Construction
EPFI	Equator Principles Financial Institutions
ERP	Emergency Respond Plan

ETP	Effluent Treatment Plant
EU	European Union
FAO	Food and Agricultural Organization
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FGN	Federal Government of Nigeria
FMEnv	Federal Ministry of Environment
GMP	Gas Master Plan
GMT	Greenwich Mean Time
GT	Gas Turbine
H	Hydrogen
H_2S	Hydrogen Sulphide
HCL	Hydrochloric Acid
HIA	Health Impact Assessment
HIV	Human Immune deficiency Virus
HNO_3	Nitric Acid
HQ	Head Quarters
HRH	His Royal Highness
HSE	health, safety and environment
HUB	Hydrocarbon Utilizing Bacteria
HUF	Hydrocarbon Utilizing Fungi
IEFCL	Indorama Eleme Fertilizer & Chemicals Limited
IEPL	Indorama Eleme Petrochemicals Limited
IFC	International Financing Institutions
IITA	International Institute of Tropical Agriculture
ISO	International Organization for Standard
IUCN	International Union for Conservation of Nature and Natural Resources
JRA	Job Risk Analysis
Kg	Kilogram
Kg/cm^2	Kilogram per centimetre squared
Kg/hr	Kilogram per hour
Kpa	Kilo Per Annum
kWh/t	Kilowatt of electricity per hour per ton
L	Litre
LGA	Local Government Area
LGAs	Local Government Areas
MDG	Millennium Development Goal
mg/l	Milligram per litre
mg/m^3	Milligram per cubic meter
MMSCFPD	Million Standard Cubic Feet per Day
MOU	Memorandum of understanding

MPN	Most Probable Number
MSDS	Material Safety Data Sheet
MTPD	Metric Tons Per Day
MW	Mega Watt
N	Nitrogen
NAFCON	National Fertilizer Company of Nigeria
NAOC	Nigerian Agip Oil Company
NAPIMS	National Petroleum Investment Management Services
NDDC	Niger Delta Development Commission
NE	North East
NEPA	National Electric Power Authority
NESREA	National Environmental Standards and Regulations Enforcement Agency
NG	Natural Gas
NGL	Natural Gas Liquid
NGO	Non-Governmental Organization
NH_3	Ammonia
NIWA	National Inland Waterways Authority
NNPC	Nigerian National Petroleum Company
NOPL	Northern Option Pipeline
NOSDRA	National Oil Spill Detection and Response Agency
NOx	Oxide of Nitrogen
NPC	Nigeria Population Commission
NTFPs	Non timber forest products
O.U.R	Obite, Ubete and Rumuji
O_2	Oxygen
^oC	Degree Celsius
OD	OUTSIDE DIAMETER
PCV	Parked Cell Volume
pH	Potency of Hydrogen
PHCN	Power Holding Company of Nigeria
PNID	Process and Instrumentation Diagram
PPE	personal protective equipment
PPM	Part Per million
PPMV	Part per million by volume
PPP	Public Private Partnership
PVC	Polyvinyl chloride
ROW	Right of Way
RSMEnv	Rivers State Ministry of Environment
RSPM	Respiratory Suspended Particulate Matter
SEIA	Socio Economic Impact Assessment
SOx	Sulphur Oxides

SPDC	Shell Petroleum Development Company
SPM	Suspended Particulate Matter
SPSS	Statistical Package for Social Science
STI	Sexually Transmitted Infection
SW	South West
TDS	Total Dissolve Solids
TEPNG	Total Exploration and Production Nigeria Limited
TF	Total Fungi
THC	Total Hydrocarbon Content
TOR	Terms of Reference
TSPM	Total Suspended Particulate Matter
UNDP	United Nation Development Programme
VOC	Volatile Organic Compound
Vol	Volume
WHO	World Health Organization
WMO	World Meteorological Organization
Wt%	Weight by Percent

EXECUTIVE SUMMARY

ES 1.1 Background

Indorama Eleme Fertilizer & Chemicals Limited (IEFCL) a member of the group company of Indorama Corporation has a fertilizer plant of 2,300 Metric Tons Per day (MTPD) ammonia plant, 4,000 MTPD Urea granulation plant, and associated offsite and utilities. The port terminal at the nearby Onne Port and a gas pipeline of 84 KM for gas supply supports the fertilizer plant. The source of the gas supply is NAOC. However, frequent shortfalls of gas supply from Nigerian Agip Oil Company (NAOC) have greatly impacted the operations of the fertilizer plant.

Indorama requires Total Exploration and Production Nigeria Limited (TEPNG) to supply 170 MMSCFPD gas to its facility from the NOPL pipeline that runs between Rumuji and Imo River Node, hence the need to tie-in a new 18" carbon steel line to its existing 24" Carbon Steel NOPL – OWAZA gas supply line by installing a 24" x 18" carbon steel reducing tee via cold tapping.

In compliance with statutory environmental laws and regulations relating to the operation of Gas facilities TEPNG engaged the services of Delta Systematics Limited to carry out an Environmental Impact Assessment (EIA) to determine the environmental health and status in the proposed NOPL pipeline tie-in point at KP-33.5 which is currently active and transports hydrocarbon. TEPNG is committed to this study because of its corporate policy of business sustainability that seek to prevent adverse environmental, and socioeconomic impacts in the project areas of operation

To actualize the assessment, a field sampling exercise was conducted in the dry season from the 20th to the 22nd of March 2020. The location of the sampling stations was at the proposed Indorama Tie-in. The survey collected samples to measure the physical, chemical, biological and socioeconomic components described in accordance with Part VIII-A of Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN, 2018) of DPR, and in fulfillment of the various guidelines of the Federal Ministry of Environment.

ES 1.2 Objectives of the EIA

The objective of this study is to determine site specific environmental baseline data that will be used in addition to literature data to assess the potential impacts of NOPL – Indorama pipeline tie-in on the environment and provide mitigation measures. Therefore, this study was carried out to:

1. Determine environmental baseline conditions (i.e., physical, chemical, biological and Socio-economic and health status) at and near the pipeline tie-in point at KP-33.5;

2. Provide a reference point to evaluate future assessment of impacts; and to identify parameters within the ecosystem that may be sensitive to significant change.
3. Identify and document any anticipated impacts that may result from the pipeline tie-in, and in cases of detrimental effects, provide appropriate mitigation measures and remedial actions for identified impacts.
4. Recommend an effective environmental management plan for the entire life span of the operational and decommissioning phase of the project.
5. Prepare an environmental Impact Assessment (EIA) report that would serve as background/scientific basis for monitoring environmental changes in the environment within the NOPL –Indorama pipeline tie-in point.

ES 1.3 The Study Area

The Northern Option Pipeline (NOPL) is a gas pipeline that transports gas from TEPNG operations to the Alaoji Power Plant. The pipeline has many nodes which are above ground installations. The process flow starts from O.U.R (Obite, Ubeta and Rumuji) pipeline Inlet to the Rumuji Node which consists of a pig Launcher and flare drum, down to the Obigbo node. The proposed tie-in point is located on the 24" NOPL line at KP33.5 (Plate 1.2), after NAOC pipeline crossing and before Obigbo node.

ES 1.4 Benefits of the EIA

The benefits of the EIA include:

- Obtaining authorization; this is required by regulatory authorities before the commencement of any major development.
- Providing a forward planning tool; when environmental implications are taken into account with other design considerations at the conceptual design stage. It allows for important decisions to be built into the project while avoiding undue damage to the environment.
- Providing a design tool that will allow a systematic evaluation of potential environmental problems from the proposed NOPL –Indorama pipeline tie-in and identification of key issues that require special consideration for effective environmental management and controls.
- Involving all stakeholders through consultation so as to address common problems, impacts and mitigating measures that might be proposed.
- Informing management with a view to achieving long-term management objectives and plans associated with specific activities, in order to minimize associated financial and environmental risks.

ES 1.5 Scope of the Study

This report represents the EIA for the proposed NOPL –Indorama pipeline tie-in Project, developed in accordance with Part VIII-A of Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN, 2018) of DPR, and relevant Federal Ministry of Environment guidelines.

The use of EIA as a management tool in this project would ensure that TEPNG complies with local, national, regional, and international environmental laws, standard design codes, promote consultation, and reduce future liabilities, so helping to protect the environment. This EIA has been undertaken to:

- Provide a comprehensive environmental baseline data of the proposed NOPL – Indorama pipeline tie-in at KP33.5;
- Identify and assess the environmental sensitivities of the tie-in to project activities;
- Evaluate the associated and potential impacts of the tie-in activities on the environment,
- Develop Environmental Management Plan that shall translate potential impact prevention and mitigation measures into control measures.

The scope of work for the NOPL –Indorama pipeline tie-in EIA includes the following:

1. A desktop review of available literature which include past environmental studies of NOPL and its environs.
2. Dry season field data gathering executed to obtain soil samples (0- 15cm, 15-30cm depths) and Air quality sampling. Socioeconomic and Health data were also collected and analysed.
3. Performance of a review and evaluation of data acquired from literature and field samples, to ascertain lines of evidence that determine potential environmental impacts.
4. Development of recommendation for mitigation, monitoring and remedial measures for observed impacts.
5. Writing and issuance of an Environmental Impact Assessment Report for regulatory review and approval.

ES 1.6 Policy, Legal and Administrative Framework

The impact assessment was undertaken in compliance with the provisions of the relevant regulatory framework stipulated by DPR's Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN) and the Federal Ministry of Environment (FMEnv.). The local and international regulations and standards consulted include Oil Pipelines Act (1965), FEPA Act No. 58 (1988), EIA Act No. 86 (1992), EGASPIN(1999, Revised Edition 2002 and 2018), Rivers State Environmental

Protection Agency Edict No. 2 (1994), Abia State Basic Environmental Law(2004), World Bank Guidelines on Environmental Assessment (1991), UNFCC (1994), IUCN (1996), Endangered Species (Control of International Trade and Traffic) Act No. 11 (1985), etc. The company shall also abide by all TEPNG HSE policies and commitments that guide its operations. These policies and commitments are of international standards and conform to the TOTAL Group Policies worldwide.

Areas adequately covered by the policies include:

- Community Affairs, Safety, Health, Environment and Security
- Sustainable Development
- Community Development
- Waste Management
- Hydrocarbon spills contingency (prevention, and timely response)
- Land Acquisition and Compensation
- Abandonment
- Environmental Management Plan
- Environmental Impact Assessment

Elements of these policies and operational philosophies have taken into consideration relevant Nigerian regulations, international laws, guidelines, conventions and treaties. TEPNG shall in the course of executing this proposed project, ensure that all relevant standards and conditions are complied with, and where double standards exist, TEPNG would as much as possible, comply with the more stringent one.

ES 2.1 Need for the Project

With Indorama Eleme Fertilizer & Chemicals Limited (IEFCL) requiring TEPNG to supply 170 MMSCFPD gas to its facility from the NOPL pipeline there is need to tie-in to 24" NOPL line at KP33.5. This is being undertaken in order to:

- Mitigate the impact of the present shortfalls of gas supply from NAOC to Indorama facilities.
- Utilize Natural gas to produce ammonia and granulated urea in a World Class Fertilizer Plant in an existing Indorama Eleme Petrochemicals Limited (IEPL) manufacturing complex in Eleme.
- Boost agricultural production and food security in Nigeria
- Offer job opportunities in various categories to a number of Nigerian professionals' skilled and semi-skilled craftsmen.

ES 2.2 Value of the Project

The proposed project shall provide a reliable and unhindered source of gas for the fertilizer plant built in the IEPL facility in Eleme. Consequently, the cost of production

of fertilizer will be lowered due to the use of reliable supply and cleaner source of raw material which in turn will lower the cost of fertilizer production in Nigeria
The utilisation of gas for the fertilizer factory will contribute to putting to an end the unnecessary gas flares from oil wells as envisaged by the Federal Government of Nigeria.

ES 2.3 Envisaged Sustainability

The project is economically, technically and environmentally sustainable because there is a pool of indigenous expertise in oil and gas technology. Innovative technologies that are economically viable and having minimal environmental, social and health impacts shall be utilised in the execution of the proposed gas pipeline Tie-in project. On completion of the gas pipeline tie-in, gas will be made wholesomely available in sufficient quantity for the production of fertilizer. Fertilizer in turn will enhance the country's security in food arising from good agriculture.

ES 2.4 EIA Activities

In the course of executing the EIA, a preliminary assessment involving literature review, desk studies, field reconnaissance survey, as well as consultations were carried out. The above activities were followed by a multidisciplinary field sampling to obtain additional baseline information and laboratory analyses were conducted. These together formed the basis for the EIA report.

ES 2.5 Project Alternatives

The project options took cognizance of environmental, safety, and operational considerations. The Project options considered are:

- No Project Option; this option is not considered viable and was therefore rejected.
- Delayed Project Option; the delayed option is not supported
- Timely Project Option; this is recommended as the preferred option.

ES 3.0 Project Description

Construction of interconnection piping with NOPL and Indorama shall follow DPR/TEPNG regulations. NOPL pipeline is currently active and transports hydrocarbon while Indorama 11KM pipeline is currently inactive and under nitrogen preservation.
The tie-in of both pipelines will be as follows:

a. An 18 inch branch will be tapped-off from the NOPL pipeline (by cold tap) and made available to the contractor, to connect pre-fabricated and tested piping,

including isolation joint to two manual isolation valve, within 30 m x 30 m fenced area.

b. Upon connection of 18 inch NOPL branch line to manual isolation valve, check valve and line break valve to be installed up to TP-2, TP-3,TP-4 & TP-5 as defined in PNID; including testing and commissioning.

Tie-in of new Indorama 18" pipeline to existing 24" NOPL pipeline via 24"X 18" Barred Tee at KP33.5 involves the below activities:

- Operational pigging with foam pigs to remove dropped out liquid in the NOPL from Rumuji to Owaza.
- Nitrogen purging of TEPNG's 50km 24" Carbon Steel gas supply line
- Installation of fully rated spades at TEPNG's OBIGBO/OWAZA and RUMUJI Nodes
- Excavation Works.
- Coating of 24" x 18" Carbon Steel barred tee.
- Ultrasonic Inspection of a segment of TEPNG's 24" carbon steel gas supply line to be used for tie in.
- Cold cutting of a segment of TEPNG 24" carbon steel gas supply line to install a 24" x 18" barred tee.
- Fit up and welding of 24" x 18" carbon steel barred tee.
- Tie in of 24" x 18" carbon steel barred tee to the adjoining valve station facility at KP33.5 facility by welding one additional pipe length to the barred Tee.
- Field coating of welded joints.
- Non-Destructive Testing of welded joints.
- Removal of previously installed spades at TEPNG's RUMUJI Node and Obigbo Node.
- Backfilling and compacting.
- Physical inspection/ validation of the Tie-in Points

ES 4.0 Description of the Existing Environment

The current environmental status of the NOPL –Indorama pipeline tie-in point study presented in this Environmental Impact Assessment Report was obtained from the one season EIA field data gathering exercise conducted between 20th and 22nd of March 2020 in line with the stated objectives of the project and the prescribed scope of work, laboratory analysis of field samples and data analyses. A multi-disciplinary approach was adopted for the ecological characterization and data acquisition. Environmental components which include climate/meteorology, air quality and noise, soil quality, vegetation, animal ecology, socio-economics, health status assessment and waste management were assessed and documented. Data generated were subjected to

statistical analysis to test for spatial variation and significance difference between data within project area and control stations. The data were also compared with previously generated data from past studies in the study area, and local and international standards where applicable.

ES 4.1 Meteorology, Noise and Air Quality

The project area is located within the equatorial belt that experiences rainfall for most of the year. The climate typifies that of the humid tropics. Literature data from NIMET shows relatively high atmospheric temperature measurements all year round with a mean of 36.41°C. During the EIA fieldwork which was carried out in the dry season, a humid atmosphere was observed with a moisture content which varied from 53.54 - 58.61 %. Relatively low wind speeds were observed and measured, with maximums of 1.0 m/s. As anticipated the predominant wind direction was observed to be Northeasterly in the dry season.

The gaseous pollutants studied during this EIA, were Carbon monoxide (CO), Volatile Organic Compounds (VOCs), methane (CH4), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2) and Carbon dioxide (CO_2). Quite remarkably, except VOC that was in very low concentrations (0.001 – 0.003) all others were not found in measurable quantity at any of the sampling stations. Though particulate matter was detected and measured at all the sampling stations, their distribution was homogenous and low with a range of 4.9-7.1 µg/m^3 for $PM_{2.5}$ and a range of 15.6-16.3 µg/m^3 for PM_{10} at the sampling stations. Noise levels measured in the study area were also within the 85 dB(A) and 90 dB(A) DPR and FMEnv regulatory limits respectively. From the above empirical data, the atmosphere of the proposed project area can rightly be adjudged excellent, especially when the few measured pollutants had similar concentrations as the control values.

ES 4.2 Soil studies

Soil samples taken at two depths (0 - 15 cm and 15 – 30 cm) from eight different locations within the project area were analysed for soil physico-chemical, heavy metals and microbiological characteristics. The colour of the soil samples at both depths ranged from light brown to dark brown. The soil moisture content ranged from 14.50 – 16.10% in top soil and 15.30 – 16.90% with the difference between mean values not significant ($p>0.05$). Soil textural classification recorded mean sand, silt and clay contents of 78.50±3.52%, 16.59±2.62% and 4.99±1.88% respectively in top soil and 78.65±4.63%, 16.03±4.37% and 5.33±1.26% respectively in subsoil. These results indicated that the soils of the project area are predominantly sandy loam and of high porosity and drainage. The soil pH values fell within the acidic value of 4.61 - 5.60 for topsoil and 4.64 - 5.21 for subsoil, similar to what were earlier reported in past studies around the

study area. Proportion of organic matter, levels of nitrogen, available phosphorus, and exchangeable cations indicate a fairly adequate nutrient base for soils of the study area. The heavy metal burden as expressed by the levels of Al, As, Ba, Cd, Cr, Cu, Fe, Hg, Ni, Pb, V, and Zn were generally low within allowable limit in soils and falling below their respective DPR Target Values. The low petroleum hydrocarbons concentrations recorded in the soil samples indicate that the soils are free of hydrocarbon contamination as it were. Soil microbiology showed low counts of hydrocarbon utilising bacteria and fungi, thus corroborating non contamination of the study area with hydrocarbons.

ES 4.3 Vegetation Study

The vegetation around the proposed facility consists of secondary forest type of vegetation, therefore, clearing trees and shrubs for cultivation is a regular practice. flora species such as *Elaeis guineensis, Alstonia boonie, Chromolaena odorata, Mimosa pudica, Pennisetum sp., Mangifera indica, Pentaclethra macrophylla, Alchornea laxiflor* and *Cyperus iria.* oil palm tree (*Elaeis guineensis*) and Common guava tree (*Psidium guajava*) are of great economic importance as the former is a source of edible oil. Among the economic plants were those used as wood for construction, medicine, food, cash crops, fruits, vegetables etc.

Among the metals determined in the vegetable sample, only iron (Fe), copper (Cu), zinc (Zn) and aluminium (Al) showed measurable concentrations 0f 2.52 mg/kg, 2.04 mg/kg, 2.00 mg/kg and 1.61 mg/kg respectively. Other metals including cadmium (Cd), chromium (Cr), lead (Pb), barium (Ba), nickel (Ni), vanadium (V), mercury (Hg) and cobalt (Co) showed concentrations below instrument detection limits in the plant. The observed results showed that the vegetation in the study area have not been impacted by heavy metals due to anthropogenic activities

ES 4.4 Wildlife Study

Fauna compositions found at the proposed area were small to medium sized mammals. Nine (9) species of vertebrates were recorded from the site, namely Cane rats, Pouch rats, Pied crows and the Guinea fowl.

ES 4.5 Socio-Economics

The closest community to the proposed NOPL-Indorama tie-in is Obigbo. Obigbo is a kingdom and the current traditional head HRH Eze Mike Nwaji, is a government recognized 1st class Chief. The community shares boundary with other LGAs in Rivers State like Etche, Port Harcourt, and Eleme, and Ukwa East LGA in Abia State. The language of Obigbo also borrows from these neighbours and shares strong similarities with Igbo.

The population of the Obigbo community is estimated as 200,598 persons. This figure was derived from 2010 NPC figure projected to 2019 at three point five percent (3.5%), the national growth rate. The documented population structure in Obigbo comprises of fifty percent (50%) male population and fifty percent (50%) female among the households.

The occupation of people in Obigbo includes self-employment, civil service, company workers and unemployed. The occupation of the self-employed are small scale business and contractors to companies, farming, fishing, trading and many others which include, hunting, non-timber forest product gatherers, artisans and transport workers. Majority of the businessmen are suppliers to the large companies in the area. According to the respondents, most of these occupations are however under threat or declining.

Industrialization is low at the community level except for the oil and gas industries and the electricity distribution company present in Obigbo. The small-scale industry within the community are visible in welding and fabrication, sand mining in all the rivers in the area, traditional food processing like fish smoking and cassava flour production. Obigbo is sandwiched between the developed areas of Port Harcourt and Aba. This provides a stimulating influence on commercial activities due to the large industries in these two cities coupled with the large population. This nearness to the city has produced a positive domino effect at Obigbo. In the formal sectors are many commercial bank branches, retail outlets, small hotels, and asphalt plants. In the informal sector, are many small trading activities, automobile mechanics, local transport business, eateries and building construction. The informal commercial sector is the most numerous business activities in the area.

Amenities are poor in the community. The sole source of domestic water supply in Obigbo is shallow hand-dung boreholes, shallow unhygienic streams and rainwater. The community is traversed by a major highway namely the Port-Harcourt-Aba Expressway which is in a dilapidated state. Most intra communal roads are however earthen. The major mode of transportation within the community is through the use of bicycles, motorcycles and private taxi cars. The respondents ~~were~~ all agreed that Primary schools were present in Obigbo, however the available secondary schools may not be functional, hence it was regarded as absent by some of the respondents. There is the presence of electricity supply but the respondents indicated that Electricity is epileptic.

ES 4.6 Health Assessment

The most prevalent health challenges in the community are malaria, stroke and hypertension. Others such as arthritis, Hernias, asthma, typhoid and diarrhoea are equally important as the commonest causes of ill health in the community. Some of the

diseases such as typhoid and diarrhoea can be linked to lack of safe drinking water in the area. Their health seeking behaviour is to patronize chemists and local practitioners. There is one general hospital, five health centers and three cottage hospitals in Obigbo. They are reluctant to visit the health centres and hospitals due to poverty; other unconfirmed reason for their health seeking behaviour is that they do not go to the government hospital because it is not functioning.

Most households have poor waste systems such as pit and latrines, only a few households have water closet toilets. This practice poses the risk of food and water contamination by flies, cockroaches and rodents from the latrine area. The waste stream in the community comprises basically domestic and household wastes and items related to agricultural produce processing such as cassava, and oil palm processing.

The people are conscious of the presence of mosquitoes, which constitute a major health risk in their neighborhoods. The insects reported to occur around the homes are housefly, cockroaches and termites. Rodents, such as rats and reptiles such as lizards are found around the homes. The keeping of domestic animals is a common practice. Animals such as goats, sheep and chicken are readily found in free-range in the area. The people have limited knowledge of zoonosis and so do not see domestic animals as any form of danger. The people are aware of preventive measures against mosquitoes; some households have their windows screened with mosquito net.

The major concerns of the community were lack of functional health facility, educational facility, lack of jobs, lack of road infrastructure and poverty. The health facility is abandoned and non-functional, while the unemployment level in the community is high. On the other hand, their minor concerns were lack of development, lack of government attention, environmental pollution, and bad drinking water. Priorities of the community were tailored towards needs such as Employment, Skill Acquisition Training with Starter Packs, Empowerment/Micro Credit Facility, Potable Water and Electricity.

The socioeconomic and health profile of the communities in the area indicated that natural resources are part of the larger mix of economic activities supported by average social and infrastructural facilities which taken together provides a low quality of life. The evident facts emerging from formal FGD shows a decline in many socioeconomic sectors. These declining trends are a mixture of many socio-political factors that cannot be attributed to the operations of the TEPNG in the areas surveyed. However, TEPNG should review the requests by the community in order to provide a platform for effective communication, conflict resolution and readiness to negotiate to guarantee mutual peaceful coexistence.

ES 5.0 Associated and Potential Impact

A methodical and rigorous impact assessment based on that developed by the World Bank and ISO 14001 Standards was conducted to establish severity levels of specific project activities on each of the potentially affected environmental media and socioeconomic aspects. Having critically assessed the proposed project, following are some of the envisaged positive impacts.

They include:

- mitigating the impact of the present shortfalls of gas supply from NAOC to Indorama facilities.
- Generation of employment opportunities for both casual and skilled workers;
- Utilize Natural gas to produce ammonia and granulated urea in a World Class Fertilizer Plant in an existing Indorama Eleme Petrochemicals Limited (IEPL) manufacturing complex in Eleme.
- Boost agricultural production and food security in Nigeria.

However, direct negative impacts associated with the project include potential impacts to the environment, socioeconomic conditions, and health and safety of workers and members of the general public. The project is expected to result into the following negative impacts which include among others:

a. Release of various gaseous and particulate emissions into the atmosphere leading to negative alterations in ambient air quality;
b. Increased ambient noise levels arising from operation activities leading to loss of habitat for fauna and potential impacts on human hearing;
c. The back filling may affect the drainage pattern of the area and induce erosion if soil is not properly re-instated.
d. Equipment failure and damage leading to injuries/fatality
e. Transportation of Personnel, Equipment, and Materials may increase the rate of exposure to accidents.
f. Generation of domestic and sanitary wastes within and around project site could impact environment;
g. The increase in population has the potential to increase the cost of living, encourage indulgence in social vices and put pressure on the existing infrastructures which are already stressed. This may indirectly result in increase in social vices in the area as well as increase potential for health hazard through communicable diseases and STIs, HIV/AIDS and COVID 19.
h. Third party agitation due to loss of jobs during demobilization;

These impacts, however, would be localized and are not expected to significantly degrade any unique or especially sensitive natural resources. When potential impacts

were initially judged to be high or moderate even with the implementation of planned mitigation measures, additional measures were recommended to reduce the anticipated impacts to lower levels.

ES 6.0 Mitigation Measures

Mitigation measures were provided for those impacts rated as moderate or major, while the identified negligible/minor impacts would be addressed by existing standard practices in TEPNG. The measures proffered were to reduce the severity of identified negative impacts and enhance the beneficial effects.

In a bid to mitigate the identified impacts, the following strategies were suggested. They include:

1) Limiting the area to be cleared to the barest minimum required for the project, this shall reduce the destruction/modification of vegetation during site preparation and construction.
2) The increase in population shall be mitigated by providing accommodation for construction workers in contractor camps.
3) Awareness campaign shall be undertaken to enlighten the field workers on the implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain the cultural values of the host communities. The TEPNG alcohol and drug policies shall be enforced to encourage a healthy lifestyle.
4) Safety signages are deployed at strategic locations;
5) Emergency response plan are in place and use of PPEs where necessary;
6) Develop security management plan for the project before mobilization;
7) All machinery and generators to be used for project activities shall be optimally maintained and comply with applicable emission standards;
8) Air quality monitoring shall be conducted during and after the construction activities.
9) The nuisance from noise, emissions and vibrations of heavy machinery used in different phases of the project shall be reduced by use of standard equipment, provision of acoustic mufflers and fume catalyzers, where necessary.
10) An integrated waste management plan involving reduction, reuse, recycle, treatment and composting as appropriate shall be carried out in line with DPR, FMEnv. and TEPNG Waste Management Guidelines.
11) Conserve and reuse topsoil during excavation works.
12) Control access to work sites, use adequate road signs on the routes leading to the work sites.
13) Establish adequate training for personnel on human health and environmental protection.

14) Perform reinstatement at the end of the work to clean and return the elements of the environment that were affected to their original condition.
15) Ensure availability of appropriate work process to lower the risk of COVID-19 transmission. Provision of Test and isolation centers for effective management of the COVID-19 pandemic among workers.
16) Formulate an emergency action plan in coordination with the interested authorities in the event of an accidental spill during the construction and operation phases.
17) Develop and maintain alignment sheets that reduce impacts by making all relevant operational control information available by operation and geographic location.
18) Ensuring that all employees adhere to the safety program.
19) Providing for the establishment of emergency action plans in the event of fire, accidents causing injury, accidental spills of contaminants, or gas leaks.
20) Require contractors to prepare and implement workers disengagement plans

The result of the assessment was that no potentially high severity impacts (as defined by the methodology) would remain after the planned mitigation measures are applied in accordance with current commitments and plans. All of the residual impacts become either moderate or low severity.

ES 7.0 Environmental Management Plan

The essence of designing an Environmental Plan (ESMP) is to monitor compliance with all the mitigation measures and commitments as discussed in the EIA during project implementation. In addition, the plan checks the effectiveness of suggested mitigation measures, demonstrate that the project activities are carried out in accordance with the prescribed mitigation measures and existing compliance regulatory procedures, and provide early warning signals whenever an impact indicator approaches a critical level. The EMP will consist of Baseline, effects and compliance monitoring.

For the proposed NOPL-Indorama tie-in project, a comprehensive EMP had been developed to achieve the above objectives. The plan describes impacts, lists mitigation measures, catalogues monitoring indicators/parameters, frequency of monitoring and the party responsible for each action under the plan.

The EMP will remain a dynamic working tool and will be owned by the project team. The project manager, as the custodian of the document may exercise auditing roles to verify compliance by the project team. The EMP will be updated and revised periodically, throughout the project's life span to incorporate improved technologies, modifications to environmental regulations, policies, guidelines, best available or affordable technologies and improved or more effective management systems.

ES 8.0 Conclusion

The EIA has shown that the NOPL-Indorama tie-in Project can be executed and operated with minimal negative impact on the surrounding environment by implementing the recommended mitigation measures, environmental management plan and other provisions of this report. The economic gains not only to Indorama Eleme Petrochemicals Limited (IEPL) but also to the communities, Local Government Area, States and the Federal government from the project outweigh the adverse impacts. No doubt, the planned project is desirable and will only have remarkably minimal negative impacts on the health and biophysical environment. More so, none of the observed impacts could be considered as irreversible. Again, affordable and plausible remediation measures are available for all these impacts.

CHAPTER ONE

INTRODUCTION

1.1 Background

Total Exploration and Production Nigeria Limited (TEPNG) is the operator "Northern Option Pipeline" (NOPL) with gas processing and metering facilities at Owaza and Rumuji nodes. The NOPL was commissioned following NAPIMS request for Total Upstream to design, construct and operate the NOPL; which is part of the required infrastructure to feed the Alaoji Power Plant for more efficient electricity generation. The NOPL is a strategic eastern connector of the National Gas Master Plan (GMP) which is opening up stranded gas resources to the eastern domestic gas market and has the highest priority of all the domestic gas pipelines in the country.

Indorama Eleme Fertilizer & Chemicals Limited (IEFCL) a member of the group company of Indorama Corporation has a fertilizer plant of 2,300 Metric Tons Per day (MTPD) ammonia plant, 4,000 MTPD Urea granulation plant, and associated offsite and utilities. The port terminal at the nearby Onne Port and a gas pipeline of 84 KM for gas supply supports the fertilizer plant. The source of the gas supply is Nigerian Agip Oil Company (NAOC). However, frequent shortfalls of gas supply from Nigerian Agip Oil Company (NAOC) have greatly impacted the operations of the fertilizer plant.

Indorama requires TEPNG to supply 170 MMSCFPD gas to its facility from the NOPL pipeline that runs between Rumuji and Imo River Node, hence the need to tie-in a new 18" carbon steel line to its existing 24" Carbon Steel NOPL – OWAZA gas supply line by installing a 24" x 18" carbon steel reducing tee via cold tapping. Indorama has an existing 18'' x 11km gas pipeline from their Eleme Facility to the proposed NOPL pipeline tie-in point at KP-33.5 which is under Nitrogen preservation.

In compliance with statutory environmental laws and regulations relating to the operation of Gas facilities TEPNG engaged the services of Delta Systematics Limited to carry out an Environmental Impact Assessment (EIA) to determine the environmental health and status in the proposed NOPL pipeline tie-in point at KP-33.5 which is currently active and part of the existing TEPNG 24'' gas pipeline named NOPL that supplies treated natural gas from TEPNG facilities located at Rumuji to third party companies. TEPNG is committed to this study because of its corporate policy of business sustainability that seek to prevent adverse environmental, and socioeconomic impacts in the project areas of operation.

To actualize the assessment a field sampling exercise was conducted in the dry season from the 20th to the 22nd of March 2020. The location of the proposed Indorama Tie-in project is at KP 33 of NOPL (N4º55'28.5", E7º3'58.5"). The survey collected samples to

measure the Physical, Chemical, biological and socioeconomic components described in the terms of reference issued by the Federal Ministry of Environment (FMEnv.) and Department of Petroleum Resources (DPR).

This document is a **draft report** for the EIA of the NOPL – Indorama gas supply pipeline tie-in point at KP-33.5 of the NOPL.

1.2 Purpose of the Environmental Impact Assessment

The data generated from the survey would serve as background/scientific basis for monitoring environmental changes in the environment within the NOPL –Indorama gas supply pipeline tie-in point. It would also serve as a basis for predicting and developing mitigation for the impacts of future activities within the area as well as support decision making in future project design, operation and management.

1.3 Benefits of the EIA

The benefits of the EIA include:

- Obtaining authorization; this is required by regulatory authorities before the commencement of any major development.
- Providing a forward planning tool; when environmental implications are taken into account with other design considerations at the conceptual design stage. It allows for important decisions to be built into the project while avoiding undue damage to the environment.
- Providing a design tool that will allow a systematic evaluation of potential environmental problems from the proposed NOPL –Indorama pipeline tie-in and identification of key issues that require special consideration for effective environmental management and controls.
- Involving all stakeholders through consultation so as to address common problems, impacts and mitigating measures that might be proposed.
- Informing management with a view to achieving long-term management objectives and plans associated with specific activities, in order to minimize associated financial and environmental risks.

1.4 Objectives of the EIA

The objectives of this study is to determine site specific environmental baseline data that will be used in addition to literature data to assess the impact of the NOPL – Indorama pipeline tie-in point on the environment. Therefore, Delta Systematics Limited embarked on this study to:

- Determine environmental baseline conditions (i.e., physical, chemical, biological and Socio-economic and health status) at and around the pipeline tie-in point at KP-33.5;
- Provide a reference point to evaluate future assessment of impacts; and to identify parameters within the ecosystem that may be sensitive to significant change.
- Identify and document any anticipated impact that may result from the pipeline tie-in, and in cases of detrimental effects, provide appropriate mitigation measures and remedial actions for identified impacts
- To develop an Environmental management plan for the implementation of the mitigation measures.

1.5 The Study Area

The Northern Option Pipeline (NOPL) is a gas pipeline that transports gas from TEPNG operations to the Alaoji Power Plant (Plate 1.1). The pipeline has many nodes which are above ground installations. The process flow starts from O.U.R (Obite, Ubete and Rumuji) pipeline Inlet to the Rumuji Node which consists of a pig Launcher and flare drum, down to the Obigbo node. The proposed tie-in point is located on the 24" NOPL line at KP33.5 (Plate 1.2), after NAOC pipeline crossing and before Obigbo node. A 30 x 30 metre plot has been acquired at the point of intersection of both pipelines, within the plot area, there shall be interconnecting piping and installation of both manual and line break valves for smooth process flow of the gas.

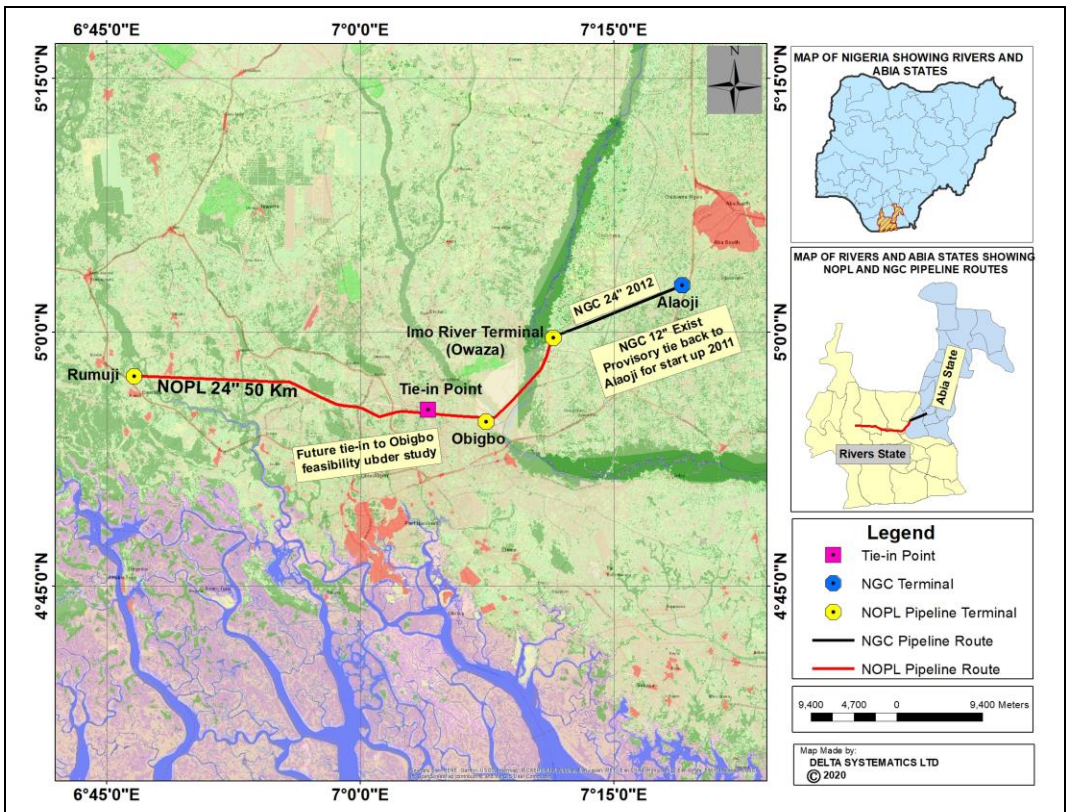


Plate 1.1: Map showing the NOPL Project Location

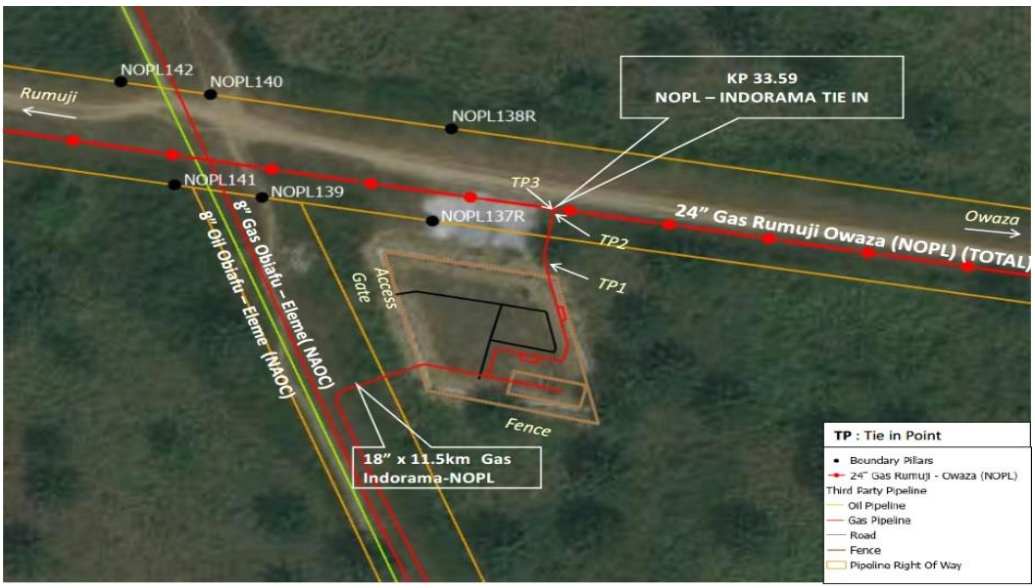


Plate 1.2: Indorama tie-in location at NOPL KP 33.5

1.6 Scope of the Study

This report is the EIA for the proposed NOPL –Indorama pipeline tie-in Project, developed in accordance with Section VIII-A of EGASPIN (2018) of DPR. Indorama Tie-in Project EIA field survey was carried out along with NOPL EES Dry Season field survey, to take advantage of simultaneous field mobilization; NOPL is the feeder line for Indorama Pipeline. The field survey report for the Indorama Tie-in Project EIA was submitted as part of NOPL EES Dry Season field survey report (Letter Reference - PH.D/HSE.2020/064; Date - June 7, 2020).

The scope of work for the NOPL –Indorama pipeline tie-in EIA includes the following:

1. A desktop review of available literature which include past environmental studies of NOPL and its environs.
2. Dry season field data gathering executed to obtain soil samples (0- 15cm, 15-30cm depths) and Air quality sampling. Socioeconomic and Health data were also collected and analysed.
3. Performance of a review and evaluation of data acquired from literature and field samples, to ascertain lines of evidence that determine potential environmental impacts.
4. Development of recommendation for mitigation, monitoring and remedial measures for observed impacts.
5. Writing and issuance of an Environmental Impact Assessment Report for regulatory review and approval.

1.7 Policy, Legal and Administrative Framework

Operations and all forms of development activities in the Nigerian oil industry sector are regulated by several specific laws, guidelines, and standards. These statutes together with applicable International Conventions and with Company health, safety and environment (HSE) Policy provide a basis for the EIA of the NOPL–Indorama pipeline tie-in project.

1.7.1 Relevant International Conventions, Guidelines and Standards

Nigeria is signatory to several laws, treaties and regulations that govern the environment. Among these are:

- International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines 1996
- United Nations Framework Convention on Climate Change (1992).
- Convention on Biological Diversity (Rio Summit) 1992
- World Bank Guidelines on Environmental Assessment, 1991

- Convention Concerning the Protection of the World Cultural and Natural Heritage Sites (or World Heritage Convention), 1990.
- Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their Disposal 1989.
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979.
- Convention on International Trade in Endangered Species of Fauna and Flora (CITES) 1973.
- Guidelines of International Financing Institutions

1.7.1.1 International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines 1996

The IUCN in conjunction with the Oil Industry International Exploration and production Forum presented a set of guidelines for oil and gas exploration and production in mangrove areas. These guidelines are aimed at conservation of mangroves and enhancing the protection of marine ecosystems during E & P activities. The document also discusses the policy and principles for environmental management in mangrove areas as well as EIA procedures, Environmental Audit and Monitoring.

1.7.1.2. United Nations Framework Convention on Climate Change (1992)

In order to achieve sustainable social and economic development, energy consumption for developing countries needs to grow taking into account the possibilities for achieving greater energy efficiency and for controlling greenhouse gas emissions in general. This also includes the application of new technologies on terms which make such an application economically and socially beneficial, determined to protect the climate system for present and future generations.

1.7.1.3. Convention on Biological Diversity (Rio Summit) 1992

The objectives of the Convention include the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising out of the utilization of genetic resources.

1.7.1.4. World Bank Guidelines on Environmental Assessment (1991)

The World Bank requires the execution of an EIA on a proposed industrial activity by a borrower as a pre-requisite for granting any financial assistance in form of loans. Details of World Bank's EIA procedures and guidelines are published in the Bank's EA Source Book Volumes I - III of 1991. Potential issues considered for EA in the upstream oil and gas industry include the following:

- Biological Diversity

- Coastal and Marine Resources Management
- Cultural Properties
- Hazardous and Toxic Materials and
- International waterways.

1.7.1.5. Convention Concerning the Protection of the World Cultural and Natural Heritage Sites (or World Heritage Convention), 1990

The convention sets aside areas of cultural and natural heritage for protection. The latter is defined as areas with outstanding universal value from the aesthetic, scientific and conservation points of view.

1.7.1.6. Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal, 1989

The convention focuses attention on the hazards of the generation and disposal of hazardous wastes. The convention defines the wastes to be regulated and control their trans-boundary movement to protect human and environmental health against their adverse effects.

1.7.1.7. Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention,) 1979

The Bonn Convention concerns the promotion of measures for the conservation and management of migratory species.

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

The fundamental principles of the Convention on International Trade in Endangered species of fauna and flora (CITES) is as follows: The Contracting States,
Recognizing that wild fauna and flora in their many beautiful and varied forms are an irreplaceable part of the natural systems of the earth which must be protected for this and the generations to come; Conscious of the ever-growing value of wild fauna and flora from aesthetic, scientific, cultural, recreational and economic points of view;
Recognizing that peoples and States are and should be the best protectors of their own wild fauna and flora; Recognizing, in addition, that international co-operation is essential for the protection of certain species of wild fauna and flora against over-exploitation through international trade.

1.7.1.9. Guidelines of International Financing Institutions

When a plan or program such as the proposed NOPL –Indorama pipeline tie-in consisting of a set of projects in a particular area is considered for finance by the International Finance Corporation, a Cumulative Environmental Impact Assessment is required. The IFC Procedure for Environmental and Social Review of Projects (IFC, December 1998) states that environmental assessment should include consideration of: "Cumulative impacts of existing projects, the proposed project and anticipated future projects." To identify which other projects need to be considered alongside the project being assessed. The IFC Procedure states that:

"Assessment of cumulative impacts would take into account projects or potential developments that are realistically defined at the time the environmental assessment is undertaken, where such projects and developments could impact on the project area". The Cumulative Environmental Impact Assessment also takes into consideration the provisions of the following IFC and World Bank guidelines relating to the environment:

- IFC Technical Guidelines on Hazardous Material Management, December 2001;
- IFC Technical Guidelines on Occupational Health and Safety, June 2003;
- IFC Policy on Forestry (OP 4.36), November 1998;
- IFC Policy on Natural Habitat (OP 4.04), November 1998;
- IFC Policy on Environmental Assessment (OP 4.01), October 1998;
- World Bank Policy on Forests (OP 4.36), November 1998;
- International Finance Corporation (IFC), Environmental and Social Standards (Equator Principle) Revised Edition, 2006
- IFC Guidelines for Noise
- IFC Guidance Note G: Assessment and Management of Cumulative Impacts, June 2001
- The IFC Procedure and Social Review of Projects (December 1998)

1.7.1.10. IFC Guidance Note G Assessment and Management of Cumulative Impacts, June 2001

The guidance note provides guidance on how to incorporate cumulative effects analysis into the components of an environmental assessment. A comprehensive CEIA comprises the cumulative effects of the projects in a plan or program.

1.7.1.11. IFC Guidelines for Noise

To assess the potential impact of a new noise source on the nearest noise sensitive receptors, the following approach shall be employed:

- Noise criteria specify absolute maximum accepted facility noise levels either at the site boundary or at the nearest noise sensitive receptors. These criteria are

expressed in LAeq. Some of these criteria are also based on a Best Available Techniques (BAT) approach.

- Noise criteria also use a comparison of relative noise levels at the nearest noise sensitive receptors using existing ambient noise levels LA90. Specific noise levels from the plant noise are assessed in terms of LAeq, with the difference between the two parameters giving the likelihood for complaints.

1.7.1.12. Equator Principles (EP)

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

Principle 2: Social and Environmental Assessment

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

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

1.7.2 Federal Regulations/Guidelines

There are legislations, guidelines and standards that govern the assessment of environmental impacts of development projects in the oil and gas industry in Nigeria. These regulations can be classified as follows:

- Environmental Impact Assessment Act CAP E12 LFN 2004.
- Environmental Guidelines and Standards for the Petroleum Industry in Nigeria, (EGASPIN), 2018 by the Department of Petroleum Resources (DPR)
- Department of Petroleum Resources (DPR) Mineral Oils Safety Regulations 1997
- S.I.8 - National Environmental Protection (Effluent Limitation) Regulation 1991
- S.I.9 – National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes Regulation), 1991.
- S.I.15 – National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations of 1991
- The Petroleum Act No. 51 of 1969

- The Petroleum Drilling and Production Regulations – 1969
- The Oil Pipeline Act and Oil and Gas Pipeline Regulation of 1995
- Endangered Species Control Act of 1985
- Land Use Act of 1978
- National Inland Waterways Authority (NIWA) Act 13 of 1997
- Factory Act, 1992
- Revised National Health Policy, 2004
- National Health Act, 2005
- National Guidelines and Standards for Environmental Protection 1991
- Nigerian Ports Authority Act No 38 of 1999
- Urban and Regional Planning Law, Decree 88 of 1992

1.7.2.1 National Policy on Environment (1989, revised 1999)

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

- Securing for all Nigerians a quality of environment adequate for their health and well-being;
- Conserving and using the natural resources for the benefit of present and future generations;
- Restoring, maintaining and enhancing the ecosystem and ecological processes essential for the preservation of biological diversity;
- Raising public awareness and promoting understanding of the essential linkages between the environment, resources and development; and Collaboration with other countries, international organizations and agencies to achieve optimal use of trans-boundary co-operation in order to prevent environmental recourses.

1.7.2.2. Environmental Impact Assessment Act CAP E12 LFN, 2004

This Act provides guidelines for activities of development projects for which EIA is mandatory in Nigeria. The Act also stipulates the minimum content of an EIA as well as a schedule of projects, which require mandatory EIAs.

1.7.2.3. The Mineral Oil (Safety) Regulations, 1963

Sections 37 and 40 of the mineral oil (safety) regulations, 1963, require provision of personal protective equipment (PPE) and the safety measures for workers in drilling and production operation in accordance with international standards.

1.7.2.4. S.I.8 - National Effluent Limitation Regulation, 1991

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

1.7.2.5. S.I.9 - Pollution Abatement in Industries Generating Wastes Regulation

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

1.7.2.6. S.I.15 – National Environmental Protection (Management of Solid and Hazardous Wastes) Regulation, 1991.

This provides that the objective of solid and hazardous waste management shall be to:

- Identify solid, toxic and extremely hazardous wastes dangerous to public health and environment,
- Provide for surveillance and monitoring of dangerous and extremely hazardous wastes and substances until they are detoxified and safely disposed,
- Provide guidelines necessary to establish a system of proper record keeping, sampling and labelling of dangerous and extremely hazardous wastes,
- Establish suitable and provide necessary requirements to facilitate the disposal of hazardous wastes;
- Research into possible re-use and recycling of hazardous wastes.

1.7.2.7. Endangered Species (Control of International Trade and Traffic) Act 11 of 1985

This Act prohibits hunting, capture and trade of some endangered species like crocodile, alligator, turtles, Parrot, etc. The Endangered (Control of International Trade and Traffic) Decree (No. 11 of 1985) has been enacted by the Federal Republic of Nigeria specifically to implement CITES. It is broader than CITES in that it also covers domestic taking of listed species. Two schedules are included: Schedule I (Endangered Species – Animals in relation to which International Trade is absolutely Prohibited), and Schedule 2 (Animals in Relation to which International Trade may only be conducted under License). The decree prohibits taking of Schedule 1 species and requires that taking of Schedule 2 species be in accordance with a license issued under the decree.

1.7.2.8. Oil Pipelines Ordinances (CAP) 145, 1956 and Oil Pipelines Act, 1965

The oil pipelines ordinance (CAP 145), 1956, as amended by the Oil Pipelines Act 1965, provides, under Section 4(2), for a permit to survey (PTS) a pipeline route to be issued to the applicant by the Minister of Petroleum Resources, for the purpose of transporting mineral oil, natural gas, or any product of oil or gas to any point of destination to which such a person requires such oil, gas or product, thereof, for any purpose connected with petroleum trade or operations.

1.7.2.9. The Oil and Gas Pipelines Regulations (1995), as published in the Federal Republic of Nigeria Official Gazette (No. 49 Gas Pipelines Regulations1995)

Federal Republic of Nigeria Official Gazette No. 26 of 2 October 1995, Vol. 82 [Government Notice No. 49], came into effect on 17 June 1995 and enlarges the scope and coverage of the pipeline Act of 1956. These regulations require that pipeline construction be performed in a manner minimizing disturbance to the provisions of API RP 1102 or other recognized equivalent international operating standards.

1.7.2.10. Procedure Guide for the Design and Construction of Oil and Gas Surface Production Facilities (2001)

These guidelines, issued by the DPR and pursuant to Regulations 36 and 39 of the Petroleum (Drilling and Production) Regulations (1969), outline permitting procedures for applications for approval of construction of all oil and gas surface production facilities in the Nigerian petroleum industry. The approval process for any project execution covers four sequential stages:

- Conceptual design
- Detailed design
- Pre-commissioning / oil and gas facility operating permit
- Decommissioning

1.7.2.11. Petroleum (Drilling and Production) Regulations (1969)

The Petroleum (Drilling and Production) Regulations (1969), empowers the holder of an OPL to do practically anything in the area covered by the license {Section 15 (1)}, but Section 15(2) holds such a holder responsible for all the actions of his agents and contractors.

1.7.2.12. Federal Environmental Protection Agency (Now FMEnv) Act No. 58, 1988

This Act, which was issued in 1988 and amended by Act No. 59 of 1992, provides the setting up of the Federal Environmental Protection Agency, as the apex organization for the overall protection of the Environment and Conservation of Natural Resources. The act also makes environmental impact assessment (EIA) mandatory for all new major projects. In compliance with its mandate, FEPA issued the procedure, guidelines and standards for the execution of EIA with emphasis on the significance associated with current and potential impacts of such projects. The procedure also indicates the steps to be followed (in the EIA process) from project conception to commissioning in order to ensure that the project is executed with adequate consideration for the environment.

1.7.2.13. FMEnv Sectoral and Procedural Guidelines for Oil and Gas (1995)

In compliance with its mandate, FEPA issued the EIA Procedural Guidelines and Sectoral Guidelines for Oil and Gas Projects in 1995. Contained in the Procedural Guidelines (pg. 8) are Category I projects (mandatory study activities) and listed under item 15, sub-item (a) on page 10) (Petroleum) is Oil and Gas Fields Development, making an EIA mandatory for the proposed project. The Procedural Guidelines also indicate the steps to be followed (in the EIA process) from project conception to commissioning in order to ensure that the project is executed with adequate consideration for the environment. Annex C contains the EIA writing format as required by FMEnv. The guidelines are intended to assist in the proper and detailed execution of EIA studies of projects in consonance with the EIA Act.

1.7.2.14. FEPA (Now FMEnv) National Guidelines on Waste Disposal through Underground Injection (1999)

These Guidelines and Standards on waste disposal through underground injection provide the 'modus operandi' for the most viable options for disposal of these wastes in a tropical environment as Nigeria.

1.7.2.15. FEPA (Now FMEnv) Nigeria's National Agenda 21 (1999)

Nigeria's National Agenda 21 was developed to:

- Integrate environment into development planning at all levels of government and the private sector;
- Intensify the transition to sustainable development;
- Address sectoral priorities, plans, policies and strategies for the major sectors of the economy and,
- Simultaneously foster regional and global partnerships.

1.7.2.16. Forestry Law CAP 51, 1994

The Forestry Act 1958 which was amended as the Forestry Law CAP 51, (1994) prohibits any act that may lead to the destruction of or cause injury to any forest produce, forest growth or forestry property in Nigeria. The law prescribes the administrative framework for the management, utilization and protection of forestry resources in Nigeria, which is applicable to the mangrove, and other forests of the Niger Delta.

1.7.2.17 National Oil Spill Detection and Response Agency (NOSDRA), 2006

The National Oil Spill Detection and Response Agency (NOSDRA) was established in 2006 as the lead Agency in ensuring timely, effective and appropriate response to oil spills, through clean up and remediation of all impacted sites to all best practical extent.

1.7.2.18 National Environmental Standards Regulatory and Enforcement Agency (NESREA), 2007.

The National Environmental Standards and Regulations Enforcement Agency (NESREA) was established as a parastatal of the Federal Ministry of Environment. NESREA is charged with the responsibility of enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria.

1.7.2.19 The Nigerian Oil and Gas Industry Content Development Act 2010

All regulatory authorities, operators, contractors, subcontractors, alliance partners and other entities involved in any project, operation, activity or transaction in the Nigerian oil and gas industry shall consider Nigerian content as an important element of their overall project development and management philosophy for project execution. There shall be exclusive consideration to Nigerian indigenous service companies which demonstrate ownership of equipment, Nigerian personnel and capacity to execute such work to bid on land and swamp operating areas of the Nigerian oil and gas industry for contracts and services contained in the Schedule to this Act.

1.7.2.20 Department of Petroleum Resources (DPR) Requirements for EIA

The Department of Petroleum Resources (in the Federal Ministry of Petroleum Resources) is empowered to ensure that petroleum industry operators do not degrade

the environment in the course of their operations. Thus, DPR is responsible for supervising operations in the oil industry and for enforcing remediation of impacted environments. Principal decrees and regulations that empower DPR to perform these functions include:

- Petroleum Act of 1969, Section 8(in)b (iii) which empowers the Minister of Petroleum Resources to make regulations for the conservation of petroleum resources, prevention of pollution of water courses and atmosphere;
- Petroleum (Drilling and Production) Regulations of 1969, Sections 25 and 36;
- Mineral Oil (Safety) Regulations of 1963, Part III, Section 7 and Part IV, Sections 44and 45;
- Petroleum Regulation of 1967; the Oil in Navigable Waters Decree No. 34/Regulations1968;
- Oil Pipeline Ordinance Cap 145 of 1956 as amended by the Oil Pipeline Act, cap 338, Laws of the Federation of Nigeria, 1990;
- Petroleum Refining Regulation of 1974, Section 43;
- Associated Gas Re-injection Decree No.99, Section 1 (a) section 2(1), and Section3(1) of 1979;
- Associated Gas Re-injection (Continued Flaring of Gas) Regulations 1984; and
- Associated Gas Re-injection (Amendment) Decree No.7 of 1985, which amends section 3(2) of the Associated Gas Re-injection Act of 1979.
- DPR requires EIA for use as an environmental management and enforcement tool. The DPR Environmental Guidelines and Standards of 2018 stipulates in Part VIII (A), Sections 3, 4, 5 and 6, the details of EIA process for the oil industry in Nigeria.

1.7.3 Rivers State Ministry of Environment

The Ministry was created from the Rivers State Environmental Protection Agency (RSEPA). RSMENV was empowered by the decree that set up the repealed FEPA (Decree 58 of 1988, as amended by Decree 59 of 1992), which encourages State governments to set up their own Environmental Protection Agencies. Consequently, RSMEnv is charged with the protection of the environment of Rivers State and operates with Edict No. 2 of 1994.

In 2002, RSMEnv published the Interim Guidelines and Standards on Environmental Pollution Control and Management in Rivers State. The guidelines seek to:

- Regulate the generation, handling, storage, disposal and management of all wastes of whatever origin in Rivers State

- Regulate physical development in compliance with the principle of sustainable development
- Enhance and where possible, restore the quality of the environment and protect the biodiversity of the flora and fauna of Rivers State.

1.7.4 TEPNG Policies and Guidelines

TEPNG has HSE policies and commitments that guide its operations. These policies and commitments are of international standard and conform to the Total Group policies worldwide. Elements of these policies and operational philosophies have taken into consideration relevant Nigerian regulations, international laws, guidelines, conventions and treaties.

TEPNG shall in the course of executing this proposed project ensure that all relevant standards and conditions are complied with, and where double standards exist, TEPNG would as much as possible comply with the more stringent one.

1.7.4.1 Project Health, Safety & Environment (HSE)

The project shall be managed in accordance with all relevant sections of TEPNG's Health, Safety and Environment (HSE) Governing Policy.

The TEPNG's HSE policy at work imposes responsibilities on all levels of management, supervision and all employees, for which they will be held accountable. Implications of the TEPNG's HSE policy are:

- The provision of a safe place of work together, thereby establishing and maintaining high standards of safety in the workplace.
- The verification of the physical capacities of personnel and evaluating working conditions.
- The execution of its activities in a manner which demonstrates respect for the quality of the environment around its facilities through the adoption of appropriate procedures to minimize any adverse effects.
- The development and maintenance of a contingency system to cope with emergency situations.
- The promotion of HSE measures as an integral part of the duties of line management and thus shall accord the implementation of such measures the highest priority.
- The development and implementation of accident probability reducing measures.
- The selection and engagement of Contractors Whose HSE risk management systems are entirely compatible with that of TEPNG and whose commitment can be clearly and continuously demonstrated.

- The compliance with all Local Authority and Government regulations pertaining to HSE issues.
- The management of HSE matters in a clear and transparent manner.

1.8 Structure of the EIA report

The EIA report is presented in eight chapters.

Chapter one is an introduction stating the background information about the project and the legal/administrative framework for EIA in Nigeria and details of the Corporate HSE Policy of TEPNG.

Chapter two discusses the project justification and presents the need, benefits/ value and the envisaged sustainability of the project;

Chapter three contains a concise description of the proposed project activities including project scope of work, design philosophy, project management and operations philosophies, project emissions and associated rejects, and the project execution schedule.

Chapter four describes the existing physico-chemical status of the study/project area as well as its baseline environmental conditions.

Chapter five contains the identified and predicted potential and associated environmental impacts of the proposed NOPL –Indorama pipeline tie-in project.

Chapter six proffers mitigation and enhancement measures and alternatives for the identified adverse and beneficial impacts.

Chapter seven describes the risk assessment and cost-effective environmental management plans that will be adopted during implementation of the proposed project. The Environmental Management Plan (EMP) is designed to ensure the effectiveness of the recommended mitigation measures. It presents a framework for providing guidance for developing suitable environmental management and monitoring practices.

Chapter eight concludes the EIA report while presenting the key findings of the study.

CHAPTER TWO

PROJECT JUSTIFICATION

2.1 Need for the Project

With Indorama Eleme Fertilizer & Chemicals Limited (IEFCL) requiring TEPNG to supplies 170 MMSCFPD gas to its facility from the NOPL pipeline there is need to tie-in to 24" NOPL line at KP33.5. This is being undertaken in order to:

- mitigate the impact of the present shortfalls of gas supply from NAOC to Indorama facilities.
- Utilize Natural gas to produce ammonia and granulated urea in a World Class Fertilizer Plant in an existing Indorama Eleme Petrochemicals Limited (IEPL) manufacturing complex in Eleme.
- Boost agricultural production and food security in Nigeria
- Offer job opportunities in various categories to a number of Nigerian professionals' skilled and semi-skilled craftsmen.

2.2 Value of the Project

The proposed project shall provide a reliable and unhindered source of gas for the fertilizer plant built in the IEPL facility in Eleme. Consequently, the cost of production of fertilizer will be lowered due to the use of reliable supply and cleaner source of raw material which in turn will lower the cost of fertilizer production in Nigeria

The utilisation of gas for the fertilizer factory will contribute to putting to an end the unnecessary gas flares from oil wells as envisaged by the Federal Government of Nigeria.

2.3 Envisaged Sustainability

2.3.1 Economic sustainability

The project has economic sustainability. On completion of the gas pipeline tie-in, gas will be made wholesomely available in sufficient quantity for the production of fertilizer. Fertilizer in turn will enhance the country's security in food arising from good agriculture. Agriculture we agree has been relegated to the background as national source of income. This project will create a boost to make Nigeria self-sufficient in food to the point that Nigeria will begin to earn sizeable income from exporting food. Thus, the project will be sustainable as funds will be available to operate and maintain the project.

2.3.2 Technical sustainability

The NOPL-Indorama Tie-in is technically sustainable because of the pool of indigenous expertise in oil and gas technology and strict adherence to internationally and nationally acceptable engineering design and construction standards. Innovative technologies that are economically viable and having minimal environmental, social and health impacts shall be utilised in the execution of the proposed gas pipeline.

2.3.3 Environmental Sustainability

Design for the proposed NOPL-Indorama Tie-in will incorporate features that will preserve its integrity so that the impact on the environment is minimal. This will be achieved through construction techniques suited to specific ecological requirements and guided by regulatory and engineering design standards. The incorporation of the findings and recommendations of this EIA at the appropriate stages of the project development and strict adherence to the mitigation measures entrenched in the environmental management plan (EMP) shall ensure environmental sustainability. In addition to environmental advantage, the replacement of oil by gas will improve local and regional air quality as well as reducing emissions of greenhouse gases.

2.3.4 Social Sustainability

The fact that the project will be executed in a dedicated ROW implies that the project is not going to infringe on the social rights of the host communities. For instance, land will not be tampered with; source of water will not be disturbed. The fact that the project has elaborate Social Action Plan will ensure that the culture of the people are not tampered with. Memorandum of understanding (MOU) entered into by both parties will be respected and aggressive employment opportunities ensure social balance in the communities.

The reliance of agricultural sector on imported fertilizers has resulted to the low agricultural yield because of the inadequacy and inconsistency of the supply chain to farmers. The availability of additional gas supply and its transport in a dedicated Right of Way (ROW) implies security of the tie-in point for so many reasons amongst which are:

- Issue of land ownership and chains have been settled
- Monitoring and surveillance of the ROW have been agreed upon with host communities; all that needs to be done is for IEFCL to redefine gray areas in the existing agreements with TEPNG and the host communities to the ROW
- Availability of right Technology, Knowledge, and manpower for operating/maintaining the ROW.
- The issue of community displacement and or economic displacement is totally absent.

2.4 Project Alternatives

Established EIA processes including the requirements of Nigerian regulations call for an analysis of reasonable alternatives to various elements of the proposed project. The aim of the analysis of alternatives to the proposed activities is to use the information developed through the affected environment's investigation and impact assessment to develop and identify the most environmentally sound, cost-effective, and practical means of accomplishing project goals and objectives. By explicitly incorporating environmental and social considerations into a high-level early stage evaluation of the proposed project, the analysis of the alternatives is expected to assist in identifying the approach to meeting project objectives that offer the best combination of cost and impact. Project alternatives analysis in environmental assessment is designed to bring

environmental and social considerations into project selection at the early stages of project planning, and the later stages of site selection, design and implementation.
For any project, there are a number of alternatives that can be considered. The project options took cognizance of environmental, safety, and operational considerations. These include the no-project option, delayed project, modified project option, and/ or the planned option. The various options considered for the NOPL-Indorama tie-in project are as follow:

The No Project option
The "No Project" option will eliminate associated and potential negative impacts within the areas of influence of the project. However, this option was rejected because it would mean persistent frequent shortfalls of gas supply which will greatly impact the operations of the fertilizer plant. It will also result in the loss of resources already invested in the project development as well as the loss of valuable baseline data of the project area.

Delayed Project option
By the "Delayed Project" option, the project would be postponed to a later date. Similar to the "No Project" option, associated and potential negative impacts within the area of influence of the project would be avoided; however, this will be temporary. It would have the advantage of allowing for further project planning and time to implement mitigation measures with longer lead times.
A "Delayed Project" option shall cause an anticipated increase in the cost of the project due to inflation and will inhibit the IEFCL's ability to meet its gas supply for its operation. It is therefore unattractive to adopt the "Delayed Project" option.

Timely Project Option
This option has the advantage of optimizing the utilization of the gas and the mitigation of persistent frequent shortfalls of gas supply which will greatly impact the operations of the fertilizer plant. This option was selected.
Options selection
Tie-in location: KP 33.5 was preferred to KP 38 (Obigbo) and Rumuji.
Tie-in method: Cold Tap (FSD) with SD which is worst case scenario was preferred to Hot Tap.
Meter: Ultrasonic Fiscal Meter and Coriolis Condensate Meter was selected based on GSAA and lower deployment lead time as against the other options of Ultrasonic Fiscal Meter and Turbine Condensate Meter and the Orifice DP Fisca Meter and Coriolis Condensate Meter.
Metering Location: Indorama was selected as against KP 33.5 and Rumuji, based on security of meter and utility. Mass balance to be deployed for inventory in event of loss of measurement.
Metering Position: Downstream Slug Catcher as against Upstream Slug Catcher was selected. The objective is to maintain full commercial value.

Power: The required power for the metering system shall be provided by Indorama, rather than K 33.5 or KP 38 (Obigbo).
Safety logic: ESDV/SDV is preferred isolation- to be implemented at INDORAMA. Line breaker valve can be implemented at K 33.5.
Emergency Fire Fighting: Fifi network/hydrants to be extended to INDORAMA phase 2.
Manning: Due to follow-up required for the metering skid especially at the early supply stage and the subsequent requirement of at least 3 visits per week, a manning scheme shall be put in place to cover the metering station.
Security: Since metering station is within Indorama, it will be covered by their site security management. Strict access control for the station shall be put in place within the ambit of the Indorama site security.
Table 2.1 shows the Indorama tie-in option selection summary

INDORAMA TIE-IN OPTION SELECTION SUMMARY

	1	2	3	Remarks	Actions
Tie In location	KP33.5	KP38 (Obigbo)	Rumuji		Information
Tie-In Method	Hot Tap	Cold Tap (FSD)	NIL	Cold tap with SD which is worst case scenarios is chosen today.	ECP
Meter	Ultrasonic Fiscal Meter and Turbine condensate meter	Ultrasonic Fiscal Meter and Coriolis Condensate Meter	Orifice DP Fical Meter and Coriolis Condensate meter	Selection based on GSAA and lower deployment lead time	Metering
Metering Location	KP33.5	Rumuji	Indorama	Selection based on security of meter, utility. Mass balance to be deployed for inventory in event of loss of measurement	Metering
Metering Position	Upstream Slug Catcher	Downstream Slug Catcher		Objective is to maintain full commercial value.	Metering
Data & Communication	Mast, Fibre Optics	Fibre Optics		Metering data shall be made available as TCP/IP data packets.	Metering, Telecoms
Power	K33.5	KP38 (Obigbo)	Indorama	The required power for the metering system shall be provided by Indorama	Metering, ECP, Safety
Safety logic	ESDV / SDV Isolation	Line Breaker Valve Isolation	Double Block and Bleed Valve Isolation	ESDV/SDV is prefered isolation - to be implemented at INDORAMA. Line Breaker valve can implemented at KP33.5	Safety
Emergency Fire Fighting	Fixed Fifi network and hydrants	Fire truck	Mobile extinguishers	Fifi network / hydrants to be extended to INDORAMA phase 2.	Safety
Manning	None	Full Manning	Partial Manning	Due to follow-up required for the metering skid especially at the early supply stage and the subsequent requirement of at least 3 visits per week, a manning scheme shall be put in place to cover the metering station	Metering
Security	Indorama's security	TEPNG		Since the metering station is within Indorama, it will be covered by their site security arrangement. Strict access control for the station shall be put in place within the ambit of the Indorama site security.	Metering

CHAPTER THREE

PROJECT DESCRIPTION

3.1 Introduction

TEPNG intends to do the Tie-in at KP 33.5 which is at a mid-point on the NOPL pipeline running between its facility in OWAZA Abia State and Rumuji Gas plant in Rivers State. The Tie-in to be done at KP33.5 location is to link the 18" Gas supply pipeline built by Indorama running from there to Eleme Petrochemicals Rivers State. TEPNG's facility in OWAZA is located in Ukwa East Local Government Area of Abia State, approximately 30km North of Port Harcourt. It is accessible mainly by road.

3.2 Facility Description

3.2.1 TEPNG Existing Facility

The existing TEPNG Pipeline is a 24'' gas pipeline named NOPL that supplies treated natural gas from TEPNG facilities located at Rumuji to third party companies. It is a 600# rating pipeline from Rumuji to Obigbo corridor. It is a buried pipeline passing through heterogeneous train.

3.2.2 Indorama Existing and Proposed Facility

Indorama has an existing 18'' x 11.5km gas pipeline from their Eleme Facility to the proposed NOPL – Rumuji Pipeline tie-in point. As shown in the Tie-in details (Table 3.1) a 18'' line size will be used in order to interconnect the NOPL 24'' pipeline to the 18'' pipeline to Indorama (Figure 3.1).

Table 3.1 Features of Indorama Pipeline at Tie-in

Line Description	Pipeline OD	Piping Class	Design Factor (ASME B31.8)	Line Pipe Material	Design Temp, (°C)	Operating Temp. (°C)	Design Pressure barg	Operating Pressure barg
18" pipeline from Tie-in at NOPL to Indorama	18"	600#	0.6 (Class 2)	API 5L x70 Spec	50	25	100.2	65-86

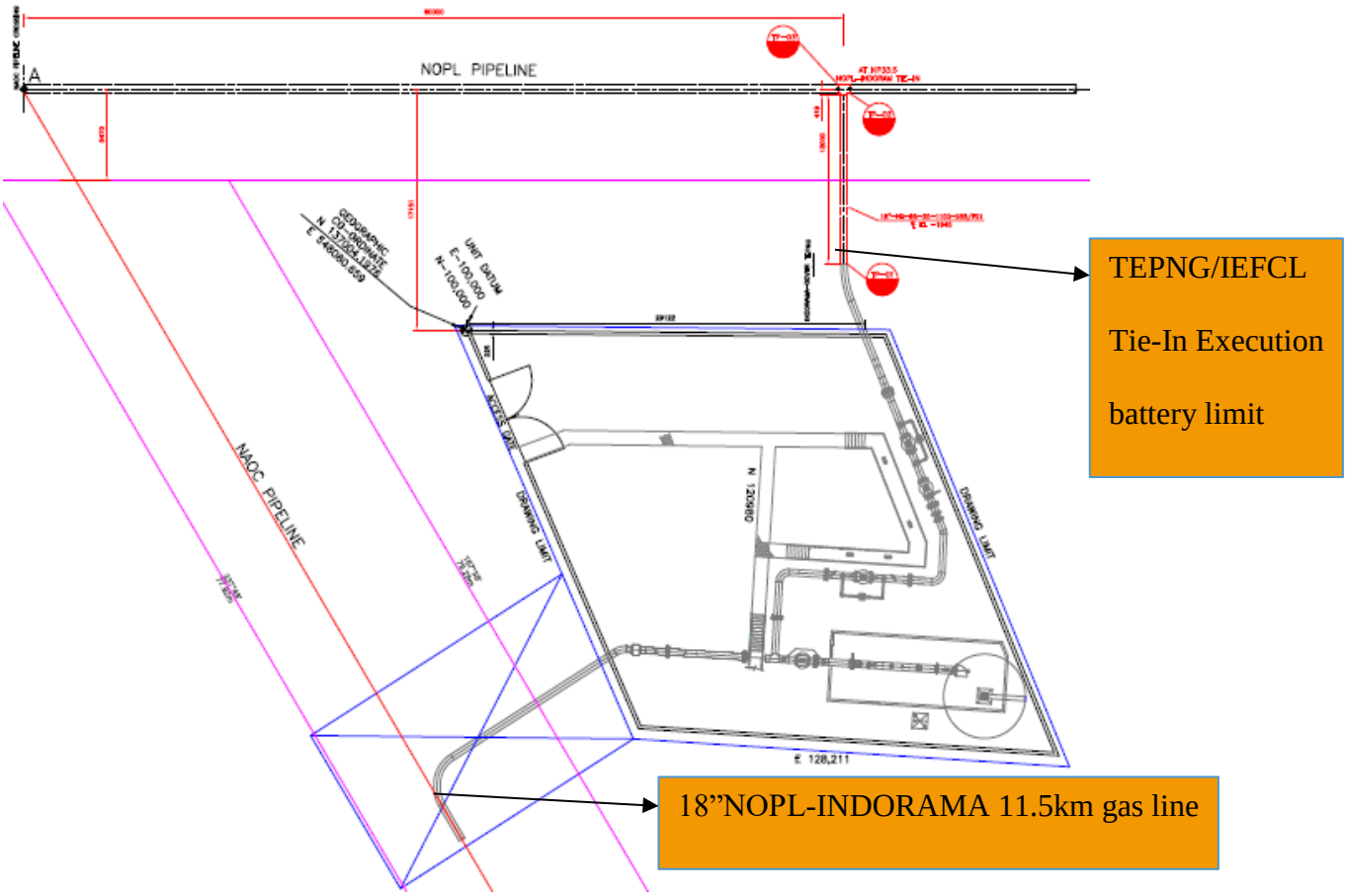


Figure 3.1: Scheme of NOPL-Indorama tie-in

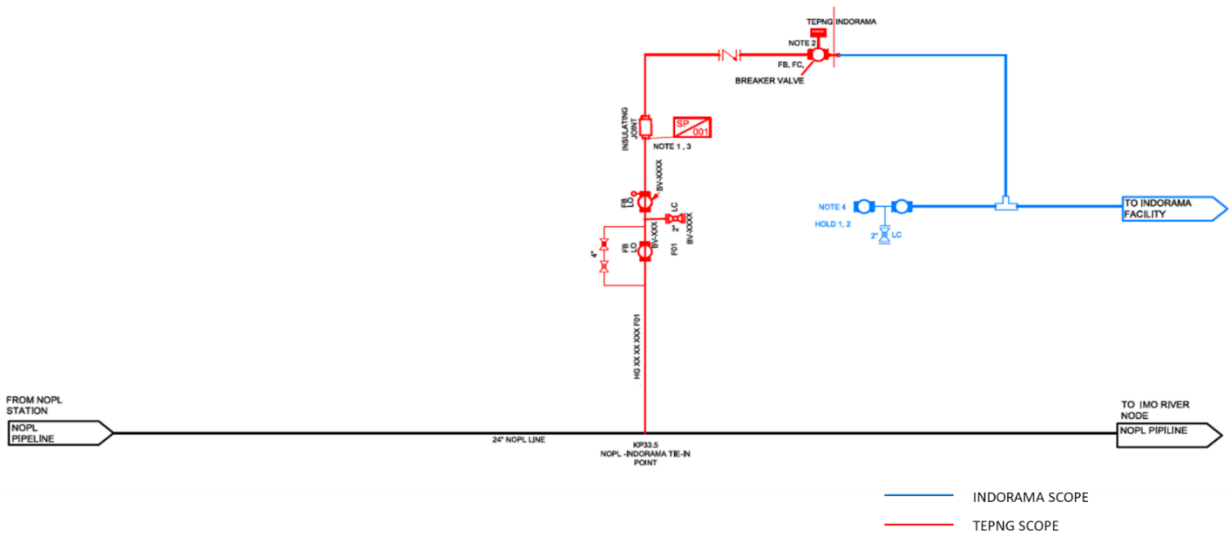


Figure 3.2: Schematic Diagram of the Tie-In Point at KP33.5

3.3 Proposed modification

Piping/Pipeline Scope

Tie-in of new Indorama 18" pipeline to existing 24" NOPL pipeline via 24"X 18" Barred Tee at KP33.5 involves the below activities:

- Operational pigging with foam pigs to remove dropped out liquid in the NOPL from Rumuji to Owaza.
- Nitrogen purging of TEPNG's 50km 24" Carbon Steel gas supply line.
- Installation of fully rated spades at TEPNG's OBIGBO/OWAZA and RUMUJI Nodes
- Excavation Works.
- Coating of 24" x 18" Carbon Steel barred tee.
- Ultrasonic Inspection of a segment of TEPNG's 24" carbon steel gas supply line to be used for tie in.
- Cold cutting of a segment of TEPNG 24" carbon steel gas supply line to install a 24" x 18" barred tee.
- Fit up and welding of 24" x 18" carbon steel barred tee.
- Tie in of 24" x 18" carbon steel barred tee to the adjoining valve station facility at KP33.5 facility by welding one additional pipe length to the barred Tee.
- Field coating of welded joints.
- Non-Destructive Testing of welded joints.
- Removal of previously installed spades at TEPNG's RUMUJI Node and Obigbo Node.
- Backfilling and compacting.
- Physical inspection/ validation of the Tie-in Points

3.4 Project Scope

Construction of interconnection piping with NOPL and Indorama shall follow DPR/TEPNG regulations. NOPL pipeline is currently active and transports hydrocarbon while Indorama 11KM pipeline is currently inactive and under nitrogen preservation.

The tie-in of both pipelines will be as follows:

a. An 18 inch branch will be tapped-off from the NOPL pipeline (by cold tap) and made available to the contractor, to connect pre-fabricated and tested piping, including isolation joint to two manual isolation valve, within 30 m x 30 m fenced area.

b. Upon connection of 18 inch NOPL branch line to manual isolation valve, check valve and line break valve to be installed up to TP-2, TP-3,TP-4 & TP-5 as defined in PNID; including testing and commissioning.

Site Installation Sequence

Procedure for the Installation of 24" X 18" Barred TEE to NOPL Gas Supply Line

- Transfer of Materials and Equipment to Work area and layout.
- Isolation, depressurization, and handover of the line to the Contractor by OWAZA & RUMUJI Production.
- Installation of fully rated spades at Owaza and Rumuji 24" NOPL PIGING AREA in the gas plant by unbolting and bolting the marked-out flanges to be spaded.
- Nitrogen purging of the 50km 24" carbon steel gas supply line from Rumuji to Owaza gas plant by OWAZA & RUMUJI Production.
- Deploy the use of metal detector at KP33.5 axis of the 50km 24" NOPL line to determine the portion to be excavated.
- Excavation of the portion marked out to access the 24" line underground.
- Installation of coffer dam & shelter
- Ultrasonic inspection on the segment of the 24" NOPL gas supply line before cutting.
- Timber logs Parking to be placed 1m away on both ends of the segment of the 24"NOPL line before cutting to prevent sagging of the line after cutting the marked section of the line.
- Securing of the portion of the 24" pipe to be cut off the line with the help of a crane to prevent the piece dropping and causing any form of accident
- Cold cutting of the marked-out section of the 24" carbon steel gas supply line with a redial cold cutter connected to the compressor.
- Installation of inflatable balloon plug at both ends of the cut NOPL prior to the fit-up and welding of the barred tee
- Beveling and pipe end preparation
- Fit up and welding of 24" x 18" carbon steel barred tee to the 24" NOPL line (golden weld).
- Retrieval of the balloon plugs at the end of the welding activities.
- Beveling and preparation of the end of the barred tee
- Installation of inflatable balloon plug in front of the bar in the tee prior to the welding of the 18" pipe to the barred tee and retrieval after the welding.
- Lifting and positioning of the 6m 18" pipe for fit-up with the aid of a crane

- Parking of the beveling of the end of the 18″ pipe in preparation for tie in to INDORAMA valve station.
- Welding of the 18″ pipe to the 24″ x 18″ barred tee on the NOPL line (Golden weld)
- Non-Destructive testing (RT UT, MPI) to be carried out on the WELDED joints.
- Field joint coating of welded joints.
- Dismantling of shelter and coffer dam
- Removal of previously installed spades at Rumuji and Owaza gas plants
- Backfilling and compacting.
- Pre-commissioning and commissioning checks.
- Site rehabilitation

The Scope of work for interconnection works include all Preparatory works, Ancillary and Tie-In works:
Preparatory works at KP33.5
WP1 (Cold Tap into 24″ NOPL at KP 33.5):

- Depressurization of the NOPL pipeline OWAZA to RUMUJI node.
- Cut out of less than 2m length and replacement with 24″x 18″ Tee.
- Routing of 1 x 12m length of 18″ pipe underground towards IEFCL `s valve station for Tie in to the valve station spool.
  WP5 (**EPC for KP33.5 installation of the valve package and connection of the Valve spool to the NOPL isolation valve and the Offtake Pipeline**):

Civil works

- Excavation and backfill works for the underground installations.
- Flatten and create concrete pads and a blast wall for siting ESDV skid if applicable at KP 33.5 end.
- Flatten and create concrete pads and a blast wall for siting ESDV skid.
- Create access for crane to lift skids
- Pre-install pipe supports to extend closed drain
- Dig trenches for drainage
- Dig trenches for instrumentation cables.
- Create walkways and provide maintenance access
- Create pads for siting pipe supports, general signage and lighting stand posts
- Erect supports for F+G sensors

Piping/Mechanical

- Perform cold tap of NOPL line at KP33.5 end and install 18" weldolet and a flanged end for tie-in by IEFCL pipeline.
- To install 24" x 18" Tee on the NOPL pipeline
- To install an 18" spool of about 30m
- To install Cathodic protection system on the pipeline
- To install a Line break Valve
- To install a PIG launcher
- To install Drain vessel
- To install cold vent
- To install double block and bleed valves and bypass lines

Tie-in Works

- To weld together by Gas Tungsten Arc Welding (GTAW) process 24"/18" reducer at the tie-in location at KP33.5.
- To perform Non-Destructive examination on the welded joints, comprising of radiography and magnetic particle inspection.
- To perform hydrotest of the installed line.

Ancillary works at IEFCL facility

Electrical

- Run and terminate electrical cables from existing distribution board to flow meter skid junction boxes, field junction boxes, lighting posts, air compressor, analyzer house, HVAC house and flow computer house
- Install CCTV

Piping/Mechanical

- Installation of metering system/skid on IEFCL facility.
- To connect flange-to-flange connection of the fiscal metering assembly.

Instruments

- Run and terminate instrument cables for all new metering skid and associated instrumentation at the designated junction boxes.
- Run and terminate all multicore core instrument cables from junction boxes to designated cabinets in the ITR.
- Run and terminate F+G cables and extend existing system as necessary
- Run and terminate inter trip cable between IEFCL and TEPNG
- Modify PSD and ESD logic diagrams and graphics to include new skid and associated instrumentation.
- Integrate new equipment into existing ICSS system

Structural Works

- All modifications (external and internal) to the Instrument Technical Room (ITR) for the placement of the metering and control cabinets to ensure the requirement for proper segregation of controls from safety signals is met.

Civil works

- Civil and structural activities required for the installation of the gas metering skid, analyzer house, flow computer room and associated HVAC and drainages.
- Civil and structural activities required for the installation of a Telecom Mast for data transmission (location and other requirements to be defined during basic and detailed engineering).
- Civil and structural activities required for the installation of the condensate metering skid and associated drainages.

3.5 Project Schedule

Due to the urgency of the Project, TEPNG plans to execute the Site Installation Works of the Tie-in of new Indorama 18" pipeline to existing 24" NOPL pipeline project within fifteen days upon mobilization to site. All the recommendation of EIA shall be followed at all the stages, from construction, commissioning to operation phase. The preliminary project schedule will be executed as shown in the breakdown of the estimated duration for site works (Table 3.2).

Table 3.2: Summary of project activities

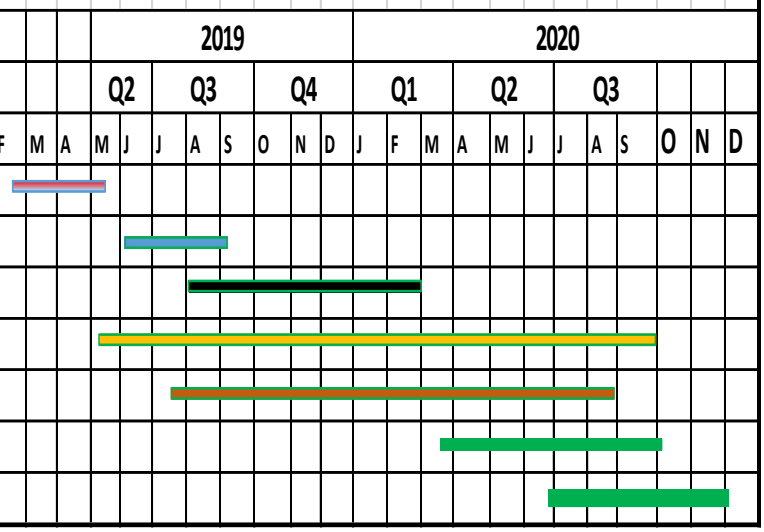
S/N	Activity Description	Duration(days)	Remark
1	Mobilization to site **7 days in advance** of the day for commencement of depressurization or as may be advised by COMPANY and to commence site preparation.	1	
2	Excavation at NOPL ROW at KP33.5 after confirmation from COMPANY, decoating and Inspection of the decoated section to commence **6 days in advance** of the depressurization and inerting of the line.	5	
3	Metrology, cold cutting, fit-up of barred tee	2	
4	Welding of the 2 ends of the 24" x 18" barred Tee to the cut ends of the NOPL with 4 welders	1	
5	Welding of the 1lenght 18" X65 line pipe to the barred Tee towards the valve station	1	
6	Pre-commissioning and commissioning of Valve station spool prior to tie-in to Cold Tap spool by others with CONTRACTOR assistance	2	
7	Weld Inspection and field joint coating	1	
8	Providing assistance to the other contractor for the Tie in of the cold tap spool to the Valve station spool	1	
9	Recommissioning of the NOPL (N2 purging) after removal spades at Rumuji and OWAZA	1	
	Total	15	

The key milestones are summarized as follows:

Table 3.3: Indorama Gas Tie-In Project Summary

INDORMAMA GAS TIE IN PROJECT SUMMARY

	Activities Description	Duration	Start	Finish
1	Preliminary Studies- Process	60 days	25/02/2019	17/05/2019
2	Basic Engineering and safety review	7 wks	03/06/2019	19/07/2019
3	Detailed Engineering	4 wks	12/08/2019	06/09/2019
4	NAPIMS/DPR Engagement,SOW,CFT & Pos	150 days	20/05/2019	13/12/2019
5	COMPANY Procurement	240 days	22/07/2019	19/06/2020
6	Construction/Execution of Tie-in	165 days	16/12/2019	31/07/2020
7	Demobilisation			31/07/2020



3.6 Wastes and Disposal Activities

Effective and responsible handling and disposal of wastes are key elements in environmental management system. Wastes are unwanted bye-products of a process. Waste management for the project shall be carried out in consultation and in line with the waste management guidelines as per appropriate directives of regulatory authorities.

3.6.1 Waste Management Approach

During this project, several steps would be taken to achieve the best results in relation to waste management. These steps are as follows:

- Inventories of waste: All wastes types and volumes generated from construction, operation, commissioning and abandonment phases of the project will be documented.
- Minimization: The minimization methods of reduce, reuse, recycle and recover will be adopted to identify appropriate waste management method so as to reduce liabilities and management costs.
- Treatment: Residue from minimization will be treated using best practicable.
- Disposal: Non-hazardous residue will be disposed to the environment by surface discharge or land farming.

3.6.2 Waste Identification / Categorization

Wastes expected during the various phases include the following

- Excavated soil
- Vegetation wastes
- Pigging Trash
- Pipe coatings
- Used oils
- Wooden pallets
- Plastic wastes
- Office wastes
- Contaminated soil
- Scrap metals
- Filters
- Welding torches and spent electrode
- Glass waste
- Food waste
- Sanitary waste
- Spent batteries
- Gaseous emission

The categories of waste and their characteristics are as indicated in Table 3.4. The physical, chemical as well as the toxicological properties of each waste type provide a guideline as to the appropriate waste management method to be utilized.

Table 3.4 Waste categories and characteristics

Waste type	Waste stream	Potential sources	Possible environmentally significant constituents
Emissions	Engine exhausts	Transportation, power generation, construction equipment and machinery	COx, SOx, Carbon monoxide and particulates
Industrial	Cleaning materials, insulation, batteries, coatings, scrap metals, plastics, paints and thinners, spent electrode, welding torches.	Construction, operations, Spills, maintenance and abandonment.	Hydrocarbons, acids, alkalis, heavy metals, PCBs, plastics.
Office	Paper, packaging materials, pins, IT wastes.	Office	
Hazardous	Contaminated soils, pigging wastes	Spills, commissioning, operations, maintenance and abandonment	Hydrocarbons, heavy metals, salts, chemicals, detergents
Domestic	Domestic sewage, food and kitchen wastes	Catering centres and camp sites	Solids, detergents, coliform bacteria

3.6.3 Waste Inventory and segregation

At the point of wastes generation, the various waste streams shall be collected in separate colour-coded bins (Table 3.5). This is to enhance easy and proper management. Each waste stream will be quantified using properly calibrated scales, these records will be maintained by competent officers.

Table 3.5: Colour codes

Waste Stream	Colour codes
Domestic	Green
Industrial	Grey
Office	Black
Hazardous	Red

3.6.4 Wastes minimization Techniques

The waste minimization approach to be utilized in the cause of this project will involve: Reduce, Reuse, Recycle and Recover. This waste management approach for the wastes generated from this project is as follows (Table 3.6 and 3.7):

Table 3.6: Wastes minimization Techniques

Waste Type	Minimization option	Remark
Batteries	Reduce/Recycle	Used rechargeable batteries transferred to approved recycling facility
Contaminated Soil	Reduce/Recover	Transfer to approved waste management facility
Glass/plastic/metals	Reduce/Recycle	Transfer to approved recycling facility
Oil Contaminated filters	Reduce/Recycle	Transfer to approved recycling facility
Office wastes	Reduce/Recycle	Use double sided printing, transfer to approved recycling facility
Domestic Waste		Transfer to approved dumpsite for composting
Sewage		Transfer to Septic/Soak-away system
Wooden pallets	Reduce/reuse	Reuse on-site for community relation
Paint and thinners	Reduce/Reuse	Transfer to approved recycling facility
Vegetation waste	Reduce/Reuse	Transfer to approved dumpsite for composting
Gaseous emissions	Reduce	Ensure vehicle and equipment maintenance in good condition
Hydro test water	Reduce/Reuse	Collect & reuse for Hydro testing
Pigging trash (sludge)	Reduce	Incineration/Transfer to approved recycling facility

Table 3.7: Project phases and waste management

Project Phase	Waste Generated	Sources	Treatment Method
Construction	Metallic wastes,	Electrode stubs Pipe cutting Metal filings	Recycling
	Paper packaging materials, pins, plastic	Office wastes	Recycling, reuse
	Fabrics, food wastes, domestic sewage, packaging materials	Domestic Wastes	Biological Treatment Processes, recycling, reuse
	Wastes oils, filters	Welding machines Vehicles (Various)	Recovery, thermal treatment
	Paints, thinner, pipe coating	Pipeline finishing	Thermal treatment
Operations	Oil contaminated wastes, Pigging wastes, filters spent lubricant,	Maintenance gas receiving stations	Recovery, Thermal treatment
	Fabrics, food wastes, domestic sewage, packaging materials	Control points take off and receiving stations Valve Station	Biological Treatment Processes, recycling, reuse
Decommissioning and abandonment	Metallic waste, Pigging Waste, contaminated	Abandonment operations	Recycling, thermal treatment
	Paper packaging materials, pins, plastic	Office wastes	Recycling, reuse
	Fabrics, food wastes, domestic sewage, packaging materials	Domestic Waste	Biological Treatment Processes, recycling, reuse
	Wastes oils, filters	Welding machines Vehicles (Various)	Recovery, thermal treatment
	Paints, thinner, pipe coating	Pipeline finishing	Thermal treatment

3.7 Procedure for Handling / Transfer of Wastes

At the point of generation, wastes will be segregated using the colour coded bins. However, the excavated spoil / soil will be stockpiled in designated points in such a manner that it will not obstruct vehicular movement and construction operations.
The first line segregation will be accomplished with the waste bins. It should be noted however that any other class of waste that comes in contact with the hazardous wastes is classified as hazardous waste. All containments for the various waste streams must be leak proof, covered and when there are valves installed, such valves must be inspected to ensure there are no leakages. Other criteria include:

- Container safe levels (to avoid spillage).
- Reduction of rusts and corrosion.
- Adequate container identification.
- Appropriate sealing.
- Emergency response PPE and equipment.

The choice of location of the waste bins must be selected with the following criteria in mind:

- It should not be located in flood prone areas.
- It should not be near food or drinking water sources.
- It should be clearly identifiable.

3.7.1 Waste Handling

- At locations where provision is made for the segregation of waste for recycling the containers will be clearly and appropriately labelled
- All waste will be stored in a safe and secure manner prior to collection for recovery, recycling or disposal.
- All waste will be stored in a manner that prevents its escape.
- Wherever possible, access to hazardous waste containers will be restricted
- Redundant IT equipment shall be appropriately labeled and stored secured.
- All personnel involved in waste handling must be adequately kitted with relevant and appropriate PPE.
- Sewage are held in septic and soak-away tanks

3.7.2 Waste Transfer

- Wastes will be transported by certified transporters using pre-mobbed vehicles.
- The Crew, vehicle and equipment to be involved will be pre-mobbed and certified.
- The HSE Team shall ensure that all personnel are adequately kitted with appropriate PPEs.
- The HSE team ensure at site will adherence to company's Transport policy.

- Ensure that the skips are intact and properly sealed. In the cases of vessels fitted with valves, ensure that the valves are intact and will not leak.
- Ensure that the waste containment is properly secured on the vehicle
- Ensure that all traffic regulations are obeyed.

CHAPTER FOUR

DESCRIPTION OF THE ENVIRONMENT

4.1. Introduction

This chapter documents the environmental setting of the project area, as presently constituted. Acquisition of baseline data on a project environment is an important phase of any Environmental Assessment Impact process. Environmental baseline data provides information on the state of the existing environment prior to the project activities. It also provides information that will aid in the identification of impacts that would occur in any sensitive area for the development of appropriate mitigation and ameliorative measures including an Environmental Management Plan.

4.2 Study Approach

4.2.1 Desktop Studies

In this study, the environmental characteristics of the project area were established through extensive literature search of relevant studies, field sampling/measurements, laboratory analysis, stakeholders' consultation and data interpretation. In addition, the baseline data collected will serve as a veritable benchmark against which data to be collected during the Post Implementation Monitoring shall be compared, in order to establish the effectiveness (or otherwise) of mitigation measures put in place for the project.

Data from literature search were obtained from the following sources:

- Environmental Baseline Assessment (EBA) for 55km by 24" NOPL Gas Pipeline Project Field Work Report (3rd-8th April 2011, late dry season);
- Environmental Impact Assessment of Obite-Ubeta-Rumuji (O.U.R.) Pipeline Project (EPNL, 2007);
- Environmental Impact Assessment of Obigbo Node Associated Gas Gathering Project (SPDC, December, 1998).
- Environmental Impact Assessment of OB/OB-Eleme Gas Pipeline Project (IEFCL, 2013).
- Environmental Evaluation Report Based Environmental Impact Assessment (EER-Based EIA) Study of the Northern Option Gas Pipeline (NOPL) Project (TEPNG, 2016).

4.2.2. Field Data Collection

A one-season (Dry season) field sampling exercise was conducted between 20th and 22nd of March 2020. A multi-disciplinary approach was adopted for the ecological characterization and data acquisition. The environmental components covered include climate/meteorology, air quality and noise, soil quality, vegetation, animal ecology, socio-economics, health status assessment and waste management. DPR Guidelines

and Standards Part VIII D (2) and FMEnv Guidelines were strictly adhered to in the cause of field sampling and measurement.

4.2.3 Fieldwork Pre-Mobilization Activities

A number of preparatory activities were undertaken in order to ensure the success of the fieldwork. These activities are highlighted below:

Mission Planning

Mission Planning was conducted by using available maps of the study area from TEPNG and approved study sampling locations from the scoping exercise. Relevant literatures were reviewed, and work plan developed and presented to TEPNG for approval. The field program was designed to cover the area within the NOPL facilities at NOPL –Indorama pipeline tie-in point at KP-33.5.

Kickoff Meeting

A kickoff meeting was held in DPR Port Harcourt office on the 10th of March, 2020. During the meeting, discussions and agreements were reached on the sampling plans, procedures, sample storage and transportation to the laboratory. The adequacy of the field work equipment, sampling materials and Personnel Protective Equipment (PPE) and personnel competence and team composition were also verified and approved.

Job Risk Analysis (JRA)

Job Risk Analysis (JRA) for the project took place on the 11th March, 2020 at TEPNG office in Port Harcourt. During the JRA, all possible hazards associated with the project were identified and closed out.

Toolbox Meeting

Toolbox talk was conducted every day prior to the commencement of sampling. During the toolbox meeting, attendance was recorded and safety issues and hazards relating to the field sampling were identified and closed out.

4.2.4 Materials and Methods of Survey

4.2.4.1 Sampling Design

The field survey for soil, vegetation, wildlife, socio-economic and Heath status and air quality was conducted and samples taken from pre-determined sampling stations. The sampling design was to ensure that representative samples that will help obtain data required to describe the baseline status of the environment around the proposed NOPL-Indorama Tie-in is obtained. A total of eight (08) stations were sampled for soil and two control stations, while three (03) stations were sampled for air and two control stations (Table 4.2). The control stations were chosen because they are the closest historically established control point nearest to the tie-in point. The vegetation study was conducted at the same location of the soil stations. Shown in Table 4.2 are the locations of the sampling points.

Table 4.2: Coordinates of sampling stations at the proposed Indorama Tie-in

Indorama Tie-in Soil Sample Coordinates		
Name	Northing (Minna midbelt)	Easting (Minna midbelt)
IND 6	102162.15	511389.64
IND 8	103535.34	510976.89
IND 10	102130.40	510484.76
IND 13	103510.12	510470.12
IND 14	103531.28	510683.14
IND 17	102236.90	512610.04
IND 18	101930.06	511190.38
TIE IN POINT/ IND SS 20	102305.81	511591.57
OB/IND – CTRL T 1	101353.49	517141.35
OB/IND – CTRL T 2	101566.81	515889.75
Indorama Tie-in Air Quality Sample Coordinates		
IND AQ 15	103479.19	510589.39
IND AQ 19	102539.66	512605.95
TIE IN POINT/ IND SS 20	102305.81	511591.57
OB/IND – CTRL T 1	101353.49	517141.35
OB/IND – CTRL T 2	101566.81	515889.75

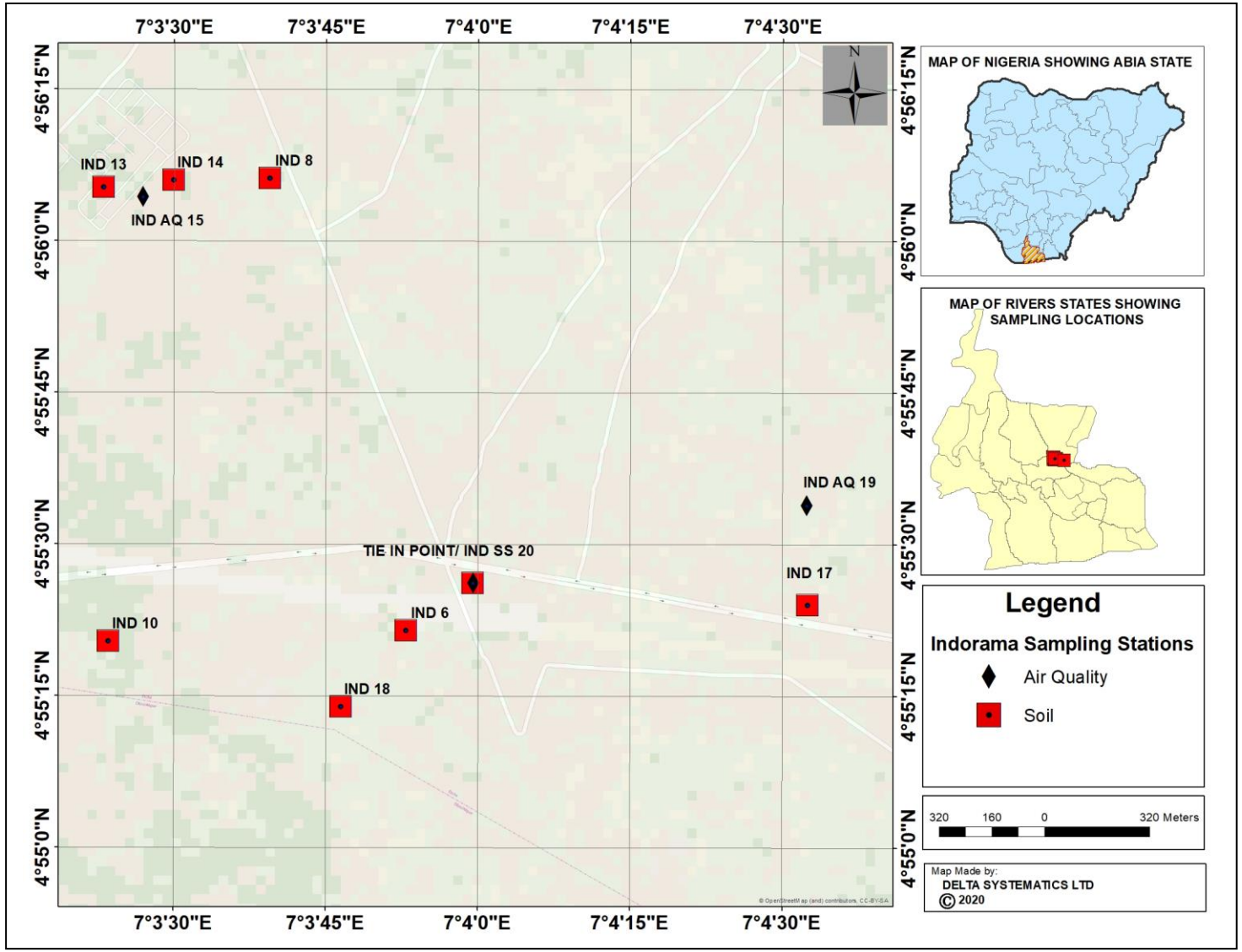


Figure 4.1a: Map of Indorama Tie-in Soil and Air Quality Sampling Stations (Source: DSL, 2020)

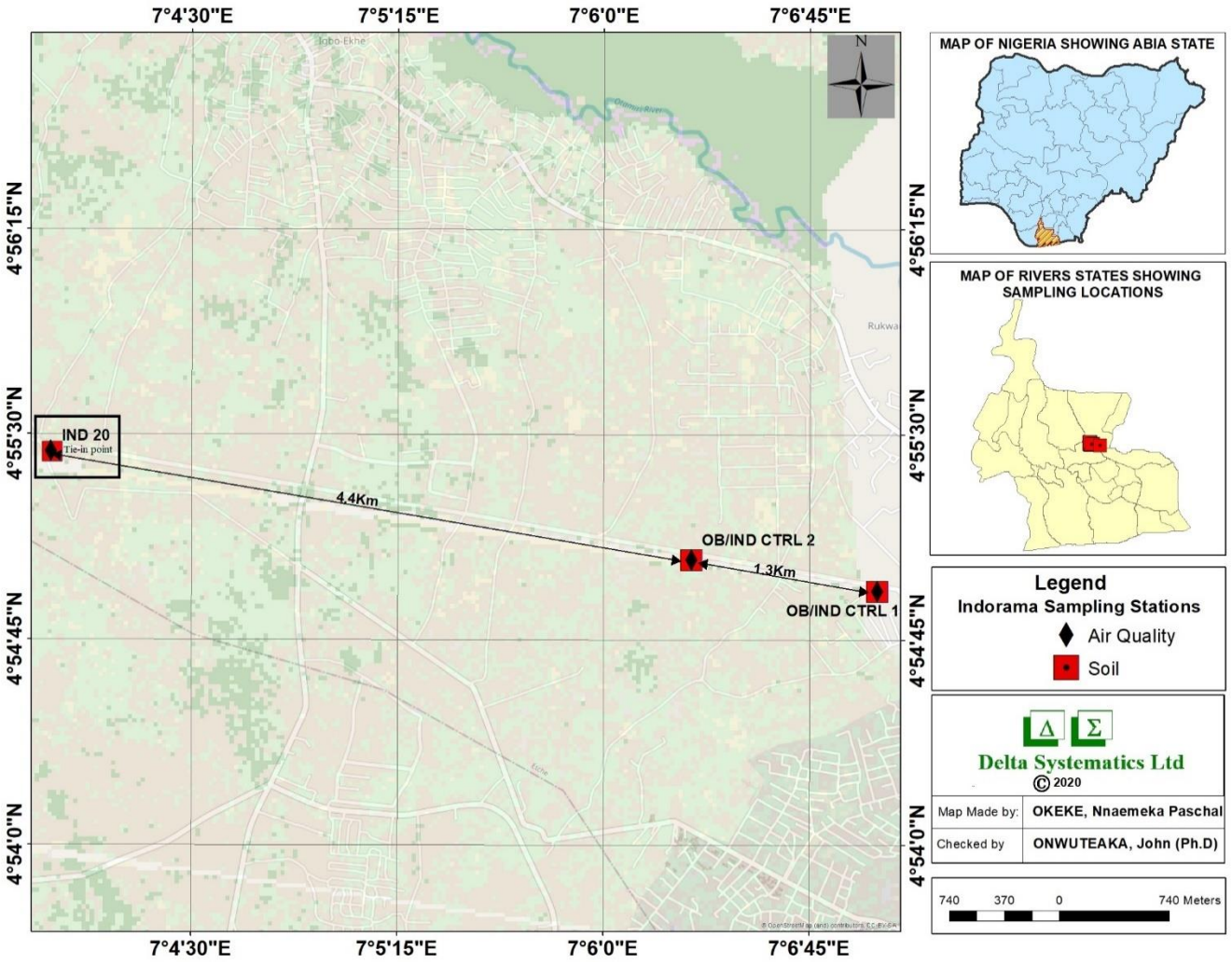


Figure 4.1b: Map of Indorama Tie-in Control Stations (Source: DSL, 2020)

This is the closest historically established control point nearest to the tie-in point.

4.2.4.2 Field Data Acquisition Methodology

4.2.4.2.1 Air Quality Measurement

Spot measurements for air quality and noise were undertaken in a total of three (3) stations at Indorama and two control stations. The parameters measured and the details of *in situ* equipment used are shown in Table 4.3. a photo of the field sampling exercise is shown in Plate 4.1

Table 4.3: Air Quality and Noise Measurement Equipment

Parameters	Equipment Name	Equipment Manufacturer	Units
CO_2	4 in 1 Multi Gas Detector	Henan Bosean Electronic	%Vol
CO	4 in 1 Multi Gas Detector	Henan Bosean Electronic	ppm
SO_2	4 in 1 Multi Gas Detector	Henan Bosean Electronic	ppm
NO_2	4 in 1 Multi Gas Detector	Henan Bosean Electronic	ppm
H_2S	4 in 1 Multi Gas Detector	Henan Bosean Electronic	ppm
CH_4	4 in 1 Multi Gas Detector	Henan Bosean Electronic	%
VOC	Series 500 – Portable Air	Aeroqual Ltd	ppm
$PM_{2.5}$, PM_{10}	831 Aerosol Mass Monitor	Metone Instruments	µg/m3
Relative humidity/Temp	Accurite Weather Station	Accurite	% / ^{0}C
Wind speed/Direction/Te	Accurite Weather Station	Accurite	m/s
Noise	Digital sound level meter	Extech Instrument	dBA

Plate 4.1: Air Quality Sampling

4.2.4.2.2 Soil Sample Collections

Composite soil samples were collected from eight (8) sampling stations within the proposed project influence zone and from two (2) control station outside the zone using standard stainless steel auger (**Plate 4.2**). At each sampling station, four different points within one meter apart were sampled and mixed together to form the composite sample. Samples were taken from 0-15 cm (Topsoil) and 15-30 cm (Subsoil) depths of the soil strata according to FMEnv/DPR protocol. The soil samples were collected in pre-cleaned black polythene bags for physical and chemical analysis, while samples for microbial and oil and grease/hydrocarbon analyses were wrapped in aluminium foil. The samples were neatly labelled, stored in ice chest in a cooler and taken to the laboratory for analysis.

Plate 4.2a: Soil Sampling at Indorama-SS-18

Plate 4.2b: Soil Sampling at Indorama-SS-18

Table 4.4: Sample Analytical Parameters and Collection Containers

COMPONENT	METHOD	NO OF SAMPLES	ANALYTICAL PARAMETERS	SAMPLE CONTAINERS
Soil	Hand Auger	10 Stations (20 Samples)	pH, Water Content, Redox Potential, Na, K, Ca & Mg, TOC, TPH, PAH, BTEX	Cellophane bag
			Heavy metals (Cu, Pb, Zn, Cd, Ba, Fe, Hg, Cr, Mn)	Foil Plate
			Microbiology (THB, THF, HUB, HUF, Coliforms)	Sterile Vial

4.2.4.2.3 Vegetation Study

Vegetation survey was conducted in around the tie-in point at KP 33.5. At the commencement of the exercise, a 100 m by 100 m transect was established, which served as a representative sample of the entire vegetation. Data was collected on the predominant vegetation type, land use types and the status and vigor of the vegetation in the area. The data collection methods are described in details as follows:

Vegetation type

The studied vegetation was characterized based on the prevalent physical and biological features. The presence of indicator plant species was evaluated. The biological feature utilized was the presence of specific indicator plant species.

Plant identification

Identification and list of plant species together with their economic importance was assessed by visual observation and with the aid of a field guide. The plants were identified to species level, plant life forms and their uses for timber and non-timber forest products were documented. These served as an indicator of the predominant vegetation type in the area.

Land use type

This was assessed by visually observing the anthropogenic activities in the surrounding. Activities such as farming, logging, and infrastructure development were documented.

Vegetation status/vigor

Knowledge of the phenological regime of the trees provided an indicator of the fruiting of the plants; more so the leaves were observed for traces of yellow and brownish coloration, in order to determine if the plants are suffering from extensive chlorosis or necrosis respectively. Using a scale of 1 to 5, a visual index of the leaves of selected plants for chlorosis was generated, where 1 = no chlorosis and 5 = severe chlorosis. More so, observation such as early blight, leaf spot, powdery mildew, ramularia spot, brown spot, target spot, rust, leaf blight, leaf streak, leaf blight provided information to determine whether or not the plants are necrotic. Vigor of the selected species was

determined by the following measurements: maximum height and diameter at breast height. More so, plant species abundance within the transects were documented for richness and diversity.

4.24.2.4 Wildlife Study

Three sampling methods namely indirect, direct and food chain analysis were used in the assessment which was from 7 am to 6pm daily. The indirect sampling method involved the use of surrogate evidence to record the activities and presence of certain animal species within the transects. Such surrogate evidence consisted of food left-overs, feathers, foot prints, burrows, faeces, talons, sloughed skin, carcass and vocalizations were all combined to detect species presence. Similarly, the portraits of previously killed animals were collected with consent from the phones of farmers, hunters and security staff.

The direct methods involved the use of field gear such as binoculars and reptilian grab stick to systematically probe burrows, leaves, grasses, and tree branches for signs of animal wildlife especially for amphibians and reptiles. In each site, an average of four (4) transects of 40m were established and patrolled dislodging logs, panels, for concealed or basking reptiles, feeding birds, other vertebrates as well as invertebrates.

The Food chain analysis involved the monitoring of feeding relationships of plant and animal species that shared the same ecological systems. This method is essential in understanding how energy (food) is transferred across trophic levels. This was used to monitor the health and stability of the ecosystem, as well as the importance and functions of all species within ecological communities (Knight, 2005., Smith and Smith 2009). As such, within each investigated site and locality, care was taken to document insect herbivory and carnivory.

4.24.2.5 Socio-economics and Health

The broad aim of the socio-economic studies was to evaluate the socio-economic and cultural impacts of NOPL facilities' operations on the host community which was Obigbo community. The specific objectives include the following:

a. Identification of the host communities impacted in the project environment.
b. Evaluation of socio- economic and health characteristics of the host communities
c. Assessment of effects of impacts on the host communities' resources and means of livelihood
d. Evaluations of public perceptions and expectations of the company by the host communities
e. Discussions of mitigations measures. and recommendations of an appropriate monitoring plan

Data Collection/ Instruments

The household questionnaires and communal interview were the data gathering instruments employed for the study. During the field survey, visits were made to the

study area by the socio-economic and health team and data were collected using four main procedures viz:

a. Discussion/oral interview
b. Questionnaire administration,
c. Field observation, and
d. Photography

Key informants such as company officials and community representatives (Chiefs, CDC officials and medical personnel) were interviewed; focused group discussions was held with community-based organizations which have stakes or interests in the welfare of the host communities.

Questionnaire Design

Survey questionnaire was used to elicit response from the respondents. The sample questionnaire (Appendix 4.1) covered information related to personal data, community concerns, socio-cultural characteristics, economic characteristics, land acquisition, claims and compensations.

4.2.4.2.6 Chain of Custody

To maintain a record of sample collection, transfer between personnel, transportation and receipt at Technological Partners International Nigeria Ltd (TPI) Laboratory; a chain-of-custody record was maintained from the time of sample collection until final deposition in the laboratory. The chain of custody form was endorsed by the TEPNG HSE department representative, Delta Systematics site supervisor and the dispatch personnel. The *in-situ* results sheet was endorsed by the TEPNG representative and the regulators (FMEnv and DPR).

4.2.4.2.7 Field Quality Assurance and Quality Control Measures

All aspects of the study were subjected to quality control procedures, as detailed in the QA/QC plan for the EIA of the NOPL-Indorama Tie-in project. Sampling of air, soil, vegetation and wildlife and sample handling and transportation were subjected to strict quality control procedures. Chain of custody documentation was carried out and the planned number of samples collected for various environmental media documented.

All samples were maintained in accordance with the following protocols;

1. Sample bottles were labeled in the field with the location name, the sample station identification number, sample date, sample time and the parameters to be analyzed. Samples were stored in coolers immediately after collection until they were transported to the laboratory.
2. The vegetation samples collected for further identification and storage were put in a plant press and secured firmly to keep the plants intact.
3. Sample containers for movement to analytical laboratory were securely sealed with tight caps and adhesive tapes. Samples were placed in a transport container

(coolers) and packed with absorbent material. Samples placed in the transport container (coolers) were packed in a manner that would prevent breakage. All sample containers were packed to maintain a temperature of 4°C.

4.2.4.28 Documentation Procedure

All activities carried out in the field were adequately reported using Field log Books, Chain of Custody forms, Project Update forms etc. and entered into computer database software (MS Excel).

4.2.4.29 Quality Assurance / Control Procedure

A detailed procedural guideline for sampling was prepared and used by all the consultants of the project team prior to the commencement of the fieldwork. This was to ensure data validity and reliability during sample collection, preservation, storage and transportation. All meters used for this study were calibrated with valid calibration certificates. An on-field check of calibration of meters was also carried out. Standard methods and procedures were strictly adhered to in the course of this study. QA/QC procedures were implemented during sample collection, labeling, analyses and data verification. Chain of custody procedures including sample handling, transportation, logging and cross-checking in the laboratory were also implemented.

All analyses were carried out in DPR accredited laboratories. The methods of analyses used in this study were those specified in EGASPIN 2018 and other internationally accepted analytical procedures, in order to ensure the reliability and integrity of the data obtained. Details of the analytical procedures for all the parameters are presented in the section below.

The laboratory quality Assurance Procedure covers all aspects of the study, and includes sample collection, handling, laboratory analyses, data coding and manipulation, statistical analyses, presentation and communication of results.

4.2.5 Laboratory Analyses

All environmental samples collected were transported to Technological Partners International Nigeria Ltd. (TPI) laboratory, Port Harcourt, a DPR and FMEnv accredited laboratory for analysis employing standard methods and best scientific practice to meeting the QA/QC expectation. All samples were logged into a laboratory log book. The chain of custody form from the field was endorsed by the Laboratory supervisor and Delta Systematics representative at the point of handover of samples for analysis.

4.2.5.1 Soil Quality Analysis

4.2.5.1.1 Soil physico-chemical characteristics

The following subsections present synoptic descriptions of the laboratory analytical methods and procedures employed for the various physical, chemical and biological parameters for soil samples.

Total Organic Carbon (TOC) in Soil

The rapid wet oxidation method based on Walkey and Black procedure was used for the determination of total organic carbon (TOC).

TOC is calculated thus:

Organic Carbon (g/kg) = ((meq$K_2Cr_2O_7$ -meq$FeSO_4$) x (003x1000x1.3))/Weight of water free sample (g)

Total Organic Matter (g/kg) = Total organic carbon (g/kg) x 1.729

Where,

meq $K_2Cr_2O_7$ = 1N x 10ml

meq $FeSO_4$ = 0.5N x volume of titrant in ml

0.003 = mill equivalent weight of carbon

1.30 = Correlation factor

1000 = Conversion factor to kg.

Chloride in Soil

APHA 4500- Cl. B was employed for the analysis of Chloride. Silver Chloride is precipitated quantitatively before red Silver Chromate is formed using Potassium Chromate as indicator.

Calculation:

Mg Cl^-/l = ((A–B) × (N×35450))/Ml sample

Where A = ml titration of sample

B = ml titration for blank

C = Normality of $AgNO_3$

Nitrate in Soil

APHA 4500 – $No3^-$. E was used for determination of Nitrate. Here, nitrate is reduced quantitatively to nitrite in the presence of cadmium treated with copper sulphate and packed in a glass column. The NO_2 produced thus is determined by diazotizing with sulphamilamide and coupling with N –(1-naphthyl) – ethylenediamine dihydrochloride to form a highly coloured azo dye that is measured calorimetrically. Concentrations of nitrate are obtained directly from standard curve plotted using standard concentration.

Phosphate in Soil

APHA 4500 – P. C was used to determine phosphate in the samples. In a dilute orthophosphate solution, ammonium molybdate reacts under acid conditions to form a heteropoly acid, molybdophosphoric acid. In the presence of vanadium, yellow vanadomolybdophosphoric acid is formed. The intensity of the yellow colour is proportional to phosphate concentration.

Phosphate concentrations are calculated as follows:

Mg P/l = (mg P(50ml final volume) × (1000))/ Ml sample

Sulphate in Soil

APHA 4500 – SO_4 E was employed for the analysis of sulphate. Here, sulphate ion is precipitated in an acetic acid medium with barium chloride so as to form barium sulphate crystal of uniform sizes. Light absorbance of the $BaSO_4$ suspension was measured by a photometer and the SO_4^{2-} concentration was determined by comparison of the reading with a standard curve.

Exchangeable Cations in Soil

Exchangeable cations (Mg, Ca, K, and Na) were determined as described by APHA 18th edition APHA 3111B and ASTM D3561. The concentrations are calculated thus:

Concentration (mg/kg) =((A-B)*C)/D

Where A = concentration of metal in sample

B = concentration of metal found in blank

C = volume of extract, ml

D = weight of dry sample, g.

Redox Potential in Soil

The ASTM D 1498 test method was used for determining redox potential using the Orion Multimeter (model 1260).

Total Petroleum Hydrocarbon in Soil

USEPA 8015C was employed for the determination of TPH. Samples were extracted using Dichloromethane for hydrocarbons analytes. The extracts were injected into Gas Chromatograph for quantitation of hydrocarbon present in the sample. The final results were calculated by relating to reference standards plotted using Chemstation Integration System.

Heavy Metals in Soil

Heavy metals content of soil samples was determined using Shimadzu AA 6650F. Atomic Absorption Spectrophotometer. The sample digestion / preparation procedure followed is as described in ASTM D5198/D3974. The AAS measurement done following the procedures indicated below.

Cd, Zn, Fe, Ni, Cr, Pb, Cd and Cu: APHA 20th edition 3111b

Ba: ASTM D3651

V: APHA 20th edition 3111 D

Metal concentration of soil sample (mg/kg) = (A – B) x C/D

Where A = Concentration of metal in sample (mg/l) as determined by AAS
B = Concentration of the metal found in blank (mg/l)
C = Volume of extract (ml)
D = Weight of dry sample

Hg: APHA 3112b & ASTM D 3223.

Mercury (Hg) concentration is determined thus: ųg/g = $\frac{(A-B)C}{D}$

Where A = concentration of mercury in sample, ųg/ml as determined by AAS (Instrument Reading)
B = concentration of mercury found in blank, ųg/ml (Procedural blank)
C = volume of extract (ml)
D = weight of dry sample (g)

Particle Size Distribution

The Hydrometer method was used and includes the following procedure:

- The sedimentation tube was filled with water and agitated at least 30 times for 2 minutes.
- The suspension was left to sediment according to determined time.
- The hydrometer was placed into the cylinder.
- The mixture was dispersed for 15 minutes with a dispersing paddle and the paddle washed with distilled water, allowing the wash water to run into the container with suspension.
- The suspension was poured into a PSD cylinder (Bouyoucos cylinder) and the jar rinsed with distilled water from the wash-bottle.
- The cylinder was filled with distilled water to the appropriate mark (1130ml for a 50 g sample) with the hydrometer inside.
- The hydrometer was removed and cylinder inverted a few times, then placed in the thermostat bath which is kept as near to $20^{O}C$ as possible.
- Then contents of the cylinder were shaken to give a homogenous suspension after which the cylinder was returned to the water-bath and the time recorded.
- Sixty minutes after the cylinder has been placed in the bath, the hydrometer was inserted and reading taken.
- Then the hydrometer was removed and the cylinder shaken again as previously described.
- The cylinder was then placed on a table and the stop-watch started. Thereafter, in about 20 seconds, the hydrometer was insert and reading taken at 40 & 60 seconds.

Calculations

The following gives the maximum diameter of the particles which are accounted for by the hydrometer after different time intervals:

HydrometerReadings(mm)	diameterofparticles	Particle (mm)
18 seconds	0.075	
40 seconds	0.050	Silt & Clay
60 seconds	0.005	Clay

Calculate the particle size (D):

Pebble and Gravel

Gravel (or Pebble) (%) = G * 100 / weight of sample taken

Where G = weight retained on sieves > 2 mm

Sand

The portion of particles retained is weighed on each of the set from 2 – 75 µm sieve. The percentage sand is calculated as a cumulative sum of the individual percentages as:

Sand (%) = Wr * 100 / (Wt)

Where;

Wr = weight of particles retained on each sieve

Wt = total weight of air (or oven) dried sample taken

Silt + Clay: (% silt = 100 – (% sand + % clay)

The particle size (D) is calculated at different times from the relationship:

D (mm) = 0.315 * k * √(L/T)

Where;

K = sedimentation constant at a given temperature & particle density. If density is not known, then value for k = 2.65 will be 0.01365 at 20^{o}C; or 0.01286 at 25^{o}C (mg/m^{3})

L = tabulated effective length for the hydrometer reading (mm)

T = sedimentation time (min) for the particle

The cumulative percentage (P) plotted against particle size diameter (D) on a semi-logarithmic, graph paper. The percentage of clay, silt and fine, coarse sand, gravel and cobble are interpolated for the following:

Clay = < 0.002 mm

Silt = 0.002 - 0.02 mm

Fine Sand = 0.02 - 0.20 mm

Coarse Sand = 0.20 - 2.0 mm

Gravel = 2.0 - 64 mm

Cobble = 64 - 256 mm

4.2.5.1.2 Soil Microbiology

Total Heterotrophic Bacteria and Fungi in Soil

Total heterotrophic bacteria and fungi in the soil samples were determined using APHA 9215B/9610B and ASTM D 5465-93 (Pour plate) test methods. Serial dilution of the samples was carried out using sterile water. Aliquots of the 10-fold dilutions were plated on Nutrient agar and Sabouraud Dextrose agar for the enumeration of heterotrophic bacteria and fungi respectively. Bacterial plates were incubated at 35^{O}C for 24-48 hours whereas fungal plates were incubated at the same temperature for 3-5 days.

Total microbial colonies were calculated as follows:

Soil samples (cfu/ml) = (colony counted/ actual vol. of sample inoculated) * dilution factor

Hydrocarbon Utilizing Bacteria in Soil

Bacteria in the soil capable of utilizing hydrocarbons as their sole source of carbon and energy were determined using APHA 9215C/ASTM 5465-93 (spread plate) test methods. Serial dilution of the samples was carried out using sterile water. Aliquots of the 10 - fold dilutions were spread on minimal medium containing the appropriate mineral salts for bacterial and fungal growth. Crude oil-moistened filter papers placed on the lid of the inverted plates provided the carbon source for growth. The plates were incubated at 35^{O}C for 7-10 days.

Total microbial colonies were calculated as follows:

Soil samples (cfu/ml) = (colony counted/ actual vol. of sample inoculated) * dilution factor

4.2.6 Data Analyses

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

4.3 Baseline Environmental Conditions

The detailed description of the environmental conditions of the study area as established during the field study and review of related literature is presented in this section.

4.3.1. Geology & Hydrogeology of the area

The geology of the Niger Delta has been described in various scientific papers (e.g, Akpokodje 1979, Akpokodje 1987, Arnajor and Ngerebara 1990, Ete-efeotor and Akpokodje 1990). The Niger Delta covers an area of about 75000 km^2, Extending from the Calabar flank and the Abakaliki trough in Eastern Nigeria to the Benin flank in the west. The Niger Delta opens to the Atlantic ocean in the south and protrudes into the Gulf of Guinea as an extension from Benue trough and Anambra Basin, The Delta complex merges westwards across the Okitipupa high into the Dahomey Embayment. The Guinea Ridge and the Cameroon Mountains form the southeast margin. The formation of the Niger Delta began in early Palaeocene time and was as a result of the accumulation of fine grained sediments eroded and transported by the River Niger and its tributaries. The Niger Delta is composed of three sub-surface lithostratigraphic units including the following formations.

Benin formation

This formation, which is approximately 2100m thick, is the most prolific aquifer in the region and is comprised of over 90% massive, porous sands with localized day/shale interbeds, The quaternary deposits, which are 40 to 150m thick, generally consist of rapidly alternating sequences of sand and silt/clay, with the latter becoming increasingly more prominent seawards.

Agbada formation

This formation underlies the Benin formation, and was deposited under a transitional environment, with an almost equi-compositional make up of sands and shale.
However increasing clays may occur with depth.

Akata formation

This formation was deposited within the marine environment and underlies the Agbada formation. It consists of marine clays, silts and shale with occasional turbidite sand lenses. The formation is rich in organic matter and is the source rock of oil in the Niger Delta. It has an approximate thickness of 5882 m. These formations are overlain by various deposits of quaternary age as indicated in table below. Shown in Table 4.5 are the geologic units present in the Niger Delta.

Table 4.5: Geologic Unit of the Niger Delta (Allen, 1965)

Geologic Units	Lithology	Age
Alluvium (general)	Gravel, sand, clay, silt	Quaternary
Fresh water back swamp meander belt	Sand, clay, some silt, gravel	Quaternary
Mangrove and salt water/back swamps	Medium fine sands clay & some silt	Quaternary
Active & abandoned beach	Sand, clay and some silt	Quaternary
Sombreiro Warri Deltaic Plain	Sand, clay and some silt	Quaternary
Benin Formation (coastal plain sand)	Coarse to medium sand with subordinate silt & clay	Miocene
Agbada Formation	Mixture of sand, clay & silt	Eocene
Akata Formation	Clay	Palaeocene

4.3.2 Climate, Meteorology, Ambient Air Quality and Noise

4.3.2.1. Climate and Meteorology

The climatic and meteorological features such as rainfall, air temperature, relative humidity, wind direction/speed and sunshine of the area were obtained from literature. However, this was also complemented with information obtained from the field (Appendix 4.2).

The weather and climate of the study area, like the entire Niger Delta area, is closely tied to the general mesoscale trend in Nigeria. It follows that the weather regime experienced at any given location in Nigeria during the year is determined primarily by the geographical location in relation to the fluctuating position of the Inter-Tropical Convergence Zone (Ayoade, 1988). In this regard, the predominant weather regime in the study area is warm and humid.

The study area is within the humid tropical zone with defined dry (November – March) and Wet (April – October) seasons. The wet season is brought about by the South-West trade wind blowing across the Atlantic Ocean. This begins around April and stretches to October. September and October are the peak of flood in the area. The flood gradually recedes from November. The dry, dusty, and often cold North-East trade winds blowing across the Sahara Desert dominates the dry season and brings a short period of harmattan (Oguntoyinbo and Hayward, 1987). This starts around November and terminates in March.

4.3.2.2 Rainfall Pattern

The level of rainfall is a function of the hydrological factors, which in turn are driven by the circulation of the oceans and the atmospheric meteorology (Derek and Oguntoyinbo, 1987).

Rainfall in the project area is seasonal, variable, and heavy. This is typical of rainfall in the coastal area of Nigeria. Generally, south of latitude 05°N, rain occurs, on the

average, every month of the year, but with varying duration. The area is characterized by high rainfall, which decreases from south to north. The mean total annual rainfall decreases from about 4,700 mm on the coast to about 1,700 mm in extreme north of the area. For example, in Rivers State, it is 4,698 mm at Bonny along the coast and 1,862 mm at Degema (Online Nigeria, 2003).

Rainfall is adequate for all year round crop production in the project area. According to Online Nigeria (2003), the mean annual rainfall as measured in Port Harcourt, the nearest major urban centre that has a weather station, shows that the wet season exhibits heavier rains with the highest occurring in September (367.1mm) and less intense in December to February (25.9-56.5mm) (Figure 4.2).

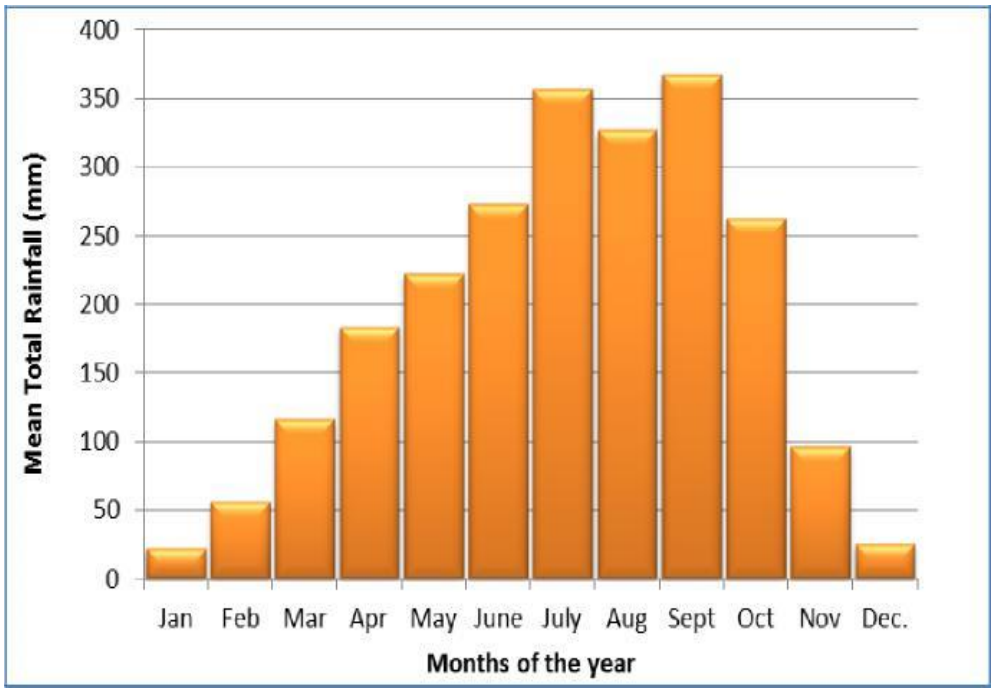


Figure 4.2 Variation in the monthly mean amount of rainfall in the project area
(Source: Nigerian Institute of Meteorology (NIMET))

According to Online Nigeria (2003), the duration of the wet season is not less than 330 days, of which a great number is rainy days (days with 250 mm or more of rain). It is worthy to note that rainfall is adequate for all year round crop production in the project area.

4.3.2.3 Temperature

The mean air temperature in the study area is fairly constant (SIDS BV, 1999). Mean maximum monthly temperatures in the study area range from 28°C to 33°C, while the mean minimum monthly temperatures are in the range of 17°C to 24°C (Figure 4.3).

According to Online Nigeria (2003), the mean annual temperature for the area is 26°C and the hottest months are February to May. Air temperature, like relative humidity and atmospheric pressure, is subject to rapid changes during the passage of thunderstorms (Gobo, 1998).

Relatively high atmospheric temperatures were measured in the study area during the fieldwork. At the sampling stations, atmospheric temperatures varied from 35.79 – 36.88°C with a mean of 36.4°C (Table 4.6). These ambient air temperature levels

recorded were typical of coastal tropical environments (Ayoade, 2004). High atmospheric temperatures enhance the formation of photochemical oxidants such as tropospheric ozone and peroxylacetylnitrate (PAN). The spatial temperature variations recorded during the study may likely be accounted for by the transient cloud cover and time of day.

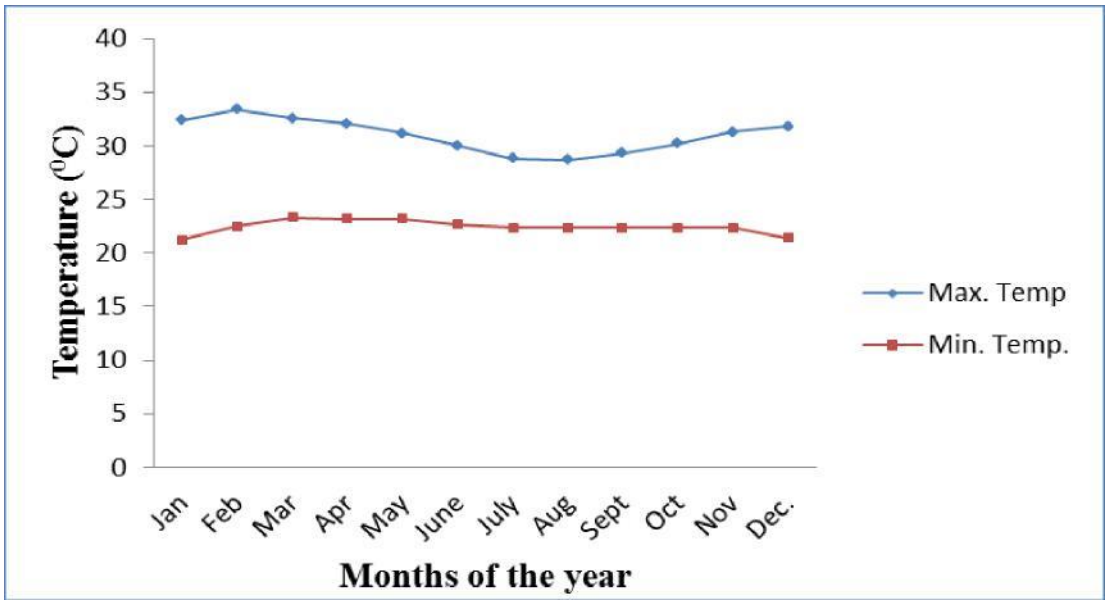


Figure 4.3: Monthly Mean Maximum and Minimum Temperature within the project area

(Source: Nigerian Institute of Meteorology (NIMET)

Table 4.6: Measured meteorological parameters at NOPL-Indorama Tie-in project area during the EIA

Parameters	Sampling stations		
	Maximum	Minimum	Mean
Temperature (°C)	36.88	35.79	36.41
Humidity (%)	58.61	53.54	56.10667
Wind speed (m/s)	1	0.8	0.9

4.3.2.4 Relative Humidity

Relative humidity is high in the area throughout the year and decreases slightly in the dry season (Salawu, 1993). The available data indicates that relative humidity in the area is very high in the early hours and evening time. Afternoon in the study area are usually hot and humid (Ayoade, 1988). During the dry months (March-November), humidity can fall sharply to as low as 20-40% for a few days during the harmattan spell, leading to larger daily variations than in other months of the year (SIDS BV, 1999). Relative Humidity averaged 56.11% in the study area during this field survey.

4.3.2.5. Wind Speed and Direction

Winds in the area are fairly consistent and sometimes very strong, especially during squalls associated with thunderstorms. It is these thunderstorms and the local 'tornadoes' accompanying them that are the dominant features of the weather in the area. They may occur throughout the year, even during the dry season, producing wind gusts of up to 100km/h (SIDS BV, 1999).

Furthermore, wind speeds were observed to be lower at nights compared to values recorded during day time hours. The highest wind speeds in the project area are recorded at the onset of the rainy season and this is usually in the month of March (Oguntoyinbo and Hayward, 1987).

Low wind velocities were observed during the sampling exercise with a range of 0.8 – 1.0 m/s at the sampling stations with a mean of 0.9 m/s (Table 4.5a). The predominant wind direction during the study varied between South and Northwest in direction. This observation agrees with the long term wind distribution data retrieved and analysed for Bonny (2004 - 2010) which shows that the wind blows generally from the south-westerly (SW/S/W) direction (Figure 4.4). 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.

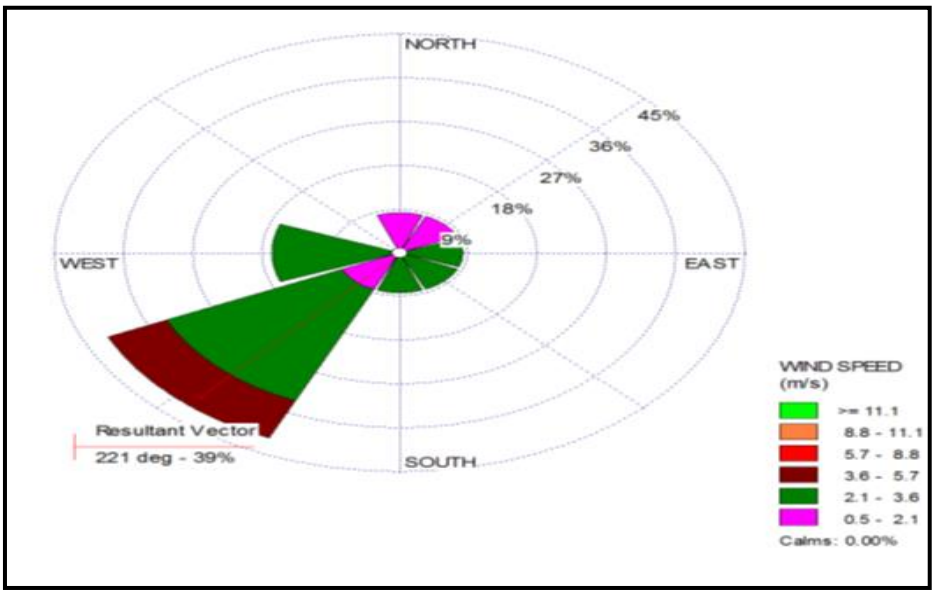


Figure 4.4: Typical Wind Rose for the study area

4.3.2.6 Ambient Air Quality

Due to the dangers of excessive release of air pollutants into the atmosphere from anthropogenic activities, which ultimately affect man and his interests, attempts have been made to limit the volume of noxious gases and particulates that are discharged indiscriminately into the atmosphere. In present times, air quality is being judged against legally adopted standards.

In Nigeria, the regulatory agencies like the Department of Petroleum Resources (DPR) and the Federal Ministry of Environment (FMEnv) have adopted standards as the national interim standards for particulates and gaseous emissions in the nation's ambient air quality.

Air quality measurements for the NOPL-Indorama tie-in project were collected from three (03) stations situated around the project area and these were compared with data collected from control stations in Obigbo/Indorama Location as well as their respective DPR/FMEnv limits. The details of the data collected from the field is attached as Appendix 4.2, while summary of the results obtained are presented in Table 4.7 which also shows the trend of the air quality parameters in the last 7 years.

The air quality parameters measured in the field include $PM_{2.5}$ and PM_{10} suspended particulate matter (SPM), carbon monoxide (CO), Volatile Organic Compounds (VOCs), methane (CH_4), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2) and Carbon dioxide (CO_2). As shown in Table 4.7, only values for $PM_{2.5}$ and PM_{10} SPM and VOCs were detectable in the atmosphere within the NOPL-Indorama tie-in area of focus and all were lower than values in the control sampling stations as well as very much below regulatory limits. The concentrations of Carbon monoxide (CO), methane (CH_4), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2) and Carbon dioxide (CO_2) in the atmosphere were too low to be captured by the handheld meter used for their measurement.

Volatile Organic Compounds (VOCs)

Volatile Organic Compounds was detected in this fieldwork at very low quantity at the sampling sites (Table 4.7). VOCs are low molecular weight organic fractions with boiling points low enough to make them readily volatile. At elevated levels, VOCs health effects include eye, nose and throat irritation, headaches, damage to liver, kidney and central nervous system (Jianfei *et al.*, 2018).

Sulphur dioxide (SO_2)

Sulphur dioxide is one of the killer constituents of classical smog. It is also an acid rain forming gas. In this study, atmospheric concentrations of SO_2 were below the equipment detection limit of 0.01 ppm and by implication, the FMEnv limit of 0.1 ppm. 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 the precursor gas for troposphere ozone formation which is a greenhouse gas. It also 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 0.01ppm the detection limit of the sampler) at any of the sites (Table 4.7). It is significant to state that NO_2 has always been found in low concentrations at the neighouring environment (Table 4.7).

Methane (CH_4)

Technically and scientifically speaking, methane is classified as a volatile organic compound. As a result of its global warming potentials, it was given a special consideration in this fieldwork. CH_4 was not detected at any of sampling and control sites in this study (Table 4.7).

Carbon Monoxide (CO)

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 study, CO was not detected which indicates healthy environment for this parameter..

Respirable ($PM_{2.5}$) and Inhalable (PM_{10}) Particulate Fractions

The most widespread and challenging of the criteria air pollutants in Nigeria is airborne particles (Akeredolu 1989; Ukpebor *et al.*, 2006). 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 $PM_{2.5}$ and PM_{10}. During the study, baseline $PM_{2.5}$ concentration was found to vary from 4.9-7.1 µg/m^3, while PM_{10} concentration varied from 15.6-16.3 µg/m^3 (Table 4.7). At all the three sampling sites the $PM_{2.5}$ and PM_{10} levels were below the FMEnv 250 µg/m^3 regulatory limit. At excessive levels, the health and environmental impacts of elevated $PM_{2.5}$ and PM_{10} can be grave (WHO 2002; Okokon *et al.*, 2018). They include inflammatory reactions in the lungs, respiratory symptoms and adverse effects on the cardiovascular system. The values recorded during this study are within the same range of values obtained during the OB/OB Eleme gas pipeline EIA study in 2013 and the NOPL Pipeline EIA study in 2016 (IEFCL, 2013 and TEPNG, 2016). In all cases the recorded values were below the FMEnv. Limit of 250 µg/m^3. Spatial variations in the respirable and inhalable fractions were found to be statistically insignificant ($P > 0.05$).

4.3.2.7 Noise levels

Noise at the study area emanates from both natural and anthropogenic sources. Quite remarkably, the baseline noise data captured in this study area were within the international and national noise regulatory limits. The noise level varied from 53.0 dB(A) to 55 dB(A) at the sampling stations with a mean noise value of 54 dB(A). A perfect compliance with the FMEnv occupational noise limit of 90 dB(A) was observed in this study. Independently, noise increases risk of annoyance, cardiovascular disorders, cognitive impairments and is a suspected risk factor for other mental health conditions such as anxiety and depression (WHO 2011; Basner et al., 2013).

4.3.2.8 Air Quality and Noise Trending

To establish the state of and trends in air quality, data were gathered on air quality parameters from the area over the period 2011 to 2020 (IEFCL, 2013 and TEPNG, 2016) and three sets of data were available (Table 4.7). The air pollutants considered were $PM_{2.5}$ and PM_{10} suspended particulate matter (SPM), carbon monoxide (CO), Volatile Organic Compounds (VOCs), methane (CH), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2) and Carbon dioxide (CO_2).

The objective of the analysis was to establish whether, and the extent to which, concentrations of air pollutants and noise level have changed over this period. Comparative analyses of the air quality parameters shows that generally they all presented in very low levels with a tendency to reduce in magnitude between 2013 and 2020, this was however, not statistically significant ($p>0.05$). The low level of air pollutant gases in the area is understandable because they are mainly products of combustion from vehicles and other fossil fuel consuming equipment such as generators which do not operate regularly in the study area.

The noise level was similarly within very narrow range but with a tendency to increase over the years. Overall, there was a downward and later an upward trend in the noise levels with significant difference ($p = 0.017$) in levels as shown by the T-Test statistics.

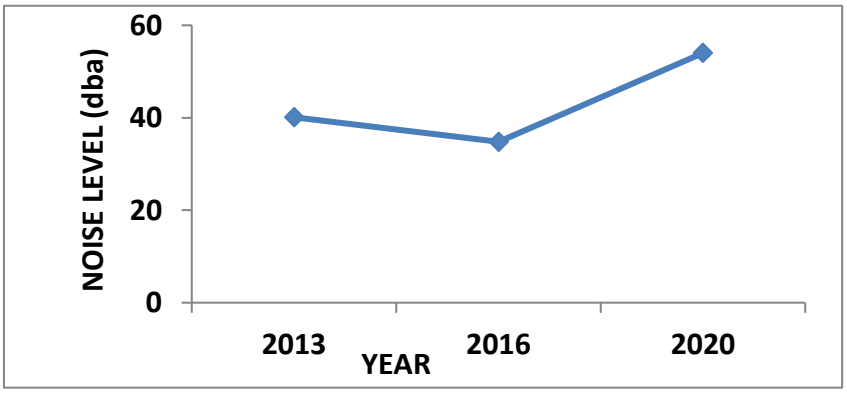


Fig 4.5:Trend of Noise level (dba) in the study area of NOPL-Indorama Tie-in

Table 4.7: Summary and Trend analysis of measured Air pollutants and noise levels during the NOPL-Indorama tie-in EIA study

Parameter	OB/OB Eleme Gas, EIA (IEFCL, 2013)	NOPL Gas Pipeline, EIA (TEPNG, 2016)	NOPL-Indorama Tie-in EIA (2020)		DPR Limit	FMEnv Limit
	Sampling stations	Sampling stations	Sampling stations	Control Stations		
	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)		
VOC (mg/m3)	0.36± 1.09 (<0.1 - 6.8)	BDL	0.002±0.001 (0.001 – 0.003)	0.001± 0.0 (0.001-0.001)	NA	160
SO_2 (ppm)	0.42± 1.36 (<0.1 - 8.6)	BDL	BDL	BDL	NA	0.04 – 0.06
NO_2 (ppm)	1.2 ± 2.82 (<0.1- 19.1)	BDL	BDL	BDL	0.04	0.1
CH_4 (%)	NA	BDL	BDL	BDL	NA	NA
CO_2 (%vol)	NA	NA	BDL	BDL	NA	NA
CO (ppm)	0.27± 0.88 (<0.1 - 5.6)	BDL	BDL	BDL	10	10 – 20
H2S	0.28±0.008 (<0.01 - 0.05)	BDL	NA	NA	NA	8
SPM	24.56 ±11.85 (7.69 - 64.8)	32.1 -62.35	NA	NA	150 - 230	250 – 600
$PM_{2.5}$ (µg/m3)	NA	NA	5.97±1.10 (4.9-7.1)	6.5 ± 1.56 (5.4-7.6)	NA	250
PM_{10} (µg/m3)	15.98 ± 8.24 (4.53 - 46.5)	NA	15.9±0.36 (15.6-16.3)	20.45±6.01 (16.2-24.7)	NA	250
Noise (dba)	40.13±5.99 (30.1 - 58)	34.80- 57.60	54 ±1.0 (53 – 55)	65 ± 4.24 (62-68)	85	90

Parameter	OB/OB Eleme Gas, EIA (IEFCL, 2013)	NOPL Gas Pipeline, EIA (TEPNG, 2016)	NOPL-Indorama Tie-in EIA (2020)		DPR Limit	FMEnv Limit
	Sampling stations	Sampling stations	Sampling stations	Control Stations		
	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)		
THC (mg/m3)	NA	BDL	NA	NA	NA	NA
Pb (mg/m3)	NA	0.029 - 0.052	NA	NA	0.5 – 1.0	NA
Cu (mg/m3)	BDL	BDL - 0.016	NA	NA	NA	NA
Cr (mg/m3)	BDL	BDL - 0.005	NA	NA	NA	NA
Zn (mg/m3)	BDL	BDL - 0.188	NA	NA	NA	NA
Ni (mg/m3)	NA	0.021-0.074	NA	NA	NA	NA
Cd (mg/m3)	BDL	0.016 - 0.36	NA	NA	NA	NA
Mn (mg/m3)	BDL	NA	NA	NA	NA	NA
Fe (mg/m3)	BDL	NA	NA	NA	NA	NA

NA: Not Available; 0.01 = detection limit for the sampler for SO_2, NO_2, VOC, CH_4, CO; BDL = Below Detection Limit

The objective of the analysis was to establish whether, and the extent to which, concentrations of air pollutants and noise level have changed over this period. Comparative analyses of the air quality parameters over the period of 2013 to 2020 shows that generally they all presented in very low levels with a tendency to reduce in magnitude between 2013 and 2020, this was however, not statistically significant ($p>0.05$).

The low level of air pollutant gases in the area is understandable because they are mainly products of combustion from vehicles and other fossil fuel consuming equipment such as generators which do not operate regularly in the study area. The noise level was similarly within very narrow range but with a tendency to increase over the years. Overall between 2013 and 2020, there was a downward and later an upward trend in the noise levels with significant difference ($p = 0.017$) in levels as shown by the T-Test statistics.

4.3.3. Soil studies

This subsection discusses the physico-chemical, heavy metals and microbiological characteristics of soils within the project area and the control stations.

4.3.3.1 Soil Physico-chemical Characteristics

The summary of results of physico-chemical characteristics of the topsoil (0 – 15 cm) and subsoil (15 – 30 cm) for the study area and control are presented in **Tables 4.8a** and **4.8b**, respectively. Detailed analytical and Paired–Samples T-test results are presented in **Appendices 4.3 to 4.8**.

Colour

Colour of soil tells much about how the soil is formed and what it is made of. The colour may range from white through brown, to black as a result of an increasing content of humus, which is finely divided, partially decomposed organic matter. Red and yellow colours are the results of small quantities of iron compounds, while the yellow may indicate the presence of limonite. The colour of the soil samples taken at both depths within the project area of influence ranged from light brown to dark brown, while the control stations showed light brown to yellowish brown.

Moisture Content

The soil moisture content correspondingly referred to as water content is an indicator of the quantity of water existing in soil. The values ranged from 14.50 – 16.10% (Mean = 15.26±0.63%) in top soil and 15.30 – 16.90% (Mean = 15.99±0.58%) in subsoil. Spatial variation across sampling stations was low (CV < 5.0%) and the difference between mean values of topsoil and subsoil was not significant ($p>0.05$). The control stations, however, showed values (Mean values = 17.95% and 19.15% at topsoil and subsoil respectively) higher than from the project area, possibly due to higher clay content in control samples, making it capable of holding more water. Previous study around the area reported higher moisture content in soil (TEPNG, 2016) (**Table 4.8**), possibly due

to the wet season period that the samples were taken as against the current study that was conducted during the dry season.

Soil moisture is a crucial variable in governing the exchange of water and warmth energy among the land surface and the atmosphere through plant transpiration and soil evaporation. In plant situation, the uptake of nutrients through the roots is intermediated by soil water. Consequently, water and soil are the elementary requirements for the life and growth of plants. Soil water also influences soil microbial processes and biological soil remediation, in addition to soil permeability for estimation of the success of *in situ* remediation.

Table 4.8a: Summary of soil physico-chemical characteristics within the project area and control (Topsoil: 0 – 15 cm)

Parameter	PROJECT AREA				CONTROL	
	Range	Mean	STD	CV (%)	Range	Mean
Colour	Light Brown – Dark Brown				Light Brown – Yellowish Brown	
Moisture Content (%)	14.50 - 16.10	15.26	0.63	4.11	17.80 - 18.10	17.95
Sand (%)	74.30 - 84.40	78.50	3.52	4.48	81.4- 84.70	83.05
Silt (%)	13.50 - 20.00	16.59	2.62	15.82	6.90 - 9.17	8.04
Clay (%)	2.10 - 8.50	4.99	1.88	37.69	6.13 - 11.70	8.92
Porosity (%)	45.20 - 51.00	48.40	1.80	3.71	53.10 - 53.40	53.25
Permeability (cm/s)	0.88 - 1.89	1.48	0.46	31.27	0.66 - 0.69	0.68
Bulk Density (g/cm^3)	1.20 - 1.31	1.26	0.04	3.12	1.10 - 1.21	1.16
pH	4.61 - 5.60	4.99	0.31	6.21	4.71 - 4.85	4.79
Redox Potential (mV)	83.70 - 296.0	143.7	63.72	44.34	147.0 - 284.0	215.50
TOC (%)	0.20 - 1.68	0.97	0.47	48.33	1.22 - 1.29	1.26
TOM (%)	0.35 – 2.91	1.68	0.80	47.62	2.11 – 2.23	2.18
Total N (%)	0.04 - 0.14	0.09	0.03	34.74	0.108 - 0.112	0.11
Nitrate (mg/kg)	5.04 - 26.50	11.15	7.20	64.61	5.43 - 7.83	6.63
Nitrite (mg/kg)	0.12 - 0.47	0.24	0.12	47.27	0.42 - 0.57	0.49
Ammoniun (mg/kg)	4.05 - 21.30	8.59	5.85	68.10	4.37 - 6.28	5.33
Total P (mg/kg)	5.81 - 44.60	18.16	12.27	67.59	94.10 - 229.0	161.55
Phosphate (mg/kg)	3.45 - 26.50	10.79	7.29	67.58	55.90 - 136	95.95
Sulphate (mg/kg)	22.60 - 120.0	70.35	29.70	42.21	113.0 - 155.0	134.00
Salinity (mg/kg)	0.01 - 0.07	0.03	0.02	66.33	0.019 - 0.086	0.05
Sodium (mg/kg)	42.00 - 48.90	46.11	2.54	5.50	51.80 - 53.30	52.55
Potassium (mg/kg)	100.0 - 127.0	113.8	10.24	9.00	135.0 - 138.0	136.5
Magnesium (mg/kg)	23.10 - 29.70	25.85	2.52	9.77	23.40 - 24.00	23.7
Calcium (mg/kg)	307.0 - 338.0	318.38	10.16	3.19	310.0 - 317.0	313.5
CEC (meq/100g)	44.70 - 47.80	45.93	1.19	2.59	46.40 - 47.20	46.80
Oil & Grease (mg/kg)	15.20 - 22.70	18.95	4.01	21.16	15.20 - 22.70	18.95
THC (mg/kg)	-	<0.10	-	-	7.58 - 15.20	11.39
TPH (mg/kg)	-	<0.010	-	-	-	<0.010

Parameter	PROJECT AREA				CONTROL	
	Range	Mean	STD	CV (%)	Range	Mean
PAHs (mg/kg)	-	<0.001	-	-	-	<0.001
BTEX (mg/kg)	-	<0.001	-	-	-	<0.001

SD – Standard Deviation; CV – Coefficient of variation

Table 4.8b: Summary of soil physico-chemical characteristics within the project area and control (Subsoil: 15 – 30 cm)

Parameter	PROJECT AREA				CONTROL	
	Range	Mean	STD	CV (%)	Range	Mean
Colour	Light Brown – Dark Brown				Light Brown – Yellowish Brown	
Moisture Content (%)	15.30 - 16.90	15.99	0.58	3.64	19.00 - 19.30	19.15
Sand (%)	71.90 - 84.30	78.65	4.63	5.88	86.90 - 88.60	86.90
Silt (%)	10.30 - 23.10	16.03	4.37	27.28	3.12 - 3.77	3.45
Clay (%)	3.60 - 6.90	5.33	1.26	23.71	6.41 - 9.98	8.20
Porosity (%)	45.70 - 50.00	47.26	1.62	3.43	51.70 - 54.90	53.30
Permeability (cm/s)	0.79 - 1.83	1.32	0.45	34.13	0.65 - 0.74	0.70
Bulk Density (g/cm^3)	1.15 - 1.30	1.23	0.05	4.20	1.16 - 1.24	1.20
pH	4.64 - 5.21	5.01	0.19	3.82	4.70 - 5.01	4.86
Redox Potential (mV)	57.10 - 279.0	133.0	68.60	51.57	156.0 - 311.0	233.50
TOC (%)	0.08 - 1.48	0.79	0.44	56.02	0.63 - 0.75	0.69
TOM (%)	0.14 – 2.56	1.37	0.76	55.53	1.09 – 1.30	1.19
Total N (%)	0.03 - 0.13	0.08	0.03	37.67	0.068 - 0.076	0.07
Nitrate (mg/kg)	6.28 - 20.20	11.47	4.39	38.24	5.57 - 8.91	7.24
Nitrite (mg/kg)	0.06 - 0.42	0.25	0.13	51.87	0.25 - 0.37	0.31
Ammoniun (mg/kg)	5.05 - 16.20	9.21	3.51	38.15	4.48 - 7.16	5.82
Total P (mg/kg)	6.75 - 50.70	19.22	14.10	73.37	157.0 - 188.0	172.50
Phosphate (mg/kg)	4.01 - 30.10	11.41	8.37	73.38	93.20 - 112.0	102.60
Sulphate (mg/kg)	32.80 - 154.0	78.13	40.39	51.70	113.0 - 155	134.00
Salinity (mg/kg)	0.01 - 0.06	0.03	0.02	60.54	0.015 - 0.052	0.03
Sodium (mg/kg)	45.40 - 53.90	49.20	3.19	6.48	53.90 - 56.20	55.05
Potassium (mg/kg)	112.0 - 148.0	127.5	13.30	10.43	148.0 - 149.0	148.5
Magnesium (mg/kg)	26.40 - 34.90	29.59	2.98	10.07	25.70 - 26.10	25.9
Calcium (mg/kg)	322.0 - 368.0	338.5	14.96	4.42	322.0 - 327.0	324.5
CEC (meq/100g)	47.30 - 54.30	49.51	2.51	5.07	48.90 - 49.20	49.05
Oil & Grease (mg/kg)	7.58 - 15.20	11.39	4.07	35.76	7.58 - 15.2	11.39
THC (mg/kg)	-	<0.10	-	-	<0.10 - 7.58	3.79
TPH (mg/kg)	-	<0.010	-	-	-	<0.010
PAHs (mg/kg)	-	<0.001	-	-	-	<0.001
BTEX (mg/kg)	-	<0.001	-	-	-	<0.001

SD – Standard Deviation; CV – Coefficient of variation

Table 4.9: Comparison of data in current study with previous study around the project area

Parameter	Current Study		NOPL EER-Based EIA (TEPNG, 2016		OBOB-Eleme Gas Pipeline EIA, (IECL, 2013)	
	Topsoil	Subsoil	Topsoil	Subsoil	Topsoil	Subsoil
Moisture Content (%)	14.50 - 16.10	15.30 - 16.90	16.94 - 25.52	17.55 - 26.25	ND	ND
Sand (%)	74.30 - 84.40	71.90 - 84.30	ND	ND	36.00 - 85.00	34.00 - 60.00
Silt (%)	13.50 - 20.00	10.30 - 23.10	ND	ND	10.00 - 32.00	10.00 - 36.00
Clay (%)	2.10 - 8.50	3.60 - 6.90	ND	ND	5.00 - 32.00	15.00 - 36.00
Porosity (%)	45.20 - 51.00	45.70 - 50.00	ND	ND	40.00 – 56.00	43.00 – 56.00
Permeability (cm/s)	0.88 - 1.89	0.79 - 1.83	ND	ND	ND	ND
Bulk Density (g/cm^3)	1.20 - 1.31	1.15 - 1.30	ND	ND	ND	ND
pH	4.61 - 5.60	4.64 - 5.21	5.42 - 5.58	5.34 - 5.56	4.18 – 6.54	3.75 – 6.40
Redox Potential (mV)	83.70 - 296.0	57.10 - 279.0	63.45 - 76.89	54.33 - 78.26	ND	ND
TOC (%)	0.20 - 1.68	0.08 - 1.48	0.99 - 1.09	0.64 - 0.87	0.34 – 2.50	0.25 – 2.61
TOM (%)	0.35 – 2.91	0.14 – 2.56	1.75 - 1.94	1.14 - 1.54	ND	ND
Total N (%)	0.04 - 0.14	0.03 - 0.13	0.09 - 0.10	0.070 - 0.08	0.01 – 1.10	0.01 – 1.00
Nitrate (mg/kg)	5.04 - 26.50	6.28 - 20.20	32.17 - 35.47	25.48 - 29.43	0.59 – 7.0	0.45 – 7.70
Nitrite (mg/kg)	0.12 - 0.47	0.06 - 0.42	ND	ND	ND	ND
Ammoniun (mg/kg)	4.05 - 21.30	5.05 - 16.20	ND	ND	0.02 – 20.2	0.02 – 22.80
Total P (mg/kg)	5.81 - 44.60	6.75 - 50.70	52.21 - 116.4	57.57 - 97.52	2.40 – 117.4	0.85 – 111.3
Phosphate (mg/kg)	3.45 - 26.50	4.01 - 30.10	38.76 - 47.46	39.79 - 52.07	ND	ND
Sulphate (mg/kg)	22.60 - 120.0	32.80 - 154.0	ND	ND	2.50 – 14.6	5.00 – 16.8
Salinity (mg/kg)	0.01 - 0.07	0.01 - 0.06	ND	ND	3.20 -25.4	1.20 – 10.00
Sodium (mg/kg)	42.00 - 48.90	45.40 - 53.90	38.68 - 45.69	35.36 - 44.89	0.10 – 61.3	0.12 – 49.5
Potassium (mg/kg)	100.0 - 127.0	112.0 - 148.00	85.02 - 100.42	77.78 - 98.78	0.08 – 10.9	0.04 – 4.96
Magnesium (mg/kg)	23.10 - 29.70	26.40 - 34.90	50.05 - 59.14	45.77 - 58.12	0.85 – 7.40	1.10 – 7.10
Calcium (mg/kg)	307.0 - 338.0	322.0 - 368.0	190.2 - 224.8	173.8 - 220.8	1.80 – 22.4	3.80 – 20.6
CEC (meq/100g)	44.70 - 47.80	47.30 - 54.30	ND	ND	7.10 – 32.7*	2.40 – 29.8*
Oil & Grease (mg/kg)	15.20 - 22.70	7.58 - 15.20	ND	ND	ND	ND

THC (mg/kg)	<0.100	<0.100	ND	ND	<0.01 – 2.5	<0.01
TPH (mg/kg)	<0.010	<0.010	15.36 - 18.16	18.37 - 23.92	ND	ND
PAHs (mg/kg)	<0.001	<0.001	1.16 - 1.41	1.34 - 1.60	ND	ND
BTEX (mg/kg)	<0.001	<0.001	<0.100	<0.100	ND	ND
Phenol (mgkg)	ND	ND	<0.100	<0.100	ND	ND
Al (mgkg)	3.32 - 4.23	4.34 - 4.92	ND	ND	ND	ND
As (mgkg)	<0.002	<0.002	<0.001	<0.001	<0.01	<0.01
Ba (mgkg)	16.80 - 18.00	16.10 - 25.80	<0.001	<0.001	ND	ND
Cd (mgkg)	1.10 - 1.35	1.19 - 1.35	0.03 - 0.06	0.02 - 7.48	<0.01 – 0.98	<0.01 – 0.80
Cr (mgkg)	1.03 - 1.30	1.10 - 1.24	0.42 - 2.10	0.46 - 1.11	0.01 – 44.05	<0.01-21.37
Cu (mgkg)	1.24 - 2.84	2.36 - 2.95	2.68 - 4.44	1.56 - 3.15	0.34 – 5.98	<0.01 – 4.89
Fe (mgkg)	24.50 - 27.90	26.20 - 29.40	47.02 - 54.61	26.06 - 41.65	208 - 3981	136 – 3561
Hg (mgkg)	<0.001	<0.001	<0.001	<0.001	<0.01	<0.01
Ni (mgkg)	2.14 - 2.69	2.32 - 2.82	0.24 - 2.30	0.41 - 1.24	<0.01 – 7.23	0.01 – 3.97
Pb (mgkg)	1.04 - 1.50	1.00 - 1.86	0.74 - 1.76	0.90 - 1.63	0.20 – 10.2	0.29 – 6.28
V (mgkg)	<0.002	<0.002	<0.001	<0.001	ND	ND
Zn (mgkg)	2.06 - 2.84	2.28 - 2.92	2.05 - 6.04	1.64 - 4.27	1.34 – 57.8	1.27 – 34.2
THB (cfu/g) $x10^4$	1.50 - 32.60	1.23 - 28.90	198.0 – 288.0	114.0 – 228.0	21.9 - 31.0	1.93 - 6.20
HUB (cfu/g) $x10^3$	<0.01 - 14.30	<0.01 - 6.05	170.0 – 264.0	82.0 – 890.0	0.01 – 0.07	0 – 0.08
THF (cfu/g)$x10^4$	0.30 - 2.00	0.10 - 5.35	162.0 – 182.0	127.0 – 164.0	1.37 - 4.80	0.18 – 0.73
HUF (cfu/g) $x10^2$	<0.1 - 18.00	<0.10 - 16.50	396.9 – 584.0	145.0 – 439.0	0.11 – 0.32	0 – 0.50
SRB (cfu/g)	<10.0	<10.0	ND	ND	ND	ND
E. Coli. (MPN/100ml	2.00 - 22.00	2.00 - 11.00	ND	ND	ND	ND

ND = Not determined

Soil Texture

The textural classification of both the topsoil and subsoil was predominantly sandy loam soil using the soil textural triangle. The mean sand, silt and clay contents of the topsoil were 78.50±3.52%, 16.59±2.62% and 4.99±1.88% respectively, while the subsoil recorded sand (78.65±4.63%), silt (16.03±4.37%) and clay (5.33±1.26%). Spatial variation across sampling stations was low in sand and silt, but moderately high in clay content, while their means in both topsoil and subsoil were not significantly ($p>0.05$) different. The control stations showed sand values within the ranges reported for the project area of influence, but lower silt and higher clay contents compared with the project area. Earlier study around the area (IEFCL, 2013), however, showed lower sand and higher clay contents than in current study.

The texture of a soil determines the water absorption/infiltration rate, the water holding capacity and the rate of migration of pollutants down the soil strata. The texture also determines the amount of soil aeration, ease of tilling, and soil fertility (Udoh 1986). Soil having low clay and high sand content is porous and will permit easy percolation of nutrients and pollutants to the groundwater table, causing depletion of soil nutrients at the topsoil and subsoil levels and make the groundwater vulnerable to pollution.

Other parameters that determine the structure of soil and dynamics of pollutants in soil include bulk density and porosity. The bulk density in particular gives a rough estimation of the aeration and permeability of a soil. The lower the bulk density, the higher is the permeability. Bulk density varies with structural conditions of the soil, therefore, it is related to packing and often used as a measure for soil structure. The results obtained in the study revealed porosity ranging from 45.20 – 51.00% and 45.70 - 50.00% for topsoil and subsoil respectively, permeability ranged from 0.88 - 1.89 cm/s for topsoil and 0.79 - 1.83 cm/s for the subsoil, while bulk density ranged from 1.20 - 1.31 g/cm^3 and 1.15 – 1.30 g/cm^3. Low spatial variation was observed in porosity and bulk density values (CV < 5.0%), while it was higher in permeability values (CV > 34%). Also, their mean values in the two soil strata were not different significantly ($p>0.05$). The control showed lower permeability in both soil depths, possibly due to higher clay content. Porosity values reported in past study around the study area (IEFCL, 2013), were also within the ranges observed for current study.

Soil pH

The soil reaction (pH) for both soil depths in the study area fell within the acidic value of 4.61 - 5.60 for topsoil and 4.64 - 5.21 for subsoil. Spatial variation across the sampling stations was very low and the difference in mean values for the topsoil and subsoil was not significant ($p>0.05$). The control stations also recorded values within these ranges, just like previous studies around the area (IEFCL, 2013; TEPNG, 2016).

Soil pH, which expresses the acidity or basicity of soil solution, often determines the soil capability and suitability to support plants growth. This is because the value of the free H^+ concentration in a soil influences the availability of nutrient elements and biochemical reactions in the soil (Bohn *et al.*, 1984). Soil reaction is thus important for nutrients availability for plants uptake as well as the dynamics of pollutants in soil. The observed pH values of the soil in this study were lower than the minimum value requirement for plant optimum growth (Table 4.10) (FAO, 1990).

Table 4.10: Classification of Soil Macro and Micro Nutrients

Soil Characteristics	Low	Medium	High
pH	<6	6 – 7	>7
Exchangeable K^+ (cmol/kg)	<0.15	0.15 – 0.4	>0.4
Organic Matter (%)	1.5	1.5 – 3	>3
Total Nitrogen (%)	0.08	0.08 – 0.15	>0.15
Total Phosphorus (mg/kg)	7	7 – 20	>20
Fe (mg/kg)	23	90	360

Source: FAO (1990)

Redox Potential

Redox Potential refers to the oxidation reduction potential (ORP) of a system. The ORP values measured in the topsoil ranged from 83.70 – 296.0 mV (Mean = 143.7±63.72 mV), while it ranged from 51.10 – 279.0 mV (Mean = 133.0±68.60 mV) in the subsoil. Although, spatial variation across the sampling stations was high in both soil depths, their mean values were not significantly ($p>0.05$) different. Values obtained in topsoil from the control stations (147.0 – 284.0 mV) were within the range obtained for the project area, while higher ORP values (156.0 – 311 mV) were recorded in the subsoil. Lower values were reported in previous study around the area due to the influence of the season (wet season) that the study was conducted (TEPNG, 2016).

The redox potential of soil is a measure of electrochemical potential or electron availability that are essential to all inorganic and organic chemical reactions in soil. Redox potential measurements allow for rapid characterization of the degree of reduction and for predicting stability of various compounds that regulate nutrients and metal availability in

soil. Processes which reduce oxygen levels and decrease redox potentials are driven by microbial consumption of oxygen. Thus, the conditions necessary for lowering redox potentials include, a source of decomposable organic materials (energy source), a population of microbes capable of utilizing this energy source for metabolism, and a restriction on the re-supply of oxygen. Redox potential is also diagnostic for determining whether an area is functioning as wetland or non-wetland. Due to frequent hydrologic fluctuations, wetland soils and sediments can have ORP values ranging from 700 mV (under drainage conditions) to −300 mV (under prolonged flooding conditions).

Total Organic Carbon /Organic Matter

Total organic carbon (TOC) contents of the soils within the project zone of influence ranged between 0.20% and 1.68% in topsoil and 0.08% and 1.48% in subsoil. Spatial variation was high, with topsoil mean value (0.97±0.47%) significant ($p<0.05$) higher than subsoil mean value (0.79±0.44%), due to the presence of more humus in topsoil than in subsoil. However, values obtained from the control stations fell within the ranges observed for the topsoil and subsoil respectively within the project area. Previous studies around the project area also revealed values similar to what were observed in current study (IEFCL, 2013; TEPNG, 2016).

The soil organic matter (SOM) which is a function of the organic carbon ranged from 0.35 – 2.91% (Mean = 1.68±0.80%) in topsoil and from 0.14 – 2.56% (Mean = 1.37±0.76%) in subsoil. Values from the control stations were also within the observed ranges. According to FAO (1990) rating, the organic matter content of the soil samples generally fell between low and medium soil macro nutrient (**Table 4.10),** with higher values recorded in topsoil**.** Many important soil properties are dependent to some degree on the quality of organic matter present. These properties include the absorption and retention of water, reserves of exchanged bases, the capacity to supply nitrogen, phosphorus and other elements to growing crops, stability of soil structure and adequacy of aeration and pollutants bioavailability (Margesin and Schinner, 2005).

Nitrogen Species

Nitrogen is one of the macro nutrients in soils that have very significant effect on plants growth. Its deficiency in plants is often observed by the yellowing of leaves and stunting of the plants. nitrate (NO_3^-), nitrite (NO_2^-) and ammonium (NH_4^+) are available forms of nitrogen in soils. Total nitrogen concentrations in the topsoil and subsoil ranged from 0.04 - 0.14% and 0.03 - 0.13% respectively falling between low and medium soil fertility rating according to FAO (1990) classification of soil macro and micro nutrients (**Table 4.10)**. Spatial variation across sampling stations was high, with mean values of topsoil (0.09±0.03%) and subsoil (0.08±0.03%) showing significant ($p<0.05$) difference. The control stations, however, showed values within the ranges observed for the project area as well

as previous studies conducted around the area. Nitrogen is one of the macronutrients in soils that have very significant role on plants growth. Its deficiency in plants is often observed by the yellowing of leaves and stunting of the plants. Soil N of more than 0.15% is considered optimal for most crops (Sobulo and Osiname, 1986).

The nitrate concentrations in the soil ranged from 5.04 - 26.50 mg/kg (topsoil) and 6.28 – 20.20 mg/kg (subsoil), with mean values (11.15±7.20 mg/kg for topsoil and 11.47±4.39 mg/kg for subsoil) not significantly ($p>0.05$) different. Spatial variation was high, while values from the control stations fell within the observed ranges obtained for the project area. While higher concentrations of nitrate were reported for soils around the study area in 2016 (TEPNG, 2016), much lower concentrations were reported in 2013 ((IEFCL, 2013), possibly due to different locations from which the soil samples were taken during the respective studies.

Nitrite concentration ranged from 0.12 – 0.47 mg/kg (Mean = 0.24±0.12 mg/kg) in topsoil and from 0.06 – 0.42 mg/kg (Mean = 0.25±0.13 mg/kg) in subsoil. Spatial variation was high for both soil depths, but the mean values showed no significant ($p>0.05$) difference. The control stations also showed values within the observed ranges.

Ammonium concentrations in topsoil and subsoil ranged from 4.05 - 21.30 mg/kg and 5.05 - 16.20 mg/kg respectively. Spatial variation was very high in topsoil, but slightly high in subsoil. However, the topsoil and subsoil mean values were not significantly ($p>0.05$) different. The control stations also recorded values within the ranges observed for the project area, while significantly lower values were reported in previous study around the study area (IEFCL, 2013).

Phosphorus and Phosphate

Phosphorus is an essential macro element in soil because of the relatively large quantity required by plants. Plant growth is limited by phosphorus more than by any other plant nutrient element. The concentrations of total phosphorus in topsoil ranged from 5.81 - 44.80 mg/kg with a mean of 18.16±12.27 mg/kg, while the subsoil recorded values between 6.75 mg/kg and 50.70 mg/kg with a mean of 19.22±14.10 mg/kg. Spatial variation across sampling stations was very high, but the difference between the mean concentrations at both soil depths was not significant ($p>0.05$). The values from control stations were, however, higher than from the project area of influence. The measured phosphorus levels in the soil were within low to high macro nutrient rating (FAO, 1990). Phosphorus levels recorded in this study fell within what have been earlier reported in studies on soils around the project area (IEFCL, 2013; TEPNG, 2016).

Phosphate concentrations in the topsoil and subsoil ranged from 3.45 – 26.50 mg/kg and 4.01 – 30.10 mg/kg respectively. Spatially, the concentrations varied considerably but with mean values not significantly different at both soil depths. Values recorded at the control

stations, as well as those from previous study were higher than from the project area. Phosphate is an oxidised and soluble form of phosphorus in soil.

Sulphate

Sulphate behaves like nitrate in the soil. In the plant nitrogen and sulphur are both essential building blocks for proteins. Sulphur deficiency will severely reduce the efficient use of nitrogen and limit protein synthesis. Sulphur can only be taken up by plants from the soil solution as sulphate. The concentrations of sulphate measured in the soil samples ranged from 22.60 – 120.0 mg/kg and 32.80 – 154.0 mg/kg in topsoil and subsoil respectively. Variation across sampling stations was high and mean values from the control stations were higher than at the project area. The mean concentrations (70.35±29.70 mg/kg in topsoil and 78.13±40.39 mg/kg in subsoil) are not significantly ($p>0.05$) different. Values reported for soils around the area in past study (IEFCL, 2013) were lower than what were recorded in the current study. Sulphate concentration up to 0.30% (3,000 mg/kg) is considered as safe limit for soil (Mitchell and Dermatas, 1992).

Exchangeable Cations,

Exchangeable cations in soil include sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions, which are loosely attached to the active surfaces of clay particles or organic matter in the soil. Several soil properties such as acidity, nutrient availability and leachability depend on the relative proportions of the exchangeable cations present.

Exchangeable cations concentrations (mg/kg) measured in the topsoil were Na^+(42.00 - 48.90), K^+(100.0 - 127.0), Mg^{2+}(23.10 - 29.70) and Ca^{2+} (307.0 - 338.0), while the subsoil recorded Na^+(45.40 - 53.90), K^+(112.0 - 148.00), Mg^{2+}(26.40 - 34.90) and Ca^{2+} (322.0 - 368.0). Spatial variations in the metals concentrations across sampling stations were very low and values recorded at the control station were within the ranges observed for the project area. Except for sodium, the difference between mean concentrations of the cations in topsoil and subsoil was significant ($p<0.05$). The order of the occurrence of these metals (mean concentration) in both the topsoil and subsoil was $Ca^{2+} > K^+ > Na^+ > Mg^{2+}$ Exchangeable potassium level in both soil depths expressed in cmol/kg (0.26 – 0.53 cmol/kg), which is the most crucial of all the cations in terms of plants requirements fell between medium and high macro nutrient rating (FAO, 1990). Sodium concentrations expressed in the current study fell within the ranges reported in 2016 study (TEPNG/NOPL EER-Based EIA, 2016), but lower potassium and calcium concentrations compared to current study were reported. On the other hand, magnesium levels in current study were lower than what were reported in 2016. Study conducted in 2012 (OBOB-Eleme Gas Pipeline EIA, 2012), however, showed concentrations far lower than what were reported in current study.

Cation Exchange Capacity

The exchangeable cations and the exchangeable acidity (Al^{3+} and H^{+}) constitute the cation exchange capacity (CEC). The cation exchangeable capacity (CEC) values in the topsoil and subsoil ranged from 44.70 -47.80 meq/100g and 47.30 - 54.30 meq/100g respectively. Spatial variation was very low across sampling stations and the values recorded in the control soil samples were within the ranges observed within the project area. It was also observed that the difference in the mean values for both topsoil and subsoil was not significant ($p>0.05$).

Oil and Grease and Hydrocarbons

Low oil and grease concentrations (15.20 - 22.70 mk/kg and 7.58 - 15.20 mg/kg in topsoil and subsoil respectively) were recorded in the soil samples. Marked spatial variation across sampling stations were observed, while the control stations recorded values within the ranges observed for the project area. The difference between the mean concentrations in topsoil and subsoil was significant ($p<0.05$), with higher mean concentration recorded in subsoil than in topsoil. Slightly higher concentrations were, however, recorded at the control station, while the parameter was not determined in previous studies around the area. Total hydrocarbon concentrations, polynuclear aromatic hydrocarbons (PAHs) and BTEX in the soil samples were below instrument detection limits in both soil depths. The control stations, however, revealed the presence of total hydrocarbon with the absence of PAHs and BTEX. Previous study around the area, however, showed higher total petroleum hydrocarbon and PAHs levels in soil (TEPNG, 2016). The observed hydrocarbons concentrations at the control stations are far lower than mineral oil target value (50 mg/kg) in soil (DPR, 2018). Low concentrations of hydrocarbon in the soil samples of current study area indicate no contamination of the project area by hydrocarbon compounds in its present status.

4.3.3.2 Heavy Metals

The statistical summary of results of heavy metals (Al, As, Ba, Cd, Cr, Cu, Fe, Ni, Pb, V and Zn) analysed in the soil samples are presented in **Tables 4.11.** All metals gave varying concentrations with the exception of arsenic (As), mercury (Hg) and vanadium (V) that showed concentration below the instrument detection limit. Spatial variation across the sampling stations and for both soil depths was very low. The control soil samples recorded values within the ranges observed for the project area for only iron (Fe) and copper (Cu), while it consistently showed higher concentrations for other heavy metals monitored in this study.

Iron (Fe) recorded the highest concentrations ranging from 24.50 – 27.90 mg/kg in topsoil and 26.20 – 29.40 mg/kg in subsoil. The subsoil mean concentration (28.35±1.02 mg/kg

was significantly ($p<0.05$) higher than that of topsoil (26.59±1.09 mg/kg), indicating geogenicity of source of the metal. The observed level of Fe in the current study is consistent with most studies carried out on Nigerian soils in which high concentrations of Fe have been reported (Ojanuga *et al.*, 1996; Aiyesanmi, 2005). The observed Fe concentrations in soils of the project area fall between low and medium soil macro nutrient rating (**Table 4.10**) (FAO, 1990). Other metals in the topsoil recorded mean concentrations (mg/kg) in the order of Ba(17.25±0.37) > Al(4.07±0.31) > Zn(2.34±0.25) > Ni(2.28±0.20) > Cu(2.25±0.56) > Cd(1.25±0.08) > Pb(1.24±0.15) > Cr(1.17±0.09), while in subsoil, the order was Ba(19.26±2.84) > Al(4.75±0.20) > Zn(2.67±0.24) > Cu(2.73±0.18) > Ni(2.51±0.16) > Pb(1.44±0.29) > Cd(1.25±0.05) > Cr(1.17±0.05).

Table 4.11: Heavy metal concentration (mg/kg) in Indorama soil samples

Parameter	PROJECT AREA				CONTROL	
	Range	Mean	STD	CV (%)	Range	Mean
TOPSOIL						
Al	3.32 - 4.23	4.07	0.31	7.52	-	4.29
As	-	<0.002	-	-	-	<0.002
Ba	16.80 - 18.00	17.25	0.37	2.17	26.30 - 30.10	28.2
Cd	1.10 - 1.35	1.25	0.08	6.68	1.21 - 1.57	1.39
Cr	1.03 - 1.30	1.17	0.09	7.41	1.37 - 1.72	1.55
Cu	1.24 - 2.84	2.25	0.56	24.72	1.58 - 1.79	1.69
Fe	24.50 - 27.90	26.59	1.09	4.09	22.60 - 24.50	23.55
Hg	-	<0.001	-	-	-	<0.001
Ni	2.14 - 2.69	2.28	0.20	8.69	2.45 - 2.65	2.55
Pb	1.04 - 1.50	1.24	0.15	12.10	2.42 - 2.54	2.48
V		<0.002				<0.002
Zn	2.06 - 2.84	2.34	0.25	10.67	2.76 - 2.81	2.79
SUBSOIL						
Al	4.34 - 4.92	4.75	0.20	4.26	4.36 - 4.89	4.63
As	-	<0.002	-	-	-	<0.002
Ba	16.10 - 25.80	19.26	2.84	14.72	27.00 - 30.90	28.95
Cd	1.19 - 1.35	1.25	0.05	4.26	1.28 - 1.68	1.48
Cr	1.10 - 1.24	1.17	0.05	4.71	1.46 - 1.88	1.67
Cu	2.36 - 2.95	2.73	0.18	6.71	1.68 - 1.86	1.77
Fe	26.20 - 29.40	28.35	1.02	3.61	25.70 -25.90	25.8
Hg	-	<0.001	-	-	-	<0.001
Ni	2.32 - 2.82	2.51	0.16	6.51	2.35 - 2.40	2.38
Pb	1.00 - 1.86	1.44	0.29	19.90	2.14 - 2.50	2.32
V	-	<0.002	-	-	-	<0.002
Zn	2.28 - 2.92	2.67	0.24	8.85	2.84 - 2.92	2.88

SD – Standard Deviation; CV – Coefficient of variation ;

As observed in iron, the subsoil consistently showed higher concentrations of the metals than topsoil, except Cd and Cr with the same mean concentrations in both soil depths. Significant ($p<0.05$) difference in the mean concentrations between the topsoil and subsoil was observed in Al, Cu, Ni, Pb and Zn, while insignificant ($p>0.05$) difference occurred in Ba, Cd and Cr concentrations. All the heavy metals determined in this study recorded mean concentrations far lower than their allowable limits (AL) in soils of most countries of the world and the DPR Target values for Nigerian soils (**Table 4.12**) (Kabata-Pendias, 1995; Aiyesanmi and Idowu, 2012; DPR, 2018), with the exception of Cd with mean concentrations higher than its target value (**Figure 4.6**). While Al and Ba showed measurable concentrations in the current study, they were either not determined or below instrument detection limits as reported in previous studies around the project area (**Table 4.9**). Cadmium (Cd), Cr and Ni showed higher concentrations in current study compared to what were reported in previous studies, whereas Fe showed much lower concentrations in the current study. Other metals, including Cu, Hg, Pb, V and Zn, showed concentrations similar to what were earlier reported in previous studies.

Table 4.12: Allowable limits (MAL) (mg/kg) for heavy metals in soil

Heavy Metals	Austria	Canada	Poland	Japan	G. Britain	Germany	Nigeria*
As	-	-	-	-	-	-	29
Ba	-	-	-	-	-	-	200
Cd	5	8	3	-	3	2	0.8
Cr	100	75	100	-	50	200	100
Cu	100	100	100	125	100	50	36
Hg	-	-	-	-	-	-	0.30
Ni	100	100	100	100	50	100	35
Pb	100	200	100	400	100	500	85
Zn	300	400	300	250	300	300	140

*DPR Target Value for heavy metals in soil/sediment
Source: Kabata-Pendias, 1995; Aiyesanmi and Idowu, 2012; DPR, 2018

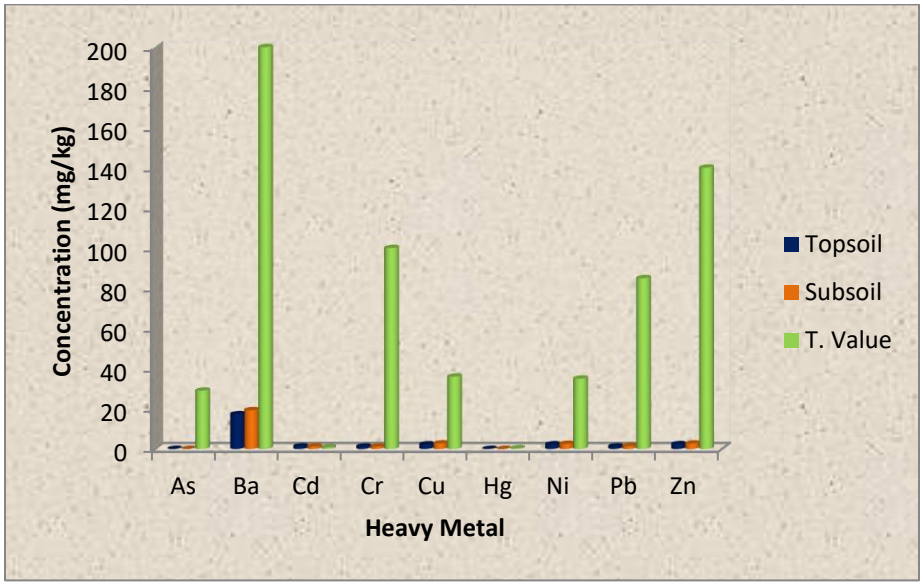


Figure 4.6: Heavy metals concentrations in soils compared with target values

4.3.3.3 Soil Microbiology

The summary of results of the microbes enumerated in the soil samples in this study are presented in **Table 4.13,** while the detailed results are presented in the Appendix 4.7. The total heterotrophic bacterial (THB) counts in topsoil taken within the project area of influence ranged from $1.50x10^4$ – $32.60x10^4$ cfu/g (Mean = 8.59±10.42 $x10^4$ cfu/g) and in subsoil $1.23x10^4$ – $28.90x10^4$ cfu/g (Mean = 7.28±9.36 $x10^4$ cfu/g). Spatial variation in microbial population was proniunced across the sampling stations, with topsoil mean value greater than subsoil value insignificantly ($p>0.05$). Higher microbial load recorded in topsoil is attributable to the presence of more decomposable materials like plant litters in the topsoil for microbial growth than in subsoil. The control stations also showed values within the ranges observed for both soil depths.

Table 4.13: Summary of microbial population in soils within the project area and control station

Parameter	PROJECT AREA				CONTROL	
	Range	Mean	STD	CV (%)	Range	Mean
TOPSOIL						
THB (cfu/g) $x10^4$	1.50 - 32.60	8.59	10.42	121.39	6.25 - 9.10	7.68
HUB (cfu/g) $x10^3$	<0.01 - 14.30	4.93	5.51	111.70	1.45 - 2.35	1.90
THF (cfu/g)$x10^4$	0.30 - 2.00	1.04	0.61	59.24	1.40 - 1.50	1.45
HUF (cfu/g) $x10^2$	<0.1 - 18.00	6.63	6.00	90.63	8.00 - 11.50	9.75
SRB (cfu/g)	-	<10.00	-	-	-	<10.00

Parameter	PROJECT AREA				CONTROL	
	Range	Mean	STD	CV (%)	Range	Mean
Faecal Coliform (MPN/100ml	2.00 - 22.00	7.63	6.44	84.39	2.00 - 4.00	3.00
SUBSOIL						
THB (cfu/g) x10^4	1.23 - 28.90	7.28	9.36	128.54	2.25 - 5.25	3.75
HUB (cfu/g) x10^3	<0.01 - 6.05	2.00	2.16	107.98	1.70 - 7.00	4.35
THF (cfu/g)x10^4	0.10 - 5.35	1.43	1.85	130.17	0.30 - 1.35	0.83
HUF (cfu/g) x10^2	<0.10 - 16.50	3.71	5.49	147.93	5.50 - 6.00	5.75
SRB (cfu/g)	-	<10.00	-	-	-	<10.00
Faecal Coliform (MPN/100ml	2.00 - 11.00	4.25	3.24	76.24	2.00 - 4.00	3.00

ND = Not determined

The hydrocarbon utilising bacteria population ranged between <10 cfu/g and 14.30x10^3 cfu/g in topsoil and between <10.00 cfu/g and 6.05x10^3 cfu/g in subsoil. The control soil samples also recorded values within the range as also obtained from previous study on the area. The mean percentage hydrocarbon utilising bacteria (HUB) in topsoil was 5.74% and 2.75% in subsoil. **Figure 4.7** compares the percentage mean hydrocarbon utilising bacteria (HUB) to non-hydrocarbon utilising (NHUB) in the soil samples.

Total heterotrophic fungi (THF) count in the topsoil ranged from 0.30x10^4 - 2.00x10^4 cfu/g and 0.10x10^4 – 5.35x10^4 cfu/g in subsoil. Spatial variation across sampling stations was very high especially at subsoil level. The mean values, 1.04±0.61 x10^4 cfu/g in topsoil and 1.43±1.85 x10^4 cfu/g in subsoil do not differ significantly ($p>0.05$). The control stations also recorded values within the ranges observed in the project area, while similar results were also reported in past study around the area. The hydrocarbon utilising fungi in the soil samples ranged from <10.00 – 18.00x10^2 cfu/g in topsoil and <10.00 – 16.50x10^2 cfu/g in subsoil. The mean percentage hydrocarbon utilizing fungi count in the topsoil and subsoil were 6.38% and 2.59% respectively. **Figure 4.8** compares the percentage mean hydrocarbon utilising fungi (HUF) to non-hydrocarbon utilising (NHUF) in the soil. The bacterial and fungal counts recorded in current study were far lower than what were reported in past studies around the project area (IEFCL, 2013; TEPNG, 2016) (**Table 4.9**). The higher values recorded in past studies could be a results of factors that enhance microbial growth, which include among others high soil moisture content, which actually favoured past studies carried out during the wet season.

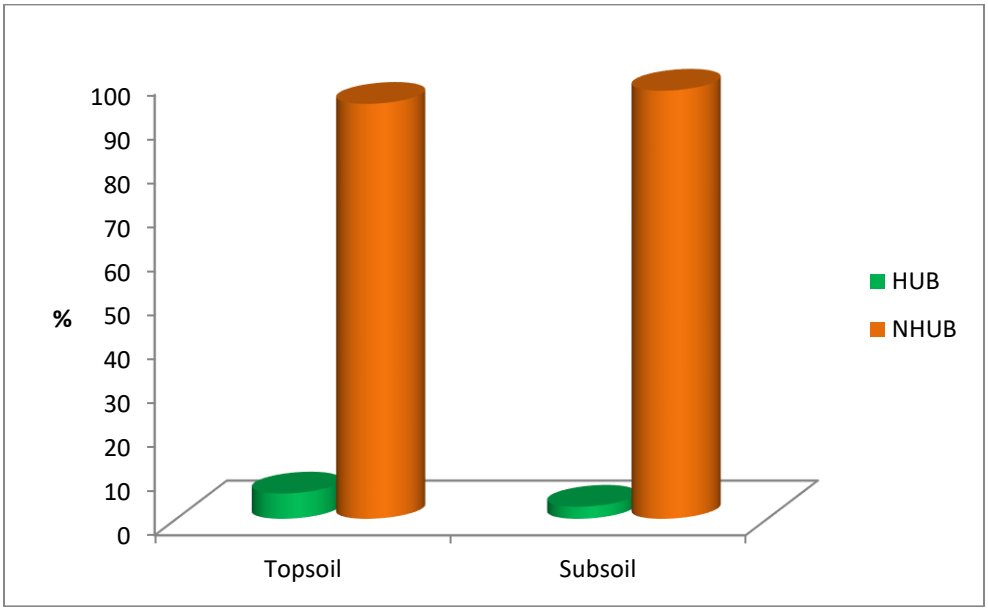


Figure: 4.7: Percentage hydrocarbon utilising and non-hydrocarbon utilising bacteria in soil

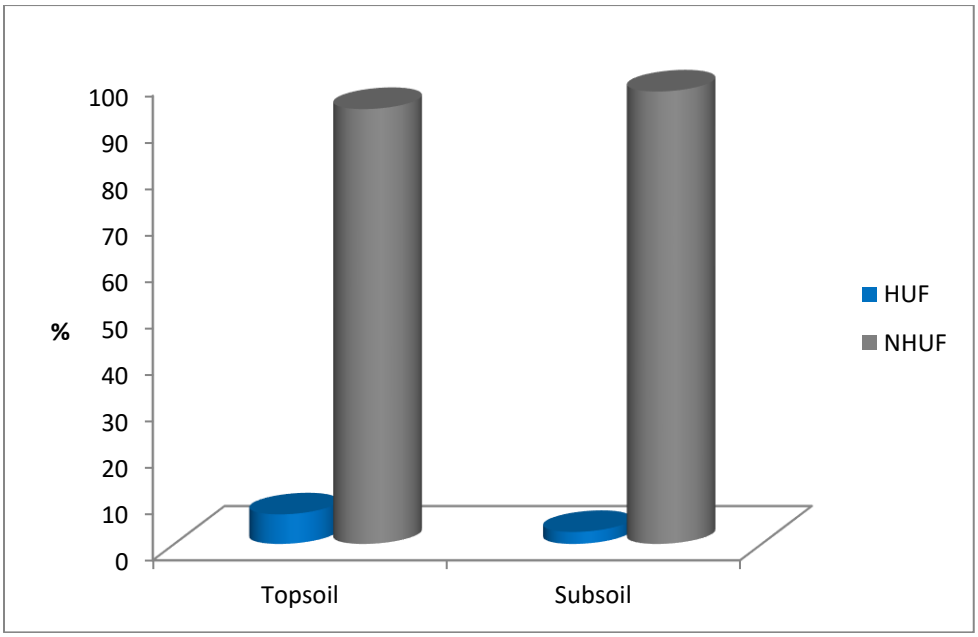


Figure: 4.8: Percentage hydrocarbon utilising and non-hydrocarbon utilising fungi in soil

Sulphur reducing bacteria (SRB) counts in both topsoil and subsoil, as well as at the control stations were <10.00 cfu/g, while faecal coliform ranged from 2.00 – 22.00 MPN/100g in topsoil and 2.00 – 11.00 MPN/100g in subsoil. Spatial variation across the sampling stations was very high, while the control showed values within the respective ranges observed for the project area.

4.3.4 Vegetation Study

4.3.4.1 Vegetation Type

Secondary forest type of vegetation was observed at the Indorama tie-in point where agriculture is the peoples' economic mainstay; therefore, clearing trees and shrubs for cultivation is a regular practice. Even so, such economic trees as oil palm tree (*Elaeis guineensis*), Common guava tree (*Psidium guajava*), are regularly left to continue providing their produce while farm lands are abandoned to fallow for some time. When left to fallow, the vegetation type is the secondary forest type. The species in the study area include life forms ranging from herbs, shrubs to trees. Generally, the frequently encountered species include flora species such as *Elaeis guineensis, Alstonia boonie, Chromolaena odorata, Mimosa pudica, Pennisetum sp., Mangifera indica, Pentaclethra macrophylla, Alchornea laxiflor* and *Cyperus iria* (**Plates 6**). Among the economic plants were those used as wood for construction, medicine, food, cash crops, fruits, vegetables etc. Other species observed are as summarised in **Table 4.14**

Plate 4.3: Secondary forest at Indorama tie-in point

Table 4.14: List of flora in the study area

Species	Common Name	Local Name	Habit	Uses	Family	DBH (cm)	Height (m)	Abundance
Anthocleista vogelii	Cabbage tree	NA	T	NA	Longanaceae	5.3	9.8	9
Bambusa vulgaris	Common bamboo	Echara	T	Wood provision	Poaceae	4.3	7.8	18
Costus afer	Bush	Ukpute	S	NA	Costaceae	NA	NA	52
Cyperus iria	Rice flatsedge	NA	G/F	NA	Cyperaceae	NA	NA	32
Dacryodes edulis	Bush pear	Ube	T	Wood provision	Burseraceae	19.5	6.4	2
Elaeis guineensis	oil palm tree	Nkwu	T	Oil production, tatch production	Arecaceae	21	15.3	30
Ipomoea involucurata	NA	Eriri ebende	C	To ease child delivery	Convolvulaceae	NA	NA	3
Mimosa pudica	Sensitive plant	Onwuete	H	To treat convulsion	Mimosoideae	NA	NA	31
Musa	Plantain	NA	S	For food	Musaceae	NA	NA	13
Psidium guajava	Common guava	NA	T	For food	Myrtaceae	11.1	5.7	3
Alchornea	NA	NA	S	NA	Euphorbiaceae	NA	NA	76
Pterocarpus santaniloides	NA	NA	T	Wood provision	Fabaceae	15.1	10.6	25
Cnestis	NA	NA	S	NA	Connaraceae	NA	NA	46
Newbouldia laevis	NA	NA	T	Wood provision	Bignoniaceae	13.1	18	6
Crotalaria	NA	NA	H	NA	Fabaceae	NA	NA	36
Alstonia boonie	NA	NA	T	Wood provision	Apocynaceae	NA	NA	4
Vernonia amygdalina	NA	NA	H	Leafy vegetable	Asteraceae	NA	NA	3
Luffa	NA	NA	C	NA	Cucurbitaceae	NA	NA	6

NA – Not available; G/F – Grass/Fern; T – Tree; C – Climber; S – Shrub; H – Herb; DBH – Diameter at breast height; m – Meters; cm – Centimeters; spp. – Species

4.3.4.2 Hydrocarbon and Heavy Metal Levels in Vegetation Sample

The results of hydrocarbon and heavy metals levels in leaf samples collected from the proposed Indorama Tie-in area are presented in **Table 4.15.** Petroleum hydrocarbon level in the analysed vegetation (leave) was below detection limit (<0.01 mg/kg).

Among the metals determined in the vegetable sample, only iron (Fe), copper (Cu), zinc (Zn) and aluminium (Al) showed measurable concentrations of 2.52 mg/kg, 2.04 mg/kg, 2.00 mg/kg and 1.61 mg/kg respectively. Other metals including cadmium (Cd), chromium (Cr), lead (Pb), barium (Ba), nickel (Ni), vanadium (V), mercury (Hg) and cobalt (Co) showed concentrations below instrument detection limits in the plant. The observed results showed that the vegetations in the study area have not been impacted by heavy metals due to anthropogenic activities and the result; thus, serve as baseline information with which future environmental performance could be evaluated. Similar results from previous study around the project area have also been reported (IEFCL, 2013).

Table 4.15: Hydrocarbon and Heavy Metals levels in vegetation sample

Parameters												
TPH	Fe	Cd	Cr	Pb	Ba	Cu	Ni	V	Zn	Hg	Co	Al
(mg/kg)												
<0.01	2.52	<0.002	<0.002	<0.002	<0.03	2.04	<0.002	<0.002	2.09	<0.001	<0.002	1.61

4.3.5 Wildlife

Literature review was carried out to synthesize documented information on characteristic wildlife of the study area. The vegetation and associated wildlife is that of the New Calabar-Sombreiro sector according to Blench 2007 citing Powell. This lies in Aluu forest, NE of Aluu Central and north of Shell pipeline, ca. 4°57'N, 6°57-58'E. (Aluu is about 20km NNW of Port Harcourt) and Rumuekeni 4°53'N, 6°56.5'E (forest NE of village). The fauna in the study area have largely been hunted, displaced and persecuted by human activities that most are near extinct or very rare.

Direct evidence, which included discussion with hunters, as well as, observations revealed that the larger mammals and reptiles have either migrated from the area because of habitat fragmentation or have had their population decimated by over hunting. Despite this scenario, the hunters interviewed confirmed that there remained a critical mass of small to medium sized mammals in the area. The traps used for hunting were locally made, with wire traps appearing to be the most common. This sustains the thriving bush meat market in all the communities of the project influence.

In the study area, nine (9) species of vertebrates were recorded from the site, namely Cane rats, Pouch rats, Pied crows and the Guinea fowl.

Plate 4.4: The remains of a *Toxicodrya. blandingii* photographed in Obigbo node (Data DSL 2020)

4.3.6 Socio-Economics and Health

The area considered for the Socio Economic Impact Assessment (SEIA) was Obigbo Community.

4.3.6.1 Study Settlement

Obigbo is a kingdom and the current traditional head HRH Eze Mike Nwaji, is a government recognized 1st class chief. It shares boundary with other LGAs in Rivers State like Etche, Port Harcourt, and Eleme, and Ukwa East LGA in Abia State. The language of Obigbo also borrows from these neighbours and shares strong similarities with Igbo.

There is a hierarchical order of leadership whereby the paramount ruler is at the apex and the ordinary citizen is at the bottom. In-between the hierarchy are family heads or chiefs who usually sit with the Eze in Council. Within the leadership structure are influential groups such as the Community Development Committee (CDC) and the youths. The CDC comprises representatives from the various units that make up the community. Notable individuals are co-opted as members if they feel that they could be resourceful in contributing to the progress of the community even if they are not initially proposed from their units.

The rise in the proportion of young people who become exposed to modern lifestyle, education and attitudes has brought youthful exuberance to the fore. The Youths Council in Obigbo are active in topical issues such as employment, scholarship, industrial relations and culture. Accordingly, sub committees of the Community Development Council are formed to address the various challenges they face. Another group with influence in Obigbo is the women and head chiefs in the various sub-clans. Other groups in the community are peer groups, age grade, trade groups and social clubs.

4.3.6.2 Settlement Pattern

The settlement pattern in the study area is semi-nucleated, moderately built up with tarred and graded roads. The internal land use structure of the community has not matured to a point where it acquires distinctive functional properties like commercial, residential or industrial uses.

4.3.6.3 Demography

The Federal Government of Nigeria estimates the growth rate of population in Rivers State as three point five percent (3.5%) annually (2007), although Nigeria grows at three point two percent (3.2%). The growth rate for Rivers State is used to project the population of Obigbo from the 2010 to the present. By the estimate, Obigbo would have 200,598 persons. The population of the communities was derived from 2010 NPC figure projected to 2019 at three point five percent (3.5%), the national growth rate. The documented population structure in Obigbo comprises of fifty percent (50%) male population and fifty percent (50%) female among the households.

4.3.6.4 Occupation and Employment at Obigbo

The distribution of occupation among the respondents in Obigbo includes self-employed, civil service, company workers and unemployed. The occupation of the self-employed are business (small scale business and contractors to companies), farming, fishing, trading and many others. Those categorized as others include, hunting, non-timber forest product gatherers, artisans and transport workers. Majority of the businessmen are suppliers to the large companies in the area.

During the FGD, the respondents indicated that many of the occupation are under threat or declining. Some of the occupation include crop farming, trading, civil service, fishing, hunting, picking of NTFPs, processing produce, marketing produce, crafts, sales of food and snacks.

The respondents all agreed that crop farming is in great decline because of the oil and gas activity that causes land degradation, including other factors like herdsmen activities. In addition, the attractive salaries paid to workers in the oil and gas industry and associated benefits is pulling many youths away from agriculture.

With regards to trading as shown in Fig. 4.9, fifty-eight percent (58%) of the respondents indicated it is under threat, while twenty-five percent (25%) said it is declining. The reasons given was the status of the poor state of the roads in the community.

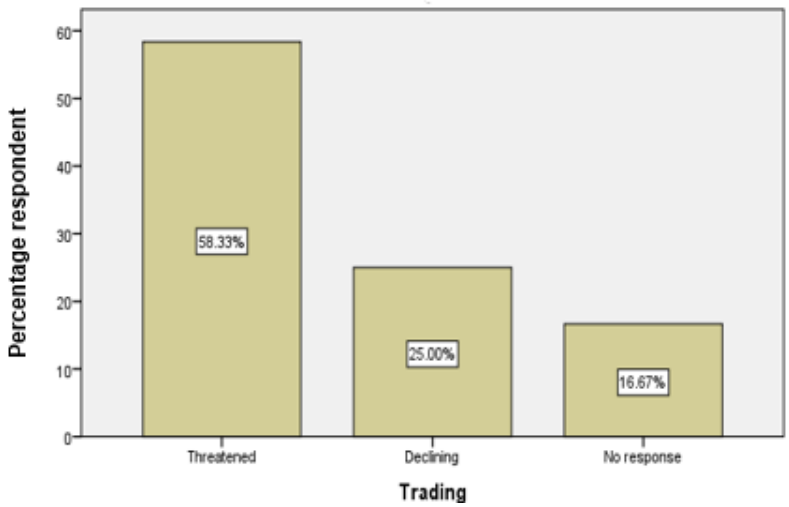


Figure 4.9: Threatened/declining status of trade in Obigbo

The occupation of civil service was considered by the fifty-eight percent (58%) of the respondents to be threatened and twenty-five (25%) to be in decline (Fig 4.10). They attributed this decline to the embargo placed on employment by the state government.

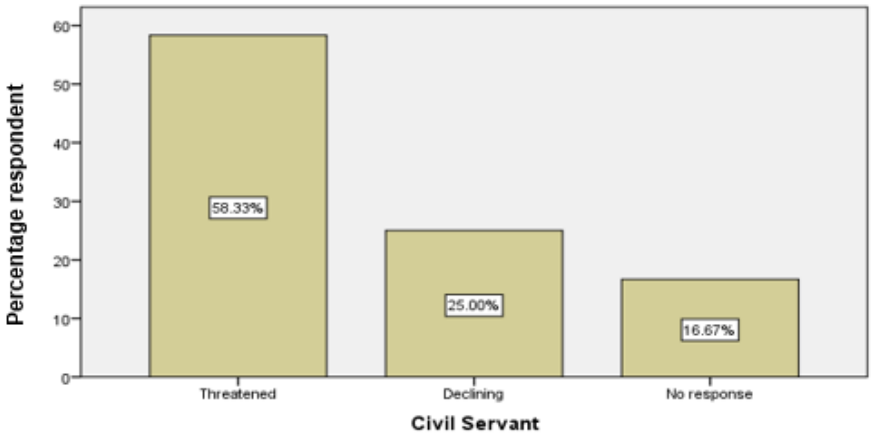


Figure: 4.10: Threatened/Declining status of Civil Service in Obigbo

With regards to fishing, thirty-three percent (33%) of the respondents reported that it is threatened, while another fifty-eight percent (58%) of the respondents reported that it is declining (Fig 4.11). The reasons for the threat and decline are dredging activities and water pollution.

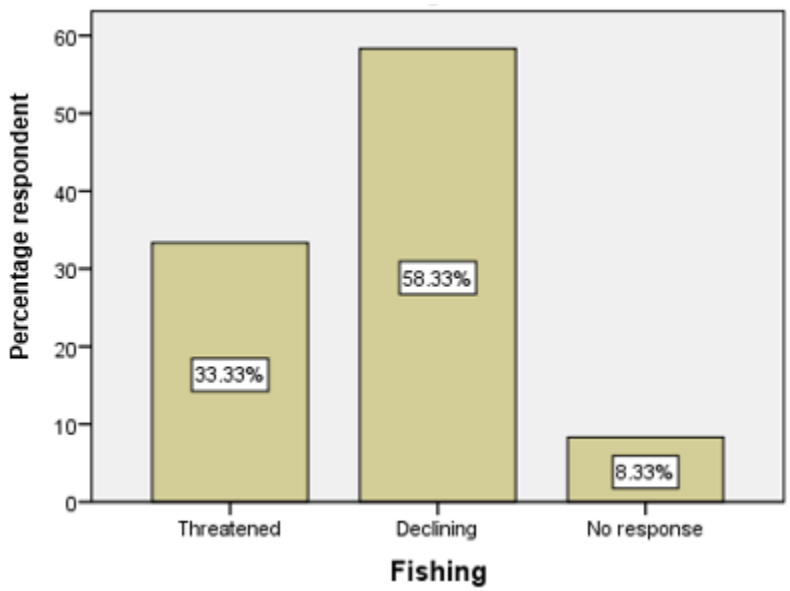


Figure: 4.11: Threatened/Declining status of Fishing in Obigbo

Eight percent (8%) of the respondents considered hunting to be threatened (Fig 4.12). This observed threat was as a result of deforestation and unregulated hunting of games in the forest. The remaining ninety-two percent (92%) could not confirm this assertion.

In fig. 4.13 the declining status of Non timber forest products was confirmed by seventy-five percent (75%) of the respondents to be due to the decreasing fertility of the land amongst many other factors such as deforestation, intense agricultural activities and reduction in fallow period allowed for recovery of cultivated land.

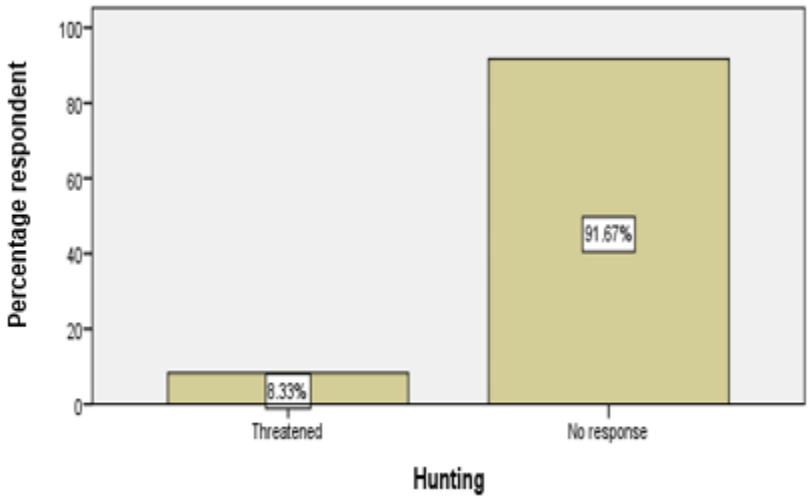


Figure: 4.12: Threatened/Declining status of Hunting in Obigbo

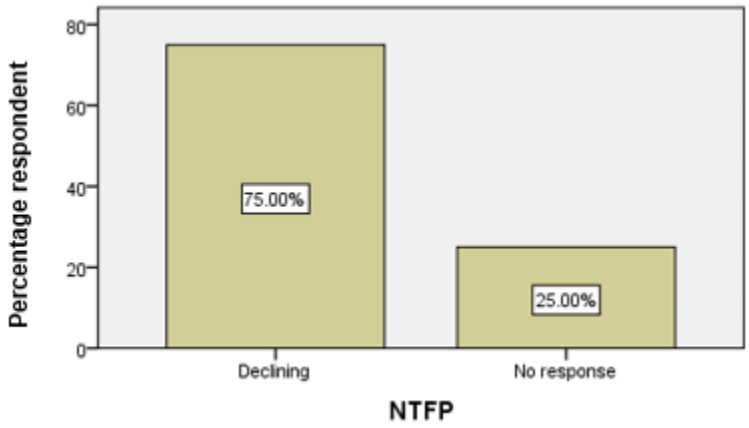


Figure: 4.13: Threatened/Declining status of NTFP in Obigbo

Sixteen percent (16%) of the respondents reported that processing of produce is threatened, while eighty-three percent (83%) considers it to be declining as a result of the bad roads and poor patronage (Fig 4.14).

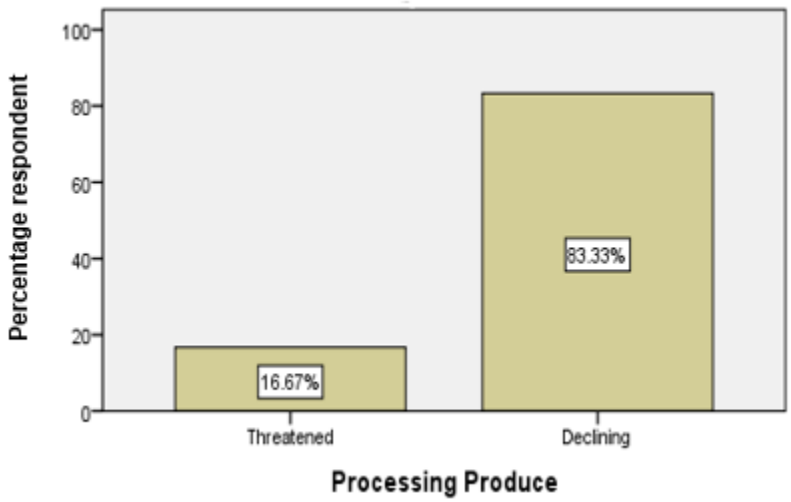


Figure: 4.14: Threatened/Declining status of Processing Produce in Obigbo

In figure 4.15, ninety-one percent (91%) of the respondents considered marketing of produce to be threatened due to inaccessibility to markets, poor roads and inadequate capital; while eight percent (8%) of the respondents considered it to be declining.

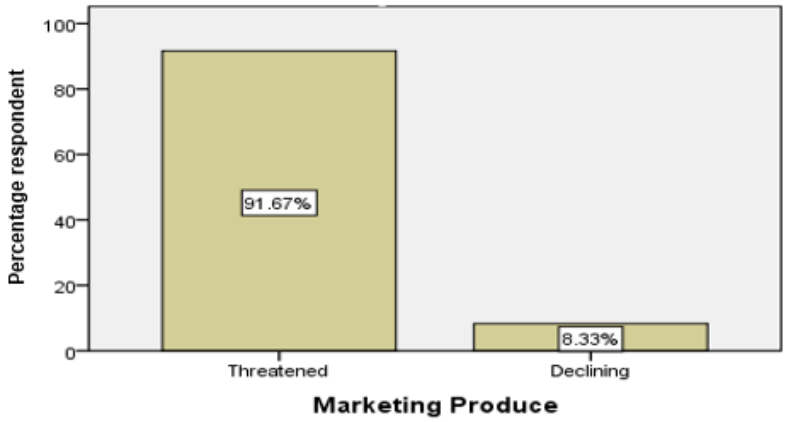


Figure: 4.15: Threatened/Declining status of Marketing Produce in Obigbo

Crafts such as carpentery and blacksmith were considered by ninety-one percent (91%) of the respondents to be in decline because more people are going to school and no skill acquisition training is being provided for the trade (Fig. 4.16).

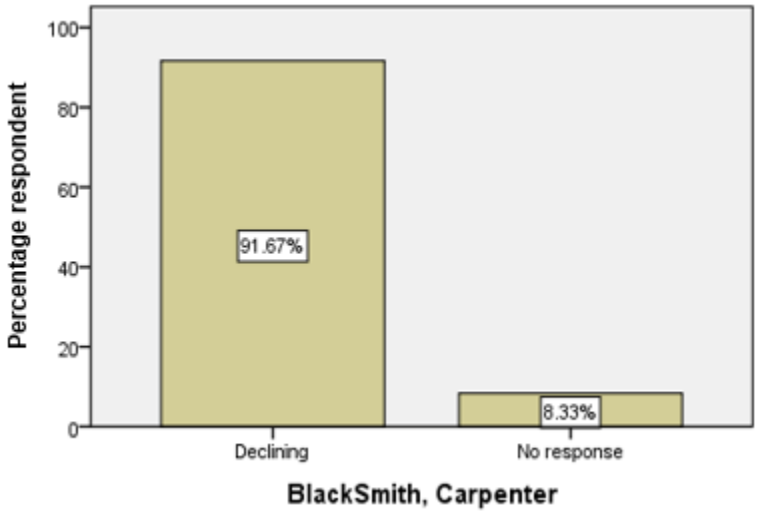


Figure: 4.16: Threatened/Declining status of Crafts in Obigbo

Food and snack retailing were considered by fifty-eight percent (58%) of the respondents (Figure 4.17) to be declining due to poor patronage resulting from migration and insufficient capital for business owners.

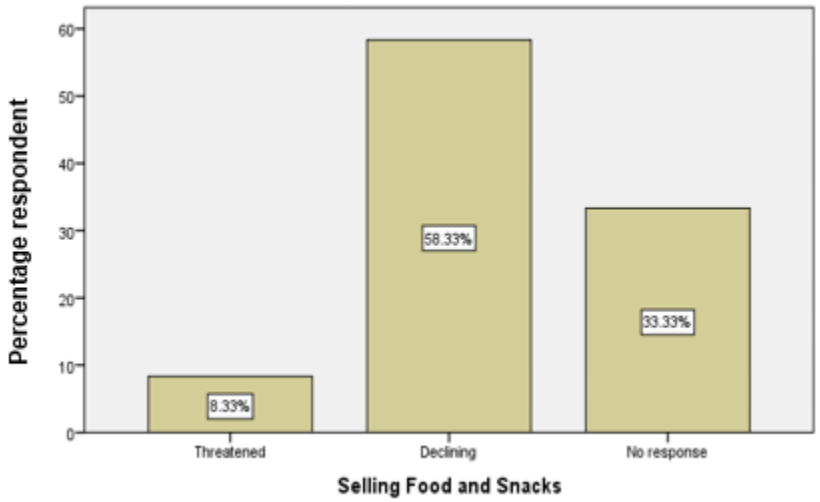


Figure: 4.17: Threatened/Declining status of Sales of food and snacks in Obigbo

The service of hired labour for agriculture and oil companies was also reported to be on the decline because of high cost of living and poor economy. The result of the economic status of Obigbo community (figure 4.18) shows that seventy-five percent (75%) of the respondents interviewed claim that one-quarter of the population live above poverty level, while the other three-quarters live below the poverty level. This shows that the majority of the population in Obigbo can be classified as poor where household income is below a necessary level to maintain basic living standards. During the FGDs (Plate 4.5a and 4.5b), the respondents indicated that they cannot adequately take care of their immediate needs or provide for the basic needs of their household members. They traced the high poverty level to the type of livelihood systems they are operating in which many factors such as access to credit, education and training make for a decline in productivity.

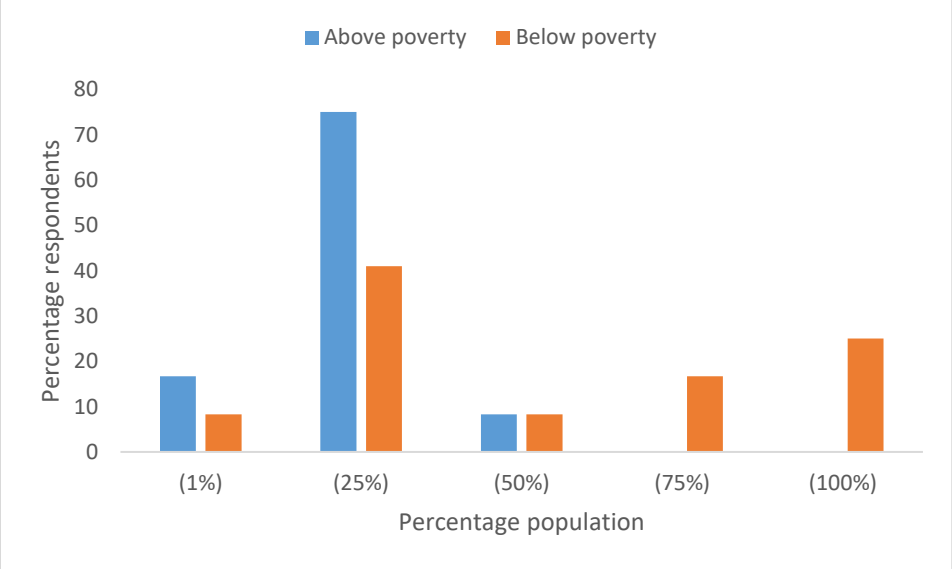


Figure 4.18: Economic Status of the People (Source: Field survey, 2019)

Plate 4.5a: FGD session in Obigbo community

Plate 4.5b: Interview session in Obigbo community

4.3.6.5 Commerce and Industry

The general trend in industrialization is low at the community level except for the oil and gas industries and the electricity distribution company present in Obigbo. As reflected in the occupation structure, people either farm, work for government or they are businessmen, of which these occupations are considered as declining or threatened (Figs 4.9 to 4.19). The small scale industry within the community are visible in welding and fabrication, sand mining in all the rivers in the area, traditional food processing like fish smoking and cassava flour production.

Fishing and hunting are reported to be a daily activity for those who earn their living from these activities, while those who use it as an extra source of income, engage in these activities weekly. From the report, daily fishers and hunters were more than those who do it weekly, implying that it is a basic livelihood activity in Obigbo community. The decision to fish and hunt is necessitated by several factors such as health, enabling environment and the availability of equipment. The volume of fish catch is reported to be scanty corroborating the decline in fishing activity as reported by the respondents.

In order to ascertain if there were any known traditional factors for the declining productivity they were asked if sacrifices were performed by the people before embarking on any farming or fishing activity. They reported there were no sacrifices being performed and are equally not aware of any repercussions due to non-performance of sacrifices before embarking on hunting or fishing. Most of the fish caught were consumed while the rest were sold. The daily income reported by the respondents' were not more than ₦2000 indicating that not much income is made from fishing activities.

Obigbo is sandwiched between the developed areas of Port Harcourt and Aba. This provides a stimulating influence on commercial activities due to the large industries in these two cities coupled with the large population. This nearness to the city has produced a positive domino effect at Obigbo. In the formal sectors are many commercial bank branches, retail outlets, small hotels, and asphalt plants. In the informal sector, are many small trading activities, automobile mechanics, local transport business, eateries and building construction. The informal commercial sector is the most numerous business activities in the area.

4.3.6.6 Agriculture and Land Practices

Land ownership in Obigbo and the rules of transfer are strict and contentious in the settlements. Distant lands from the community are devoted to subsistent farming. The crops cultivated in their order of importance are cassava, maize, yam and green vegetables; while the common fishes harvested from the river include tilapia, mullet,

mudfish, catfish and crabs, of which fishing is threatened by dredging activities and water pollution (Fig. 4.19).

The farming system is a limited form of shifting cultivation whereby land is cleared and cultivated for several years until productivity diminishes; it is then abandoned until natural processes regenerate the soil. The fallow period was up to seven (7) years about thirty (30) years ago. Presently fallow period is reduced to a year or two. Consequently, agriculture in the study area as a main stay of the people's income has reduced to exceptionally low levels of subsistence farming. Hence most of the agricultural activities in the area are categorized by the respondents as either threatened or declining.

Fishing activity is considered both threatened and declining as reported by thirty-three percent (33%) and fifty-eight percent (58%) of the respondents respectively. The reasons for this threat and decline are dredging activities and water pollution.

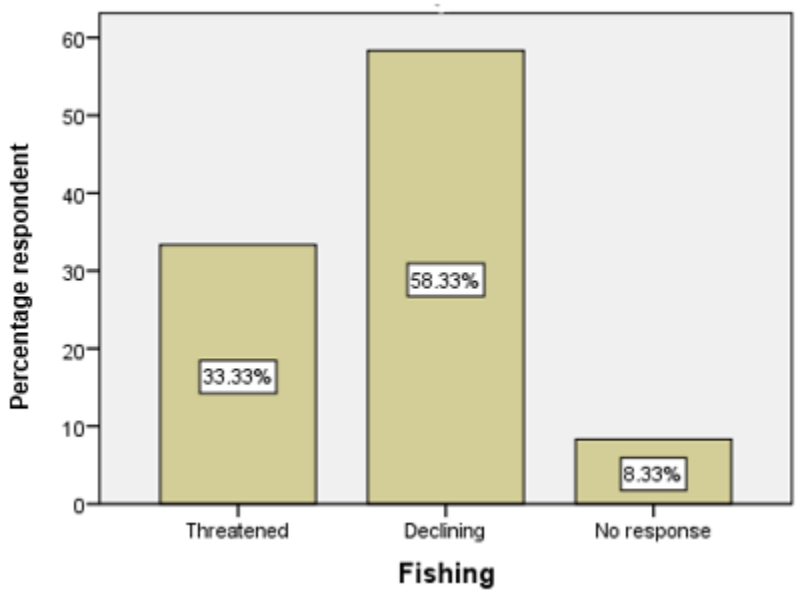


Figure: 4.19: Threatened/Declining status of Fishing in Obigbo

4.3.6.7 Water Supply and Sanitation

The sole source of domestic water supply in Obigbo is shallow boreholes and rainwater. The water tables in the study areas are close to the surface and water can be tapped at ten meters (10m) in most cases from the first aquifer. All domestic water supplies in the study area rely on this ubiquitous method. It is augmented by rainfall during the peak of the rainy season when the harvest is cleaner. The respondents however complained that sometimes their rainwater is polluted by emissions washed out from the various plants nearby.

4.3.6.8 Transportation

The community is traversed by a major highway namely the Port-Harcourt-Aba Expressway that begins from Port Harcourt and terminates in Enugu. The Port-Harcourt-Aba Expressway is in a dilapidated state. Most intra communal roads are however earthen. Movement from one place to another is by road in the study settlement. The settlement is large in land space to require some sort of transportation and it is met through the use of motorcycles and private taxi cars. The basic infrastructures present in Obigbo from the survey are the access road for which ninety-one percent (91%) of the respondents (Fig 4.20) indicated are not tarred. They also have no information from government and agencies about a known plan to improve the road condition any time soon. Dilapidated trucks and ramshackle passenger/goods vehicles traverse the area. Motorcycle machines, especially, large engine CG 115, 150 and 175 double silencer types predominate. Popular brands include Nanfang, Frajend, Suzuki and Q-link; which are all reported to be strong and hardy enough to traverse the rough, erosion ravaged and poorly maintained road networks. Bicycles may serve for intra settlements /communities movement. Human porterage on heads/shoulders is also a common activity, especially by the female gender.

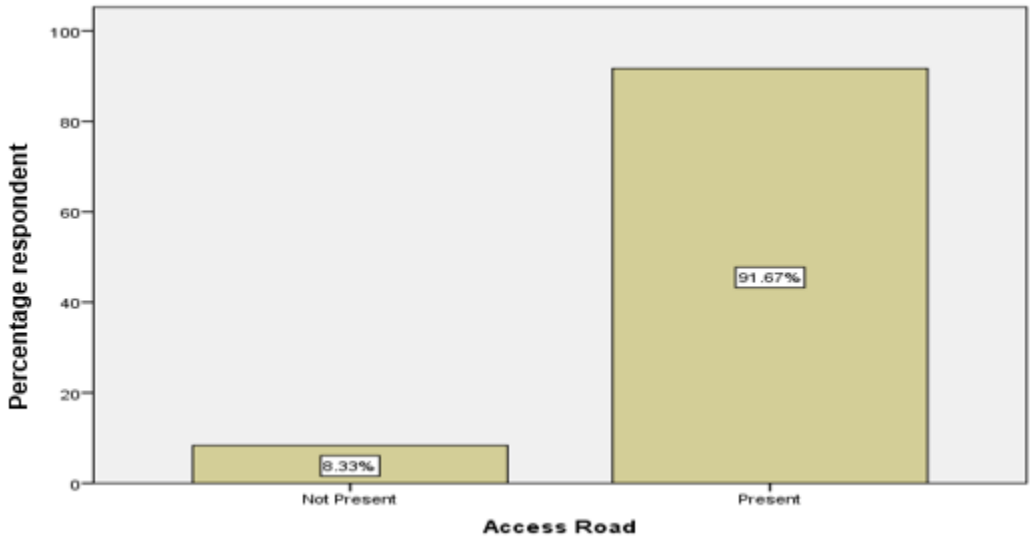


Figure: 4.20: Presence of Access Roads in Obigbo

4.3.6.9 Education

The respondents were all agreed that Primary schools were present in Obigbo. However, the majority of the respondents (75%) reported that secondary schools were absent while twenty-five percent (25%) reported the presence of secondary school (fig 4.21). This implies that the available secondary schools may not be functional, since it was regarded

as absent by some of the respondents. The respondents also all agreed there were no known plans to their knowledge of improving the educational infrastructure in the community.

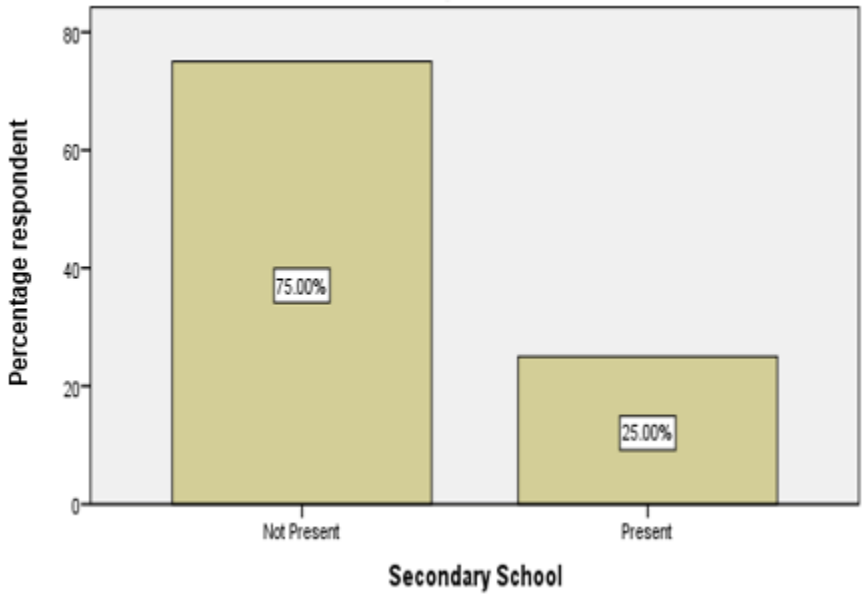


Figure: 4.21: Presence of secondary schools in Obigbo

4.3.6.10 Energy and Electricity

Energy demand in the study area is for lighting, cooking, maintenance workshop and driving machines, (including automobile). Vehicles are driven with gasoline and diesel, electricity and kerosene are used in lighting, while wood and kerosene are used in cooking. Our experience during the field work showed that all these energy types are in short supply. The respondents indicated that Electricity is epileptic (Fig 4.22), which they attributed is due to the poor management by Power Holding Company of Nigeria. Electricity generating plants are utilized by very few relatively well-off individuals and by bars and eateries. Bush lamps and candles (rarely) provide illumination in the night.

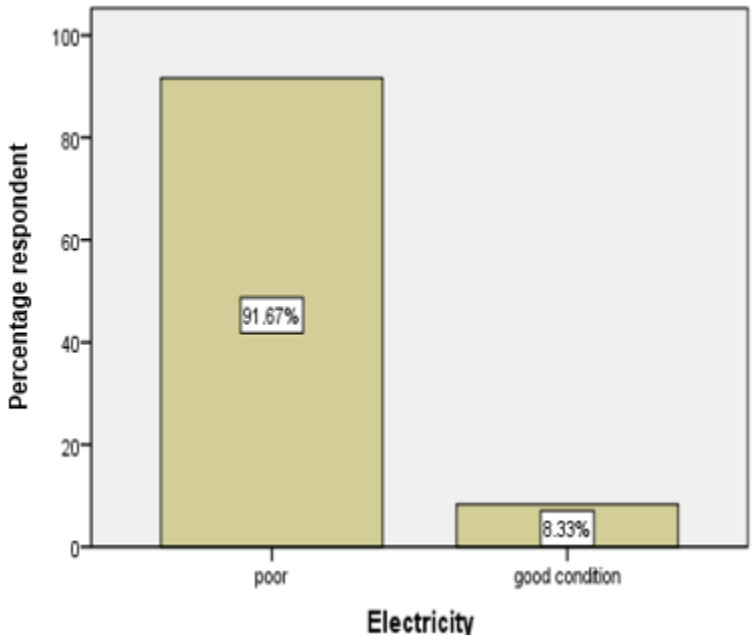


Figure: 4.22: Condition of electricity in the study area in Obigbo

4.3.6.11 Conflict Resolution in Communities

The respondents indicated that dispute over land boundary and ownership is the primary cause of intra and inter communal conflicts in the study settlements. Others include tussle for chieftaincy titles and other forms of recognition by the paramount ruler. These kind of cases are usually resolved in the paramount ruler's palace, elders house and courts.

4.3.7 Health Assessment

4.3.7.1 Health Status and Quality of Life

Due to the unreceptive nature of the community to questionnaire administration and FGD, indirect interviews were used to elicit information on the health status of the community.

4.3.7.1.1 Disease Trend and Health-Seeking behaviour

The results of the interview indicated that malaria, stroke, hypertension were prevalent. Others such as typhoid and diarrhoea are equally important as the commonest causes of ill health in the community. Some of the diseases such as typhoid and diarrhoea can be linked to lack of safe drinking water in the area. Other disease conditions mentioned during interview include arthritis and Hernias. He also noted an increase in asthma which he suggested may be linked to the general air pollution. Their health seeking behaviour is to patronize chemists and local practitioners as they are reluctant to visit the health centres and hospitals due to poverty. The other unconfirmed reason for their health seeking behaviour is that they do not go to the government hospital because it is not functioning.

4.3.7.1.2 Health Infrastructure at Obigbo

It has been reported by the UNDP (2006) that infrastructural and social services in the Niger Delta are generally deplorable and grossly inadequate for an estimated regional population of about thirty (30) million people. The case is not different for many parts of the Obigbo study area. With regard to healthcare facilities, there is one general hospital, five health centers and three cottage hospitals in Obigbo, out of which only one cottage hospital (Imeh Cottage Hospital) is domiciled in the host community (Plate 4.6).

4.3.7.1.3 Occupational Health Risks

The major occupation of the people in the area is fishing and farming while some proportion of the population are involved in trading, a variety of artisanship and the civil service. The attendant health risks which community members are exposed are mosquitoes, tse-tse fly, sand fly and rats.

4.3.7.1.4 Nutrition

The nutritional habits gathered during the interview showed that they mainly feed on carbohydrate-based diets from cassava, yam and rice. Their major sources of protein are fish, crayfish, beef and beans. In relation to the declining crop production, food insecurity is likely threatened.

4.3.7.1.5 Water Supply, Sanitation and Waste Management

Potable water supply is lacking in the survey area. Major sources of water supply for consumption and domestic uses are from rain water run-off – collected from thatched/woody/rusty iron sheet roofs. These are invariably unhygienic and particles/germs infested. In the dry season, domestic water supply is from shallow hand-dung wells, the liquid contents of which are separated from the earth surface by rusty iron –wrought containers. Water may also be collected from shallow unhygienic streams which become water logged during the rains and from private and public bore holes.

The information gathered on waste and sanitation showed that most households have poor waste systems such as pit and latrines, only a few households have water closet toilets. This practice poses the risk of food and water contamination by flies, cockroaches and rodents from the latrine area. The waste stream in the community comprises basically domestic and household wastes and items related to agricultural produce processing such as cassava, and oil palm processing. The common practice of waste disposal is by open dumping and burning as seen in plate 4.7.

Plate 4.6: Imeh Cottage Hospital in Obigbo

4.3.7.1.6 Disease Vectors and Pests

The typical rural settlement pattern of the community which is within patches of wild and cultivated vegetation, gives indications of risk of vector-borne diseases in such areas. The people are conscious of the presence of mosquitoes, which constitute a major health risk in their neighbourhoods. The insects reported to occur around the homes are housefly, cockroaches and termites. Rodents, such as rats and reptiles such as lizards are found around the homes. The keeping of domestic animals is a common practice. Animals such as goats, sheep and chicken are readily found in free-range in the areas. The people have limited knowledge of zoonosis and so do not see domestic animals as any form of danger. The people are aware of preventive measures against mosquitoes; some households have their windows screened with mosquito net.

Plate 4.7: Open waste dumping in Obigbo

4.3.7.1.7 Community Perception

The major concerns of the community were lack of health facility, educational facility, lack of jobs, lack of road infrastructure and poverty. This is because their health facility is abandoned and non-functional, while the unemployment level in the community is high. On the other hand, their minor concerns were lack of development, lack of government attention, environmental pollution, and bad drinking water. Priorities of the community were tailored towards needs such as Employment, Skill Acquisition Training with Starter Packs, Empowerment/Micro Credit Facility, Portable Water and Electricity.

4.3.7.2 Findings, Conclusion and Recommendations

a. The socioeconomic and health profile of the communities in the area indicated that natural resources are part of the larger mix of economic activities supported by average social and infrastructural facilities which taken together provides a low quality of life. The evident facts emerging from formal FGD at Obigbo shows a decline in many socioeconomic sectors namely trading due to the poor state of the roads in the community;
b. civil service occupations due to the government embargo on employment;
c. fishing due to dredging and water pollution from small and large scale commercial and industrial activities including poor waste management;
d. hunting and NTFP picking due to deforestation and uncontrolled hunting;
e. processed and marketing produce due to bad roads, and poor access to capital;

f. crafts due to lack of skills acquisition center.
g. food and snack retailing due to migration and poor social infrastructure
h. quality and educational and health facilities due to negligence by government and oil and gas operators;
i. electricity supply due to the transfer from SPDC to Power Holding Company of Nigeria and subsequent poor management
j. Poor public waste management with its likely health implications
k. unavailable energy such as gas for cooking resulting in use of wood and other sources that have respiratory health problems

These declining trends are a mixture of many socio-political factors that cannot be attributed to the operations of the TEPNG in the areas surveyed. However, TEPNG should review the requests by the community in order to provide a platform for effective communication, conflict resolution and readiness to negotiate to guarantee mutual peaceful coexistence.

CHAPTER FIVE

ASSOCIATED AND POTENTIAL IMPACT EVALUATION

5.1 General

The Northern Option Gas Pipeline (NOPL)–Indorama pipeline tie-in project is likely to have biophysical, social and health impacts on the project area. These impacts may be associated impacts (i.e. those that *will* occur) and/or potential impacts (i.e. those that *could* occur). The objectives of the impact assessment are to identify the associated and potential environmental, social and health impacts associated with the proposed project activities, evaluate the likelihood of occurrence, magnitude and significance of identified impacts. Mitigation measures will then be proffered for the anticipated negative impacts, while measures would be provided for enhancing the positive (beneficial) impacts.

This chapter identifies and describes these potential impacts and also presents the criteria for predicting the sensitivity, intensity as well as severity of such impacts. It is aimed at qualifying and quantifying the impacts derived from evaluation of results from field work, data analysis, literature search, etc. Stipulated standards of the enabling legislative framework and guidelines for sustainable practices in the infrastructural sector and established facts in relevant literatures, stakeholders' perceptions and evaluations and general observations obtained during field data gathering were also considered in the impact assessments.

5.2 Impact Assessment Methodology

A systematic impact assessment process presented in Figure 5.1 was used to identify, quantify and qualify the impacts of the NOPL–Indorama pipeline tie-in project activities on the project environment. This process is based on the methodologies developed by the World Bank and ISO 14001 Standards as well as the Federal Ministry of Environment guidelines as set out in the sectoral guidelines, and TEPNG's recommended methodology for impact evaluation as expressed in various documents including GS EP ENV 120 (Environmental Impact assessment of E&P activities), with an objective to ensure a comprehensive and systematic evaluation of all potential positive and negative effects associated with the project. This is also in congruence with TEPNG"s commitment to high quality EIA process and documentation towards the achievement of a sustainable project. The ISO 14001 method is simple to apply and provides a high level of detail and also relies on limited data. This method was therefore selected for the evaluation of potential impacts for the proposed project. In line with general guidelines for an Environmental Impact Assessment (EIA) process, the following were the basic steps adopted for identification and evaluation of impacts:

- Impact identification
- Impact description
- Impact qualification
- Impact risk and severity rating

The impact assessment methodology adopted for this project consists of the following major steps:

- Exhaustive review of each Effect of the project and classification
- Environmental Sensitivity classification of each receptor
- Severity of Impact definition and Significant Impacts determination

These steps were then further broken down in order to achieve a thorough assessment of the impacts

Step 1: Identification of Project activities/effects (sources of impact), and environmental receptors;

Step 2: Comprehensive preliminary identification of potential impacts;

Step 3: Determination of the effect intensity ("I" from 1 to 4). This involves the detailed assessment of the identified impacts that are likely to be significant through impact quantification/characterization techniques; quantification of impacts to the extent possible and qualitative characterization of impacts that cannot be quantified; and

Step 4: Environmental sensitivity of each receptor determination ("Sen"or SI from 1 to 4)

Step 5: Severity qualification from "Negligible" to "Major". Final assessment of the severity levels of impacts through application of the results of the rigorous quantitative and qualitative characterization of impacts developed in previous steps to a set of objective impact severity criteria; identification of impacts warranting mitigation.

The processes enumerated above involve the use of various impact assessment tools that include: checklists, interaction matrices, and other impact evaluation techniques, etc.

5.2.1. Establishing the basis of Impact Assessment

For the baseline study of the project area, covering the biophysical, social and health aspects, data were collected through field work, laboratory analysis and data interpretation, and these led to the preparation of an integrated environmental (biophysical, social, and health) baseline report which provides understanding of the existing natural and social environment. The baseline infrastructure of the recipient environment has been described in Chapter 4 of this report.

Other bases include:

- the knowledge of the project activities
- equipment types and layout of project facilities
- accumulated knowledge of generic information on potential impacts of similar projects;

- series of expert group discussion/meetings and experience of similar projects.

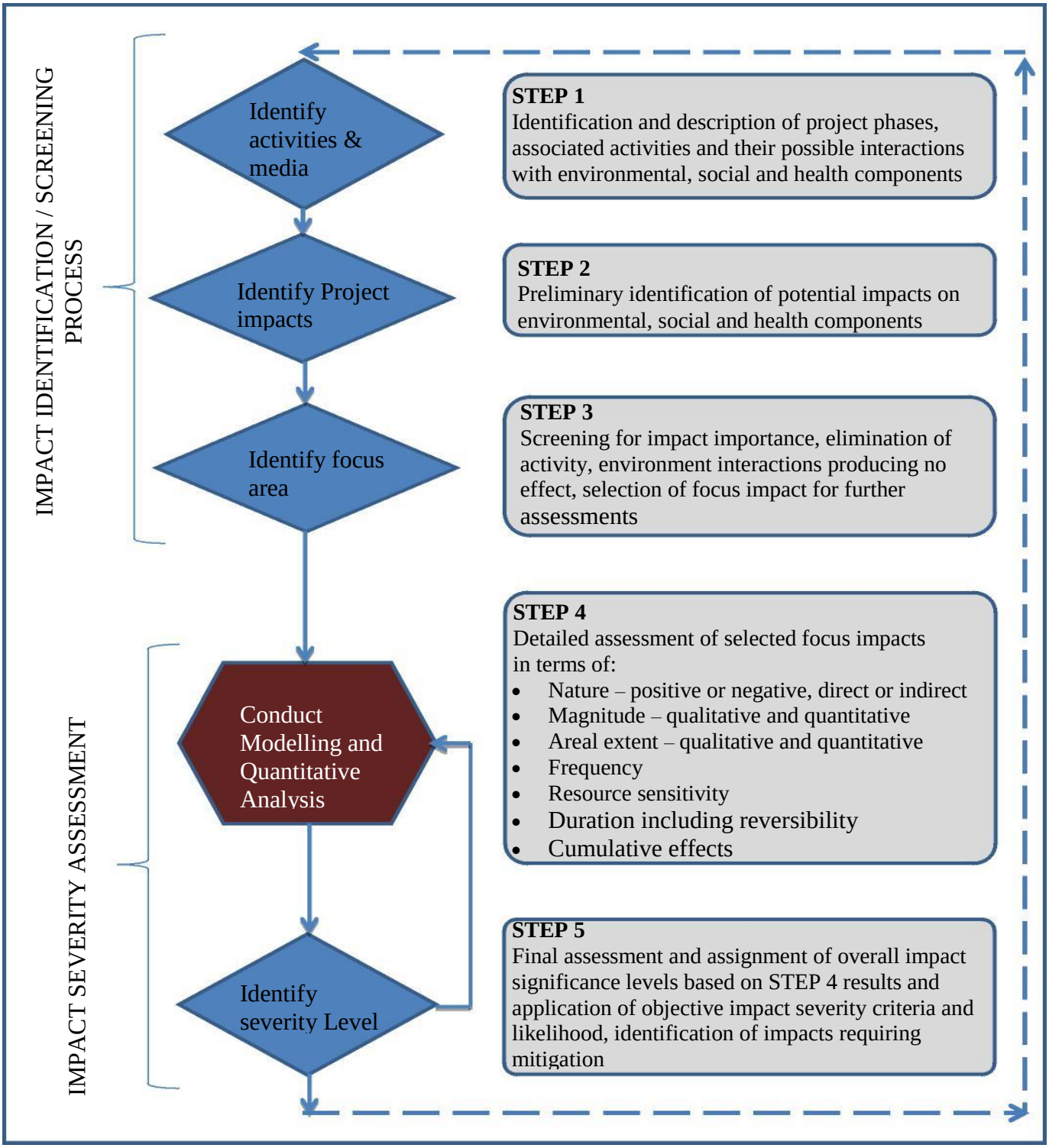


Figure 5.1 Impact Assessment Process

5.2.2. Identification of Project Activities

A good knowledge of the project activities and the environmental (biophysical, socioeconomic and health) receptors is essential to be able to effectively capture the impacts that will arise from the project. Based on the proposed project which has been described in detail in **Chapter 3**, a list of activities which interact with the social and natural environment in a distinct way either due to their nature or due to timing was compiled. The list of project activities is summarized as follows:

- Pre-mobilization of contractor
- Mobilization
- Operational pigging with foam pigs
- Nitrogen purging of TEPNG's 50km 24" Carbon Steel gas supply line
- Installation of fully rated spades
- Excavation Works.
- Coating of 24" x 18" Carbon Steel barred tee.
- Ultrasonic Inspection of a segment of TEPNG's 24" carbon steel gas supply line
- Cold cutting of a segment of TEPNG 24" carbon steel gas supply line
- Fit up and welding of 24" x 18" carbon steel barred tee.
- Tie in of 24" x 18" carbon steel barred tee
- Field coating of welded joints
- Non-Destructive Testing of welded joints
- Removal of previously installed spades at TEPNG's Rumuji and Obigbo Nodes
- Backfilling and compacting
- Physical inspection/ validation of the Tie-in Points
- Commissioning and handover
- Site cleanup
- Operation activities
- Decommissioning/abandonment

5.2.3. Preliminary Identification and Screening

In line with the recommended impact assessment approaches (UNEP, 1996; Canter, 1996, Lohani et al., 1997), the first level of impact assessment involves the preliminary identification and screening of potential environmental impacts by anticipating activity-environment interactions. This requires a thorough understanding of the project activities (project description), the project setting (the environmental description), and the interaction with environmental components. ISO / World Bank methodology of assessment was used for the identification and screening. The matrix arrays project activities against environmental (biophysical, social, and health) components, and

supports a methodical, comprehensive, and objective identification of the impacts which each project activity may have on each biophysical, social, and health component.

Impact identification is based on Wathern (1988), who defines an impact as "having both spatial and temporal components and can be described as the change in an environmental parameter over a specified period within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initiated".

To further guide the identification and screening of impacts for the proposed NOPL–Indorama pipeline tie-in project using the matrix, established environmental impact indicators or indices are developed for each of the environmental interaction categories. Impact indicators are the observable and measurable parameters of each environmental condition. Table 5.1 gives the specific environmental components and sub-elements used and a description of the indicators.

Table 5.1: Environmental, Social and Health Components and Impact Indicators

COMPONENTS	IMPACT INDICATORS
Biophysical	
Biodiversity	Vegetation, wildlife
Soil	Changes to soil quality indices (physico-chemical properties, hydrocarbons, heavy metals, Microbiology.
Air	Emissions of NO_2, SO_2, $PM_{2.5}$, PM_{10}, CO, VOC, greenhouse gases (CO_2, CH_4)
Noise	Change in noise levels at sensitive receptors
Social	
Population	Changes in population indices, total population, gender ratio,
Infrastructure	Improvement or pressure on existing urban/rural infrastructure including waste handling facilities
Macro and micro economy	Change in macro and micro economy, employment, standard of living, occupation,
Social and Cultural Structure	Disruption in local authority and governance structure; change in social behavior, intra- and inter-ethnic clashes
Transportation	Alteration in means of transportation or ability to move efficiently
Education	Change in primary, secondary and tertiary education school enrolment and attendance

Health	
Pollution Related Health Effects	Increase in concentration of air pollutants of concern (NO_2, SO_2, $PM_{2.5}$, PM_{10}, CO, VOC) and contamination of surface waters and potable ground water, increased noise beyond regulatory limits, increased night time beyond acceptable
Communicable and Non-Communicable diseases	Change in incidence of communicable and non-communicable diseases or disease-causing factors
Morbidity and mortality	Change in health of workers and general public, change in security of the area
Health care / recreational facilities	Changes in availability of and access to health care and recreational facilities
Psychosocial factors	Drug use/abuse, communal violence, crime, suicide, depression and prostitution; changing expectations of quality of life
Accidents / Fires / Explosions	Changes to rate of occurrence and severity of accidents / fires / explosions

The aim of impact identification is to ensure that both significant and insignificant potential and associated bio-physical, social and health impacts are accounted for. The anticipated impacts were determined based on the interaction between project activities and environmental sensitivities. A check list of the identified associated and potential impacts of the project is listed in **Table 5.2.**

Table 5.2: Checklist of Associated and Potential Impacts of Proposed NOPL–Indorama pipeline tie-in project

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts
Site Preparation	Bush Clearing	Biodiversity (Vegetation/ wildlife) loss
		Ecological degradation
		Exposure to allergic plants
		Injuries and attacks from wild animals
		Loss of access to farmland
		Opportunity for business
		Third party agitation
Mobilization	Mobilization of personnel, materials and equipment to site by road.	Air/Noise pollution from increased vehicular movement
		Damage to existing access roads
		Kidnappings
		Road traffic accidents with injuries from increased vehicular movements on local roads
	Employment of local labour and award of contracts to members of the host communities	Increased cash flow and stimulation of local economies within the Host Communities
		Inter and intra community conflicts
		Localized economic benefits from materials supplies by local contractors
		Third party agitations
	Influx of workers into the host Communities	Increased sexual immorality especially among young women
		Increase pressure on existing social amenities and infrastructure
		Increased prevalence of sexually transmissible infections (STIs) including HIV
		Socio-cultural conflicts between the construction team and members of the host communities
		Stimulation of local economy and markets from increased demand for food, and other products in the local market.

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts
Construction	Excavation and Trenching	Damage to roads
		Damage to soil Structure and Texture
		Increase in dust and SPM during dry season.
		Increase in noise and exhaust gases from excavators.
		Temporary vehicular traffic obstruction/diversion at road crossing.
	Welding	Air pollutants effects of CO_x, NO_x, SO_x from welding and other activities.
		Exposure of welders to heat and light radiation.
		Integrity testers exposed to X-rays.
		Release of Toxic fumes during welding operations
		Risk of electrocution and burns during welding
	Back filling, revegetation, Transportation of workers and maintenance of construction equipment's, waste disposal	Air pollutants effects of dust.
		Alteration of soil texture and structure through compaction
		Contamination and degradation of soil from discharges and spills of sanitary, construction related solids wastes.
		Onsite exposure of workers to noise and vibration from use of heavy duty equipment
		Road users would be exposed to higher road accidents due to increase in heavy traffic. Temporary road obstructions/diversions
		Workplace accidents/incidents
	Linking of gas pipes	Noise associated with hook-up procedure
	Operations of machines and vehicles	Emission of exhaust gases from the fuel combustion engines can alter the local ambient air quality.
		Soil contamination and loss of aesthetics from liquid leaks
		Vibrations affecting existing pipelines
	Base camp	Domestic waste from base camp shall cause poor aesthetic if it is dumped on soil and vegetation

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts
Operation / Maintenance	Disposal of industrial and domestic wastes	Odour and aesthetic devaluation may result from improper handling.
	Maintenance	Release of gases through isolation valves.
	Gas leaks	Accidental damage to equipment or fire
Abandonment / Decommissioning	Excavation to remove pipeline and Re-vegetation	Soil contamination
		Increase in income
		Return of land to indigenes for farming
	Transportation of removed structures from site	Occupational and traffic accidents

5.2.4 Impact Description and Qualification

The identified impacts of the project were described based on the following criteria:

- Positive or negative
- Direct or indirect

Negative impacts are those that adversely affect the biophysical environments while positive impacts are those which enhance the quality of the environment. Direct impacts refer to those impacts that are caused by the project activity and occur at the same time and place. Indirect impacts are impacts caused by a project activity but would occur in the future or outside the project area and are reasonably foreseeable. Impacts are qualified either as:

- Short term < 3 months (S) or
- Long term > 3 months (L), or
- Reversible (R) or
- Irreversible (I)

For this study, short term means a period of time less than three months while any period greater than three months is considered long term. Reversible means the environment can revert to its previous conditions while irreversible means the impacts remain permanent even after the activity causing the impact is terminated.

The first stage in the Impact Assessment procedure shown in Figure 5.1 involves the collation and use of various source references to develop and/or establish:

- Checklist of associated and potential impacts;
- Checklist of legal and other requirements; and
- records of consequences, severity, probability and frequency of occurrence of various environmental impacts/incidences.

The key source references used at this stage were:

- FMEnv Sectorial Guideline for the Oil and Gas/Infrastructure Sectors (1995);

- Rivers State Guidelines & Standards on Pollution Control (2001)
- ISO 14001 Environmental Management System;
- Project Risk Assessment Study;
- Project design reports, map and drawings; and
- Environmental and Socio-economic baseline status of the project area acquired both from field work, literature search and information gathered from various data gathering techniques (Oral discussions, small group interviews, Questionnaires) and the project based specific description earlier highlighted in Chapter 3.

5.2.5 Evaluation of impacts and Significance Criteria

In order to objectively review the potential impacts and to determine the likely significance of those impacts when compared to baseline conditions, the general significance criteria shown in Table 5.10 (adapted from WAPCo, 2004) were developed and used. This EIA uses the significance criteria to evaluate impacts, which enables systematic identification and focus on those resources most likely to be impacted by the proposed project. Significance criteria were established to systematically determine whether potential impacts would likely be **positive**, or **negative**. Negative impacts were further classified as **major**, **moderate**, **minor**, or **negligible**. Those issues determined to be inconsequential or not applicable after mitigation were eliminated from or "screened out" from further consideration.

This impact severity assessment takes into account two main categories of significance criteria: intensity of the impact and the sensitivity of the receptor. Other criteria for the characterization of impact and consideration in the overall severity assessment include: temporal factors (duration, frequency, and reversibility), indirect or secondary effects as well as cumulative effects. These assessment criteria are described as follows, in no order of importance.

5.2.5.1 Temporal Factors

An assessment of certain temporal factors associated with potential impacts is presented as part of the significance criteria listed in Table 5.10. The relative significance level (e.g. **minor**, **moderate**) described under each affected category (e.g., environment, socioeconomic) is a combined assessment of the duration of the impact, the impact reversibility, and the frequency of the impact.

Duration is defined as the time that is estimated for a population or resource to return to "baseline" (pre-project) conditions. The duration is calculated from the time the impact begins, which may coincide with the start of the activity that causes the impact. The duration of an impact may be characterized as follows (**Table 5.3**):

Table 5.3: Showing Duration of Impact Characterization

Significance Level	Description
Major (4)	Long-term impact, recovery not expected to occur within five years
Moderate (3)	Moderate-term impact, recovery time between six months and five years
Minor (2)	Short-term impact, recovery time within six Months
Negligible (1)	Impact or recovery is very short term or immediate

Source: TOTAL Exploration and Production (EP) General Specification: GS-EP-ENV-120: Environmental Impact Assessment of E&P Activities)

Characterization of the duration of an impact as **major**, **moderate**, or **minor** includes consideration of the degree of reversibility of the impact. Impacts for which the duration is classified as **major**, as defined above, would be long-term impacts.

Frequency is defined as the number of times an impact is expected to occur over the life of the project. The frequency of an impact may be characterized as follows (**Table 5.4**):

Table 5.4: Showing Frequency of Impact Characterization

Significance Level		Description
Major	4	Continuous impact, impact will occur continuously throughout the life of the project
Moderate	3	Intermittent impact, impact will occur intermittently over the life of the project
Minor	2	Rarely occurring impact, impact will occur a very limited number of times
Negligible	1	Very rarely occurring impact, less than twice in a period of one year

5.2.5.2 Geographical extent

Geographical extent for the purpose of this report refers to the location of an impact in terms of the amount of area affected i.e. Localized versus wide spread. In this EIA, impacts are considered "localized" if they are likely to occur only within 100m of the impact source. The extent may be quantified in units of area affected (e.g., square kilometres). The geographical extent of an impact is characterized in general terms as follows (**Table 5.5**):

Table 5.5: Showing Areal Extent of Impact Characterization

Significance Level		Description
Major	4	Impact to the national, regional, or global environment (e.g., greenhouse gas emissions)
Moderate	3	Impact to the general vicinity of the project site or study area
Minor	2	Impact limited to the immediate vicinity of the project activity
Negligible	1	Impact limited to a very small part of the activity area and is within the project ROW

5.2.5.3 Intensity of effect

The intensity of an impact is partially quantifiable in terms of the percent of resource affected and by the relative concentration at receptor points.

Percent of resource affected is defined as the quantitative intensity of the impact and can be measured as the percentage of a resource or a population within the study area that may be affected by an impact. The definitions of **major**, **moderate**, **minor**, and **negligible** in this respect may vary depending upon the specific receptor. The intensity of an impact is characterized as follows (**Table 5.6**) for this EIA:

Table 5.6: Showing Intensity (magnitude) on Resources or Receptors

Significance Level		Description
Major	4	Large amount of the resource or population is affected. An easily observable and measurable effect
Moderate	3	Moderate amount of the resource or population is affected. Generally measurable and observable effect
Minor	2	Small amount of the resource or population is affected. A low intensity impact may be within the range of normal variation of background conditions
Negligible	1	The amount of resource or population affected is unnoticeable or immeasurably small

Concentration at receptor points may also be defined with respect to quantitative or semi-quantitative criteria, if available and applicable (e.g., noise level in units of decibels, or milligram per cubic meter (mg/m3) of an air pollutant, measured at a particular location). The identified quantitative criteria (benchmarks) would align with standard best industry standards (e.g., for noise impacts, noise exposure limits as set by international standards for worker health and safety), and/or established national standards in the project country. The concentration factor, when quantifiable, may be characterized as follows (**Table 5.6**):

Table 5.6: Showing Characterization of Intensity (magnitude) at Receptor Points

Significance Level		Description
Major	4	Exceeds the quantitative or semi-quantitative benchmark
Moderate	3	At or near the quantitative or semi quantitative Benchmark. Periodically and briefly exceeds this benchmark although generally within the benchmark
Minor	2	Generally, only a fraction of (e.g., less than 75 percent) the quantitative or semi quantitative benchmark
Negligible	1	Impact not detected or at background conditions, or well below (e.g., less than 10 percent of) the quantitative or semi quantitative benchmark

5.2.5.4 Sensitivity of the receptor

This refers to economic, social, and/or environmental/ecological importance of the receptor, including reliance on the receptor by people for sustenance, livelihood, or economic activity, and to the importance of direct impacts to persons associated with the resource. Impacts that directly affect people or vital natural resources are deemed to be more important than impacts that indirectly affect people or vital resources.

The sensitivity of the receptor criterion also refers to potential impacts to Environmentally Sensitive Areas and impacts to species, including loss of endangered species, effects of introduction of invasive species, and similar environmental/ecological impacts. The reversibility or irreversibility of consequence of impact on receptor is also considered in determining the sensitivity of a receptor. It also depends on its local regional or international sensitivity classification and extent of consequence on the resource.

Sensitivity of the receptor has been given a classification from 1 to 4 based on whether the effect could result in significant negative impact on the resource that are limited to the site, local surrounding of the project, regional or international.

Additional impact assessment criteria

Indirect or secondary influence of a primary impact is considered as an additional factor when assessing the significance level of a potential impact. The direct impact of an activity is taken into consideration while considering the key assessment criteria described above. An indirect or secondary influence are those reasonably foreseeable effects that are expected to be "caused" by the proposed action but occur later in time or are removed in distance, such as influences on adjacent or upstream/downstream areas. Therefore, the secondary nature of the impact is taken into account when evaluating the temporal factors, geographical extent, and intensity of the potential impact.

Cumulative effects are those that result from the incremental consequences of an action when added to other past and reasonably foreseeable future actions. The cumulative effects of a particular project activity must be considered when assessing the overall significance level of that impact.

5.2.5.5 Significance Levels and Criteria

Table 5.8 is arranged to show the general media category across the rows of the table (i.e. Physicochemical Environment, Biological Environment, Socioeconomic Environment, and Health and Safety). Each significance level category is indicated by a gray separator row, beginning with "negligible", then describing "minor", "moderate", and "major" negative significance. Each major significance level includes a short discussion of the specific criteria outlined above.

Positive impacts are not ranked in terms of significance levels for this severity assessment. If an impact is deemed to be positive, rather than neutral or negative for any of the general media types, it is given a "positive" label and is described qualitatively and where possible quantitatively in the impacts discussion.

Table 5.8: Negative Impact Significance Levels and Criteria

Significance Criteria	Physicochemical Environment	Biological Environment	Socioeconomic Environment	Health and Safety (Personnel and Public)
Negligible (negative)				
Temporal	Very temporary effect, even less significant than periodic stress by nature. The duration of the effect is likely to be naturally reversible within a short period of time (less than one week). The frequency of the impact is extremely low (less than two times/year)	The duration of the effect is likely to be naturally reversible within a short period of time (less than one week). The frequency of the impact is extremely low (less than two times/year)	Temporary influence (impact discernable for less than one week). The effects are completely reversible and of extremely low frequency (less than two times/year)	No discernable health effects for any period of time.
Geographical	The impact to the land, air, and water is localized, existing only within the pipeline ROW or facility boundary.	Some impact localized on a community or individual level, but not distinguishable from natural background perturbation.	Localized, isolated change in socioeconomic conditions or commercial activities; not affecting persons other than project personnel.	No discernable health effects in any area.
Intensity	Little or no change in physical environment, barely measurable above background conditions (less than five percent change from background). Concentration at receptor points is well below (e.g., no more than ten percent of) identified industry benchmark levels or established national standards.	Little or no change in biodiversity, habitat availability, or community Structure and function in comparison to background levels.	Unlikely to have any measurable impact.	No discernable health effects to any part of the population.

Significance Criteria	Physicochemical Environment	Biological Environment	Socioeconomic Environment	Health and Safety (Personnel and Public)
Moderate (negative)				
Temporal	The duration of the effect is more than six months but less than five years and reversible within that period of time. Frequency of impact may occur from five to ten times per year.	The duration of the effect is more than six months but less than five years and reversible within that period of time. Frequency of impact may occur from five to ten times per year.	For single events, duration of the effect is more than six months but less than five years, and fully reversible after that period of time. For recurrent events, duration of each event is no more than a month, impacts are reversible after each event, and frequency of impact is from five to eight times per year.	For single events, duration of the effect is more than six months but less than five years, and fully reversible after that period of time. For recurrent events, duration of each event is no more than a month, and frequency of impact is from five to eight times per year.
Geographical	Localized, relatively isolated change in physicochemical environment. Impact consequence is realized up to 500m from ROW or facility boundary.	Local to widespread change in habitat availability or quality, likely to modify abundance or distribution of species. Impact consequence is realized up to 500m from ROW or facility boundary.	Impacts affecting not only project personnel but also surrounding population, local communities/public up to 500m from ROW or facility boundary.	Impacts affecting not only project personnel but also surrounding population (public) up to 500m from ROW or facility boundary.
Intensity	Local modification of considerable severity in atmospheric, surface, or subsurface conditions. Significant measurable change from baseline conditions (10 to 20 percent change from baseline). Concentration at receptor points is at, near, or periodically exceeds identified industry benchmark levels or established national standards.	Impact evident at community or population level, significant change in population density (e.g., decline in fish species abundance), habitat quality, etc.	Pronounced change in socioeconomic conditions, livelihood, living conditions, or social structure, likely to result in significant hardships or reduction in living standards for a significant portion (but less than half) of the affected community population. Impacts too severe to be overcome or ameliorated with existing individual or community resources.	Injury or illness affecting less than half of the affected population to a greater or lesser degree, with a few cases requiring hospitalization and/or resulting in long-term disability.

Significance Criteria	Physicochemical Environment	Biological Environment	Socioeconomic Environment	Health and Safety (Personnel and Public)
Major (negative)				
Temporal	The duration of the effect is long-term (greater than five years) or is not reversible (permanent). Frequency of the impact may occur more than ten times/year	Long-term (greater than five years). Modification will persist beyond the duration of the project or is not reversible. Frequency of the impact may occur more than ten times / year.	The effect is long-term or likely to last more than five years, or is not reversible. For recurrent events, duration of each event is greater than a month; impact frequency is high (more than eight times / year) and impact durations may overlap.	Effects are of long-term duration (more than five years) or permanent, i.e., not reversible. For recurrent events, duration of each event is greater than a month; impact frequency is high (more than eight times / year) and impact durations may overlap.
Geographical	Widespread modification of considerable severity in atmospheric, surface, or subsurface conditions. Geographical extent of impact consequence is realized beyond 500m of ROW or facility boundary.	Widespread change in habitat availability or quality, which would likely modify natural abundance or distribution of species beyond 500m of ROW or facility boundary.	Widespread (possibly even beyond study area communities).	Impacts affecting not only project personnel but also surrounding population (public) more than 500m from ROW or facility boundary; may cause regional effects.
Intensity	Modification of considerable severity in atmospheric, surface, or subsurface conditions. Significant, measurable change from baseline conditions (more than 20 percent change from baseline when applicable). Concentration at receptor points exceeds identified industry benchmark levels or established national standards.	Impact to affect organisms at or above the ecosystem level.	Very pronounced change in socioeconomic conditions, livelihood, living conditions, or social structure, likely to affect the majority of people in the affected communities and result in serious hardships, reduction in living standards, or impoverishment. Impacts overwhelm the ability of individuals or communities to recover or overcome.	Impacts affect a large portion or even the majority of the affected population to a greater or lesser degree, with some cases of permanently disabling injury / illness; chronic and irreversible health impacts that may shorten life expectancy, or immediate fatalities.

5.2.6 Severity Criteria

The severity of the impact is defined by comparing the intensity of the effect of the project and the sensitivity of the environmental receptors. It is qualified according to a scale which ranges from "negligible" to "major", based on the World Bank's definitions (**Table 5.9**). The severity value was derived as Severity = Intensity X Sensitivity. This is expressed in the severity matrix.

Table 5.9: Impact Severity Categorization according to World Bank

Severity	Criteria
Major	Substantial adverse changes in an ecosystem or resource. Changes are well outside the range of natural variation and assisted rehabilitation is required.
Moderate	Moderate adverse changes in an ecosystem or resource. Changes may exceed the range of natural variation. Potential for natural recovery in the medium or moderate term is good. However it is recognised that a low level of impact may remain.
Minor	Minor adverse changes in an ecosystem or resource. Changes might be noticeable, but fall within the range of normal variation. Effects are short-lived and Minor natural recovery takes place in the short term, however, it is recognised that a low level of localised impact may remain.
Negligible	Changes in ecosystems or resources that are unlikely to be noticeable (i.e. well within the scope of natural variation).
Positive	Changes resulting in positive, desirable, or beneficial effects on a resource.

Source: TOTAL Exploration and Production (EP) General Specification: GS-EP-ENV-120: Environmental Impact Assessment of E&P Activities

5.2.6.1 Likelihood Criteria

To obtain a measure of the severity associated with each potential negative impact, the likelihood criteria shown in Table 5.10 were developed. These likelihood criteria were applied to all potential negative impacts to determine whether they can be prevented, mitigated, or are unavoidable. The likelihood of the impact occurring, *not* the activity occurring is evaluated here. The severity of an impact is defined by its significance (or consequence) and its likelihood of occurrence. For example, a **moderate** impact that has a **high** likelihood of occurrence would be more severe than a **major** impact with a very low likelihood of occurrence.

Table 5.10 Likelihood Criteria

Significance Level		Description
Very Low	1	Impact has less than 1 or 2 percent likelihood of occurring: impact not known to have previously occurred in similar circumstances in the industry
Low	2	Impact highly unlikely, given the controls in place (e.g. between 2 to 20 percent likelihood of occurring, impact has been known to occur, but only very rarely, in similar circumstances).
Moderate	3	Impact could occur infrequently during normal operations, but given a breakdown of the safeguards and controls (i.e. lack of maintenance for a protecting device) it could occur more readily (e.g. between 20 to 70 percent likelihood of occurring, impact has been known to result in many similar circumstances, but does not result routinely.
High	4	Given the controls in place, the impact is likely to occur during normal operations (e.g. over 70 percent likelihood of occurring, impact has been known to result routinely, though not necessarily in all similar circumstances)

5.2.6.2 Severity Matrix and Conclusions

The Severity Matrix presented in Table 5.11 is constructed by placing the sensitivity ranking on the y-axis and the effects intensity ranking on the x-axis. Assigning an intensity ranking and a sensitivity ranking to each impact allows for semi-quantitative evaluation of the severity of the impact.

Table 5.11 Severity Matrix

Sensitivity	X	Intensity			
		NEGLIGIBLE	MINOR	MODERATE	MAJOR
	VERY LOW / NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	MINOR	MODERATE
	MINOR / LOW	NEGLIGIBLE	MINOR	MODERATE	MODERATE
	MODERATE	NEGLIGIBLE	MINOR	MODERATE	MAJOR
	HIGH	MINOR	MODERATE	MAJOR	MAJOR

Impact sensitivity **X** Impact intensity = Impact severity

Key:

1-2	NEGLIGIBLE
3 - 4	MINOR
5 - 9	MODERATE
>9	MAJOR

Intensity	X
SEVERITY	**Z**
Sensitivity	Y

5.2.6.2 Impact Significance

The overall severity of an impact, for this EIA is defined by its intensity and the sensitivity of the receptor. Using an indication of severity to comparatively assess and evaluate impacts enables this EIA to systematically identify and focus on those resources most likely to be at risk as a result of the proposed Tie-in project. This overall severity of impacts is presented in Table 5.12.

The overall impact severity level is indicated by the position on the impact severity matrix. For example, impacts placed within the red boxes have a high likelihood of occurrence and serious consequence; thus they have a **high** severity rating. These high-severity impacts become high priority issues for further evaluation or management action. Similarly, impacts in the yellow category are **moderate** impacts, with a medium priority. Impacts in the **blue** boxes are low/minor and the lowest priority is negligible which is given in **green**.

The criteria and severity matrix set forth in this section are widely applicable to all the types of events and impacts identified. A high-severity rating for a given impact in this chapter does not mean that the project will definitely cause that high impact, but rather the impact is potentially high and warrants additional mitigation.

Table 5.12: Impact Severity Calculation Table

General Activity	Specific Activity Description	Environmental				Socio-Economics			Health and Safety	
		Land Use	Biological resources (Vegetation,	Soil, Topography and geology	Air Quality and noise	Transportation and Infrastructure	Security (Third party agitation & Kidnappings	Social, and Cultural Conditions	Public Health and Safety	Workers' Health and safety
IMPACTS										
Mobilization & Site Preparation	Bush Clearing	2 2 1	2 4 2	2 4 2	2 4 2		2 2 1	1 1 1		
	Mobilization of personnel, materials and equipment to site by road.				2 4 2	2 4 2	2 2 1	2 4 2	2 2 1	2 4 2
	Influx of workers into the host Communities					2 4 2	2 2 1	2 2 1	2 2 1	
Construction	Excavation and Trenching	2 4 2	2 4 2	2 4 2	2 4 2					
	Welding				2 4 2					2 4 2
	Back filling, revegetation, Transportation of workers and maintenance of construction equipment's, waste disposal			2 4 2	2 4 2	2 4 2			2 2 1	2 2 1

Table 5.12: Impact Severity Calculation Table contd

General Activity	Specific Activity Description	Environmental				Socio-Economics			Health and Safety	
		Land Use	Biological resources (Vegetation, Wildlife)	Soil, Topography and geology	Air Quality and noise	Transportation and Infrastructure	Security (Third party agitation & Kidnappings	Social, and Cultural Conditions	Public Health and Safety	Workers' Health and safety
IMPACTS										
Construction	Linking of gas pipes				2 4 2				2 4 2	2 4 2
	Operations of machines and vehicles		2 2 1		2 4 2	2 4 2				2 4 2
	Base camp			2 4 2					2 4 2	

Table 5.12: Impact Severity Calculation Table cont.

General Activity	Specific Activity Description	Environmental				Socio-Economics			Health and Safety	
		Land Use	Biological resources (Vegetation, Wildlife)	Soil, Topography and geology	Air Quality and noise	Transportation and Infrastructure	Security (Third party agitation & Kidnappings	Social, and Cultural Conditions	Public Health and Safety	Workers' Health and safety
Operations	Disposal of industrial and domestic wastes			2 4 2					2 4 2	
	Maintenance	1 1 1	1 1 1							
	Gas leaks				2 4 2				2 4 2	
Decommissioning , Restoration and Abandonment	Excavation to remove pipeline and Re-vegetation	2 4 2	2 2 1	2 2 1	2 4 2					
	Transportation of removed structures from site		2 4 2	2 2 1	2 4 2	2 4 2				

key: 1-2 Negligible 3-4 Minor 5-9 Moderate >9 Major

Source: TOTAL Exploration and Production (EP) General Specification: GS-EP-ENV-120: Environmental Impact Assessment of E&P Activities

Table 5.12 shows that the maximum severity, which is based on intensity and sensitivity is negligible and minor in all environmental, socio-economics and health aspects. In the next stage of assessment, the environmental, socio-economics and health aspects will be scaled and weighted according to criteria set by ISO 14001.

5.2.7 Determination of Overall Impact Rating and Significance

The second stage involved evaluation to determine whether or not the impact is significant. The criteria and weighting scale used in evaluating this significance are as follows:

- Legal/regulatory requirements (L)
- Risk factor (R)
- Frequency of occurrence of impact (F)
- Importance of impact on an affected environmental components (I) and
- Public perception/interest (P).

The quantification scale of 1, 3 and 5 was used. This is a modification of the arbitrary scale proposed by Vesilind, *et al.* (1994). The ratings are as described below and are adapted from The International Organization for Standardization ISO 14001 – Environmental Management System Approach.

These criteria and ratings are as follows:

Legal/Regulatory Requirements (L) – Is there a legal/regulatory requirement or a permit required?

Condition	Rating
No legal / regulatory requirement or provision for carrying out project activity or that is related to impact of activity	Low=1
Legal / regulatory requirement or provision exist for carrying out activity or that is related to impact of activity	Medium=3
A permit is required prior to carrying out project activity which may result in impact on the environment	High=5

Risk Factor (R) – What is the risk/hazard rating based on the Risk Assessment Matrix?

Risk	Attribute
Low=1	This means that no further mitigation may be required
Medium=3	This means that the impact can be mitigated with additional controls and modifications
High=5	This means that the impact requires avoidance or major control/mitigation

Frequency of Impact (F) – What is the frequency rating of impact based on the Risk Assessment Matrix?

- 1 = Low frequency (rare)
- 3 = Intermediate frequency (likely)
- 5 = High frequency (very likely)

The frequency of occurrence of each impact was determined from historic records and consensus of experts' opinion.

Public interest/perception (P) – What is the rating of public perception and interest in proposed project and impacts based on consultation with stakeholders?

- 1 = Low interest/perception
- 3 = Intermediate interest/perception
- 5 = High interest/perception

The perception of the general public on each potential impact was determined through consultation and consensus of opinions of environmental professionals.

Importance of affected environmental components and impacts (I) – What is the rating of importance based on consensus of opinions? *Will the impact be localized or spread to cover greater areas of the environmental component?*

- 1 = Low
- 3 = Medium
- 5 = High

The importance of affected environmental component was determined through consultation and consensus of opinions.

This approach was adopted considering its interactive and descriptive analysis of the relationship between the proposed project activities and the ecosystem components. It combines the following factors in assessing the overall impact rating of the project on the environment:

- The sensitivity/vulnerability of the ecosystem components;
- The productivity evaluation/rating of the ecosystem components;
- Knowledge of the possible interactions between the proposed project and the environment;
- Envisaged sustainability of the project environment;
- The economic value of the proposed project; and
- Projected duration of the impact of each project activity on various environmental components.

The overall impact significance rating is determined as shown in Table 5.12. The potential and associated impacts of the project are presented in Table 5.13. All impacts with the Medium and High Ranking are considered significant and will require mitigation measures. Impacts with Low ranking will be addressed by application of the company's

Health, Safety and Environment Policy. Impacts rated as positive do not require mitigation and are considered beneficial. Significant and beneficial impacts are discussed in the proceeding paragraphs.

Table 5.12: Impact Value and Rating

Impact value	Cut off values	Impact Rating	Impact Significance
L+R+F+I+P	<8	Low	Not Significant
	≥8 but <15	Medium	Significant
	≥15	High	
F + I	>6		
P	= 5		
Positive		Positive	Beneficial

The frequency of occurrence of each impact was determined from historic records while the importance of affected environmental component was determined through consultation and consensus of opinions. The manner in which the host communities and the general public would perceive each potential impact and its effects were again determined through consultation with the host communities and consensus of opinions of environmental professionals. For this study, the frequency, the importance and public perception were judged to be superior indicators of the impacts. Significant impact was therefore based on the sum of F+I+P+R+L. The maximum possible point from this sum is 25. Impacts whose sum of F+I+P+R+L was less than 8 were rated as low. These impacts were judged not to require mitigation. Those whose sum of F+I+P+R+L was ≥8 but <15 were rated as having medium significance while those whose sum of F+I+P+R+L was greater than 15 were of high significance**.** For this study, medium and high significant negative impacts were judged to require mitigation. Significant positive impacts were believed to require enhancement. This is in compliance with best professional practice (Cox and Guy, 2002). The combination of these approaches is shown in **Table 5.13**.

Table 5.13: Overall Impact Significance of NOPL - Indorama tie-in project

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts	Impact Qualification								Impact Significance Evaluation						Sum	Overall Significance Rating
			Adverse	Beneficial	Direct	Indirect	Short term <3months	Long term >3months	Reversible	Irreversible	L	R	F	I	P	L+R+F+I+P	F+I	Overall Ranking (High/Medium/Low)
Site Preparation	Bush Clearing	Biodiversity (Vegetation/ wildlife) loss			X		X		X		3	1	1	1	1	7	2	L
		Ecological degradation			X		X		X		3	1	1	1	1	7	2	L
		Exposure to allergic plants			X		X		X		0	1	1	1	1	4	2	L
		Injuries and attacks from wild animals			X		X		X		0	1	1	1	1	4	2	L
		Loss of access to farmland			X			X	X		3	1	1	1	1	7	2	L
		Opportunity for business			X			X	X									P
		Third party agitation			X		X			X	0	1	1	1	1	4	2	L

Table 5.13: Overall Impact Significance of NOPL - Indorama tie-in project contd

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts	Impact Qualification								Impact Significance Evaluation						Sum	Overall Significance Rating
			Adverse	Beneficial	Direct	Indirect	Short term <3months	Long term >3months	Reversible	Irreversible	L	R	F	I	P	L+R+F+I+P	F+I	Overall Ranking (High/Medium/Low)
Mobilization	Mobilization of personnel, materials and equipment to site by road.	Air/Noise pollution from increased vehicular movement			X		X		X		3	1	1	1	1	7	2	L
		Damage to existing access roads			X		X		X		0	1	1	1	1	4	2	L
		Kidnappings			X		X		X		3	1	1	1	1	7	2	L
		Road traffic accidents with injuries from increased vehicular movements on local roads			X		X		X		3	1	1	1	1	7	2	L

Table 5.13: Overall Impact Significance of NOPL - Indorama tie-in project contd

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts	Impact Qualification								Impact Significance Evaluation						Sum	Overall Significance Rating
			Adverse	Beneficial	Direct	Indirect	Short term <3months	Long term >3months	Reversible	Irreversible	L	R	F	I	P	L+R+F+I+P	F+I	Overall Ranking (High/Medium/Low)
Mobilization	Employment of local labour and award of contracts to members of the host communities	Increased cash flow and stimulation of local economies within the Host Communities		X	X		X		X									P
		Inter and intra community conflicts			X		X		X		0	1	1	1	1	4	2	L
		Localized economic benefits from materials supplies by local contractors			X			X		X								P
		Third party agitations			X		X			X	0	1	1	1	1	4	2	L

Table 5.13: Overall Impact Significance of NOPL - Indorama tie-in project contd

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts	Impact Qualification								Impact Significance Evaluation						Sum	Overall Significance Rating
			Adverse	Beneficial	Direct	Indirect	Short term <3months	Long term >3months	Reversible	Irreversible	L	R	F	I	P	L+R+F+I+P	F+I	Overall Ranking (High/Medium/Low)
Mobilization	Influx of workers into the host Communities	Increased sexual immorality especially among young women			X			X	X		0	1	1	1	1	4	2	L
		Increase pressure on existing social amenities and infrastructure			X		X		X		0	1	1	1	1	4	2	L
		Increased prevalence of sexually transmissible infections (STIs) including HIV			X			X	X		0	1	1	1	1	4	2	L
		Socio-cultural conflicts between the construction team and members of the host communities			X			X		X	0	1	1	1	1	4	2	L

Table 5.13: Overall Impact Significance of NOPL - Indorama tie-in project contd

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts	Impact Qualification								Impact Significance Evaluation						Sum	Overall Significance Rating
			Adverse	Beneficial	Direct	Indirect	Short term <3months	Long term >3months	Reversible	Irreversible	L	R	F	I	P	L+R+F+I+P	F+I	Overall Ranking (High/Medium/Low)
Mobilization	Influx of workers into the host Communities	Stimulation of local economy and markets from increased demand for food, and other products in the local market.			X		X		X		0	1	1	1	1	4	2	L
Construction	Excavation and Trenching	Damage to roads			X		X		X		0	1	1	1	1	4	2	L
		Damage to soil Structure and Texture			X		X		X		0	1	1	1	1	4	2	L
		Increase in dust and SPM during dry season.			X		X		X		3	1	1	1	1	7	2	L
		Increase in noise and exhaust gases from excavators.			X		X		X		3	1	1	1	1	7	2	L
		Temporary vehicular traffic obstruction/diversion at road crossing.			X		X		X		0	3	1	1	1	6	2	L

Table 5.13: Overall Impact Significance of NOPL - Indorama tie-in project contd

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts	Impact Qualification								Impact Significance Evaluation						Sum	Overall Significance Rating
			Adverse	Beneficial	Direct	Indirect	Short term <3months	Long term >3months	Reversible	Irreversible	L	R	F	I	P	L+R+F+I+P	F+I	Overall Ranking (High/Medium/Low)
Construction	Welding	Air pollutants effects of CO_x, NO_x, SO_x from welding and other activities.			X		X		X		3	1	1	1	1	7	2	L
		Exposure of welders to heat and light radiation.			X		X		X		3	1	1	1	1	7	2	L
		Integrity testers exposed to X-rays.			X		X		X		3	1	1	1	1	7	2	L
		Release of Toxic fumes during welding operations			X		X		X		3	1	1	1	1	7	2	L
		Risk of electrocution and burns during welding			X		X		X		0	1	1	1	1	4	2	L

Table 5.13: Overall Impact Significance of NOPL - Indorama tie-in project contd

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts	Impact Qualification								Impact Significance Evaluation						Sum	Overall Significance Rating
			Adverse	Beneficial	Direct	Indirect	Short term <3months	Long term >3months	Reversible	Irreversible	L	R	F	I	P	L+R+F+I+P	F+I	Overall Ranking (High/Medium/Low)
Construction	Back filling, re-vegetation, transportation of workers and maintenance of construction equipment and waste disposal	Air pollutants effects of dust.			X		X		X		3	1	1	1	1	7	2	L
		Alteration of soil texture and structure through compaction			X		X		X		3	1	1	1	1	7	2	L
		Contamination and degradation of soil from discharges and spills of sanitary, construction related solids wastes.			X		X		X		0	1	1	1	1	4	2	L
		Onsite exposure of workers to noise and vibration from use of heavy-duty equipment			X		X		X		3	1	1	1	1	7	2	L
		Road users would be exposed to higher road accidents due to increase in heavy traffic and temporary road obstructions/diversions			X		X		X		0	1	1	1	1	4	2	L
		Workplace accidents/incidents			X		X		X		0	1	1	1	1	4	2	L

Table 5.13: Overall Impact Significance of NOPL - Indorama tie-in project contd

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts	Impact Qualification								Impact Significance Evaluation						Sum	Overall Significance Rating
			Adverse	Beneficial	Direct	Indirect	Short term <3months	Long term >3months	Reversible	Irreversible	L	R	F	I	P	L+R+F+I+P	F+I	Overall Ranking (High/Medium/Low)
Construction	Linking of gas pipes	Noise associated with hook-up procedure			X		X		X		3	1	1	1	1	7	2	L
	Operations of machines and vehicles	Emission of exhaust gases from the fuel combustion engines can alter the local ambient air quality.			X		X		X		3	1	1	1	1	7	2	L
		Soil contamination and loss of aesthetics from liquid leaks			X		X		X		3	1	1	1	1	7	2	L
		Vibrations affecting existing pipelines			X		X		X		0	1	1	1	1	4	2	L

Table 5.13: Overall Impact Significance of NOPL - Indorama tie-in project contd

Project Phase	Project Activities / Environmental Aspects	Potential and Associated Impacts	Impact Qualification								Impact Significance Evaluation						Sum	Overall Significance Rating
			Adverse	Beneficial	Direct	Indirect	Short term <3months	Long term >3months	Reversible	Irreversible	L	R	F	I	P	L+R+F+I+P	F+I	Overall Ranking (High/Medium/Low)
Construction	Base camp	Domestic waste from base camp shall cause poor aesthetic if it is dumped on soil and vegetation			X		X		X		0	1	1	1	1	4	2	L
Operation / Maintenance	Disposal of industrial and domestic wastes	Odour and aesthetic devaluation may result from improper handling.			X		X		X		0	1	1	1	1	4	2	L
	Maintenance	Release of gases through isolation valves.			X		X		X		0	1	1	1	1	4	2	L
	Gas leaks	Accidental damage to equipment or fire			X		X		X		0	1	1	1	1	4	2	L
Abandonment / Decommissioning	Excavation to remove pipeline and Re-vegetation	Soil contamination			X		X		X		3	1	1	1	1	7	2	L
		Increase in income			X			X		X								P
		Return of land to indigenes for farming			X			X		X								P
	Transportation of removed structures from site	Occupational and traffic accidents			X		X		X		0	1	1	1	1	4	2	L

5.3 Description of Potential Impacts

The impacts associated with the proposed NOPL - Indorama tie-in project has been identified and evaluated vis-a-vis the recipient environment. They have also been subjected to the impact severity evaluation. The results revealed that the impacts fall into four categories, namely: beneficial, negligible, minor and moderate. A description of each of the impacts is provided in the following sections:

5.3.1 Negative impacts

Vegetation/ Biodiversity/Destruction of the ecosystem:

As the baseline information indicated, the spatial project area is within secondary forest home to a number of plant-dwelling and land-based animals (insects, reptiles and amphibians).

Potential Impacts

During the pre-construction (site clearing), vegetation clearing will lead to loss of habitats for terrestrial fauna and important species, however, clearing will be limited to the ROW so as to limit the impact.

It will rather result in a permanent change in the use of this land space for the lifetime of the project

Site preparation (clearing & excavation) removes the grass cover over the soil leading to increased evaporation that dries the soil (mainly due to increased exposure to the sun). This drying may make the soil less favourable for the fauna of the soil.

Site preparation shall involve removal of limited amount of vegetation to provide space for site camps and equipment parking. The removal of wildlife habitat (vegetation) will lead to temporal migration of wildlife. The effect is not significant in the short term since the used site would be re-vegetated naturally.

The back filling of the pipeline may lead to soil inversion. Inclusion of debris in the backfilling material would lead to caving-in. The effect is temporary, reversible and not significant.

The impact on plant loss of vegetation and biodiversity will be negligible to moderate because the project will be sited within an existing facility. The only effect on vegetation and biodiversity will be along the pipeline ROW. This impact is expected to have been naturally reversed within six months after completion of the backfilling.

Soil

The severity classification of the soil impacts is minor. The potential for these impacts could either be along the pipeline ROW or within the project area.

Back filling involves the dumping of soil back on the pipeline. The working procedure for back filling shall be based on the nature of the soil/terrain. In general, the first stage will be to return the soil in the reverse order. The back filling may affect the

drainage pattern of the area if not properly done. The back-filling may induce erosion if soil is not properly re-instated. The effect is non-significant, reversible and has short-term duration.

Soil will be exposed to direct sunlight rays since vegetation has been removed (especially along the pipeline route). This may elicit erosion, high temperature and changes in soil moistures regimes. This will lead to changes in soil physical and chemical characteristics and subsequent death of soil organisms; regeneration of vegetation from seed banks will be impeded. There is also the potential of soil contamination in the event of gas leakage due to pipeline failure as well as improper waste management. Generally, the impact will be short term and localised. The residual impact of the project on the soil quality of the project area is considered negligible.

Traffic/Transportation

The soils of the project area would be compacted if vehicles drive on earth roads. The increase in traffic may increase the rate of exposure to accidents.

It is anticipated that road traffic will increase during mobilization of personnel and equipment to site over a period of time. During the construction phase which is expected to last about 15 days, intensive movement of personnel and equipment will take place. Given the present condition of the road in the communities, there is the potential for increase in traffic accidents/injuries during these phases. Roads may temporarily be obstructed or diverted as a result of movement of heavy equipment and materials.

Interference with traffic flow revealed a severity rating of minor impact and has the potential to occur during mobilization and construction, as well as during abandonment and decommissioning of the project life cycle.

The proposed project will require installation of new pipes and other auxiliary equipment. The mobilization of these equipment and personnel to project site during construction shall cause occasional increased movement/traffic. The severity of the impact from traffic at the road intersection is minor, short-term, and reversible. The interference with traffic by construction vehicles can aggravate the existing situation on the road.

Traffic impacts during the construction phase can be minimized for some large equipment by embarking on night delivery. However these impacts shall be short term.

Traffic impacts during operational phase of the project will not be different from those impacts experienced historically on that road.

Air Quality/ Noise Level

Air quality remains one of the most significant issues for gas projects. Short term air quality impacts of the project will occur during construction activities as transitory emissions of air pollutants from construction equipment. The potential for air quality

impairment as a result of the construction activities of the Project is confined to exhaust emissions from vehicles and equipment and it is low. During operation, pipeline leakage of compressed gases may occur and cause explosion and consequent fire outbreak. These emissions and fire if it occurs will increase the health risk associated with the project. The communicable diseases associated with air quality impairment are respiratory tract infections and skin rashes while the non-communicable diseases are injuries, noise- related hearing loss.

The severity classification for the project is moderate. The contribution to air pollution from the project will be negligible. It is however noteworthy that the tie-in is being located in an area that is already playing host to two other gas pipelines. The overall assessment of the potential impact on air quality due to the proposed project is considered moderate.

The severity derived for the noise impact is minor. Even though the existing noise-level measurements in the communities of the project area range from 53 to 55 dBA, noise has the potential of causing disturbance and inconvenience to communities. This can be aggravated by noise from site clearing, construction and operational activities due to the use of motorized equipment. Other sources of noise identified around the project area include vehicular traffic.

Environmental Sanitation and Waste Management

Waste will be generated during some of the project activities such as site clearing, trenching, and in the operational and decommissioning/abandonment phases.

Personnel injury/death resulting from malfunction & mal-operation of equipment

Injury and fatality can result from occupational accidents during construction and the operation of the facility. This could result from equipment malfunction or human error.

Accidents resulting in injury/death of personnel

In the event of an accident workers may suffer injury which may result in lost time or even fatality. The likelihood of occurrence of this is low in view of the HSE guidelines and strict operational standards that TEPNG has in place and plans to implement for this project.

Socio-economic Resources

Behavioural influences - Agitation for employment and supply contract by community

The increased movement of persons into the project area and when the community become aware of employment of casual workers, and award of supply contracts for some materials for the construction may result in reactions such as agitation for specific people or for higher number of persons to be employed by the community.

Loss of gainful employment as a result of end in project cycle

At the end of the project life cycle, abandonment and decommissioning of the project may result in loss of gainful employment by some of the personnel

Life style/Habit

As a result of immigration, life style/habit changes involving crime, drug abuse, prostitution will be more pronounced in the communities. This will adversely affect the health status of those involved. Immigrants may, however, introduce beneficial habits/practices into the communities.

5.3.2 Positive impacts

Increase in gas utilization by TEPNG with resultant reduction in gas flared

Nigeria as a country and all the oil companies operating within the country have committed to ensuring putting an end to gas flaring in view of its environmental consequence. This project is one of such steps aimed at accomplishing that objective. It therefore provides an alternative environmental cleaner technology to the gas flaring and diesel generator option. At the same time it contributes to power generation which is another cardinal programme encouraged by the Federal Government towards solving the constant power outage in the country.

Local economy

Finally, the study revealed positive impacts of the planned project on the local economy of the host community and the nation as a whole, in terms of tax revenue to the three tiers of Government; profit, employment opportunities, the opportunities for contract works and welfare improvements in the host community.

Power generation is a very important part of the programme of the Federal Government of Nigeria and the Rivers State Government.

The overall impacts assessment revealed that TEPNG gas turbine project beneficial impacts outweighed the adverse effects.

CHAPTER SIX

MITIGATION MEASURES

6.1 Introduction

The actions and measures that TEPNG intend to take to reduce (or eliminate) negative impacts and promote positive impacts of the proposed Project are presented in this chapter. In this mitigation measures, emphases are placed on those negative impacts rated as significant (medium and high impacts). The measures are aimed at reducing these impacts to As Low As Reasonably Practicable (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. None significant impacts are expected to be mitigated through effective implementation of TEPNG Safety and Environment policies that will be put in place during the different phases of the project.

The mitigation measures proposed are in consonance with the following:

- Environmental Guidelines and Standards for Petroleum Industries in Nigeria (EGASPIN) (DPR, 2018)
- International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines, 1996.
- Harmful Waste (Special Criminal Provisions) Decree, 1998.
- National Environmental Protection (Pollution abatement in industries and facilities generating waste) Regulations, 1991.
- The following criteria were used to define mitigation measures for the identified impacts:

Prevention:	Exclude significant potential impacts and risks by design and management measures.
Reduction:	Minimize the effects or consequences of those significant associated and potential impacts that cannot be prevented, to a level as low as reasonably practicable by implementing operational and management measures.
Control:	Implement operational and management measures to ensure that residual associated impacts are reduced to a level as low as reasonably practicable.

Factors for determining implementation of mitigation measures are

- Avoiding the impacts altogether by not taking a certain action or parts of an action;
- Minimising impacts by limiting the degree or magnitude of the action and its implementation;
- Rectifying the impact by repairing, rehabilitating or restoring the affected environment.

- Compensating for the impact by replacing or providing substitute resources.
- Feasibility;
- Ease of implementation;
- Local suitability;
- Institutional requirements;
- Training requirements;
- Monitoring requirements;
- Cost (capital and operating); and
- Cost-effectiveness.
- The Required General and Specific Mitigation measures, apply to the Tie-in Project includes:
- Pre-construction;
- Site Preparation and Construction;
- Commissioning and Start-up;
- Operations and Maintenance; and
- Decommissioning and Abandonment.

The mitigation measures are categorized by relevant impact category, potential impact, and affected specific area. The Required General and Specific Mitigation measures are divided into three sections, labelled Environmental, Socioeconomic, and Health and Safety, and subsequently into seven categories of potential impacts. These categories of impacts by section are:

Environmental

- Land Use;
- Topography, Geology, and Soils;
- Habitats, Biological Resources and
- Air Quality (including Noise and Vibration).

Socioeconomic

- Cultural (and Archaeological) Conditions; and
- Socioeconomic Conditions (Means of Livelihood, and Transportation and Infrastructure).

Health and Safety

- Public and Worker Health and Safety.

6.2 Mitigation Measures

A summary of the mitigation measures for the potential impacts is presented in Table 6.1. These measures are recommended to ameliorate all the significant associated and potential impacts for the proposed Project.

Table 6.1: Proposed Mitigation Measures

Project Phase	Description of Impact	Significance Rating Before Mitigation	Mitigation measures	Impact Rating After Mitigation
Site Preparation	Biodiversity (Vegetation/ wildlife) loss, Loss of access to farmland, Ecological degradation, Exposure to allergic plants, Injuries and attacks from wild animals	**Low**	TEPNG shall; • Use existing route/path for site survey. • Minimize bush clearing. • Enforce no hunting during bush cleaning. • Ensure that adequate and prompt compensation are paid as agreed with land owners. • Support efforts of farmer groups and cooperatives. • Land take shall be limited to the minimum required. • Support community – based food and nutrition programs. • Wildlife studies shall be carried out to the status of endangered/threatened species (species diversity and abundance) shall be carried out one year after major construction activities. • Ensure that appropriate PPEs are provided and used. • Anti- venom shall be provided on site. • Awareness shall be created among site workers and nearby communities on the likelihood of exposure to poisonous wildlife and plants.	Negligible
	Third party agitation	**Low**	TEPNG shall • Ensure adequate consultations and enlightenment of host communities using established channels of communication to ensure transparency of activities. • Support traditional conflict resolution structures in the project communities. • Require local labour (both male and female, skilled and unskilled) to be employed as a priority to the extent practicable. • Maintain a record and social data of all those compensated and or displaced by the project. • Adequate and prompt compensation are paid as agreed with land owners. • Any form of agitation is looked into and addressed promptly.	Negligible

Project Phase	**Description of Impact**	**Significance Rating Before Mitigation**	**Mitigation Measures**	**Impact Rating After Mitigation**
Mobilization	Potential increase in road traffic volume	Low	TEPNG shall • Ensure that large and slow-moving vehicles are scheduled for periods. • Raise community awareness of unusual activity.	**Negligible**
	Potential increase in road traffic incidents	Low	• Pre-mobilization of all vehicles. • Visible warning signs on roads and vehicles. • Vehicle monitoring device/TEPNG journey management pol driving and alcohol policy shall be enforced. • First aid training of workforce and provision of first aid boxes operational vehicles.	**Negligible**
	Increase in noise levels	Low	• Enforce night driving policy (no night driving except when unavoidable). • TEPNG shall ensure that all vehicles and equipment conform t Bank limits for noise.	**Negligible**
	Reduction in air quality (dust, exhaust fumes)	Low	• TEPNG shall ensure that only vehicles with premobilization ce are used to reduce emissions from vehicle exhaust.	**Negligible**
	Damage to existing access road	Low	• TEPNG shall ensure repair of road when damage is caused by project.	**Negligible**
	Kidnappings	Low	TEPNG shall • Develop and implement a security management plan for the project • Work with the Government, communities and other relevant agencies to improve security in the project area. • Ensure that security orientation and awareness is conducted for workforce. • Ensure that staff adhere to instructions on daily journey management plan.	**Negligible**

Project Phase	Description of Impact	Significance Rating Before Mitigation	Mitigation measures	Impact Rating After Mitigation
Mobilization	**Inter and intra community conflicts**	**Low**	TEPNG shall; Ensure effective consultation with stakeholders Form and ensure commitment and transparent adherence to GMoU programmes. Identify and address legacy issues	**Negligible**
	Third party agitations	**Low**	TEPNG shall Ensure adequate consultations and enlightenment of host communities using established channels of communication to ensure transparency of activities. Support traditional conflict resolution structures in the project communities. Require local labour (both male and female, skilled and unskilled) to be employed as a priority to the extent practicable. Maintain a record and social data of all those compensated and or displaced by the project. Adequate and prompt compensation are paid as agreed with land owners Any form of agitation is looked into and addressed promptly	**Negligible**
	Increase in social vices	**Low**	Awareness campaign shall be carried out to enlighten the communities/field workers on the implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values. Movement of field workers shall be restricted to camp/work sites. Alternative recreational facilities shall be provided at camp sites. Alcohol and drug policy shall be implemented to encourage healthy lifestyle for workers (TEPNG/contractor staff).	**Negligible**

Project Phase	Description of Impact	Significance Rating Before Mitigation	Mitigation measures	Impact Rating After Mitigation
Mobilization	Increased prevalence of sexually transmissible infections (STIs) including HIV	**Low**	TEPNG shall Carry out awareness campaign and health education on dangers of sexually transmissible diseases to members of communities and workers Support activities of the Rivers States Action Committee on AIDS	**Negligible**
	Increase pressure on existing social amenities and infrastructure	**Low**	TEPNG shall Construct camp site for its workers during and after mobilization to ease pressure on existing infrastructure Provide amenities based on community needs via GMoU Upgrade the existing access road to the project area Ensure the employment of community members who shall come from their homes	**Negligible**
	Socio-cultural conflicts between the construction team and members of the host communities	**Low**	Awareness campaign and health education on dangers and problems of unwanted pregnancy and sexually transmissible diseases to members of communities and workers. Ensure that workers respect the norms and values of the project communities.	**Negligible**
	Stimulation of local economy and markets from increased demand for food, and other products in the local market.	**Low**	Work camps shall be provided with necessary utilities to reduce pressure on local community facilities. Communities shall be empowered through provision of jobs, increased patronage to produce (fishes, farm produce etc) and encourage income generating activities.	**Negligible**

Project Phase	Description of Impact	Significance Rating Before Mitigation	Mitigation measures	Impact Rating After Mitigation
Construction	Damage to roads, soil Structure and Texture, Alteration of soil texture and structure through compaction	**Low**	• Excavated soil shall be backfilled in line with standard construction practices for pipeline. • ensure that the original topography is maintained as far as practically possible.	**Negligible**
	Increase in noise and exhaust gases from excavators. Air pollutants effects of COx, NOx, SOx from welding and other activities.	**Low**	• Standard machinery with noise levels within acceptable limits (85 dB (A)) shall be used. • Site construction shall be done within the shortest possible time. • Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits • TEPNG HSE policy of wearing ear muffs/ plugs, with signs indicating noisy areas shall be applied in all construction sites. • Sufficient separation distances shall be provided for sources of high energy sound to reduce noise levels • Workers with existing hearing impairment shall not be deployed to site. • Emissions from machineries shall be reduced by the use of standard equipment that meet existing emissions requirements and fume catalysers provided on all suitable equipment. • There shall be regular maintenance of combustion systems (generators etc) • Ambient air quality monitoring programme shall be developed, detailing the monitoring location, parameters (THC particulates CO_2, SO_2, NO_2, SPM and VOCs), methods and frequency. • High efficiency (low energy) motors shall be used.	**Negligible**

Project Phase	**Description of** Impact	**Significance Rating Before Mitigation**	Mitigation measures	**Impact Rating After Mitigation**
Construction	Exposure of welders to heat, toxic fumes and light radiation. Risk of electrocution and burns during welding	**Low**	TEPNG shall • Ensure that adequate safety measures (appropriate PPE and engineering techniques) are put in place to avoid exposure to radioactive materials and electrical hazards. • Ensure that adequate safety measures (appropriate PPE) are put in place to avoid inhalation of welding fumes	**Negligible**
	Contamination and degradation of soil from discharges and spills of sanitary, construction related solids wastes.	**Low**	TEPNG shall • Adhere to HSE control framework for waste management • Generated solid waste shall be segregated at source by the provision of colour coded bin for different types of waste and disposed of according to TEPNG waste management guidelines • The generated paper waste shall be shredded and sold to any TEPNG approved paper recycling company • De-contaminated scrap metals/drums shall be collected and taken to TEPNG waste recycling depot • Safe Handling of Chemicals cards (SHOC) / Material Safety Data Sheets (MSDS) are available on site to provide information on safe handling of chemicals. • all maintenance and repair of equipment and vehicles are done in a secure location with clean-up materials (drip pans, containers, absorbent materials etc). • Appropriate waste management procedures will be employed	**Negligible**

Project Phase	Description of Impact	Significance Rating Before Mitigation	Mitigation	Impact Rating After Mitigation
Operation / Maintenance	Reduction in air quality as a result of release of gases through isolation valves.	**Low**	TEPNG shall • Ensure that appropriate maintenance programs are in place for all equipment.	**Negligible**
	Accidental damage to equipment or fire	**Low**	TEPNG shall • Ensure that blowout preventers are installed • Ensure provision of adequate firefighting equipment • Ensure that emergency response procedures are in place	**Negligible**
Decommissioning Restoration and Abandonment	Occupational and traffic accidents	**Low**	• Awareness shall be created on the potential of increased traffic for road users and community members • TEPNG policy on road borne traffic journey management shall be adhered to (all journey must be approved, no night journeys, speed limits on land and water). • TEPNG shall upgrade existing roads to suite the proposed project activities with additional access roads provided, where necessary • Traffic signs shall be provided on all the approved routes for the project	**Negligible**

6.2.1 MITIGATION OF ENVIRONMENTAL, SOCIAL AND HEALTH IMPACT

6.2.1.1 Socio- Economic

Mitigation measures are measures designed to address the impacts of projects. The measures are largely a function of the adverse social impacts of projects since it is such impacts that require mitigation. The expected impacts of the NOPL-Indorama Tie-in Project include the following:

- Demographic Impacts (redirection of labour, inflation).
- Socio-economic Impacts (redirection of labour, inflation).
- Impacts on Lifestyles (sexual laxity, alcoholism, youth militancy).
- Impacts on Cultural Properties (religious sites/shrines, etc).
- Impacts on Social Infrastructure (health care facilities, water supply).
- Impacts on natural resources (disruption of vegetation and farms).

The usual practice is to differentiate these impacts for purposes of analysis. However, in reality they tend to be closely interrelated. For example, an increase in population (demographic impact) can increase pressure on natural resources and social infrastructure. Project activities will be very visible and transient in the communities around the project area during the construction phase. They will be much less visible in these communities during the operation phase. This low visibility should not be seen as reducing the stake of the communities in the project. The company should continue to show interest in these communities after the construction phase for the maintenance of good community relations.

Mitigation Measures

The possible adverse social impacts of the project were spelt out in the previous chapter. These impacts were derived from experience elsewhere and from the views of respondents in the host communities of the project. The impacts provide the basis for the articulation of appropriate mitigation.

Relevant measures needed at each stage of the project, i.e. construction, operation and decommissioning are indicated in the discussion.

Table 6.2: Key Mitigation Measures

	Impacts	Mitigation Measures
1	Population growth due to immigration	Use local labour as much as possible
2	Inflation in the local economy	Use local labour as much as possible
3	Pressure on local infrastructure	Use local labour as much as possible in order to minimize additional demand for infrastructure.
		Help increase the capacity of local
		infrastructure
4	Destruction of farms	Compensation
5	Sexual laxity	Disruption
		Public enlightenment about potential health risks (STDs).
6	Youth militancy/unemployment	Use local labour as much as possible to have the youths gainfully employed.
		Facilitate skills acquisition programmes.

Table 6.2 shows the major mitigation measures required to address each impact. The impact of population growth and others due to immigration, particularly during the construction phase can be mitigated by engaging local labour. Farmer/farm relocation and compensation are very sensitive issues that need to be addressed after effective consultation with, and participation of the local people.

Health

The adverse health impacts will require appropriate mitigation measures while the beneficial health impacts will be enhanced. The proposed mitigation/enhancement measures for the respective impacts are summarized as follows:

Environmental Sanitation/Waste Management

The objective here is to achieve proper management of refuse, sewage and vectors of diseases. The Environmental Health Unit of each local government area manages this area.

Refuse Management

The ultimate goal is refuse collection in waterproof polythene bags. Biodegradable organic matter shall be collected in separate bags from that of non-biodegradable materials (cans, plastics, glass etc.). The biodegradable matter shall be used for composting while the non – biodegradable shall be reused, recovered and recycled.

Disease

Disease such as malaria shall be controlled by use of bed nets, and spraying of rooms with insecticides, proper sanitation measures such as clearing of bushes around base camps.

Water Quality Impairment

Boiling and filtering of water for drinking shall be encouraged. The ultimate measure is the provision of regular potable water, accompanied by hygienic practices in camps.

Noise

The present low noise level (53 – 55) dBA should be sustained. In the project area, excessive noise from heavy machinery used in construction and operational activities require mitigation as follows:

Ear protection devices (muffs) should be provided and worn by construction staff within the working zone.

Deploy low noise type equipment

Housing

Housing shortages will become more acute with influx of people into the communities. The problem associated with housing can be solved by:

Use of base camps.

Health Education

Most of the mitigation measures recommended up to now need proper health awareness amongst workers to succeed. Therefore, modern basic health centers within the project area shall be encouraged to provide good health education to the existing communities and the workforce on the control of infectious diseases, sanitation etc.

CHAPTER SEVEN

ENVIRONMENTAL MANAGEMENT PLAN

7.1 General

An Environmental Management Plan (EMP) is an important tool that initiates management's strategies and procedure for controlling the potential environmental impacts associated with the proposed project.

Environmental management is concerned with a planned, integrated programme aimed at ensuring that identified and unidentified impacts of a proposed project are contained and brought to an acceptable minimum. It provides confidence on the part of project planners that a reliable scheme will be put in place to deal with any contingency that may arise during all phases of development, from preliminary study to abandonment.

In consonance with the Federal Ministry of Environment regulations and TEPNG policy on protection of the environment, this EMP is designed based on the interaction of the proposed project with the various components of the environment.

The EIA of the NOPL –Indorama pipeline tie-in project has addressed the impacts of the project and its location and confirmed that the impacts of the project are acceptable. As part of the continuing process of management of Health, Safety and Environment issues relating to the project, the issues of monitoring and auditing can now be addressed.

To ensure that the environmental consideration and mitigation recommendations of the EIA for the NOPL –Indorama pipeline tie-in are implemented, an Environmental Management Plan (EMP) has been developed. The EMP consists of plans, procedures and programs, covering areas such as:

- The handling of hazardous materials and wastes;
- Emission and discharge monitoring;
- Site inspection and auditing.

The EMP is formulated to ensure that the environmental mitigation requirements outlined in the EIA are central to the operation and management of the proposed project. It has been developed by following international standards for environmental management planning, such as the International Standards Organisation (ISO 14001), or the Health, Safety and Environment Management System (HSE-MS), as developed by the Joint Oil Industry International Exploration and Production Forum. The EMP covers all the phases of the project from project design to project decommissioning. The various responsibilities and tasks involved in implementing the EMP for the development project vary with the project stage and are summarized in Table 7.1.

Table 7.1: Summary of Environmental Management Responsibilities for Various Stages of the NOPL –Indorama pipeline tie-in Project

Project Phase	Action
Project Design	Review design compliance with EMP and regulations
Project Planning and Scheduling	Setting up of an environmental focal point
Contingency Planning	Training, plan development and implementation
Project Mobilization	Supervision of the process
Construction Phase Supervision	Supervision including inspection, monitoring, and auditing activities
Construction, Demobilization	Supervision of the process
Operations and Maintenance Phase Supervision	Supervision including inspection, monitoring and auditing of activities
Project Decommissioning	Post project monitoring and auditing

7.2 Objectives of the EMP

The EMP is designed to:

1. Ensure that the impact of the project on the environment is kept As Low As Reasonably Practicable (ALARP) or completely mitigated.
2. Provide part of the basis and standards needed for overall monitoring and review of environmental safety throughout the project lifespan.

These objectives shall be achieved by:

- Ensuring compliance with all legislations on protection of the environment and the environment policy of the Federal Ministry of Petroleum Resources
- Ensuring that environmental concerns are fully integrated into project planning;
- promoting adherence to the provisions of the HSE Policy of TEPNG;
- Promoting environmental management awareness among workers during the construction phase.
- Encouraging adherence to the principles of good housekeeping and the use of best available technologies;
- Ensuring that the Project is successfully and safely implemented with minimal harm to both the environment and the health of the workers;
- Provide standards for overall planning, operation, audit and review; and
- Enable management to establish environmental priorities.

7.3 Enforcing the EMP

This project is based on national and international standards and codes which specify environmental safety. Implementation of those guidelines will be encouraged by teams from Federal Ministry of Environment (FMEnv) and Department of Petroleum Resources (DPR) in administration of the Guidelines and Standards.

7.4 Management Structure and Organization

TEPNG has an established policy and schedule for responsibilities and training on matters relating to the environment. There is a line responsibility for which all level of staff is accountable. Line management will take full responsibility for environmental issues. The management of TEPNG will ensure that there is total commitment to environmental considerations through the provision of induction and training courses for staff as part and parcel of the Environmental Management System. A focal point will be appointed to co-ordinate HSE performance throughout the lifespan of the project.

The tasks for the focal point shall include:

- The development and maintenance of the Environmental Management Plan (EMP) and associated plans for materials management, waste management, spill preparedness and response, inspection and monitoring and staff training;
- The implementation of the Environmental Management Plan and related tasks;
- Conducting or organizing periodic audits;
- Initiating or organizing corrective actions as and when necessary;
- Preparing and managing documentation related to environmental performance;
- Regular and incidental reporting to the TEPNG management and to the appropriate environmental regulatory authorities.

The Environmental Management Plan is a very important management tool. It shall be kept dynamic and be used as focus for the implementation of the NOPL –Indorama pipeline tie-in project. The input of all stakeholders will be continuously sought through dialogue at the Weekly Safety Meetings, daily pep talks and through the use of consultant experts. All of these will help ensure constant improvement of all aspects of the plan that may be found deficient.

7.5 Implementation and Reporting

TEPNG shall not wait for confrontation either from the Regulatory bodies or the communities to implement all mitigative measures or understanding. In the monitoring program of the EMP, environmental reports of monitoring exercise/incidents shall also be submitted to the Federal and State Ministries of Environment, and Department of Petroleum Resources (DPR) if incident occur on any part of the project. Both the

Regulators and Proponent working in synergy will monitor effective sustenance of the objectives of the EMP, the indicators parameters and frequency as stated in Table 7.2

7.6 Guidelines used for Preparing the EMP

The Technical Guide prepared in-house by TEPNG environmental personnel was followed in preparing the Environmental Management Plan proposed below (Table 7.3). The logistics for the project was also carefully planned.

Table 7.2 Monitoring Program of EMP

S/N	Impact Parameter	Impact Indicator	Sampling Location	Sampling Method	Sampling Frequency	Monitoring Duration	End Use of Data
1	Air Quality; Ambient Noise	Ambient air quality	Tie-in point and surrounding	In-situ measurement	Weekly during Excavation / construction and yearly thereafter	Long-term	FMENV, RSMENV, DPR
2	Vegetation status	Diversity Morphology Pathology	Tie-in point and surrounding	Field Assessment Taxonomic studies and identification	Once in three years	Long- term	FMEnv, RSMEnv, DPR, Data bank (in-house record)
3	Soil quality	pH, TOC, TPH, PAH, BTEX Heavy metals (Cu, Pb, Zn, Cd, Ba, Fe, Hg, Cr, Mn)	Tie-in point and surrounding	AAS PH Meter	Yearly after construction	Long- term	FMEnv, RSMEnv, DPR, Data bank (in-house record)
4	Consultation		All stakeholders	Interviews, Dialogue	Yearly	Long-term	Openness/constant discussion

FMENV Federal Ministry of Environment
DPR Department of Petroleum Resources
RSMENV Rivers State Ministry of Environment

S/N	Potential Impacts	Description of Impact	Severity Rating		Mitigation Measures	Action Party
1	Soil degradation	▪ Exposure to direct sunshine	High	▪ Reduce vegetation clearing and soil disturbance to barest minimum	▪ Construction supervisor ▪ Civil engineering supervisor	Prior to and after Commencement of construction
		▪ Elevated soil temperature	High	▪ Minimise exposed land area and duration of exposure.		
		▪ High mortality of soil fauna.	Medium	▪ Install temporary (during construction) and permanent erosion control measures.		
		▪ Erosion.	High	▪ Ensure proper backfilling and revegetation of all excavated areas and trenches		
		▪ Topographic changes	Low	▪ Maintain a ground cover of native plant species at all times		
2	Socio-economic impact/cultural conflicts	▪ Increased demand on services of local communities because of large concentration of workers.	High	▪ Employ majority of unskilled labour force from the communities.	Project Manager Environmental Manager	During construction, Installation

S/N	Potential Impacts	Description of Impact	Severity Rating		Mitigation Measures	Action Party
		▪ Economic depression due to withdrawal of labour force at the end of project.	High	▪ Ensure gradual and phased withdrawal of personnel at the end of construction.		
		▪ Conflict between locals and non-native workers on culture, traditions and lifestyles	Medium	▪ Educate all employees to ensure awareness of, and sensitivity to, the local		
		▪ Risk of car accidents on	Medium	▪ Cultures, traditions and life style.		
				▪ Regulate and coordinate traffic flow.		
				▪ Create awareness on all		

Table 7.3: Impact Management and Monitoring Plan – Mobilization Phase

Project Activity	Impact (positive or negative	Mitigation/ Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
Movement of goods, equipment and personnel	Potential increase in road traffic volume	As much as possible, large and slow-moving vehicles should be scheduled during off peak periods	Journey management record; IVMS record, night driving permit and statistics	Weekly	Monthly	Contractor HSE adviser
		Ensure maintenance of the road	Road maintenance	Monthly	Six monthly	TEPNG
		Raise community awareness of unusual activity through the SD team	Record of awareness sessions	Monthly	Six monthly	TEPNG CLOs
	Potential increase in road traffic incidents	Pre-mobilization of all vehicles	Pre-mob certificate and statistics	Weekly	Monthly	TEPNG Contract Holder
		Visible warning signs on roads and vehicles	Number and adequacy of signs and speed breakers	Weekly	Monthly	TEPNG
		Speed breakers at sections transversing communities	Number of speed breakers	Monthly	Six Monthly	TEPNG
		Defensive driving course for TEPNG and contractor drivers	Driving permit and statistics	Monthly	Six Monthly	TEPNG Contract holder
		Vehicle monitoring device/TEPNG journey management policy/ night driving and alcohol policy shall be enforced	Journey management record	Weekly	Monthly	TEPNG

Project Activity	Impact (positive or negative	Mitigation/ Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
		First aid training of workforce and provision of first aid boxes in operational vehicles	Number of first aid certificates issued and records of vehicle first aid boxes audit	Weekly	Monthly	TEPNG
		TEPNG shall repair Roads (camp site road) any damage caused by project	Percentage of completion	Monthly, six months prior to mobilization	Monthly	TEPNG

Table 7.3: Impact Management and Monitoring Plan – Mobilization phase Contd.

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
	Increase in noise levels	Enforce night driving policy (no night driving except when unavoidable)	Night Driving permit and statistics	Weekly	Monthly	TEPNG
		TEPNG shall ensure that all vehicles and equipment conform to World Bank limits for noise	Vehicle maintenance records	Monthly	Monthly	TEPNG
	Reduction in air quality (dust, exhaust fumes)	TEPNG shall ensure that only vehicles with pre-mobilization certificates are used to reduce emissions from vehicle exhaust	Pre-mob certificates and statistics	Weekly	Monthly	TEPNG
	Damage to the Roads	TEPNG shall maintain the Roads	Road maintenance records	Six months prior to mobilization	Monthly	TEPNG

Table 7.4: Impact Management and Monitoring Plan – Construction Phase

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
Site preparation (Land clearing, excavation)	Loss of flora and fauna	Site clearing shall commence from developed (e.g. roads) to undeveloped areas to provide escape routes for wildlife	Site clearing inspection records	Daily	Weekly	TEPNG
		Hunting by the workforce shall be prohibited	Compliance records	Weekly	Monthly	TEPNG
		TEPNG shall educate construction workers and host communities on the sensitive nature of the biodiversity of the area and the need for conservation	Records of HSE meetings and community enlightenment sessions	Weekly	Monthly	TEPNG
	Loss of habitat	TEPNG shall limit cleared area to what is required	Site clearing inspection records	Daily	Weekly	TEPNG
		TEPNG shall encourage the re-vegetation of land cleared for temporary use where feasible	Implementation records	One month after site clearance	Three monthlies	TEPNG
	Community unrest	TEPNG shall ensure that all host communities are represented in the employment of locals during land clearing and excavation to avert any conflict that could arise from perceptions of unfairness	Employment records for locals	Weekly	Monthly	TEPNG
		TEPNG shall ensure that land clearing and excavation jobs are reserved exclusively for the host communities	Employment records for locals	Weekly	Monthly	TEPNG

Table 7.4: Impact Management and Monitoring Plan – Construction Phase contd.

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
		TEPNG shall abide by all MoUs entered understandings the host communities	Records of compliance with Agreement items	Monthly	Quarterly	TEPNG
	Stress on existing security structures	TEPNG shall ensure that both contractor and TEPNG personnel develop a high level of security consciousness both within and outside the work area	Statistics of security breaches	Weekly	Monthly	TEPNG
		If required, special security force shall be established and deployed for the project. This shall include deploying some of TEPNG police to strengthen security in the area	Number of special security personnel on site	Weekly	Monthly	TEPNG
		TEPNG shall ensure that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained	TEPNG-community meetings	Monthly	Monthly	TEPNG
		In order to beef up security for the project, TEPNG shall contact government authorities to improve the strength of the police force and shall consider providing assistance, to ensure improved security	Deployment of police personnel and records of security equipment.	Monthly	Annually	TEPNG

Table 7.4: Impact Management and Monitoring Plan – Construction Phase Contd.

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
		TEPNG shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized	Records of security workshops	Monthly	Quarterly	TEPNG
	Increase in dust and noise	TEPNG shall ensure that nose masks and earmuffs are worn by site workers during excavation	SPM, records of respiratory diseases and noise levels	Monthly	Monthly	TEPNG
		Water shall be sprayed on construction sites to reduce dust levels especially during dry season	Records on compliance, SPM at selected sites within 500m band	Weekly	Monthly	TEPNG
	Potential increase in erosion	TEPNG shall re-vegetate areas not needed for construction as soon as possible.	Records of re-vegetation exercise	Monthly	Quarterly	TEPNG
	Threat to health of workers (snake bites, insect stings, injuries etc)	TEPNG shall provide and ensure usage of PPE by field workers	Compliance records	Weekly	Monthly	TEPNG
		TEPNG shall ensure that an adequate numbers of trained first aiders are available at work sites	First aid training records and statistics	Monthly	Quarterly	TEPNG
		TEPNG shall ensure that anti-venom/anti-histamine is provided on site to mitigate snake bites and insect stings	Records of anti-venom/anti-histamine at site clinic	Monthly	Quarterly	TEPNG

Table 7.4: Impact Management and Monitoring Plan – Construction Phase Contd

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
		TEPNG shall ensure that awareness is created among site workers on the likelihood of exposure to poisonous wildlife and plants	Awareness records	Monthly	Monthly	TEPNG
Influx of Labour and followers (dependents, bounty seekers, CSWs etc)	Changes in local population	Prior to commencement of the construction phase, TEPNG shall advertise construction jobs that will be available. This will hopefully discourage unqualified personnel from moving into the project area, thus reducing the rate at which population will grow	Records of applications at employment office and copy of advertisement	Weekly	Monthly	TEPNG
		TEPNG will look into the development of off-site job recruitment to discourage influx of people.	Documentary evidence of implementation	3-months	6-monthly	TEPNG
		Movement of unauthorized persons into camps shall be strictly restricted	Records of access control	monthly	Quarterly	TEPNG
	Increase in morbidity (including STIs) and mortality	Health awareness on the mode of transmission of STIs (including HIV/AIDS)	Statistics of health awareness lectures	Intensive phase one to two months prior to mobilization and quarterly there after	Quarterly	TEPNG SD and Occupational Health teams

		As much as possible, psychological support shall be provided to persons living with the HIV virus	Records of HIV support programs	Quarterly	6-monthly	TEPNG SD and Occupational Health teams
		Immunization of workforce as appropriate	Records and statistics of immunization	During mobilization	Quarterly	TEPNG
		TEPNG shall enforce malaria policy	Compliance	Monthly	Annually	TEPNG
		Vector control to reduce incidence of malaria (such as regular spraying of camp and provision of insecticide treated nets) (ITN)	Records and statistics of ITN distribution	Monthly	Quarterly	TEPNG
		Awareness campaign shall be carried out to enlighten the communities/field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values	Statistics of health awareness lectures	Monthly	Quarterly	TEPNG
		Alcohol and drug policy shall be implemented to encourage healthy lifestyle for workers	Records of violations	Monthly	6-monthly	TEPNG
		TEPNG shall support the activities of the state action committee on STIs/HIV/AIDS within the local communities	Records of supportive action	Monthly	Quarterly	TEPNG Occupational Health team

Table 7.4: Impact Management and Monitoring Plan – Construction Phase Contd.

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
		TEPNG shall provide site clinic to take care of minor illnesses for all workers	Statistics of attendance, morbidity and mortality	Weekly	Monthly	TEPNG
		TEPNG shall provide condoms for construction workers	Condoms availability to workers	Monthly	Quarterly	TEPNG
	Increase in social vices	Intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol in the communities and among workers throughout the life of the project	Enlightenment campaign/health education statistics; records of cases of abuse in the workforce	At least 3 months before commencement of construction activities then 6-monthly thereafter	Annually	TEPNG
		TEPNG shall ensure that contractor enforces the alcohol and drug policy for staff	Records of violation	6-monthly	Annually	TEPNG
		TEPNG shall support sporting activities	Number of sporting activities	6-monthly	Annually	TEPNG team
		TEPNG shall support public health lectures with emphasis on common communicable diseases such as malaria, TB, STIs including HIV/AIDS	Statistics of health awareness lectures	1 to 3 months before mobilization and then quarterly thereafter	Quarterly	TEPNG
		TEPNG shall support local security systems	Record of TEPNG support	Quarterly	6-monthly	TEPNG
		TEPNG shall provide condoms for construction workers	Number of condoms provided and distributed	Monthly	Quarterly	TEPNG

Table 7.4: Impact Management and Monitoring Plan – Construction Phase Contd.

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
		TEPNG shall ensure that contractor implements social and health awareness programs for all workers at induction and on a continuous basis throughout the life of the project	Statistics of social and health awareness programmes	At induction and quarterly thereafter	Annually	TEPNG
	Pressure on existing infrastructures and utilities	TEPNG shall make adequate accommodation arrangement prior to mobilization of workforce to reduce pressure on local housing	Accommodation plan	3 months prior to mobilization	1 month to mobilization	TEPNG
		TEPNG shall support the health facilities around project sites	Support provided	Monthly	Monthly	TEPNG Occupational Health team
		TEPNG shall provide basic recreational facilities for workers within their camps	Number and types of facilities	Quarterly	6-monthly	TEPNG
		TEPNG shall extend water supply from camps/worksites to communities at strategic points	Number of water stand points outside the camps	Monthly	Quarterly	TEPNG
	Increase in inflation level	TEPNG shall support skill development and enhancement of the local communities through training	Number of beneficiaries of skill acquisition	6-monthly	Annually	TEPNG team

Table 7.4: Impact Management and Monitoring Plan – Construction Phase Contd.

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
	Changes in culture, lifestyle and habits	TEPNG shall carry out enlightenment campaigns to encourage positive influences on cultural values and healthy lifestyles (e.g. breast feeding habits, alcohol and drug use, exercise, monogamy, high moral values with regard to sexuality etc) and discourage adverse influences (e.g. prostitution, drug abuse, alcoholism etc)	Records of enlightenment sessions	6-monthly	Annually	TEPNG
Waste generation and disposal	Increase in breeding ground for disease vectors and other agents of diseases	TEPNG waste management policy shall be enforced	Compliance	Weekly	Monthly	TEPNG
	Increase in Nuisance effect	TEPNG shall enforce adequate waste management on site	Compliance	Monthly	Quarterly	TEPNG
	Blockage of natural drainages	TEPNG shall ensure that wastes are disposed of at appropriate locations provided for waste disposal and collected as quickly as possible	Compliance	Monthly	Quarterly	TEPNG
	Pressure on existing waste management system	TEPNG shall explore ways to assist the communities in managing wastes	Records of supportive action	Quarterly	Annually	TEPNG

Table 7.4: Impact Management and Monitoring Plan – Construction Phase Contd.

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
	Increase in noise and vibration levels	TEPNG shall alert communities in advance of the activities that are likely to increase noise and vibration levels	Records of information/consultation sessions	1 month before Work	2 weeks before commencement of Work	TEPNG team
		TEPNG shall as far as possible ensure that worksites are at least half a kilometre away from the nearest human settlement	Compliance	Once before Work activities	Once before Work activities	TEPNG
	Contamination of the environment by Work wastes	TEPNG shall ensure regular collection and disposal of wastes in accordance with the TEPNGs waste management plan	Compliance	Weekly	Monthly	TEPNG
		TEPNG shall ensure that disposal of Work wastes is in line with regulatory standards	Compliance	Weekly	Monthly	TEPNG

Table 7.4: Impact Management and Monitoring Plan – Construction Phase Contd.

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
Construction	Reduction in air quality (emissions)	TEPNG shall ensure that all stationary sources along the ROW are properly maintained	Maintenance records	Monthly	Quarterly	TEPNG
	Changes in aesthetic quality of the environment	TEPNG shall alert communities on anticipated visual environmental changes during the activities	Records of consultation/ information	1 month before the commencement of activities	Once during activity	TEPNG SCD team
		TEPNG shall ensure that the site restoration certificate process is completed	Compliance	3 months after tie-in works	6 months after tie-in works	TEPNG
		TEPNG shall re-vegetate areas that are not required for operation and maintenance of the well head cellar	Compliance	3 months after tie-in works	6 months after tie-in works	TEPNG
	Contamination of the environment by chemicals	TEPNG shall ensure that chemicals are stored in lined bunded areas in sealed containers with rain protection	Compliance	Weekly	Monthly	TEPNG
		TEPNG shall ensure that SHOC cards/MSDS are available at site to provide advice on clean-up in the event of spills and leaks	Compliance	Weekly	Monthly	TEPNG
	Contamination of the environment by domestic wastes	TEPNG shall ensure regular collection and disposal of wastes in accordance with the project waste management plan	Compliance	Weekly	Monthly	TEPNG

	Soil degradation from spills and leaks	TEPNG shall ensure that all maintenance and repair of equipment and vehicles are done in a secure location with clean-up materials (e.g. drip pans, containers, absorbent materials etc) are readily available	Compliance	Monthly	Quarterly	TEPNG
	Change in topography	TEPNG shall ensure that the original topography is maintained as far as practically possible	Site inspection reports	Weekly	Monthly	TEPNG

Table 7.4: Impact Management and Monitoring Plan – Construction Phase Contd.

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Compliance Requirement (if any)	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
Constructi on	Exposure to radiation materials	TEPNG shall ensure that adequate saf measures (appropriate PPE and engin techniques) are put in place to avoid e to radioactive materials	TEPNG Policy	Site inspection reports	Daily	Weekly	TEPNG
	Potential for inhalation of welding fumes	TEPNG shall ensure that adequate safety measures (appropria are put in place to avoid inhalation of welding fumes	TEPNG Policy	Compliance	Weekly	Monthly	TEPNG
	Potential for conflicts arising fr issues (welders)	TEPNG shall ensure that it abides by agreements reached with the welder's before their engagement	TEPNG Policy	Compliance with MOUs; Records of complaints and conflicts	Monthly	Quarterly	TEPNG

Table 7.5: Impact Management and Monitoring Plan – Commissioning phase

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
	Threat to health of workers	TEPNG shall ensure that fully equipped first aid facility and trained first aiders are available on site at all times and valve stations	Records of first aid box inventory and health statistics from Retainership clinics	Weekly	Monthly	TEPNG
		TEPNG shall enforce appropriate use of Personal Protection Equipment (PPE)	Compliance	Weekly	Monthly	TEPNG
		TEPNG shall ensure the training of first aiders at least 1:50	Records of first aid training	Monthly	Quarterly	TEPNG
		TEPNG shall ensure that anti-venom/anti-histamine is provided on-site to mitigate snake bites and insect stings	Records and adequacy of anti-venom/anti-histamine	Monthly	Quarterly	TEPNG
		TEPNG shall ensure regular collection and disposal of wastes in accordance with the TEPNGs waste management plan	Compliance	Weekly	Monthly	TEPNG
		TEPNG shall ensure that disposal of Work wastes is in line with regulatory standards	Compliance	Weekly	Monthly	TEPNG

Table 7.6: Impact Management and Monitoring Plan – Operation and Maintenance Phase

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspection/ Monitoring	Frequency of Formal reporting	Action Party
Operation and Maintenance of facility	Increase in noise levels	TEPNG shall encourage Community members Not to settle near the facility	Visual monitoring of the level of encroachment	6-monthly	Annually	TEPNG
		TEPNG shall place warning signs including noise maps at strategic locations within the facility	Display of warning signs and locations	6-monthly	Annualy	TEPNG
		TEPNG shall protect Hearing of Workers through the Enforcement of the Recommendations of Job Hazard Analysis (JHA)	Compliance	6-monthly	Annualy	TEPNG
	Reduction in air quality	TEPNG shall ensure that appropriate maintenance programs are in place for all equipment	Maintenance Records	6-monthly	Annually	TEPNG
	Degradation of soil and surface water from spills and leaks	TEPNG shall provide containment for chemicals and liquid discharges	Compliance	6-monthly	Annually	TEPNG
		TEPNG shall ensure that chemicals are stored in lined bunded areas in sealed containers with rain protection	Compliance	6-monthly	Annualy	TEPNG

Table 7.6: Impact Management and Monitoring Plan – Operation and Maintenance Phase Contd

Project Activity	Impact (positive or negative	Mitigation/Enhancement	Compliance Requirement (if any)	Parameter For Monitoring	Frequency of Inspectional / Monitoring	Frequency of Formal reporting	Action Party
Operation and Maintenance of facility		TEPNG shall ensure that SHOC cards/MSDS are available at site to provide advice on clean-up in the event of spills and leaks	TEPNG Policy	Compliance	Quarterly	Annually	TEPNG
		TEPNG waste management policy shall be enforced	TEPNG Policy	Compliance(waste consignment notes)	Quarterly	Annually	TEPNG
		TEPNG shall ensure that a controlled fuelling, maintenance and servicing protocol for operation machinery at worksite is established and followed to minimise leaks and spills	TEPNG Policy	Compliance	6-montly	Annually	TEPNG
	Relative drop in economic activities	TEPNG shall support skill development and enhancement of the local communities through training as agreed in the Stakeholders Plan (SP) and Social Action Plan (SAP) see Appendix 7.1	TEPNG Policy	Compliance with SP and SAP	6-montly	Annually	TEPNG SCD team
		TEPNG shall ensure the training of first aiders at least 1:50	TEPNG Policy	Records of first aid training	Quarterly	Annually	TEPNG
		TEPNG shall ensure that anti-venom/anti-histamine is provided on site to mitigate snake bites and insect stings	TEPNG Policy	Records of anti-venom/anti-histamine provision and adequacy	Monthly	Quarterly	TEPNG

Table 7.7: Impact Management and Monitoring Plan – Decommissioning, Restoration and Abandonment Phase

Project Activity	Impact (positive or Negative	Mitigation/Enhancement	Parameter For Monitoring	Frequency of Inspectional/ Monitoring	Frequency of Formal reporting	Action Party
Surface equipment dismantling, Excavation, Removal and Disposal of concrete works and pipes	Increase in dust generation	TEPNG shall ensure proper use of appropriate PPE	Compliance	Weekly	Monthly	TEPNG
		TEPNG shall ensure that water is sprayed to reduce dust levels	Records of Compliance	Daily	Weekly	TEPNG
	Increase in noise levels	TEPNG shall inform communities in advance of likely increase in noise level during decommissioning	Compliance	2 weeks before commencement of Work	--	TEPNG
		TEPNG shall ensure proper use of PPE (ear muffs)	Compliance	Weekly	Monthly	TEPNG
	Increase in respiratory tract diseases	TEPNG shall ensure that all personnel are medically certified for the operation prior to engagement	Compliance	Monthly	Annually	TEPNG
		TEPNG shall enforce appropriate use of PPE (nose mask)	Compliance	Weekly	Monthly	TEPNG,
		TEPNG shall use barriers to minimise the spread of dust	Compliance Record	Monthly	Quarterly	TEPNG
	Increase in waste generation	TEPNG shall ensure that wastes are disposed of in accordance with her waste management plan for this project	Compliance	Weekly	Monthly	TEPNG,
	Potential for community unrest (from employment, pollution and resistance to dismantling of equipment)	TEPNG shall ensure fair community representation in the employment of local labour	Employment Records	Quarterly	Six – monthly	TEPNG, FMEnv
		TEPNG shall abide by the Agreements signed with the communities for this project	Compliance with Agreement items	Yearly	Once during de-commissioning	TEPNG,

7.7 Contingency Planning

Despite all care and diligence exercised in project execution, accidents still do occur. Accidents could occur from equipment failure or third-party error or sabotage, all to the detriment of the environment. Consequently, Gas Contingency Plans are usually made to handle such accidental emissions. Although serious incidents are considered unlikely in this project, TEPNG has in place a Contingency Plan that has been activated, regularly updated through regular and periodic checks conducted by the Department of Petroleum Resources.

7.8 Waste Management

7.8.1 Introduction

The operation in the facility is not expected to generate significant volume of solid or liquid wastes. The technology for operating gas pipeline is well-developed. No significant leakage is expected.

Furthermore, the project design and implementation briefs to contractors contain extensive quality assurance instructions which include details of actions that must be taken by the contractor to ensure that the works are performed with safety and concern for the environment in clear view. Thus, limited negative impact from waste generation is envisaged.

7.8.2 Waste Composition

Site clearing and excavation will result in the generation of large quantity of solid waste, essentially biodegradable vegetation, wood debris and soil. Civil engineering works will generate volume of wastes which will include wood and iron rod cuttings. Mechanical engineering works will generate pipe cutting wastes, welding wastes, x-ray photographic waste, radiation materials container wastes, Electrical works will generate waste cartons, cable cutting etc. Administration wastes are mainly paper from site construction offices and from the Central Processing Facility during operations. Sewage generated during construction will be handled via mobile toilets, which shall be emptied by sewage trucks or chemically treated

7.8.3 Waste Management

Waste generated throughout all stages of this project shall as a matter of deliberate commitment be managed from cradle to grave. The Proponents of this project will:

- Take all practical and cost-effective measures to minimize the generation of wastes, by implementing the four R's (reduce, reuse, recycle, recover) of waste

management through process optimizations, efficient procedure and good housekeeping;

- Minimizing the hazards presented by all wastes and ensuring that all wastes shall be managed and disposed of in an environmentally acceptable manner. This policy implies that:
- All activities planning must, at inception, address waste management, and shall not be approved without this being seen to have been done;
- The management of waste is a line responsibility and key/front -line staff shall be actively involved in controlling the wastes generated by their activities.

7.8.3.1 Construction Phase

The following procedures shall be adopted in handling wastes emanating from the construction stage:

All waste generated shall be classified and registered.

- Waste shall be segregated at site into the following categories:
- vegetation debris (leaves, cut grass, tree branches)
- Construction debris
- Scrap metals and welding off-cuts
- Cable cutting
- Drums
- Spent lube oil
- Oil and fuel filters
- Hazardous wastes e.g. - solvents.
- Glass
- Biodegradable domestic wastes
- Office and stationery wastes (toner cartridges, diskettes, etc.)

All wastes shall be quantified, and the inventory data recorded

Table 7.8: Waste and Management options

Vegetation debris (leaves, cut grasses, tree branches)	Approved Dumpsite/incinerator
Construction debris	Approved Dumpsite/incinerator
Scrap metals	Recycling
Cable cuttings	Recycling
Drums	Recycling
Spent lube oil (Hazardous)	Approved Incinerator
Oil and fuel filters (Hazardous)	Approved Incinerator
Hazardous waste; e.g. solvent, thinners (Hazardous)	Approved Incinerator
Radiation waste (cartridge or radiation source container)	Recycling
Glass	Recycling
Biodegradable domestic wastes	Approved/Dumpsites
Office/stationary wastes (toner cartridge, diskettes, etc.)	Recycling

Waste tracking system shall be established and operated for all construction sites.

CHAPTER 8

CONCLUSIONS

This EIA has provided the description of the proposed NOPL–Indorama pipeline tie-in point at KP-33.5 project and the baseline environmental, social and health conditions.. The study established the existing state of the environment through desktop studies, field studies and laboratory analyses in order to relate the environmental components to the quality indicators so as to determine the impacts positively or negatively in the short and long term. The potential and associated impacts cover all stages of the project, from site clearing and preparation through construction operation and demobilization, decommissioning and closure.

The potential impacts of the proposed project have been identified and are related to traffic, air quality, noise level, socio-economics, construction waste management, fauna and flora, and safety.

Although the project has the following potential impacts as listed above, the beneficial impacts from socioeconomic, environmental and health aspects far outweigh the negative impacts.

A number of potential negative impacts identified were mitigated through a lifecycle process of the project. Adherence to these measures and regulatory compliance requirements shall ensure that impacts assessed as having low significance subsequently remain at acceptable levels. Those impacts identified as having potentially moderate and major significance consequences will also be either eliminated or curtailed through the implementation of appropriate mitigation measures as recommended in this report

The monitoring programme of the EMP shall comprise the Environmental Components i.e. Air quality, Wastes management, Sewage, Risk assessment, Abandonment or decommissioning during the construction and operational phases. It should be noted that the EMP will only be successful if the Environmental regulatory agencies and stakeholders play their role where applicable.

The EIA has demonstrated that the overall impacts associated with the NOPL–Indorama pipeline tie-in Project can be managed within reasonable and acceptable limits by applying all identified mitigation measures contained in this report.

TEPNG is committed to implementing the EMP and the whole project in a safe and environmentally accountable manner. TEPNG will also work with government and all other stakeholders towards the implementation of this EMP.

TEPNG shall adhere to appropriate environmental and safety requirements, fixed mitigation measures, and the additional mitigation measures as recommended, to ensure a sustainable environment.

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APPENDICES

Appendix 4.1: Socio-Economic and Health Impact Assessment of Obigbo EER/EIA

SOCIO –ECONOMIC POST IMPACT ASSESSMENT OF EER/EE STUDY

FOCUS GROUP DISCUSSION GUIDE

Name of Community_____ **LGA:**_____

Type of Group:_____ Male:_____ Female:_____

List of Participants (b/w 8 – 10)

1 2
3. 4.
5. 6.
7. 8
9. 10.

Name of Moderator _____Name of Note taker _____Date_____

A. Community Characteristics

1. Composition of the community: How would you describe this community in terms of the proportion of the population by sex, age, religion, social status, migrant status and ethnic background? (use the table to record responses.)

Characteristic Proportion	none	¼	½	¾	All	Characteristic Proportion	none	¼	½	¾	all
Age: Adults						Children/Youth					
Religion: Christian						Muslim					
Indigenes						Migrants					
Status: Better-off						Poor					
Gender: Male						Female					
Majority ethnic Group(_____)						Minority ethnic Group					

Record the consensus of opinion not the responses of one person.
* Indicate here if there is a proportion of the population that are traditional worshippers.

2. How would you rate the level of infrastructural development in this community?
High _____ average _____ very low _____

10

Use the table below to indicate the type of facilities available and their condition:

Type of facility	Tick if present	Tick if functioning	Condition: Good/ poor	Any plan to Improve.
Access road				
Public transportation				
Local market				
Primary school				
Secondary school				
Dispensary/maternity				
Electricity				
Stable water supply				
Others:				

Record the consensus of opinion not the responses of one person.
* Indicate here if there is any plan by community or outside agency to improve the facility.

3. A) In the past one year, have you seen many people move out of this community to other places? Yes _____No _____ if yes, who is most likely to migrate? (Describe those most likely to migrate in term of sex, age, social status etc.)

   B). Why do people migrate out from this area?

4. In the last one year have you seen any changes in the people living in this Community?
   - In terms of number: ___ Yes, more people now; ___no change; __fewer people now
   - In terms of composition:___ yes, there are changes; ____no it is basically the same (by composition one is considering age distribution, presence/absence of migrants, etc.- describe how it has changed)

5. List the common social groups in this community:

6. A). How is the general health status of people in this community? Good;_____ Just fair; _____ poor _____
   B) What are the common diseases affecting people here?

   C) Are there any reasons for particular health problems here? (Probe to see if there are health problems caused by water pollution, oil spillage or other activities of oil companies).

7. A). How would you characterize this community in terms of cooperation and social harmony? Do people work together or are there cases of fighting between groups within the community? What are the likely causes of such conflict, if they occur?

   B). In the case of conflict between groups within the community, how are such problems resolved?

   D) Have there been any recent cases of conflict with groups outside the community? Yes; ___ No; _____ if yes, what were the causes?

E). How have such conflicts with outside groups been resolved?

B. Livelihood Activities of Local Population

8. Which of the following activities are practiced in this community? Indicate if women, men or both are engaged in each activity. Also indicate if each activity is declining or not

Activity	Gender M/F/B*	Tick if activity is threatened or declining	If threatened, give reasons
Crop farming			
Trading			
Livestock rearing			
Civil servant			
Fishing			
Hunting			
Gathering non-timber forest products			
Processing produce			
Marketing Produce			
Blacksmith, carpenter			
Crafts			
Selling food, snacks			
Hired labourer: Agricultural or oil company			
Other:			

* M = Males only engage in this activity; F = females only; B = both males and females engage in this activity.

9.A) Over the last 5 -10 years, have there been any changes in these activities?
Yes, improved; ___ Yes, declined; ___ No change ____

B) Which activities have improved?

Which has remained the same?

C) Why has there been a change, if any?

10 In the past one year, what changes have you observed in the above- mentioned activities?
Which has remained the some?
Why has there been a change (if any)

11. List the major crops grown here:
Which of these crops have been affected by the operations of Total?

12. List your major agricultural problems?

13. Have there been any projects specifically to improve your farming activities in this community? Yes; ____ No _____ if yes, by which organization and what was done?

14. List the common fish breeds and other river/swamp produce harvested in your waters?

15. Which of the listed river produce are no more common (at least in the past 1year)?

16 Please itemize the various problems affecting volume of fish/Hunting catch, especially in the last one year

C. Environmental problems

17 What are the major environmental problems in this community?

18. Which of the following resources have been affected by petroleum exploitation activities and how?

Resource	Effect
Land/soil	
Forest	
NTFPs	
Water	
Crop yield	
Livestock Health	
Air Quality	
Employment	
Farming	

D Fish/Hunting Catch Analysis

19. How often do you embark on fishing /Hunting trips? (a) daily------- (b) weekly-------

20. What conditions affect your decision to embark on fishing/Hunting trips? ----------
---

21. Please list the equipment you utilize for your fishing/Hunting trips.

22. What is your present volume (baskets, head pans,etc) of fish/Hunt catch?----------

23. Are there periods (day or night) or seasons (rainy or dry) in which you have high or low volumes of fish catch? ------- (Yes or No). If yes, kindly explain ----------
---

24. Are there some sacrifices you have to perform/ or procedures you have to undertake before you embark on a fishing trip? ----------
---

25. Is there any repercussion or bad effect for not performing the sacrifice or procedure explained above?----------

26. How do you dispose of your fish catch? (Sales, gifts, deterioration, etc.)----------

27. How much do you make fro your fish sales? Daily---------- Weekly ----------

28. Have there been changes in any of the above specified activities
In the last 10 years? No----- Yes-----(In what form)?----------
In the last 5 years? No------Yes-----(In what form)?----------
In the last 1 year? No------Yes-----(In what form)?----------
In the last 3 months? No------Yes-----(In what form)?----------

E. Post Impact Activities

29. How far from human habitation are any oil installations in your community?_____

30. When did oil companies first come to this area?_____

31. Did they come to your community to discuss with you what they were planning to do?_____

32. Do oil company officials ever come to discuss their activities with your community? Yes, regularly; _____ Yes, occasionally; _____ no, not at all _____ if yes, what do they discuss? _____
_____

33. Do they ever discuss your problem with you or consult you before they site their installations? _____
_____

34. How would you characterize the relationship between the oil company and your community? Very good; _____ fair; ____ poor;_____ hostile; ___what is the reason for the "chosen" relationship? _____

35. Has any of your communal lands been taken over by the oil company? Yes; _____No; _____ If yes, what proportion of your land has taken over? Over ½; _____ ¼ - ½; _____ over ¼; _____ a very small size; ____

36. Have there been cases of oil prospecting related problems (e.g. oil spill) in this community? Yes; ___ No;_____ I don't know;_____

37. If Yes, give details about the latest problem_____
_____
_____

38. What is the effect of the oil related problem on your environment?_____

39. What is the effect of the oil related problem on your livelihood?_____

40. What is the effect of the oil related problems on your health?

41. What should be done to ameliorate the effect of the oil related problem in your community?_____

42. A). Has the Government/Total embarked on any activity to try to reduce the environmental problems in your locality? Yes _____ No. _____

B) Has any oil company embarked on any activities to help the rural people? Yes_____ No._____

If yes, what kinds of development programmes have been implemented in your community, by which organizations and what has been the impact?

43. What are the advantages and disadvantages of the activities of oil corporations upon:

	Advantages	Disadvantages
Females in the Community:		
Males in the community		
Community as a whole		
Environment		
Farming		
Hunting		
Others		

44. Overall, do you think the activities of the oil companies have had?
Good effect; _____ No. effect; _____Bad effect_____

45. What should be done to help the people of this area?

Thank you for your assistance. God bless you.

Appendix 4.2: Measured Climatic and meteorological data, Air Pollution indicators and noise levels during the NOPL-Indorama tie-in EIA study

Sampling Stations at the Study Area in and Around the Tie-In Point

Site ID	Date	Time	VOC (mg/m^3)	SO2 (ppm)	NO2 ppm	CH4 (%)	CO^2 % vol	CO (ppm)	PM 2.5 µg/m3	PM 10 $\mu g/m^3$	Noise (dba)	Ambient Temp (°C)	Rel. Humidity (%)	Wind speed (m/s)	Wind Direction
IND AQ 19	22/03/20	1:30 PM	0.001	0	0	0	0	0	4.9	15.8	55	36.56	58.61	0.8	NW
TIE IN POINT	22/03/20	1:47 PM	0.003	0	0	0	0	0	7.1	15.6	54	35.79	56.17	0.9	SW
AQ IND AQ 15	22/03/20	3:24 PM	0.002	0	0	0	0.1	0	5.9	16.3	53	36.88	53.54	1	S

Control Sampling Stations

Site ID	Date	Time	VOC (mg/m^3)	SO_2 (ppm)	NO_2 (ppm)	CH_4 (%)	CO^2 (% vol)	CO (ppm)	PM 2.5 (µg/m3)	PM 10 ($\mu g/m^3$)	Noise (dba)	Ambient Temp (°C)	Rel. Humidity (%)	Wind speed (m/s)	Wind Direction
OB/IND CTRL 1	22/03/20	11:55 AM	0.001	0	0	0	0	0	7.6	24.7	62	35.88	61.53	1.2	NNE
OB/IND CTRL 2	22/03/20	12:39 PM	0.001	0	0	0	0	0	5.4	16.2	68	34.93	62.02	0.8	N

Appendix 4.3a: Physico-Chemical characteristics of the soil samples from 0-15cm in the proposed Indorama Tie-in stations.

SAMPLING STATION ID	Parameters											
	Colour	pH	CEC (meq/100g	TOC (%)	Moisture Content (%)	Redox Potential (mV)	T. Nitrogen (%)	Salinity	T. Phosphorus	Particle Size Distribution		
										Sand (%)	Silt (%)	Clay (%)
IND – SS – 6 T	Dark Brown	5.25	44.7	1.00	16.1	296	0.093	0.072	44.60	81.7	14.3	4.00
IND – SS – 8 T	Dark Brown	4.77	46.5	0.762	15.4	122	0.077	0.019	18.7	74.3	20.0	5.70
IND – SS – 10 T	Light Brown	4.90	45.7	1.04	15.0	130	0.096	0.010	21.4	77.1	18.3	4.60
IND – SS – 13 T	Greenish Brown	4.61	45.0	0.200	14.5	139	0.039	0.028	5.84	74.5	19.4	6.10
IND – SS – 14 T	Reddish Brown	5.60	47.8	0.521	14.8	83.7	0.061	0.033	20.7	80.2	15.9	3.90
IND – SS – 17 T	Light Brown	4.82	44.8	1.68	15.7	131	0.139	0.027	13.6	79.0	16.0.	5.00
IND – SS – 18 T	Dark Brown	4.96	45.5	1.28	14.6	122	0.112	0.016	5.81	76.8	14.7	8.50
IND – SS – 20 T	Brown	5.03	47.4	1.28	16.0	126	0.112	0.024	14.6	84.4	13.5	2.10
OB/IND – CTRL T 1	Light Brown	4.86	46.4	1.29	18.1	147	0.112	0.019	94.1	84.7	9.17	6.13
OB/IND – CTRL T 2	Yellowish Brown	4.71	47.2	1.22	17.8	284	0.108	0.086	229	81.4	6.90	11.7

Appendix 4.3b: Physico-Chemical characteristics of the soil samples from 15-30cm in the proposed Indorama Tie-in stations.

	Parameters											
SAMPLING STATION ID	Colour	pH	CEC (meq/100g)	TOC (%)	Moisture Content (%)	Redox Potential (mV)	T. Nitrogen (%)	Salinity	T. Phosphorus	Particle Size Distribution		
										Sand (%)	Sand (%)	Sand (%)
IND – SS – 6 B	Brown	5.18	47.3	0.842	16.9	279	0.082	0.055	50.7	84.3	12.1	3.60
IND – SS – 8 B	Brown	4.64	48.0	0.642	16.1	129	0.069	0.016	22.6	77.1	16.3	6.60
IND – SS – 10 B	Light Brown	5.11	48.7	0.561	15.8	138	0.064	0.010	17.9	82.3	12.6	5.10
IND – SS – 13 B	Reddish Brown	4.95	47.3	0.080	15.3	59.0	0.031	0.040	6.75	71.9	23.1	5.00

	Parameters											
SAMPLING STATION ID	Colour	pH	CEC (meq/100g)	TOC (%)	Moisture Content (%)	Redox Potential (mV)	T. Nitrogen (%)	Salinity	T. Phosphorus	Particle Size Distribution		
										Sand (%)	Sand (%)	Sand (%)
IND – SS – 14 B	Light Brown	4.87	52.3	0.481	15.5	57.1	0.058	0.061	22.4	78.4	17.0	4.60
IND – SS – 17 B	Dark Brown	5.21	54.3	1.48	16.4	119	0.125	0.028	13.8	82.8	10.3	6.90
IND – SS – 18 B	Light Brown	4.99	49.5	1.16	15.4	143	0.104	0.016	6.94	72.5	20.8	6.70
IND – SS – 20 B	Light Brown	5.14	48.7	1.08	16.5	140	0.098	0.024	12.7	79.9	16.0	4.10
OB/IND – CTRL T 1	Light Brown	4.70	48.9	0.747	19.0	156	0.076	0.015	188	88..6	3.77	6.41
OB/IND – CTRL T 2	Yellowish Brown	5.01	49.2	0.629	19.3	311	0.068	0.052	157	86.9	3.12	9.98

Appendix 4.3c:Soil Physical Characteristics

	0-15cm			15-30cm		
SAMPLING STATION ID	Porosity (%)	Permeability (ml/s)	Bulk Density (g/cm^3)	Porosity %	Permeability ml/s	Bulk Density g/cm3
IND – SS – 6 T	47.7	1.8	1.2	45.9	1.65	1.25
IND – SS – 8 T	45.2	0.91	1.25	46	0.79	1.3
IND – SS – 10 T	48.8	1.74	1.3	47.2	0.95	1.24
IND – SS – 13 T	50.2	0.98	1.22	45.7	1.74	1.3
IND – SS – 14 T	48	1.85	1.27	46.2	1.83	1.19
IND – SS – 17 T	47.3	1.77	1.31	50	0.87	1.22
IND – SS – 18 T	51	0.88	1.23	49.1	1	1.15
IND – SS – 20 T	49	1.89	1.28	48	1.7	1.21

OB/IND – CTRL T 1	53.4	0.66	1.1	54.9	0.74	1.16
OB/IND – CTRL T 2	53.1	0.69	1.21	51.7	0.65	1.24

Appendix 4.4a: Anions and Cations characteristics of the soil samples from 0-15cm in the proposed Indorama Tie-in stations

SAMPLING STATION ID	Parameters									
	Sodium	Potassium	Magnesium	Calcium	Phosphate (mg/kg)	Sulphate (mg/kg)	Nitrate (mg/kg)	Nitrite (mg/kg)	Carbonate (mg/kg)	Ammonium (mg/kg)
IND – SS – 6 T	48.2	100	24.1	314	26.5	87.0	8.98	0.266	<0.50	7.22
IND – SS – 8 T	43.1	104	29.7	325	11.1	120	16.4	0.121	<0.50	13.2
IND – SS – 10 T	47.8	116	23.6	317	12.7	54.6	6.14	0.300	<0.50	4.94
IND – SS – 13 T	44.9	121	25.8	307	3.47	22.6	5.04	0.299	<0.50	4.05
IND – SS – 14 T	48.9	127	28.2	324	12.3	55.9	7.77	0.170	<0.50	6.25
IND – SS – 17 T	42.0	108	28.2	310	8.10	79.8	11.8	0.126	<0.50	6.49
IND – SS – 18 T	46.3	126	23.1	312	3.45	88.8	6.56	0.200	<0.50	5.27
IND – SS – 20 T	47.7	108	24.1	338	8.68	54.1	26.5	0.467	<0.50	21.3
OB/IND – CTRL T 1	53.3	135	23.4	310	55.9	113	7.83	0.416	<0.50	6.28
OB/IND – CTRL T 2	51.8	138	24.0	317	136	155	5.43	0.572	<0.50	4.37

Appendix 4.4b: Anions and Cations characteristics of the soil samples from 15-30cm in the proposed Indorama Tie-in stations

SAMPLING STATION ID	Parameters									
	Sodium (mg/kg)	Potassium (mg/kg)	Magnesium (mg/kg)	Calcium (mg/kg)	Phosphate (mg/kg)	Sulphate (mg/kg)	Nitrate (mg/kg)	Nitrite (mg/kg)	Carbonate (mg/kg)	Ammonium (mg/kg)
IND – SS – 6 B	51.3	121	27.3	322	30.1	154	12.5	0.422	<0.50	10.0
IND – SS – 8 B	45.8	112	30.7	332	13.4	75.1	20.2	0.064	<0.50	16.2
IND – SS – 10 B	49.2	132	26.6	333	10.6	34.2	6.28	0.150	<0.50	5.05
IND – SS – 13 B	47.1	114	28.3	327	4.01	65.1	8.03	0.411	<0.50	6.45
IND – SS – 14 B	52.8	148	30.5	351	13.3	92.4	9.30	0.277	<0.50	7.48
IND – SS – 17 B	53.9	139	34.9	368	8.23	110	12.9	0.344	<0.50	10.4
IND – SS – 18 B	45.4	117	32.0	343	4.12	61.4	8.85	0.161	<0.50	7.11
IND – SS – 20 B	48.1	137	26.4	332	7.52	32.8	13.7	0.195	<0.50	11.0
OB/IND – CTRL T 1	56.2	148	26.1	322	112	113	8.91	0.250	<0.50	7.16
OB/IND – CTRL T 2	53.9	149	25.7	327	93.2	155	5.57	0.370	<0.50	4.48

Appendix 4.5a: Heavy Metal characteristics of the soil samples from 0-15cm in the proposed Indorama Tie-in stations.

SAMPLING STATION ID	Parameters											
	Fe	Cd	Cr	Cu	Ni	V	Pb	Zn	Ba	Hg	As	Al
	(mg/kg)											
IND – SS – 6 T	27.0	1.10	1.13	2.16	2.69	<0.002	1.17	2.06	16.9	<0.001	<0.002	4.11
IND – SS – 8 T	26.9	1.27	1.14	2.71	2.17	<0.002	1.10	2.10	17.1	<0.001	<0.002	4.18
IND – SS – 10 T	27.1	1.34	1.03	2.17	2.24	<0.002	1.29	2.34	17.2	<0.001	<0.002	4.20
IND – SS – 13 T	27.9	1.17	1.25	2.84	2.18	<0.002	1.04	2.84	18.0	<0.001	<0.002	4.18
IND – SS – 14 T	24.5	1.35	1.30	2.50	2.17	<0.002	1.50	2.37	17.5	<0.001	<0.002	3.32
IND – SS – 17 T	25.4	1.26	1.23	2.67	2.14	<0.002	1.17	2.34	17.3	<0.001	<0.002	4.23
IND – SS – 18 T	27.0	1.28	1.17	1.68	2.16	<0.002	1.37	2.48	16.8	<0.001	<0.002	4.12
IND – SS – 20 T	26.9	1.23	1.11	1.24	2.47	<0.002	1.24	2.17	17.2	<0.001	<0.002	4.22
OB/IND – CTRL T 1	24.5	1.57	1.72	1.58	2.45	<0.002	2.54	2.76	30.1	<0.001	<0.002	4.29
OB/IND – CTRL T 2	22.6	1.21	1.37	1.79	2.65	<0.002	2.42	2.81	26.3	<0.001	<0.002	4.29

Appendix 4.5b: Heavy Metal characteristics of the soil samples from 15-30cm in the proposed Indorama Tie-in stations.

SAMPLING STATION ID	Parameters											
	Fe	Cd	Cr	Cu	Ni	V	Pb	Zn	Ba	Hg	As	Al
	(mg/kg)											
IND – SS – 6 B	29.3	1.22	1.10	2.60	2.64	<0.002	1.43	2.28	18.3	<0.001	<0.002	4.34
IND – SS – 8 B	28.2	1.25	1.19	2.84	2.43	<0.002	1.33	2.37	19.4	<0.001	<0.002	4.79
IND – SS – 10 B	28.9	1.23	1.13	2.36	2.57	<0.002	1.38	2.73	18.1	<0.001	<0.002	4.92
IND – SS – 13 B	28.4	1.29	1.10	2.95	2.51	<0.002	1.19	2.90	18.9	<0.001	<0.002	4.88
IND – SS – 14 B	26.2	1.35	1.15	2.70	2.37	<0.002	1.78	2.64	19.3	<0.001	<0.002	4.85
IND-SS-17 B	28.6	1.19	1.22	2.86	2.82	<0.002	1.00	2.92	25.8	<0.001	<0.002	4.92
IND – SS – 18 B	27.8	1.20	1.21	2.78	2.32	<0.002	1.86	2.84	16.1	<0.001	<0.002	4.67
IND – SS– 20 B	29.4	1.28	1.24	2.72	2.42	<0.002	1.54	2.71	18.2	<0.001	<0.002	4.59
OB/IND – CTRL T 1	25.7	1.68	1.88	1.68	2.40	<0.002	2.14	2.84	30.9	<0.001	<0.002	4.89
OB/IND – CTRL T 2	25.9	1.28	1.46	1.86	2.35	<0.002	2.50	2.92	27.0	<0.001	<0.002	4.36

Appendix 4.6: Hydrocarbon characteristics of the soil samples in the proposed Indorama Tie-in stations.

SAMPLING STATION ID	Parameters				
	Oil & Grease (mg/kg)	THC (mg/kg)	TPH (mg/kg)	PAH (mg/kg)	BTEX (mg/kg)
Topsoil (0 – 15 cm)					
IND – SS – 6 T	22.7	<0.10	<0.01	<0.001	<0.001
IND – SS – 8 T	15.2	<0.10	<0.01	<0.001	<0.001
IND – SS – 10 T	22.7	<0.10	<0.01	<0.001	<0.001
IND – SS – 13 T	15.2	<0.10	<0.01	<0.001	<0.001
IND – SS – 14 T	15.2	<0.10	<0.01	<0.001	<0.001
IND – SS – 17 T	22.7	<0.10	<0.01	<0.001	<0.001
IND – SS – 18 T	15.2	<0.10	<0.01	<0.001	<0.001
IND – SS – 20 T	22.7	<0.10	<0.01	<0.001	<0.001
OB/IND – CTRL T 1	15.2	7.58	<0.01	<0.001	<0.001
OB/IND – CTRL T 2	22.7	15.2	<0.01	<0.001	<0.001
Subsoil (15 – 30 cm)					
IND – SS – 6 B	15.2	<0.10	<0.01	<0.001	<0.001
IND – SS – 8 B	7.58	<0.10	<0.01	<0.001	<0.001
IND – SS – 10 B	7.58	<0.10	<0.01	<0.001	<0.001
IND – SS – 13 B	7.58	<0.10	<0.01	<0.001	<0.001
IND – SS – 14 B	15.2	<0.10	<0.01	<0.001	<0.001
IND – SS – 17 B	15.2	<0.10	<0.01	<0.001	<0.001
IND – SS – 18 B	7.58	<0.10	<0.01	<0.001	<0.001
IND – SS – 20 B	15.2	<0.10	<0.01	<0.001	<0.001
OB/IND – CTRL T 1	7.58	<0.10	<0.01	<0.001	<0.001
OB/IND – CTRL T 2	15.2	7.58	<0.01	<0.001	<0.001

Appendix 4.7: Microbiology characteristics of the soil samples in the proposed Indorama Tie-in stations.

SAMPLING STATION ID	Parameters					
	THB (cfu/g)	HUB (cfu/g)	THF (cfu/g)	HUF (cfu/g)	SRB	Faecal Coliform (MPN/100ml)
Topsoil (0 – 15 cm)						
IND – SS – 6 T	4.40×10^{4}	6.10×10^{3}	2.00×10^{4}	6.50×10^{2}	$<10^{1}$	7.00
IND – SS – 8 T	3.25×10^{4}	2.50×10^{3}	1.05×10^{4}	1.80×10^{3}	$<10^{1}$	4.00
IND – SS – 10 T	3.26×10^{5}	1.23×10^{4}	1.50×10^{4}	5.00×10^{2}	$<10^{1}$	11.0
IND – SS – 13 T	1.60×10^{4}	$<1.00\times10^{1}$	3.00×10^{3}	$<1.00\times10^{1}$	$<10^{1}$	2.00
IND – SS – 14 T	1.21×10^{5}	1.43×10^{4}	1.20×10^{4}	5.50×10^{2}	$<10^{1}$	7.00
IND – SS – 17 T	3.55×10^{4}	2.40×10^{3}	1.40×10^{4}	1.30×10^{3}	$<10^{1}$	4.00
IND – SS – 18 T	9.70×10^{4}	6.00×10^{2}	3.00×10^{3}	3.00×10^{2}	$<10^{1}$	4.00
IND – SS – 20 T	1.50×10^{4}	1.25×10^{3}	5.00×10^{3}	2.00×10^{2}	$<10^{1}$	22.0
OB/IND – CTRL T 1	6.25×10^{4}	1.45×10^{3}	1.40×10^{4}	1.15×10^{3}	$<10^{1}$	4.00
OB/IND – CTRL T 2	9.10×10^{4}	2.35×10^{3}	1.50×10^{4}	8.00×10^{2}	$<10^{1}$	2.00
Subsoil (15 – 30 cm)						
IND – SS – 6 B	1.40×10^{4}	2.60×10^{3}	2.00×10^{3}	2.00×10^{2}	$<10^{1}$	4.00
IND – SS – 8 B	7.00×10^{4}	1.95×10^{3}	5.35×10^{4}	1.65×10^{3}	$<10^{1}$	2.00
IND – SS – 10 B	2.89×10^{5}	6.05×10^{3}	1.35×10^{4}	2.00×10^{2}	$<10^{1}$	7.00
IND – SS – 13 B	1.35×10^{4}	$<1.00\times10^{1}$	1.00×10^{3}	$<1.00\times10^{1}$	$<10^{1}$	2.00
IND – SS – 14 B	1.03×10^{5}	4.00×10^{3}	2.95×10^{4}	1.70×10^{2}	$<10^{1}$	4.00
IND – SS – 17 B	1.95×10^{4}	1.20×10^{3}	1.00×10^{4}	6.00×10^{2}	$<10^{1}$	2.00
IND – SS – 18 B	6.10×10^{4}	2.00×10^{2}	1.00×10^{3}	1.50×10^{2}	$<10^{1}$	2.00
IND – SS – 20 B	1.23×10^{4}	$<1.00\times10^{1}$	3.50×10^{3}	$<1.00\times10^{1}$	$<10^{1}$	11.0
OB/IND – CTRL T 1	2.25×10^{4}	7.00×10^{2}	3.00×10^{3}	5.50×10^{2}	$<10^{1}$	2.00
OB/IND – CTRL T 2	5.25×10^{4}	1.70×10^{3}	1.35×10^{4}	6.00×10^{2}	$<10^{1}$	4.00

Appendix 4.8: Paired–Samples T-test results

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	pHTOP - pHBOT	-.01875	.35389	.12512	-.31461	.27711	-.150	7	.885
Pair 2	CECTOP - CECBOT	-3.58750	2.63300	.93091	-5.78874	-1.38626	-3.854	7	.006
Pair 3	TOCTOP - TOCBOT	.17963	.13152	.04650	.06967	.28958	3.863	7	.006
Pair 4	REDTOP - REDBOT	10.70000	32.45797	11.47563	-16.43554	37.83554	.932	7	.382
Pair 5	NITROTOP - NITROBOT	.01225	.00876	.00310	.00492	.01958	3.954	7	.006
Pair 6	NTRATOP - NITRABOT	-.32125	5.44583	1.92539	-4.87408	4.23158	-.167	7	.872
Pair 7	NTRITOP - NITRIBOT	-.00937	.16750	.05922	-.14941	.13066	-.158	7	.879
Pair 8	PHOTOP - PHOBOT	-1.06750	3.02840	1.07070	-3.59931	1.46431	-.997	7	.352
Pair 9	PHOSTOP - PHOSBOT	-.62250	1.79932	.63616	-2.12677	.88177	-.979	7	.360
Pair 10	NaTOP - NaBOT	-3.08750	3.87720	1.37080	-6.32892	.15392	-2.252	7	.059
Pair 11	KTOP - KBOT	-13.75000	15.21982	5.38102	-26.47409	-1.02591	-2.555	7	.038
Pair 12	MgTOP - MgBOT	-3.73750	2.65703	.93940	-5.95883	-1.51617	-3.979	7	.005
Pair 13	CaTOP - CaBOT	-20.12500	19.34231	6.83854	-36.29558	-3.95442	-2.943	7	.022
Pair 14	SULPTOP - SULPBOT	-7.77500	40.87010	14.44976	-41.94326	26.39326	-.538	7	.607
Pair 15	NH4TOP - NH4BOT	-.62125	4.56210	1.61295	-4.43526	3.19276	-.385	7	.712
Pair 16	OGTOP - OGBOT	7.56000	4.04137	1.42884	4.18133	10.93867	5.291	7	.001
Pair 17	SANDTOP - SANDBOT	-.15000	3.86634	1.36696	-3.38234	3.08234	-.110	7	.916
Pair 18	SILTTOP - SILTBOT	.48750	4.47164	1.58096	-3.25088	4.22588	.308	7	.767
Pair 19	CLAYTOP - CLAYBOT	-.33750	1.35535	.47919	-1.47060	.79560	-.704	7	.504
Pair 20	PORTOP - PORBOT	1.13750	2.12060	.74975	-.63537	2.91037	1.517	7	.173
Pair 21	PERTOP - PERBOT	.16125	.51982	.18378	-.27333	.59583	.877	7	.409
Pair 22	BULKTOP - BULKBOT	.02500	.07151	.02528	-.03479	.08479	.989	7	.356

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	FeTOP - FeBOT	-1.76250	.89752	.31732	-2.51284	-1.01216	-5.554	7	.001
Pair 2	CdTOP - CdBOT	-.00125	.08871	.03136	-.07541	.07291	-.040	7	.969
Pair 3	CrTOP - CrBOT	.00250	.10485	.03707	-.08515	.09015	.067	7	.948
Pair 4	CuTOP - CuBOT	-.48000	.51989	.18381	-.91464	-.04536	-2.611	7	.035
Pair 5	NiTOP - NiBOT	-.23250	.23481	.08302	-.42881	-.03619	-2.801	7	.027
Pair 6	PbTOP - PbBOT	-.20375	.19138	.06766	-.36375	-.04375	-3.011	7	.020
Pair 7	ZnTOP - ZnBOT	-.33625	.17029	.06021	-.47861	-.19389	-5.585	7	.001
Pair 8	BaTOP - BaBOT	-2.01250	2.76325	.97696	-4.32263	.29763	-2.060	7	.078
Pair 9	AlTOP - AlBOT	-.67500	.38634	.13659	-.99799	-.35201	-4.942	7	.002
Pair 10	THBTOP - THBBOT	1.30875	2.44789	.86546	-.73774	3.35524	1.512	7	.174
Pair 11	HUBTOP - HUBBOT	2.93125	3.62786	1.28264	-.10172	5.96422	2.285	7	.056
Pair 12	THFTOP - THFBOT	-.39000	1.84676	.65293	-1.93393	1.15393	-.597	7	.569
Pair 13	HUFTOP - HUFBOT	2.91250	2.18203	.77146	1.08828	4.73672	3.775	7	.007
Pair 14	COLITOP - COLIBOT	3.37500	3.29231	1.16401	.62256	6.12744	2.899	7	.023