The Shell Petroleum Development Company of Nigeria Limited Operator for the NNPC/Shell/NAOC/TEPNG

FINAL ENVIRONMENTAL IMPACT ASSESSMENT (EIA) REPORT FOR THE ADIBAWA-GBARAN 3D RESHOOT SEISMIC DATA ACQUISITION PROJECT IN BAYELSA AND RIVERS STATES

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LIST OF ABBREVIATIONS AND ACRONYMS

‰	Parts per thousand
%	Percentage
BDL	Below Detection Limit
BH	Borehole
BOD	Biochemical Oxygen Demand
bopd	Barrels of oil per day
CAP	Capitulus
CDC	Community Development Council
cfu/g	colony forming units per gram
cm	Centimetre
CO	Carbon monoxide
CSR	Company Site Representative
°C	Centrigade
DO	Dissolved Oxygen
DPR	Department of Petroleum Resources
dB(A)	A-weighted Decibel
E	East
E&P	Exploration and Production
EGASPIN	Environmental Guidelines and Standards for the Petroleum Industry in Nigeria
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Environmental Protection Agency
FEPA	Federal Environmental Protection Agency
FMEnv	Federal Ministry of Environment
ft	Feet
H_2S	Hydrogen Sulphide
HC	Hydrocarbon
HIV	Human Immunodeficiency Virus
HSE	Health, Safety and Environment
HUB	Hydrocarbon Utilizing Bacteria
HUF	Hydrocarbon Utilizing Fungi
ITCZ	Inter-Tropical Convergence Zone
ITD	Inter-Tropical Discontinuity
IUCN	International Union for Conservation of Nature and Natural Resources
km	Kilometre
km^2	Kilometre square
L	Litre
m	Metres
m^2	Square metres
m^3	Cubic metres
Max	Maximum

Min	Minimum
mg/L	Milligram per litre
mg/kg	Milligram per kilogram
MM bbls	Million barrels
MMscfpd	Million square cubic feet per day
MPN	Most Probable Number
MW	Molecular Weight
N	North
N/A	Not Applicable
NCA	National Council on Environment
NE	Northeast
NH_3	Ammonia
NIMET	Nigerian Meteorological Agency
NNPC	Nigerian National Petroleum Corporation
NW	Northwest
O_3	Ozone
OML	Oil Mining Lease
PAH	Polycyclic Aromatic Hydrocarbon
Q1	Quarter 1
ppm	Parts per million
RH	Relative Humidity
s	Second
S	South
SCiN	Shell Companies in Nigeria
SE	Southeast
SOx	Oxides of Sulphur
SPM	Suspended Particulate Matter
sp	species
SPDC	Shell Petroleum Development Company
STI	Sexually Transmitted Infections
SW	Southwest
t	Tonnes
TDS	Total Dissolved Solids
Temp	Temperature
THB	Total Heterotrophic Bacteria
THC	Total Hydrocarbon Content
TF	Total Fungi
TSP	Total Suspended Particles
TSS	Total Suspended Solids
UNEP	United Nations Environmental Protection
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Carbons
W	West

W/S	Wind Speed
WHO	World Health Organisation
μ	Micro
$\mu g/m^3$	Microgram per meter cubic
μS/cm	Microsiemen per centimeter

EIA PREPARERS

S/N	NAME	QUALIFICATION	ROLE
1	Prof. Anthony Ogbeibu	Ph.D Hydrobiology and fisheries	Team lead/Aquatic biology
2	Prof. Emeka Oguzie	Ph.D Physical Chemistry	Air quality/Water/Sediment Physicochemistry
3	Prof. Chris Emerole	Ph.D Agricultural Economics	Social Impact Assessment
4	Dr. Igbiks Tamuno	MBBS, Medicine and Surgery	Health Impact Assessment
5	Mr. Ogboru Omonefe	M.Sc Plant Taxonomy	Vegetation/Wildlife

SPDC REVIEWERS

1	Mr. Nick Tagney	Environmental Assuranced Manager
2	Mr. Ajibade Temitope	Senior Impact Assessment Adviser
3	Mr. Godswill Bornu	ESHIA Support
4	Prof. Erema Daka	Principal Environmental Adviser
5	Prof. Gabriel Umoh	Senior Research Adviser
5	Mr. Adesola Ojesanmi	Environmental Inspector

EXECUTIVE SUMMARY

ES 1.0: Background information

The Shell Petroleum Development Company Limited (SPDC), in pursuing its E&P business to explore and deliver additional hydrocarbon (Oil and Gas) production, (i.e. recover volumes of hydrocarbon remaining in the fields and also search for new hydrocarbon opportunities), is planning to embark on a 3D seismic data acquisition survey over OMLs 27 and 28 covering Adibawa and Gbaran fields located within Bayelsa and Rivers state in the Niger Delta with Gbaran, Etelebou and Koroama fields located some 100km North-West of Port – Harcourt. 3-D seismic data was acquired by SPDC over Gbaran fields in 1991/1993, while the 3D seismic data over Adibawa acquired in 1995 was done by Nigerian Agip Oil Company NAOC. The planned acquisition is within the Ughelli-central swamp depobelts of the Niger Delta. In the light of the aforementioned, the proposed project activities will have several interactions with the environment, hence the need to conduct an Environmental Impact Assessment studies in line with the provisions of the EIA Act 86 of 1992. Consequently, SPDC has been mandated by Federal Ministry of Environment (FMEnv) to conduct a desktop study for the EIA of Adibawa-Gbaran Seismic 3D Reshoot Seismic Data Acquisition Project**.** This EIA study has identified the key potential impacts of the project activities on biophysical, social and health components within the project area and proffered mitigation measures for Environmental Management.

ES 1.1: Objectives of the EIA

The objectives of the EIA are to:

- Acquire baseline data of the environment as well as the socio-economic and health conditions of the host communities;
- Use the baseline data to describe and characterize the study area;
- Identify the environmental sensitivities of the project area;
- Determine and evaluate the potential impacts of the proposed project activities on the identified environmental sensitivities and the interactions between the sensitivities;
- Recommend appropriate mitigation measures; and
- Develop an Environmental Management Plan (EMP).

ES 1.2: Project location

The planned onshore 3D seismic data acquisition activity is in OMLs 27 and 28, with Gbaran, Etelebou and Koroama fields located about 25 Km South-West of Yenagoa. The proposed EIA surface coverage area is about 1,400 sq. km and will cut across six Local Government Areas in Bayelsa and Rivers States. The Local Government Areas include: Sagbama, Kolokuma/Opokuma, Yenagoa, Ogbia (Bayelsa State), Abua/Odua and Ahoada West (Rivers State).

ES 1.3: Legal and Administrative Framework

The EIA was carried out in accordance with the Mineral Oil (Safety) Act CAP 350 LFN 1990, Federal Environmental Protection Agency (Now FMEnv) Act No. 58, 1988, FMEnv Sectoral and Procedural Guidelines for Oil and Gas (1995), S.I. 15 - National Environmental

Protection Management of Solid and Hazardous Wastes Regulation (1991) (FMEnv), Environmental Impact Assessment Act CAP E12 LFN 2004 (FMEnv), FEPA (Now FMEnv) Nigeria's National Agenda 21 (1999), FEPA (Now FMEnv) National Policy on the Environment (1989), National Environmental Standards Regulatory and Enforcement Agency (NESREA), 30th July, 2007. Others include: Rivers State Environmental Protection Agency Edict No 2 of 1994; Rivers State Private Health and Allied Establishments Authority Law, 2001; Rivers State Public Health Law, 1999; Rivers State Noise Pollution Control Law of 1984; Rivers State Environmental Protection Agency Law No. 2 of 1994; Bayelsa State Environmental and Development Planning Authority Law 1998; Bayelsa State Pollution Compensation Tax Law 1998 and Bayelsa State Forestry Law 1998.

ES 2.0: Project Justification

Value of the Project

The estimated value of the project is about $108million including the cost of executing the EIA studies.

Need for the Project

Shell Petroleum Development Company Limited (SPDC) has recognized deep exploration opportunities around the Adibawa-Gbaran axis to maximize economic recovery of hydrocarbons and increase production. This will be done through Seismic data acquisition (Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition Project) which will help enhance the appraisal and developmental activities in the field.

ES 2.1: Envisaged Sustainability

The proposed project is envisaged to be sustainable Environmentally, Technically, Economically and Socially. The envisaged sustainability of the proposed project is as follows:

Environmental Sustainability

The proposed project will be on existing traverse cutting hence very low environmental impacts. However, the incorporation of the findings and recommendations of this EIA at the various stages of the project development and strict adherence to the Environmental Management Plan (EMP) will ensure environmental sustainability.

Technical Sustainability

The Shell Petroleum Development Company Limited in its over 30 years’ experience in Exploration and Production activities has proven ability to conduct seismic survey. Strict adherence to internationally and nationally acceptable standards, innovative technologies that are economically viable and environmentally friendly shall be utilized in the execution of the proposed project.

Economical Sustainability

The economic sustainability of the proposed project would depend on the viability of the hydrocarbon bearing reserves that would be discovered through seismic data interpretations. However, stakeholders along the seismic transects will benefit from the project through local contracting and employment opportunities, increased cash flow and stimulation of local economies within the communities and stimulation of local economy and markets from increased demand for food, and other products in the local market.

Social Sustainability

The proposed project will:

- Develop and maintain effective long term relationships with relevant stakeholders;
- Assure that the EIA process leads to development and implementation of social investment;
- Continuous consultation with stakeholder communities will further promote social sustainability of the project;
- Develop manpower skills for enterprising members of the communities.

ES 2.2: Project Options

The Project options considered were: No Project Option, Delayed Project Option and Conduct Seismic Survey.

No Project Option:

Advantage: No capital expenditure, No new risks and No impact on the environment
Disadvantage: Decline in hydrocarbon reserve, Loss of revenue to the Federal Government and company from inability to adequately appraise and develop the Gbaran Adibawa field.
Recommendation: Not recommended

Delayed Project Option:

Advantage: More time to plan and assess risks
Disadvantage: This will lead to a delay in scheduled dates for drilling and hence loss of expected revenue for that period of time to Government and SPDC
Recommendation: Not recommended.

Conduct Seismic Survey:

Advantage: Enhance the appraisal and developmental activities in the field, Help in optimizing infill well locations through reservoir surveillance, Very high competence levels and Seismic survey is on existing traverse cutting hence very low environmental impacts.
Disadvantage: Transects cutting across different terrains may be challenging
Recommendation: Recommended

ES 2.3: Project Alternatives

The alternatives for the Adibawa-Gbaran 3D Reshoot Seismic Data acquisition Project include Seismic data acquisition techniques and Energy sources. The seismic techniques considered for the proposed project are: 2D, 3D and 3D Reshoot (4D) techniques while the acoustic energy sources considered are vibroseis and explosives. The 3D Reshoot (4D) technique is the recommended option for this campaign because the project impact on the environment will be significantly minimized. This is because as a 4D intended survey, majority of the bush cutting would be on the 1991/1993 and 1995 cut traverses due to the surface repeatability of shots and receiver positions requirements. Similarly, explosives have been proposed to be used as the energy source because it has the full range of frequency content and can easily be taken into the seismic line and extra access need not be created when using dynamite.

ES 3.0: Project/Process Description

A typical seismic data acquisition project last for a relatively short period of time and does not usually involve the establishment, or use of long-term facilities and structures. The survey activities have been planned to commence in Q4 2015 while the actual data recording is planned to commence in Q4 2015. With an average seismic data recording production of $30Km^2$ / month, the survey activities would last for about 24 months. The planned 3D Seismic data acquisition is proposed to cover an area of about 1,400 sqkm in OMLs 27 and 28 covering Adibawa and Gbaran fields. The estimated workforce is expected to be over 1,500 at peak of operations.

ES 3.1: Project objectives

The objectives of this project are:

To acquire 3D reshoot seismic data with increased multiplicity and longer offset that will:

- Significantly improve the structural imaging of the producing intervals;
- Help in optimizing infill well locations through reservoir surveillance;
- The new seismic data will be beneficial in identifying deep exploration opportunities (by leveraging on the existing technology, using longer recording cable lengths and recording higher fold) which will maximize economic recovery of hydrocarbons, increase production, maximize economic use of existing facilities by keeping the facilities full and grow SPDC as well as Nigeria's reserve base.

ES 3.2: Project Activities

A reputable Geophysical Acquisition Contractor would be contracted by SPDC to carry out the 3D seismic re-shoot data acquisition over Gbaran (OML 28/31) and Adibawa (OML 27) fields. Company Site Representatives (CSRs) and SPDC staff would closely supervise the 3D seismic re-shoot data acquisition activities. The Gbaran and Adibawa seismic survey shall include the following activities:

- Scouting exercise
- Permitting / Stakeholder engagement – License To Operate (LTO)
- Environmental Impact Assessment (EIA)
- Mobilization of contractor to site
- Land clearing for campsites, fuel dumps and explosives magazine sites
- Surveying - line cutting for receiver/shot positions
- Drilling of shot holes
- Recording – Laying of recording equipment & detonation of explosives
- Road repairs and Community Assisted Projects (CAPs)
- Damages assessment and compensation
- Environmental restoration

ES 3.3: Waste Management

Wastes will be generated from the various project activities. However, the bulk of waste generated will be from logistics, offices and the Base camp area. The anticipated wastes from these activities include domestic wastes (e.g. food and trash), sanitary wastes, batteries, cabes and scraps. The waste management strategy will involve Recycle or reuse of batteries and cables, composting and incineration. Details of the waste mangement strategy are presented in Table 3.5.

ES 3.4: Project Schedule

Mobilization to site is expected to commence by end Q4, 2015 whilst seismic activities are scheduled to be completed by December 2016.

ES 4.0: Description of the Existing Environment

The Environmental baseline status was assessed based on reviews of recent reports (desktop studies) around the Gbaran and Adibawa area as directed by the Federal Ministry of Environment (FMEnv) (Appendix 1). To properly evaluate the baseline status of the proposed project area, the Adibawa-Gbaran area was divided into four Zones (Zone 1, Zone 2, Zone 3 and Zone 4). The zoning criteria include: Ecological sensitivities, spatial coverage of the proposed project, SPDC’s footprint and the availability of existing data. Reports convering these zones were used to provide information on the Baseline conditions of the proposed project area. Reports reviewed includes but not limited to the following:

- Environmental Impact Assessment For Gbaran Field Logistics Base (FLB)/Jetty For Gbaran/Ubie Integrated Oil & Gas Project, Final Report, July 2007;
- Environmental Impact Assessment for The Drilling of two new Wells (E2/ E4) In Gbaran Field, June 2007;
- Post Impact Assessment of Etegwe-Tombia Road (Final Report), April, 2008;
- Environmental Impact Assessment of Gbaran Ubie Phase 2 Integrated Oil And Gas Project (EIA Cluster 1 – Koroama, Gbaran And Kolo Creek Fields) Final Report, October 2009;
- Environmental Impact Assessment of Gbaran Ubie Phase 2 IOGP (EIA Cluster 3), 2010; Environmental Evaluation (EE) - Based EIA Study of Gbaran Ubie Node Integrated Oil & Gas Project, 2012;
- Environmental Impact Assessment (With Revalidated Baseline Data) of Gbaran Ubie Phase 2 Integrated Oil and Gas Project (EIA Cluster 2 – Epu Field), Final Report, March 2015 and
- Environmental Impact Assessment of Kolo Creek NAG Manifold to Soku Gas Plant Pipeline Project Final Report, July 2012.

Climate and Meteorology

The entire project area falls under the humid tropical climate characterised by a wet and semi-hot equatorial regime. Wind regimes controlling the area are (a) the North-East and (b) the South-West Trade Winds which separate the year into two seasons, the dry season and wet season respectively. Field measurements of wind show that the south and south-westerly was predominant accounting for about 65 % of the total wind run.

Rainfall

Rainfall in the study area as monitored from the nearest meteorological centre of the Nigerian Meteorological Agency (NIMET) from 2002 to 2011, shows that the mean monthly rainfall ranges between 19.8mm and 365.7mm, with the highest occurring in July (365.7 mm) and least intense rainfall occur during the dry season in January (19.8 mm). Details of the rainfall patterns were obtained from the Port Harcourt synoptic station.

Relative Humidity

The environment experiences a high relative humidity all year round. The field data indicate that relative humidity of the study area during the field exercise ranged from 74.0 – 80.0 % for dry season while RH data recorded wet season ranged from 83.0 – 90.0 %.

Temperature

The mean minimum monthly temperature during the dry season ranges from 23.0 to 28.0 ^{o}C, with corresponding maximum temperatures 32.0 – 34.0 ^{o}C. The minimum temperatures in the wet season fall between 23.0 and 24.0 ^{o}C, while the maximum temperatures range from 29.0 – 32.0 ^{o}C.

Air Quality

Air quality measurements showed that the mean concentrations of suspended particulate matter (SPM) within the study area were 8.0µg/m^3; outdoor and 6.38 µg/m^3; indoor, which fall below Nigerian ambient air quality standards. There were no visual indications of SPM pollution in area. Nitrogen oxides concentration was below detection limit for wet season while highest concentration recorded for dry season results was 3.55 µg/m^3. CO was not detected within the ambient environment in the study area for both seasons, but was however detected indoors (7.60 3.55 µg/m^3) in the dry season. The concentrations of all the parameters were within the FMEnv allowable limits.

Noise Level

Ambient noise level measurements in the study area showed that the recorded noise levels ranged from 59.61 – 63.15 dB(A) for dry season and 43.4 – 72.1 dB(A) for wet season. Indoor noise levels ranged from 61.50 – 63.59 dB (A) (dry season) and 40.0 – 63.1 dB (A) (wet season). These levels were classified as low and within FMEnv permissible noise level of 90 dB (A) for 8-hour working period.

Soil Characteristics

The soils of the Adibawa-Gbaran Seismic reshoot project area varied in colour (moist soils – using the Munsell Soil Colour Chart) from brown superficial (7.5YR 5/3) to light brown (7.5 6/3) at the subsurface level. The darker shade of brown coloration of the surface soil is attributable to decomposition of dead organic matter. The textural features were Sandy Clay Loam to Loamy Sand from the surface to subsurface soil levels. The sand fraction ranged from 46.5 to 83.1% at the surface soil level and from 27.0 to 83.1% at the subsurface soil level, silt fraction ranged from 2.0 – 37.52 % at the surface soil level and from 8.6 – 79.0 % at the subsurface soil level. The clay fraction ranged from 11.5 – 38.0% at the surface soil level and from 7.92 – 39.0% at the subsurface soil level. The dry season pH values of the soil in the project area ranged from 3.84 – 6.50, suggesting that the soil was acidic in some areas and near-neutral in other areas. The values ranged from 3.88 to 6.50 at the surface soil level and from 3.84 to 6.30 for the sub surface soil level. The pH values in the wet season ranged from 3.70 -7.60 (surface) and 4.08 – 7.60 (subsurface). The values of electrical conductivity of soils in the study area ranged from 20 µS/cm to 260µS/cm during the dry season and 20.0 – 810.0 µS/cm during the wet season. The heavy metals detected in the study area include manganese – 373/2054 mg/kg; zinc – 20.5/92.1 mg/kg; chromium – 3.52 mg/kg (dry season) and 15.6 mg/kg (wet season); lead 0.70 mg/kg (dry season) and 1.61 mg/kg (wet season); nickel 4.80 mg/kg (dry season) and 7.46 mg/kg (wet season). Iron was the dominant heavy metal in the area, with dry and wet season concentrations of 993 mg/kg and 10,886 mg/kg respectively. Soil organic matter in the study area ranged from 0.42% to 3.22% in the dry season and from 0.53% to 6.13% in the wet season. Available phosphorus in the studies soils ranged from 0.001 to 7.96 mg/kg in the wet season and 16.3 – 28.9 mg/kg in the dry season, while nitrate content for both dry and wet seasons ranged from 5.03 mg/kg and 79.0 mg/kg.

Soil microbiology

The soil microbiology in all four zones were very similar with maximum counts of x10^5cfu/g for THB and TF and a hydocarbonoclastic counts of 10^3cfu/g. Predominat bacteria counts include: *Pseudomonas, Arthrobacter, Acinetobacter, Norcadia, Klebsiella, Enterococci, Enterobacter, Vibrio, Micrococcus, Bacillus.* Fungi isolates include: *Aspergillus, Saccharomyces, Mucor, Fusarium, Candida* and *Penicillium*.

Vegetation

The tropical fresh water swamp forest is the characteristic vegetation cover type of the study area and is characterised by perennial heavy rain falls, seasonal flooding, and unstable marshy terrain. It is represented by the Niger Delta Flood Forest, and Raffia (*Raphia hookerii*) Swamp Forest ecotypes based on vegetation structure, species composition and dominance patterns. Generally the vegetation is significantly open canopy forest as the seasonally flooded freshwater swamp forest area is under considerable anthropogenic pressure from indigenous sources. Agricultural farmlands and home gardens are most prominent in Zone 1 and 2. Taxonomic diversity is the same across the four zones within the study area and is represented by 119 species belonging to 52 plant families. Diversity at the rank of family is dominated by 6 families which account for a total of 56 species; these families in decreasing order of their number of representative species are: Fabaceae (15) > Euphorbiaceae > (12) Annonaceae (9) > Poaceae (7); Rubiaceae (7) > Moraceae (6). Tall trees emerging above the flood forest vegetation canopy reach 20 meters in height and both vegetations retain the Mesophanerophytic life form dominance, and physiognomy. Dominant tree species include *Alstonia boonei*, *Elaeis guineensis*, *Ceiba pentandra*, *Cleistopholis patens,* and *Irvingia gabonensis.* Palm dominated areas are however more common. Flora associated with the tree canopy is dominated by ferns and lianas including *Phymatodes scolopendria, Oleandra distenta, Platycerium stemaria*, *Asplenium* africanum; and *Macaranga heudelotii*, *Ficus ovata*, *Cissus aralioides,* and *Combretum racemosum* respectively. Aquatic macrophytes were found to be common within the fresh water swamp ecosystem across the zones of the study area. The invasive Water Hyacinth (*Eichhornia crassipes*) was observed to be a menace along most of the water courses. Dominant species include rooted aquatic macrophytes: *Cyclosorus striatus, Sacciolepis africana, Cyrtosperma senegalensis,* and *Sagittaria sagittifolia.* Agricultural activity is common across the study area and consists mainly of mixed cropping of annuals which are cultivated during the short dry whether spell. Maize, Yam, Cassava, Okra, Groundnut and Melon are the prominent crops which include Edible Fruits/Seeds/Stems, Vegetables, Staples, Medicine, and Condiments.

Wildlife

A total of 84 wildlife species were identified across the study area and the dominant groups are in the following order: Aves (29 species; 15 families) > Mammals (27 species; 12 families) > Reptiles (22 species; 11 families). All the previous studies reported species distribution patterns favouring a larger concentration of wildlife in the areas which are in closer proximity to the forest reserves. There is a sharp seasonal migration pattern across the study area with the fauna migrating out of the area during the floods and returning in the dry season. This is explained by the fact that the ecosystem supports abundance of vegetation nearly all year round since it experiences a shorter dry spell. This favourable condition supports a larger population of Herbivores particularly the ungulates, and Reptiles. Hunting is rife and carried out by use of traps and native guns. During field surveys, it was easy to come by game killed the same day: common species reported included Bush buck (*Tragelaphus scriptus),* Mona monkeys (*Cercopithecus mona*), Putty nosed monkeys (*Cercopithecus nictitans*), Forest monitor, Cusimanse (*Crossarchus obscurus),* Squirrels (*Xeru erythropus*), Crested Porcupine (*Atherurus africanus*), Pythons (*Python regius*), Pangolins (*Manis tetradactyla*), Genets (*Viverra genetta)*, and Maxwell's duiker (*Cephalophus maxwelli*). These species are becoming locally vulnerable as hunting pressure is high. Relic populations of endangered species are still present in the wild as hunters reported a rare case of sighting and killing an elephant recently. Bosmann's potto (*Perodicticus potto)* and the white throated monkeys (*Cercopithecus erythrogaster*) are among those species that are near endangered in the area.

Hydrogeology

The study area lies within the Niger Delta sedimentary Basin. This Basin was formed in the Tertiary Period from the interplay between subsidence and deposition arising from a succession of transgressions and regressions of the sea. There are three constituent lithostratigraphic units in this sedimentary basin. These are Akata, Agbada, and Benin Formations in order of decreasing age. The overall thickness of these Tertiary sediments is about 10,000 metres. The Akata Formation is known to be the source rock of petroleum in the Niger Delta and is approximate thickness is about 1000 metres. The Agbada formation with a thickness of 3000 metres is the reservoir rock for petroleum in the Niger Delta while the Benin formation is the major aquifer in the Delta, and the bearing medium for most of the engineering structures; and outcrops on the surface in the Niger Delta and the study area. Lithologic logs of the boreholes drilled show that the site (within the depth of investigation) is made up of three main lithologies. These include clay, clayey sand, and sand. The entire clayey layer is found from the surface to a maximum depth of 7 meters in BH2 and has permeability values of 3.025 x 10^{-3} cm/s in BH3 1m; to 9.6 x 10^{-3} in BH2 1m; while the aquiferous sand has slightly higher values of 1.21 x 10^{-2} cm/s in BH 4, 8m; to 2.56 x 10^{-2} cm/s in BH5, 3 - 5m. Consequently, if there is any pollution in the area, the pollutants would flow through these layers at the permeability values stated. The flow rate would be faster within the aquifer than through the ground into the aquifer. The lithologic logs in the study area also show that the aquifers in the Gbaran location are confined by 1m to 4m of clay. Groundwater flow direction in the study area as determined during this study is from Northeast to Southwest; this defines how any pollutant that gets to the ground water, would flow from pollution. Static Water Level in the area is determined to be very high and so pollutants should not be dumped on the ground surface in view of such closeness of groundwater to the surface. The ground water is near neutral to slightly basic with pH values ranging from 6.88 to 9.45 which fall outside the maximum level of FMEnv standard set at 8.5. mean conductivity values in the zones ranged from 126 µS/cm to 579 µS/cm. Mean BOD values ranged from 1.10 mg/l to 5.18 mg/l, while mean nitrate values ranged from 0.16 mg/l to 4.52. All the heavy metal parameters were within FMEnv/WHO guideline limits of water for human consumption.

Ground Water Characteristics

The range of mean pH values for groundwater in the study area (6.88 to 9.45) shows the water to be slightly basic, even exceeding the FMEnv limit of pH 8.5. The mean conductivity and mean BOD values of the groundwater ranged from 126 µS/cm - 579 µS/cm and 1.10 mg/l - 5.18 mg/l respectively. Though nutrient concentrations in the groundwater were high, they were however within FMEnv permissible limits; mean nitrate values for instance ranged from 0.16 mg/l to 4.52 mg/l. The most obvious heavy metals detected in the groundwater were iron, having a concentration range of 0.44 – 11.9 mg/l and zinc, with concentration ranging from 0.02 – 8.5 mg/l. BOD and DO values ranged from 0.10 – 7.1 mg/l and 0.48 – 6.80 mg/l respectively.

Surface Water Characteristics

The mean pH of surface waters in the study area ranged from 6.66 to 7.95 (wet season). However, these values comply with the WHO limit of 6.0 to 9.0 for pH of good quality water. The mean electrical conductivity for surface water all over the study area ranged from 45.9 to 121 µS/cm, whereas DO ranged from 4.49– 6.25 mg/l. The DO values recorded are suitable for survival of aquatic life. Mean BOD values were between 2.26 and 5.96 mg/l, total hardness; 11.7 to 186.6 mg/l and alkalinity 1.52 – 10.1 mg/l. Some heavy metals like vanadium, arsenic and mercury were below analytical instrument detection limit (<0.01 mg/l) in the surface water from the study area. The concentrations recorded for iron ranged from 0 - 1.99 mg/l for dry season and 2.01 – 4.70 mg/l for wet season. Chromium ranged from 0 to 0.34 mg/l and 0 – 1.01 mg/l for dry and wet season respectively. Similar dry season versus wet season concentration ranges of some other heavy metals include: lead = 0 – 0.05 mg/l vs. 0 – 0.11; cadmium = 0 - 0.04 vs. 0 – 0.26 mg/l; zinc = 0 – 0.33 mg/l vs. 0 – 0.47 mg/l. The concentrations of iron exceeded FMENV limits. The high concentrations of iron could be traced to the local geology of the study area. All the heavy metals displayed higher abundance in the wet season. Sediment samples from the study area had pH in the range of 5.10 to 6.39, suggesting slight acidity. Total organic carbon content ranged from 39.4% to 86.9%, while chloride content was from 17.2 to 27.6 mg/kg. Polycyclic aromatic hydrocarbons (PAH) and BTEX were not found in the sediments. Electrical conductivity was from 1.36 to 100.7 µS/cm.

Surfacewater Microbiology

The surface water microbiology in all four zones were very similar with maximum counts of x10^6cfu/ml. Coliform counts were higher than average for normal surface water especially in the Gbaran area. Hydrocarbonocalstic counts were <1% suggesting previous esposure to petroleum hydrocarbon. The Bacterial isolates identified in the water sample include *Escherichia coli, Serratiasp, Bacillus sp, Staphylococcus sp, Enterococci sp, Bacillus sp, Micrococcus sp, Pseudomonas sp, Vibrio sp, Klebsiellasp, Enterobactersp* and *Arthrobacter sp.* The fungal isolates belonged to the genera*Aspergillus, Mucor, Fusarium, Penicillium* and *Candida.*

Sediment Physicochemical Properties

In Zone 1, the mean pH value was 5.83, while the mean value of the electrical conductivity was 59.5 µS/cm. The mean values of organic matter content, phosphate, calcium, nitrates, total hydrocarbon content were respectively 1.39%, 8.64 mg/kg, 2.72 mg/kg, 0.04 mg/kg and 1.79 mg/kg. Heavy metals detected in the sediment include zinc and iron.

Sediment Microbiology

The surface water microbiology in all four zones were very similar with maximum counts of x10^7cfu/g. Coliform counts were higher than average for normal surface water esoeciall in the Gbaran area. Hydrocarbonocalstic counts were <1% suggesting previous esposure to petroleum hydrocarbon. Bacterial genera isolated in the sediment sample include *Serratia, Staphylococcus, Bacillus, Micrococcus, Pseudomonas, Arthrobacter* and *Klebsiella.* The fungal isolate mainly belonged to the genera *Aspergillus, Mucor, Fusarium* and *Candida.*

Hydrobiology

The phytoplankton community was represented by five divisions: Bacillariophyceae (diatoms), Chlorophyceae (green algae), Cyanophyceae (blue green algae), Dinophycaea (dinophytes), and Euglenophyceae. Diatoms are the most prominent category except in the dry season of 2012 where the blue greens were reported to be dominant. The most common species amongst the Centrales were *Melosira* and *Cylindrotheca gracilis* while for the Pennate diatoms were *Gyrosigma acuminatum* and *Bacillaria*. Others are *Closteruim* and *Richterella* for Chlorophyceae and *Oscillatoria* for Cyanophyceae respectively. There was a statistically significant difference ($P<0.05$) in the abundance of Bacillariophyceae, Cyanophyceae and Chlorophyceae between 2008 and 2014. The numbers of species in the phytoplankton communities have increased over the years compared with 60 species in the most recent survey. However, the generally depressed numbers of the green algae (Chlorophyceae) in the study area; the stability of the community as deduced from Shannon diversity index; high evenness; and low dominance; in all the samples indicate a normal unpolluted environment. The adult and larval zooplankton assemblage was a mixed and poorly diverse community represented by Rotifera, Copepoda, Cladocera, meroplanktonic larvae and Protozoa. The Copepoda dominated the community with mostly calanoids and cyclopoids. This was followed by the Rotifera. Seasonal variation in the total number of species and abundance of zooplankton is reported favouring the wet season although the difference is statistically insignificant. The reports indicate a relatively stable species number in the study area with respect to Benthic fauna community.

Fish and Fisheries

A total of Thirty five (35) fish families made up of 120 species were reported for the study area. Out of these, 61 species are pure river dwellers at the adult life, 29 dwell in swamps and 30 species thrive in both habitats**.** Fisherfolks in the area reported that one bagrid catfish (*Arius gigas)* has disappeared in the project area while two members of the Citharinidae (*Citharinops distichodoide*s and *Citharinus latus*) are very difficult to find. Similarly, *Polyprerus ansorgii* and *P. endlicheri* (Polypteridae) which were once common in the area are now hardly seen in the swamps. Few numbers of the fresh water turtle (*Pelusis niger*) is found in swamps. Migrant species from coastal/brackish water such as *Ethmalosa fimbriata* (Clupeidae), *Polynemus quadrifilis* (Polynemidae) and *Liza falcipinus* (Mugilidae) occur occasionally in the area during the dry season. The fishing gears reportely used in the area include gillnets, tow nets, cast nets, beach seines, lift nets, traps, hooks and lines, fences and stakes as well as wounding implements. Bailing of ponds to collect stranded fish in swamps is an age-old traditional fishing method.The catch reported for the lotic and lentic water bodies were dominantly members of the family Clariidae (*Clarias gariepinus*), Mochokidae (*Synodontis* spp), Channidea (*Parachana obscura, Parachana africana*), Cichlidae (*Tilapia zilli, Oreochromis niloticus*), Polypteridae (*Erpetoichthys* spp). However, members of the Clariidae and Channidae were most predominant in the lentic water bodies and constituted about 90% of the total fish catch observed in the study area. Swamp lake fishing are important sources of fish production in the study area and serve as reservoirs for fishes during the flood season; which together with the seasonal channels are important to the freshwater shrimp fisheries of the area during the flood period.The dug-out canoes without engines were observed to be the most predominant fishing craft in the study area with sizes ranging from 2m to 5m in length usually carrying one to three persons and used to operate gill nets and lifts nets in the lotic surface water bodies i.e. Taylor Creek, Orashi River and Nun River. Dug-out canoes with outboard engines also exist but in relatively small numbers. The period of June through September are known with low fishing activities attributed to high river discharge and flooding. Information from tissue analysis shows there is no evidence of heavy metal contamination in the fish tissues examined, and the fishes are fit for human consumption. Smoke-drying over fire was the most common form of fish preservation. Fishes to be dried were spread out on raised platforms or altars and energy for drying was from wood which was abundant in the area. Fresh and dried fish are transported and sold at distant markets in Yenagoa, Mbiama, Ahoada and Port Harcourt.

Socioeconomics

This social baseline is a report on people whose communities this project will traverse. The map of the project area shows that the project will traverse 6 Local Government Areas- 4 in Bayelsa State and 2 in Rivers State. A total of 68 communities will be involved in the project. This comprises 50 communities in Bayelsa and 18 communities in Rivers State. The communities are: Sagbama, Ogolowa, Egbedi, Seibokorogha, Asaingbere, Gbaranma, Igbainwor, Sampou, Igbaniwari, Aya Ama, Kalamakalama, Ibie, Ikarama, Zarama, Agbobiri, Anyambele, Akumoni, Igbogene, Epie, Nyenegwe, Okutukutu, Elemini, Edepie, Akenfa Epie, Ovelemini, Agudama Epie, Etegwe, Opolo Epie, Kpansia, Yenizia Epie, Yeneka, Ovomovum, Opuama, Ikolo, Akabi, Fangbe, Akaubiri, Bumadi, Bumodi, Gbarantoru, Tombia, Agudama, Polaku, Okotiama, Okolobiri, Korama, Obunagha, Otuasega, Ibelebiri, Oruma (Bayelsa State) and Odau, Odua, Ususu, Chebele, Akala-Olu, Oshi, Akinima, Oruama, Mbiama, Agbo, Odiopitis, Odieke, Otegwe, Okarki, Orashi, Kunusha, Manuso, Igovia (Rivers State). This socio-economic report is based on a review of previous EIA and PIA reports.

History of the People and Power Structure

Various reports (EIA of EE based Gbaran Ubie Node Integrated Oil and Gas Project (2013) and EIA of Gbaran Ubie Phase 2 IOGP (EIA Cluster 2 Epu-Field) (2015)) indicate that the Koroama, Obunagha, Ogbolama, Okolobiri and Polaku constitute the Gbarain Clan in the Yenagoa Local Government Area of Bayelsa State. The individual founders of each of these settlements were all descendants of Gbarainowei (The founder of Gbarain Clan/kingdom). The language group here is Izon as they are indigenous Ijaw (Izon) ethnic group. Obunagha was founded by Ogoro, one of the sons of Gbaran-owei years ago along with Okolobiri and Ben-Obunagha. **Otuasega Community** was founded by ASEGA, descendant of Olei,in Ogbia LGA. Olei first settled at Emeyal and later moved to Otuasega. **Opolo Epie Community** is one of the Communities in Epie clan that migrated from Benin kingdom with five compounds in the community. **Agudama-Epie Community** is also one of the descendants of Epie who migrated from ancient Benin Empire. This community was founded by Aguda some years ago with a total of three compounds namely: Ogbobiri, Biogbolo and Agbosi. Agudama-Epie. **Gbarantoru Community** is situated in Gbaran Ekpetiama Clan of Yenagoa LGA and is made up two main compounds: Ogbabiri and Ayaibiri with Ayakumama and Kanofa Layouts. **Tombia Community** is of Gbaran Ekpetiama clan in Yenagoa LGA founded by Tombia-owei.The community is made up of three quarters/compounds namely: Friebawari, Ingbelebiri and Adimo.

On the Rivers State axis are the Obua/Odua and Ahoada west communities. **Ahoada West Communities** are descendants of Akoh, the second son of Ekpeye. Akoh a brave hunter, a trader, a trader, a farmer, and a great medicine man lived at Ula-Ehuda. He named his son after the Ula-Ehuda (Ahoada). He founded the waterside at the bank of Sombriero River which was developed as a fort against invasion.

Traditional Line of Authority and Governance: The traditional line of authority of communities in Yenogoa, Kolokuma/Opokuma, and Ogbia axis (Bayelsa State) of project area begins with Clan Council of Chiefs headed by a Clan Head. At the community level, there is a paramount ruler at the apex, who presides over the affairs of a community, called an Amananaowei in Izon and Ebeniken in Epie. Among the Ahoadas' and Abua/Odua communities of the Rivers State arm of the project communities there is the paramount ruler known as Eze or Ochioha who heads Council of Chiefs in taking community decisions. The Ezes or Ochiohas are assisted in their task of community governance by a Council of Chiefs and Elders. On both sides of the project communities, there are the Community Development Council (CDC), youth and women groups who play key roles. The hierarchy of Influence/Line of Authority in Rivers and Bayelsa State-baseline of authority are similar in the sense that they discharge their powers to members of the society through the same set (type) of stakeholders. However, they differ in the sense that the Bayelsa State-Base line of authority has in-built Advisory Elders' Council that is missing in Rivers state-based line of authority. This should be noted and accorded the necessary treatment to avoid them becoming a clog in the wheel of implementation of this project.

Household Population Structure: Findings in many SPDC recently conducted studies (EIA, and PIA) reports reveal household characteristics that will help inform policies. These characteristics include: **Age:** These studies all agreed that in terms of age that the population is a young one characterized with dominance of working population aged 18-60 years. **Age-Sex Structure:** The age sex structure from these studies helped to confirm the growing nature of the household population in the area. The age-sex structure varied from one community to another in terms of dominance of one sex over the other. Male dominance in rural households suggest availability employment in such communities (practice of traditional occupations), while female dominance suggests out-migration of the male folk to urban centres in search of jobs. **Marital Status:** The proportion of married household respondents was overwhelmingly higher than singles in all the study communities. This distribution shows that marriage is an important social institution in the area cherished and respected by many, and a relatively stable institution in the communities. Different studies gave different proportions of married persons to the singles. **Household Size:** The size of the household seen as the number of persons in a household who eat and feed from the same pot but who may not necessarily be living under the same roof was extensively examined by these studies. The estimated household size varied from 5 to 11 persons. **Dependency Ratio:** This is a measure of the ratio of the economically dependent part of the population to the productive part; arbitrarily defined as the ratio of the elderly (ages 65 and older) plus the young (under age 15) to the population of the 'working ages'(ages 15-64) (Haupt and Kane, 2004). The EIA of Kolo Creek NAG Manifold to Soku Gas Pipeline report (2012) estimated the dependency ratio in Kolo Creek /Soku project communities as 83.5%.Similarly, the EIA report of Gbaran Ubie Phase 2 IOGP (EIA Cluster 1) (2008) estimated the dependency ratios of 106.2, 122.6 and 115.1 for Agbobiri, Zarama, and Ahoada communities respectively. This means that in a household of ten persons, at least eight persons depend on a bread winner for their livelihood.

Education Facilities: All the communities to be impacted by this Seismic activity have at least one primary school. Primary school enrolment has been on the increase in the area. All the communities are equally within walking distance to a secondary school. Public post-primary institutions in the communities are relatively few. With the exception of Opolo-Epie, and Okutukutu that have their own secondary schools, others own theirs jointly with their kindred communities.

Other community Social and Economic infrastructures: The level of available or functional infrastructure and amenities in any area or community has direct implications on the quality of life in that area, and therefore the willingness of people to live and remain there. These amenities may be physical, social or institutional in nature and service. The infrastructure as they are called also influences socio-cultural and economic identities of people in an area. Details of community infrastructure/social amenities in the project area include: Schools, Health centre, Eleectricity and Potable water and presented in Table 4.3.8.7.

Employment: The employment situation in the communities has been reported in Kolo Creek NAG Manifold to Soku Gas Plant Pipeline EIA study (SPDC, 2010). One common phenomenon was the problem of unemployment. The unemployment problem was felt mostly among secondary school leavers who were unskilled and who had also neglected traditional farming and fishing activities of the people. Unemployment was more among males than females. The females adapted better to economic hardship by engaging in petty trading. High level of unemployment suggests greater dependency ratios since the unemployed will add to the burden of catering for the needs of the very young, very old, and invalids by individuals within the work force that are gainfully working.

Livelihood Activities: Livelihood activities identified in the study area included farming, fishing, petty trading (especially shop keeping and hawking) timber works (logging, sawing), food processing (especially palm oil milling and gari production) and artisan practices (especially carpentry, welding, masonry). Others include residents who are engaged in public/civil services, and persons who provide transportation services and contractors. Crop farming especially at subsistence level is a major livelihood activity in the area. Farming implements have remained use of traditional hoes, machetes and cutlasses. Many of these local farmers do not make use of fertilizers but bush fallow, organic mulch and land rotation in maintaining fertility of their soils. Residents grow crops in their farms which they sell in the markets. Crop farming especially at subsistence level is a major livelihood activity in the area. Farming implements have remained use of traditional hoes, machetes and cutlasses. Many of these local farmers do not make use of fertilizers but bush fallow, organic mulch and land rotation in maintaining fertility of their soils. Residents grow crops in their farms which they sell in the markets. Fishing equipment is also rudimentary with capture fisheries being the common practice. Residents who perform most of the fishing activities live in fishing camps in satellite communities such as Gbara-Ama. The popular fishing sites are the rivers, creeks, ponds and swamps around the communities. Fishing equipment are mostly different sizes of nets, hooks and traps. Petty trading has become quite an important livelihood activity in terms of the number of household members that are engaged in it. In all the project communities there were small shops which sold variety of products ranging from food items to stationery and minor electrical appliances. There are also itinerary traders who hawk vegetables, fruits and fresh fish. Many of the artisans do not have workshops to work from.

These people are consulted in their homes but in communities of Otuasega, and Oruma there is a good number welding and carpentry workshops. Petty activities yield income to inhabitants. Monthly income of houseolds in Ogbia group of communities (mostly from farming, petty trading and public/civil service employment) was between ₦35, 000 and ₦50, 000. Likewise, households in the Odual group of communities earned relatively lowly, between ₦ 20,000 to ₦ 35,000 monthly. Personal and household monthly income varied on account of type of occupation and ability to effectively combine money yielding activities.

Community Perceptions, Concerns and Expectations: All the communities had been exposed to oil and gas activities in the past. Across the communities, the proposed project shall be welcome but with strong reservations. These reservations are in form of perceptions, concerns, and expectations. The concerns of seismic project communities on activities are quite general and similar. They are:

- There are concerns on type of seismic operations to be used;
- There are concerns on type and power of energy source (dynamite or Vibroseis truck) mounted on their land might produce deafening sound;
- There are concerns about where the seismic lines and access routes will pass through and cause damage to personal and/or communal buildings/investments;
- There are concerns about the extent of vegetation to be cleared along proposed seismic lines and access routes.
- Concerns that social interaction in the past had turned local girls into seasonal wives, exploited and dumped by itinerant workers.
- Increased promiscuity.
- Occurrence of teenage pregnancies and unwanted babies.
- Damage to cultural resources, especially shrines in the forests;
- Concerns that Farmland, crops and economic trees would be destroyed during vegetation clearing for seismic lines;
- Increased insecurity due to the fact that the project would attract large population;
- There would be price increases, especially of transport and food
- Increased pressure on the already inadequate infrastructures with no local capacity to attend to needs especially medical.

Expectations of the communities may differ based on their different needs and concerns. These expectations amongst others shall be:

- That the project would bring about new interactions and relationships that may result in marriages;
- Expectations that there would be skilled interactions with workers from other places resulting in increase in knowledge and ideas about seismic activities;
- Some communities would expect a repeat of previous experiences on use of their communal resources and inter-personal relationships;
- Expectations of a positive impact in the employment of local hands in construction of seismic lines, and drilling of shot holes;
- Expectations of increased income from increased volume of commerce;

Health Impact Assessment

A review of various HIA studies done against some projects cutting across two states and spanning a period of six years was done. Health assessment data indicates that study communities were in stable health but most lacked functional modern health facilities making untrained traditional medical practitioners, and traditional birth attendants major providers of medical services. Malaria, gastrointestinal and respiratory tract diseases are the common ailments in the communities. This is attributable to poor sanitary and housing conditions while child nutritional status needs attention. Uninhibited use of alcohol and multiple sex partners pose a threat to the lowering of STI/HIV prevalence in the communities. The siting of a new project in the study area could be an opportunity for putting in place adequate measures to drive down disease burden. A sustainable health education programme coupled with training of traditional medical practitioners and TBA‘s would be useful in the pre-execution, execution and post execution phases of any new project.

ES 5.0: Potential Impact Assessment

The assessment of the degree of alteration to natural conditions due to the project activities were carried out. The overall potential negative impacts of the project activities on the environment are minimal. The project activities which has potential negative impacts includes but not limited to the following: Site preparation, survey line cutting, drilling of shot holes and shooting. These negative impacts will be generally minimal, localized and short-term, particularly given the fact that the adverse impacts will be properly mitigated with the strict implementation of the Environmental Management Plan developed for the proposed project. Consequently, the long-term beneficial impact of the proposed project makes it more beneficial than adverse. Significant negative impacts of the proposed project include but not limited to the following:

- Third party agitations over compensations, land disputes, wrong stakeholder identification, leadership tussles etc.
- Increase in usage of roads and waterways with possibilities of accidents;
- Increase in usage and resultant Obstruction of /damage to existing roads;
- Nuisance (Noise, vibration etc.) from machinery;
- Increase of population in communities, thereby exerting pressure on infrastructure;
- Exposure of workers and community members to poisonous snakes, bees, scorpions, other wildlife and contact with poisonous plants;
- Injuries during vegetation clearing;
- Increased access for hunting and logging;
- Possibility of lines cutting across sensitive locations, property, sacred places, public utilities;
- Contamination of ground and surface water;
- Vibrations resulting in cracking of structures.

Positive impacts of the proposed project include:

- Acceptance of project and co-operation/participation from stakeholders (communities and government) leading to peaceful and timely execution of the project

- Increased opportunity for employment and contracting resulting in increased income level.
- Opportunities for contracting, supply of food and other supplies
- Increased financial flow due to compensations leading to improved standard of living.

ES 6.0: Mitigation Measures

To ensure that all negative impacts are reduced to the barest minimum in the execution of the Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition, the following mitigation measures shall be applied:

- Early stakeholders' engagement sessions shall be held, with all the agreed issues properly documented and signed.
- Journey management shall be employed to limit the amount of traffic
- Regular maintenance /checks of vehicles and boats shall be carried out
- Sufficient separation distances shall be provided for detonation of explosives to reduce noise levels and vibration effects on structures.
- Personnel handling explosives shall be licensed in line with 1967 Explosive Regulatory Act
- Explosive handlers training with regard to seismic operations
- Awareness shall be created on the existence and locations of shot holes through appropriate markings/signs
- Pattern shot holes shall be used as much as possible
- Uphole location (single deep hole drilling) shall be spaced on 4 x 4 km grid across the prospect area
- The appropriate beneficiaries of damaged property shall be identified and the loss evaluated
- Consultations with the relevant communities and property owners shall be carried out
- Adequate and prompt compensation shall be made when liable

ES 7.0 : Environmental Management Plan

The Environmental Management Plan (EMP) for the proposed project incorporates various mitigation measures to ensure that adverse impacts associated with the development of the project are reduced to the lowest level. The EMP addresses consultation, waste management, environmental audit and environmental monitoring programmes of the project. The plan shall provide for compliance monitoring of the various environmental components during the project activities and comply with FMEnv requirements.

ES 8.0: Decommissioning and Abandonment

The decommissioning and abandonment of the Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition Project shall be executed with keen considerations to issues arise from the need to address public safety, legal requirements, environmental protection, and future land use. During the pre-abandonment review a risk assessment shall be performed to identify and closeout all applicable risk issues arising from the abandonment scope, and execution methods and issues identified shall be documented for implementation in the execution contractor's procedures and method statements and tracked for closure by the project team.

ES 9.0: Conclusion and Recommendation

This Environmental Impact Assessment Report was carried out in accordance to the directives of the Federal Ministry of Environment (i.e. to conduct a desktop study). The EIA study involved detailed literature review, data analyses, impact identification/evaluation, and reporting. The Adibawa-Gbaran 3D Reshoot Data Acquisition Project will be beneficial in identifying deep exploration opportunities (by leveraging on the existing technology, using longer recording cable lengths and recording higher fold) which will maximize economic recovery of hydrocarbons, increase production, maximize economic use of existing facilities by keeping the facilities full and grow Nigeria's / SPDC's reserve base.

Furthermore, the impact assessment of the proposed project showed that it would have significant impacts which includes but not limited to Creation of opportunities for employment and contracting and increased financial flow due to compensations leading to improved standard of living. The identified adverse impacts were generally short-term and can be prevented, reduced, ameliorated, or controlled if the recommended mitigation measures are implemented. An Environmental Management Plan and a Monitoring Plan have been developed to ensure that the identified potential impacts can be reduced to "as low as reasonably practicable" (ALARP). The EMP should therefore form the basis for the actual project implementation and future monitoring of environmental components. The approval of this EIA report for the execution of the proposed project is hereby recommended.

ACKNOWLEDGEMENT

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CHAPTER ONE
INTRODUCTION

1.1 Background information

The Shell Petroleum Development Company Limited (SPDC), in pursuing its E&P business to explore and deliver additional hydrocarbon (Oil and Gas) production, (i.e. recover volumes of hydrocarbon remaining in the fields and also search for new hydrocarbon opportunities), is planning to embark on a 3D seismic data acquisition survey over OMLs 27 and 28/31 covering Adibawa and Gbaran fields located within Bayelsa and Rivers state in the Niger Delta with Gbaran, Etelebou and Koroama fields located about 25 Km South-West of Yenagoa. 3-D seismic data was acquired by SPDC over Gbaran fields in 1991/1993, while the 3D seismic data over Adibawa acquired in 1995 was done by Nigerian Agip Oil Company NAOC. The planned acquisition is within the Ughelli-central swamp depobelts of the Niger Delta.

Structurally, the Gbaran field is faulted rollover anticline at Shallow levels while the deep sections are hanging wall dip closure, and hydrocarbons are trapped mainly in fault-assisted dip closures. The Adibawa structure is an elongated, east-west trending rollover anticline bounded to the north by a main growth fault. There exists a smaller fault, which intersects the northern boundary fault that splits the field into two accumulations (east and west). Hydrocarbon accumulations occur in variety of trap mechanisms, from full dip closure through fault-assisted dip closure to dip-assisted fault closure.

In the light of the aforementioned, the proposed project activities will have several interactions with the environment, hence the need to conduct an Environmental Impact Assessment studies in line with the provisions of the EIA Act 86 of 1992. Consequently, SPDC has been mandated by Federal Ministry of Environment (FMEnv) to conduct a desktop study for the EIA of Adibawa-Gbaran Seismic 3D Reshoot Data Acquisition Project (**Appendix 1.1).** This EIA study has identified the key potential impacts of the project activities on biophysical, social and health components within the project area and proffered mitigation measures for Environmental Management

1.2 Objectives of the EIA

The objectives of the EIA are to:

- Acquire baseline data of the environment as well as the socio-economic and health conditions of the host communities;
- Use the baseline data to describe and characterize the study area;
- Identify the environmental sensitivities of the project area;
- Determine and evaluate the potential impacts of the proposed project activities on the identified environmental sensitivities and the interactions between the sensitivities;
- Recommend appropriate mitigation measures; and
- Develop an Environmental Management Plan (EMP).

1.3 Project location

The planned onshore 3D seismic data acquisition activity is in OMLs 27 and 28, with Gbaran, Etelebou and Koroama fields located some 100km North-West of Port - Harcourt. It lies in the geographical region that can be approximately defined by the following coordinates **(Table 1.3.1).** The proposed EIA surface coverage area is about 1,400 sqkm and will cut across six Local Government Areas in Bayelsa and Rivers States. The Local Government Areas include: Sagbama, Kolokuma/Opokuma, Yenagoa, Ogbia (Bayelsa state), Abua/Odua and Ahoada West (Rivers state).

Table 1.3.1: Adibawa - Gbaran EIA Co-ordinates (Nigeria West-belt projection)

Point	Eastings	Northings
1	447,893	102,311
2	420,059	102,311
3	420,059	127,817
4	442,284	127,817
5	442,495	147,607
6	466,202	147,502
7	465,990	134,590
8	461,334	134,378
9	461,334	129,722
10	470,012	121,572
11	465,990	115,646
12	447,893	115,540
13	447,893	102,311

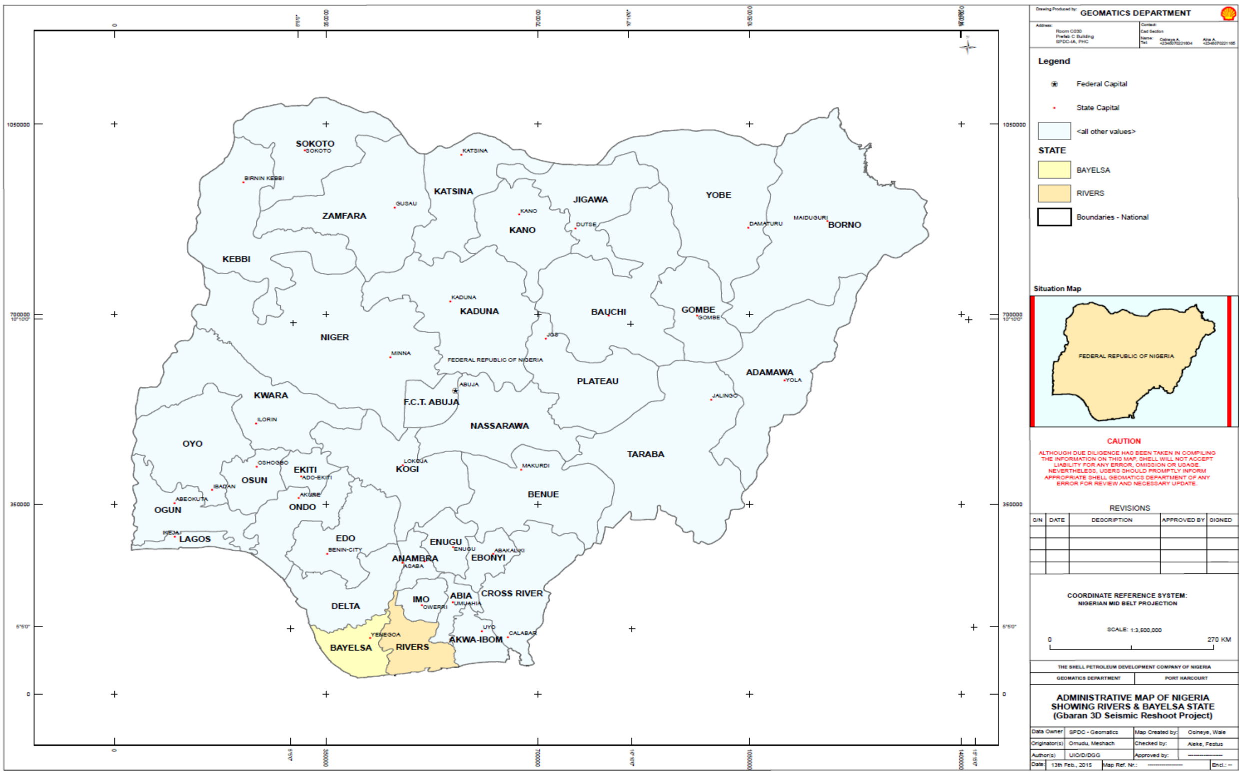


Fig 1.3.1: Map of Nigeria showing Rivers and Bayelsa States

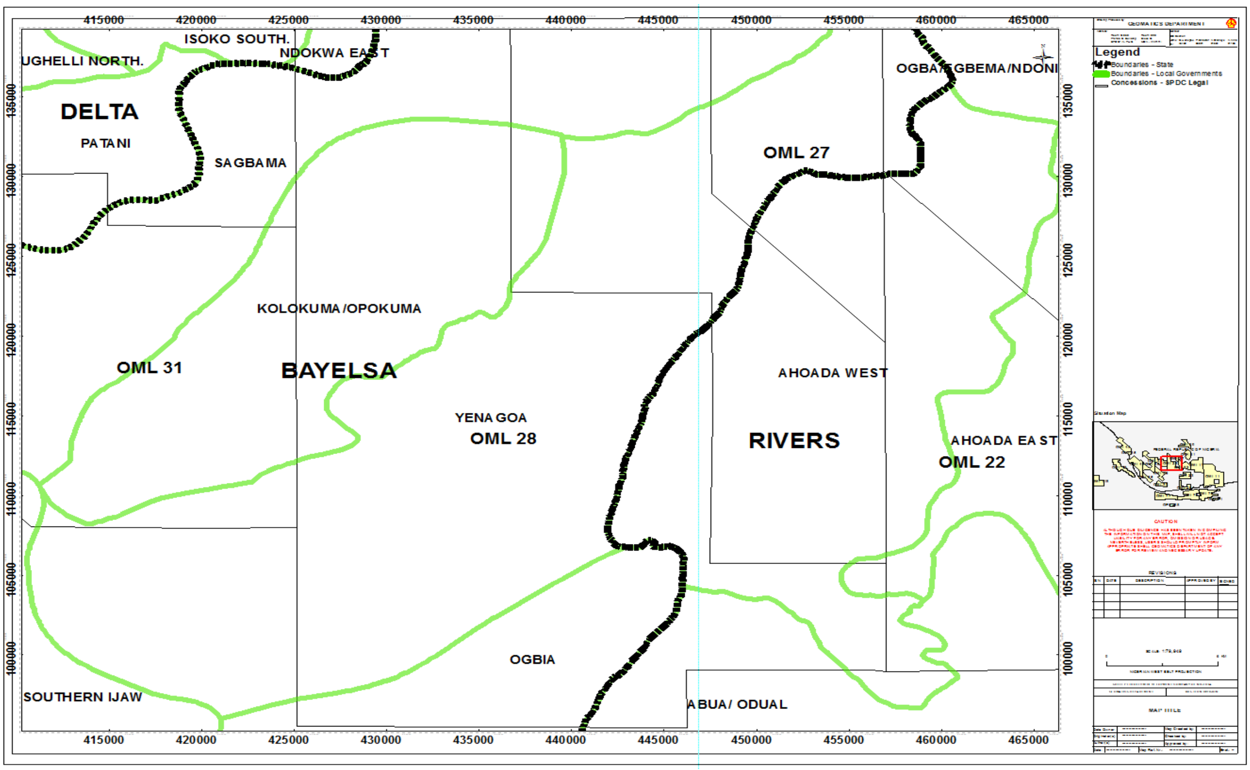


Fig 1.3.2: Map showing the Local Government Areas in Rivers and Bayelsa States

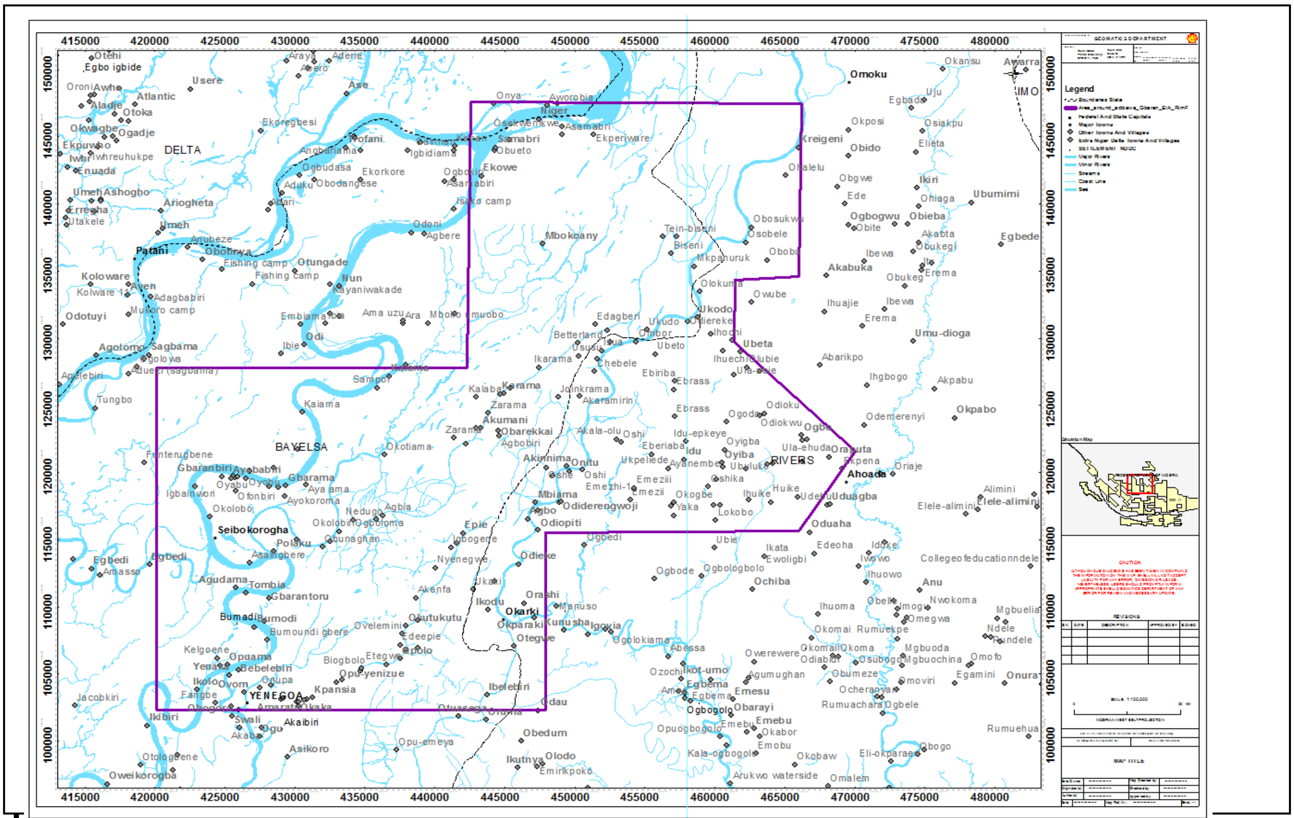


Fig.1.3.3: Map of the Project area showing communities in Rivers and Bayelsa States

1.4: Legal and Administrative Framework

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:

1.4.1: International Laws and Regulations

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

(i) World Bank Guidelines on Environmental Assessment {EA} (1991)

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

(iii) Convention on the Migratory Species of Wild Animals (Bonn Convention)

(iv) Convention of Biological Diversity

(v) Convention Concerning the Protection of the World Cultural and National Heritage Sites (World Heritage Convention)

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

(vii) United Nations Framework Convention on Climate Change (1992)

World Bank Guidelines on Environmental Assessment {EA} (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 vols. 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.

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

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.

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

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

Convention on Biological Diversity

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.

Convention Concerning the Protection of the World Cultural and Natural Heritage Sites (or World Heritage Convention)

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.

Basel Convention on the Control of Trans-boundary Movements ofHazardous Wastes and their Disposal

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.

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.

1.4.2: Legislations guiding Environmental management in Nigeria

The Mineral Oil (Safety) Act CAP 350 LFN 1990

Sections 37 and 40 of the Mineral Oil (Safety) Act CAP 350 LFN 1990 require provision of Personal Protective Equipment (PPE) and the safety measures for workers in drilling and production operation in accordance with international standards.

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.

EIA Sectoral Guidelines for Oil and Gas Industry Projects, 1995

In compliance with its mandate, FEPA issued the EIA Sectoral Guidelines for Oil and Gas Industry Projects, 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.

S.I. 15 - National Environmental Protection Management of Solid and Hazardous Wastes Regulation (1991) (FMEnv)

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.

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.

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.

FEPA (Now FMEnv) National Policy on the Environment (1989)

This gave the policy goals, conceptual framework and strategies for implementation.

Forestry Law CAP 51 LFN 1994

The Forestry Act 1958 which was amended as the Forestry Law CAP 51 LFN 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.

Land Use Act CAP 202 LFN 1990

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

National Inland Waterways Authority Act No 13 of 1997

This Act established the National Inland Waterways Authority with a view to improving and developing inland waterways for navigation, providing an alternative mode of transportation for the evacuation of economic goods and persons, executing the objectives of the national transport policy as they concern inland waterways. The Act also prescribes regulations and sanctions on the use and exploitation of resources of inland waterways such as dredging, sand or gravel, mining and erection of permanent structures within the right-of-way or diversion of water from a declared waterway.

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.

Endangered Species Act CAP E9 LFN 2004

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.

Petroleum Act CAP 350 LFN 1990

An Act to provide for the exploration of petroleum from the territorial waters and the continental shelf of Nigeria and to vest the ownership of, and all on-shore and off-shore revenue from petroleum resources derivable therefrom in the Federal Government and for all other matters incidental thereto.

Territorial Waters Act CAP 428 LFN 1990

The territorial waters of Nigeria shall for all purpose include every part of the open sea within twelve nautical miles of the coast of Nigeria (measured from low water mark) or of the seaward limits of inland waters. Any act or omission which-

(a) is committed within the territorial waters in Nigeria, whether by a citizen of Nigeria or a foreigner; and

(b) would, if committed in any part of Nigeria, constitute an offence under the law in force in that part, shall be an offence under that law and the person who committed it may, subject to section 3 of this Act, be arrested, tried and punished for it as if he had committed it in that part of Nigeria

Water Resources Act CAP W2 LFN 2004

The Water Resources Act vests the right to the use and control of all surface and groundwater and of all water together with the bed and banks in any watercourse affecting more than one state in the Government of the Federation. However, the Act essentially preserves existing rights, including customary rights, provided they are for domestic use, watering of livestock and personal irrigation schemes. A proviso to section 1(1) states that the subsection shall not be deemed to infringe or to constitute a compulsory right over or interest in property. Apparently, the idea is to separate rights over water resources from other rights in property.

Explosive Act and Explosive Regulations (CAP E18 LFN 2004)

The Explosive Act and Explosive Regulations the transportation, storage and use of explosives in connection with minning activities. It specifies the licensing requirements for explosives and detonators magazines as well as the handling of explosives.

1.4.3: Legislations guiding Environmental management in Rivers and Bayelsa State

The Rivers and Bayelsa state regulations guiding Environmental management includes but not limited to the following:

- Rivers State Private Health and Allied Establishments Authority Law, 2001;
- Rivers State Public Health Law, 1999;
- Rivers State Noise Pollution Control Law of 1984;
- Rivers State Environmental Protection Agency Law No. 2 of 1994.
- Bayelsa State Environmental and Development Planning Authority Law 1998;
- Environmental Sanitation Law 1984 (Law No.6 of 1984)*
- Refuse Collection and Disposal Law 1991 (Law 8 of 1991)*
- Bayelsa State Pollution Compensation Tax Law 1998;
- Bayelsa State Forestry Law 1998.

*N.B: *These are legislations of the Old Rivers State before the creation of Bayelsa state in 1996 and have now being adopted by the Bayelsa State Government.*

1.4.4: SPDC Policies and Principles

Shell Petroleum Development Company (SPDC) operates under the guidelines of Shell International and complies strictly with them. Where national standards and regulations are more stringent than Shell guidelines, SPDC's policy is to comply with the existing national legislation.

(a) Business Principles

Shell companies have a systematic approach to health, safety, security and environmental management in other to achieve continuous performance improvement. To this end, Shell companies manage these matters as critical business activities, set standards and targets for improvement, and measure, appraise and report performance externally.

(b) Governing Policies

The SPDC 1998 Corporate Policies emerged with five Business Governing policies. Of interest to this document is the section on HSE referred to as 'Health, Safety and Environment Policy'. This policy addresses the health, safety, and environmental risks to the business and the potential impacts on staff, personnel, and the host communities. The policy reflects good practice and is mandatory.

(c) HSE Policy

It is SPDC's Policy that all activities shall be planned and executed in a manner that,

- Preserves the health, safety and security of all Company and contractor personnel and members of the public;
- Preserves the integrity and security of Company assets;
- Minimizes the impact of operations on the environment; and
- Is sensitive to the needs and concerns of the Host Communities.

The implications of implementing this policy are that,

- All activities shall be analyzed to systematically identify related hazards, risks and sensitivities;
- Arrangements shall be put in place to control the hazards, risks and sensitivities and to deal with consequences should they arise;
- Any activity which is unhealthy, unsafe, environmentally unsound or may adversely impact relations with the community, shall be suspended until an acceptable solution is found;
- All personnel, including those of contractors, shall be trained and made fully aware of the hazards, risks, sensitivities and controls in place; and
- Plans and procedures shall be in place to respond to any emergency or loss of control.

Every employee and contractor employee must plan and perform his work in accordance with this policy. Each employee is required to report, and where necessary, suspend any activity considered to be in contravention of this policy.

(e) SCiN Biodiversity Policy

''In Shell, we recognize the importance of biodiversity. Therefore, we are committed to:

- Work with others to maintain Ecosystems
- Respect the basic concept of Protected Areas
- Partner with others to make positive contributions towards the conservation of biodiversity in our areas of operations
- Conduct Environmental Assessments with increased focuson impacts on biodiversity
- Engage and collaborate with other stakeholders to manage biodiversity responsibly especially in sensitive environments''

(f) Waste Management Policy

It is the policy of SPDC to:

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

(g) Emergency Response Policy

This states that the response to any emergency within SPDC will be directed towards

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

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

(h) Community Relations Policy

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

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

1.5: Structure of this EIA Report

- **Chapter One** - Introduction presents the background information, EIA objectives, Legal and administrative framework.
- **Chapter Two -** Project Justification, discusses the project background, project objectives, rationale for the project, envisaged sustainability, and development options considered;
- **Chapter Three** - Project Description, describes the type of project, scope, location, material input/output and by-products, waste generation, technical layout and process, operation and maintenance, project schedule;
- **Chapter Four -** Description of Existing Environment - provides information on the baseline environmental conditions of the project area describing the physical, chemical, biological social, and health environment
- **Chapter Five** - Associated and Potential Environmental Impacts - highlights the Associated and Potential Environmental Impacts of the proposed project;
- **Chapter Six** – Mitigation Measures/Alternatives – describes the mitigation options of impacts;
- **Chapter Seven -** Environmental Management Plan - provides the proposed plans for environmental management;
- **Chapter Eight -** Decommissioning and Abandonment Plan; and
- **Chapter Nine** - Conclusion and Recommendations – provides remediation plans after decommissioning/abandonment.

CHAPTER TWO
PROJECT JUSTIFICATION

2.1: Introduction

The planned 3D Seismic data acquisition is proposed to cover an area of about 1,400 sqkm in OMLs 27 and 28/31 covering Adibawa and Gbaran fields. The planned acquisition is within the Ughelli-central swamp depobelts of the Niger Delta spanning Rivers and Bayelsa state. This subsection highlights the need for the project, Envisaged sustainability and the Project Options/Alternatives.

One 2D seismic line will also be acquired within the project area extending into an open acreage (OPL 2005) during the project execution with denser sampling. This is required to validate the planned 3D seismic data acquisition parameters and also provide information that will benefit future seismic data acquisition campaigns parameterisations. The length of the 2D seismic line is about 51kms. The process of acquiring the one 2D seismic line is the same as that of the 3D seismic re-shoot campaign. The only difference is that both the sources and receivers will be on the same single seismic line in the 2D seismic acquisition as mentioned in Chapter 2 (project alternatives) and shown in Figs. 2.1a and 2.1b. The co-ordinates of the one 2D seismic line are P1 (438004.07E, 85557.18N), and the end points are P2 (427531.68E, 134958.68N) west belt coordinate system.

2.2: Value of the Project

The estimated value of the project is about $108million including the cost of executing the EIA studies.

2.3: Need for the Project

Shell Petroleum Development Company Limited (SPDC) has recognized deep exploration opportunities around the Gbaran Adibawa axis to maximize economic recovery of hydrocarbons and increase production. This will be done through Seismic data acquisition (Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition Project) which will help enhance the appraisal and developmental activities in the field.

2.4: Envisaged Sustainability

Shell Petroleum Development Company Limited has built significant expertise in Seismic activities over the years. The proposed project is envisaged to be sustainable Environmentally, Technically, Economically and Socially. The envisaged sustainability of the proposed project is as follows:

2.4.1: Environmental Sustainability

Shell Petroleum Development Company shall comply with all statutory regulations and its own corporate guidelines on Environmental Sustainability, continuously striving for performance improvement. The proposed project will be on existing traverse cutting hence very low environmental impacts. However, the incorporation of the findings and recommendations of this EIA at the various stages of the project development and strict adherence to the Environmental Management Plan (EMP) will ensure environmental sustainability.

2.4.2: Technical Sustainability

The Shell Petroleum Development Company Limitedin its over 30years experience in Exploration and Production activities has proven the ability to conduct seismic survey. Strict adherence to internationally and nationally acceptable standards, innovative technologies that are economically viable and environmentally friendly shall be utilized in the execution of the proposed project.

2.4.3: Economical Sustainability

The economic sustainability of the proposed project would depend on the viability of the hydrocarbon bearing reserves that would be discovered through seismic data interpretations. However, stakeholders along the seismic transects will benefit from the project through local contracting and employment opportunities, increased cash flow and stimulation of local economies within the communities and Stimulation of local economy and markets from increased demand for food, and other products in the local market.

2.4.4: Social Sustainability

The proposed project will:

- Develop and maintain effective long term relationships with relevant stakeholders;
- Assure that the EIA process leads to development and implementation of social investment;
- Continuous consultation with stakeholder communities will further promote social sustainability of the project;
- Develop manpower skill to enterprising members of the communities.

2.5: Project Options

The Project options considered were:

- No Project Option
- Delayed Project Option
- Conduct Seismic survey

The advantages and disadvantages of each project options are presented in Table 2.1.

Table 2.1: Project Options considered

S/N	Option	Advantages	Disadvantages	Remarks
1	No Project Option	• No capital expenditure • No new risks • No impact on the environment	• Decline in hydrocarbon reserve • Loss of revenue to the Federal Government and company from inability to adequately appraise and develop the Gbaran Adibawa field.	Not Recommended
2	Delayed Project Option	• More time to plan and assess risks	• This will lead to a delay in scheduled dates for drilling and hence loss of expected revenue for that period of time to Government and SPDC	Not Recommended
3	Conduct Seismic survey	• Enhance the appraisal and developmental activities in the field. • Help in optimizing infill well locations through reservoir surveillance • Very high competence levels • Seismic survey is on existing traverse cutting hence very low environmental impacts	• Transects cutting across different terrains may be challenging	Recommended

2.6 Project Alternatives

The Project alternative for the Adibawa-Gbaran 3D Reshoot Seismic Data acquisition Project includes Seismic data acquisition techniques and Energy sources. This subsection highlights the project alternatives for the proposed project.

2.6.1 Seismic Data Acquisition techniques

The seismic techniques considered for the proposed project are: 2D, 3D and 4D techniques while the acoustic energy sources considered are vibroseis and explosives. The project alternatives for the Seismic data acquisition techniques include but not limited to the following:

2D Seismic Technique

In 2D seismic technique, data is collected along a linear array of receivers. The seismic line is shot by moving the shot point and the array forward in sync as the data is recorded until the entire line is completed. The resultant subsurface image is only two dimensional (x,z) and would not give the true shape of the subsurface structures. This technique will impact less on the environment in terms of line cutting, but it does not give the true shape of the subsurface structures. It is used to resolve simple structures at depth. Therefore, it was not chosen. 2D

seismic data are displayed as a single vertical plane or cross-section sliced into the earth beneath the seismic lines' location as shown in **Fig 2.1a and 2.1b.**
Recommendation: Not Recommended as a full survey.

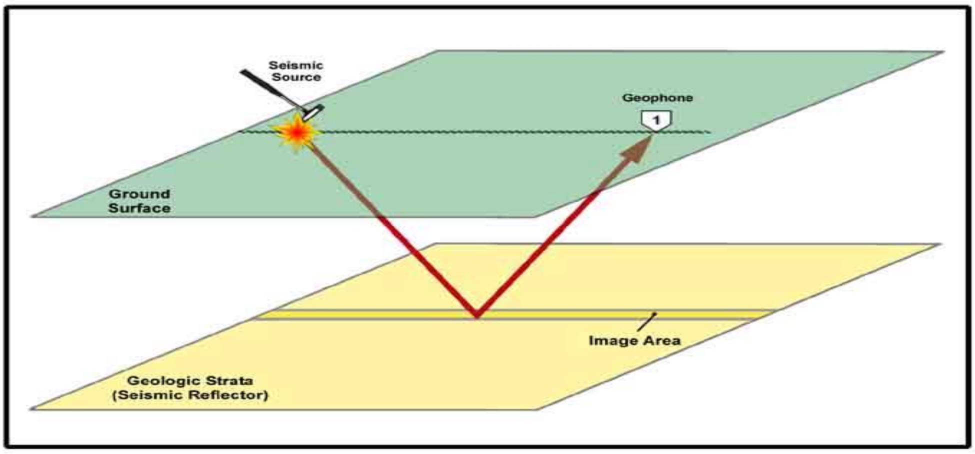


Fig 2.1a: Schematic diagram of 2D Seismic Technique

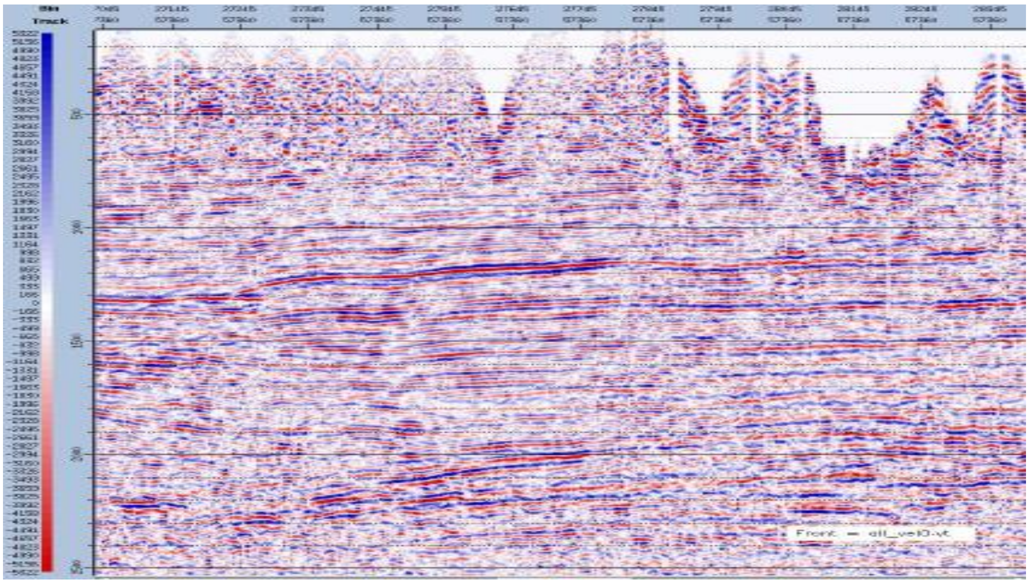


Fig.2.1b: 2D Seismic data line display

3D Seismic Technique

While 2D surveys can be used for reconnaissance and to resolve simple structures at depth, complicated structures causing out-of-plane reflections (sideswipe) can only be imaged properly using 3D reflection techniques in which a 3D volume (x,y,z) of crust is sampled and monitored using a planar, rather than a linear array of shots and receivers. In practice, this is accomplished by laying out thousands of geophones on land (and hydrophones in creeks and rivers) along parallel lines of receiver groups and then shooting into the entire array (receivers) from each shot point along a series of orthogonal shot lines. The 3D seismic technique can be laid out in a variety of geometries. Seismic geometry is the areal configuration of the shots and receivers on the surface. Two geometries are prominent, the narrow geometry e.g. the brick wall and the wide geometry e.g. cross spread. The schematic diagram of the 3D seismic technique is presented in Figure 2.2a. Although complicated by the fact that a typical 3D survey contains orders of magnitude more data to process, the actual processing steps are fairly similar to those for 2D surveys. The end result, however, is a seismic data cube that can be displayed as a three dimensional cube and that can be sliced to produce synthetic 2D profiles in any arbitrary direction through the data, horizontal slices at arbitrary depths (time slices), horizon slices showing reflectivity variations in map plan for picked marker horizons, and 3D tomographic images that can be viewed from any perspective as shown in **Figures 2.2b and 2.2c.**

Recommendation: Not Recommended.

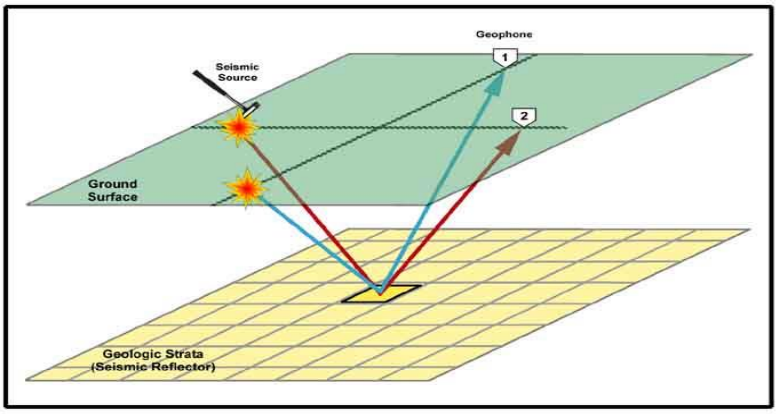
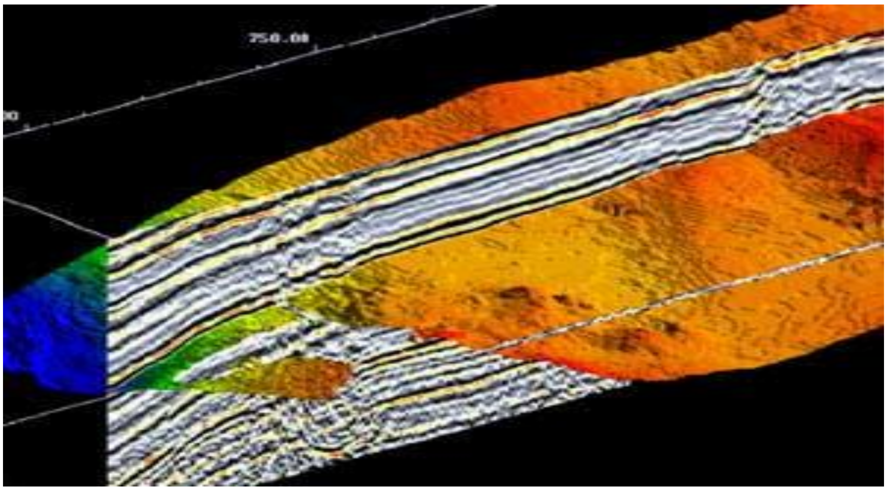


Fig. 2.2a: Schematic diagram of 3D Seismic Technique



(b)

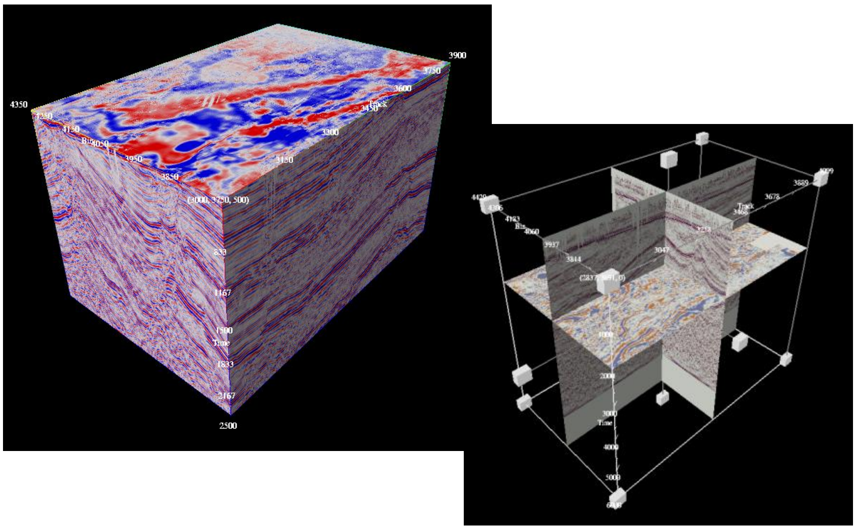


Fig.2.2 (b) and (c): A 3D Seismic data line display. Can be sliced through any arbitrary direction

3D Reshoot (4D) Seismic Technique

4D seismic data is a time-lapse seismic data. It is therefore a three-dimensional (3D) seismic data acquired at different times over the same area to assess changes in a producing hydrocarbon reservoir with time. Changes may be observed in fluid location and saturation, pressure and temperature. Some of the prospects in the project area have been explored and the fields are producing. Even though the deeper exploration opportunities have not been explored, 4D reservoir surveillance is the primary focus of this seismic data acquisition project. As such, the 4D seismic technique has been adopted for this campaign. In addition to the technical justifications, the project impact on the environment will be significantly minimized. This is because as a 4D intended survey, majority of the bush cutting would be on the 1991/3 and 1995 cut traverses due to the surface repeatability of shots and receiver positions requirements.

Recommendation: Recommended.

2.6.2 Energy Source Alternatives

The sources of energy considered for the project are: vibrators and explosives sources. Among these sources of energy, explosives were preferred because of its technical efficiency and environmental appropriateness.

Vibrators

Vibrators are instruments that produce mechanical oscillations. The vibrators when coupled to the earth surface transmit energy into the subsurface. The vibrators can be mounted on a buggy or truck. This arrangement limits its use in the Niger Delta region due to lack of access to the seismic lines for the truck.

Recommendation: Not Recommended.

Explosives and Airguns

One advantage of explosives is that it has the full range of frequency content and can easily be taken into the seismic line. In this manner, extra access need not be created when using dynamite unlike a vibroseis operation where an access needs to be created for the truck that carries the vibrators. The risk of contamination of ground water by the chemical components of dynamite is minimized through complete combustion. Explosives are accepted as the source of energy for this campaign. Air guns will be used in the marine portion of the survey area. This is the only industry recognised marine source of energy. The air gun is made from the highest grades of corrosion resistant stainless steel.

Recommendation: Recommended.

CHAPTER THREE
PROJECT/PROCESS DESCRIPTION

3.1: Introduction

Seismic data acquisition survey is one of the first activities in oil prospecting, exploration and exploitation. It is essentially carried out to locate viable hydrocarbon reservoirs in the sub-surface, develop new fields and meet the Joint venture (SPDC, AGIP, ELF, and NNPC) commitments. A typical seismic data acquisition project last for a relatively short period of time and does not usually involve the establishment, or use of long-term facilities and structures. The survey activities have been planned to commence in Q4 2015 while the actual data recording is planned to commence end of Q4 2015. With an average seismic data recording production of $30km^2$ / month, the survey activities would last for about 24 months. The planned 3D Seismic data acquisition is proposed to cover an area of about 1,400 sqkm in OMLs 27 and 28/31 covering Adibawa and Gbaran fields. The estimated workforce is expected to be over 1,500 at peak of operations. The satellite image over the area is shown in Figure 3.1.

3.2: Project objectives

The objectives of this project are:

To acquire 3D reshoot seismic data with increased multiplicity and longer offset that will:

- Significantly improve the structural imaging of the producing intervals;
- Help in optimising infill well locations through reservoir surveillance;
- The new seismic will be beneficial in identifying deep exploration opportunities (by leveraging on the existing technology, using longer recording cable lengths and recording higher fold) which will maximize economic recovery of hydrocarbons, increase production, maximize economic use of existing facilities by keeping the facilities full and grow Nigeria’s / SPDC’s reserve base.

3.3: Project location

The planned onshore 3D seismic data acquisition activity is in OML 27 and OML 28/31, with Gbaran, Etelebou and Koroama fields located about 25 Km South-West of Yenagoa (fig. 3.1). Gbaran field was discovered in 1967. 3-D seismic data was acquired over Gbaran, Etelebou and Koroama fields in 1991/3. Adibawa is covered by Biseni Samabri 3D seismic acquired by 3rd Party in 1995. The Adibawa field is situated in a seasonally flooded area in block OML-27 and was discovered by exploration well Adibawa-1 in 1966. The planned acquisition is in the Ughelli and central swamp depobelt of the Niger Delta within Bayelsa and Rivers States. Fig 3.2 shows the proposed 2D/3D project locations and some communities the seismic survey will traverse. The co-ordinates of the one 2D seismic line are P1 (438004.07E, 85557.18N), and the end points are P2 (427531.68E, 134958.68N) west belt coordinate system.

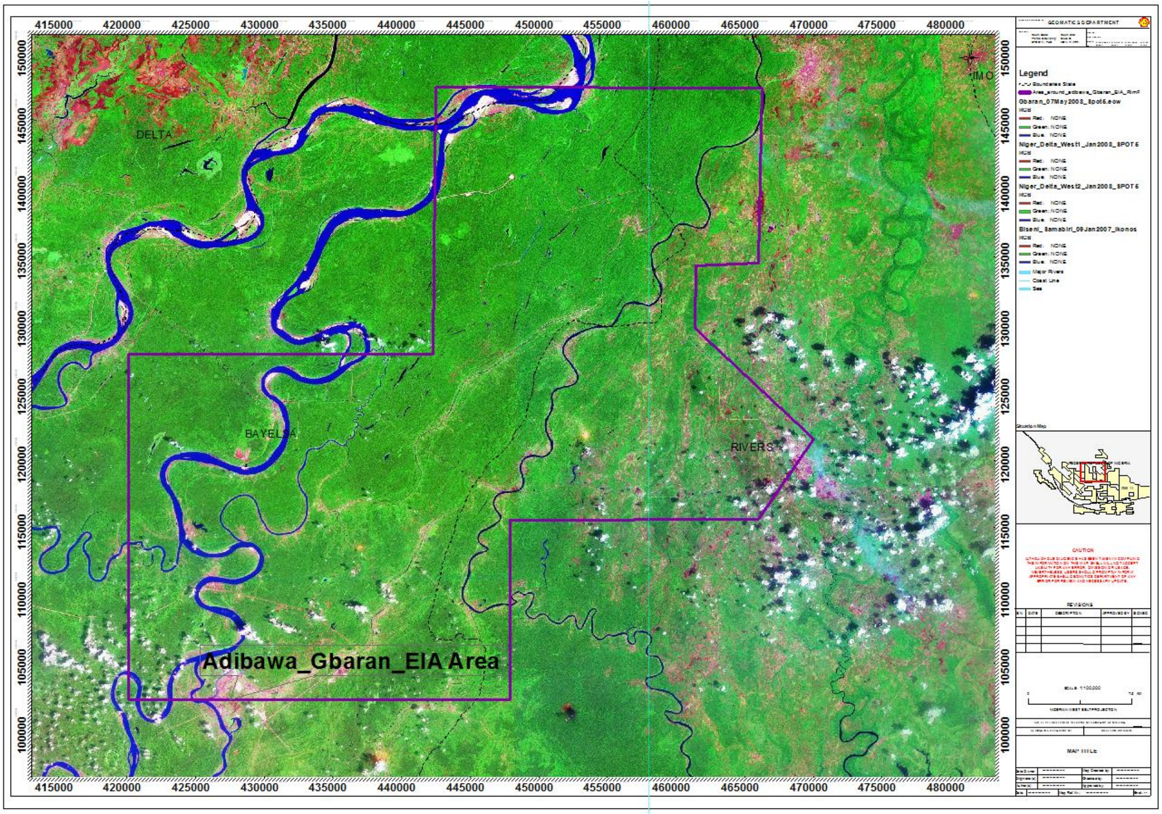


Fig. 3.1: Satellite Image of the proposed Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition EIA Area

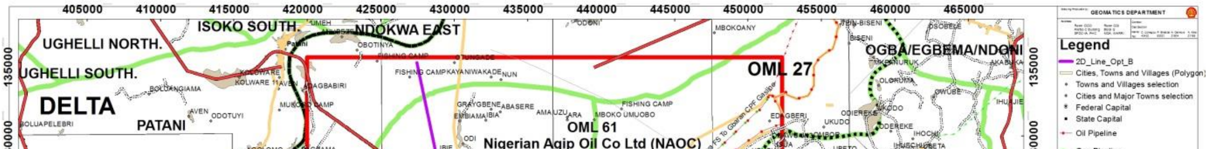


Fig. 3.2: Map of the proposed EIA project location

3.4: Project Activities

A reputable Geophysical Acquisition Contractor would be contracted by SPDC to carry out the 3D seismic Reshoot data acquisition over the Adibawa and Gbaran fields. Company Site Representatives (CSRs) and SPDC staff would closely supervise the 3D seismic re-shoot data acquisition activities. The Adibawa-Gbaran seismic survey shall include the following activities:

- Scouting exercise
- Permitting / Stakeholder engagement – Freedom To Operate (FTO)
- Environmental Impact Assessment (EIA)
- Mobilization of contractor to site
- Land clearing for campsites, fuel dumps and explosives magazine sites
- Surveying - line cutting for receiver/shot positions
- Drilling of shot holes
- Recording – Laying of recording equipment & detonation of explosives
- Road repairs and Community Assisted Projects (CAPs)
- Crops and other economic trees damages assessment and compensation
- Environmental restoration and Demobilization

3.4.1: Scouting Exercise

The contractor would carry out a general scouting exercise of the area with the main objectives of identifying the communities within the project area; roads and rivers/creeks that would be used for the movement of personnel/equipment as well as material supply, communication equipment, health facilities, etc. The contractor would also establish/choose suitable site for camps (with due regards to the expected production rate), and the best access around the different types of obstructions that may affect subsurface coverage in the course of the survey.

3.4.2: Permitting / Stakeholder Engagement – Freedom To Operate (FTO)

Permitting is the process of obtaining consent from the community/individuals as the case may be and relevant government bodies to enable uninhibited access to living premises and farmlands in the course of seismic operations. The host communities would be informed on seismic operations during permitting and other subsequent fora (people's parliament, Project Advisory Committee meeting/Cluster Development Boards meetings, etc.). Their consent would be obtained during permitting so as to operate in their area. The contractor's community affairs staff would engage communities, individuals, relevant government bodies and other stakeholders at an agreed date to explain the processes involved in seismic operations and possible associated hazards. After the meeting, a permit form that would serve as agreement would be presented for signatures so as to ensure that peace and harmony prevail during and after the seismic operations. Cluster Development Boards (CDB) shall be used to manage issues related to the project where such bodies exists. Where such boards or any existing SPDC stakeholder relations committee arrangement have not been firmed up, a Project Advisory Committee (PAC) which will serve as a stakeholder relations committee comprising government representatives, community leaders/elders, youths and women representatives shall be set up prior to commencement of the seismic operations. The stakeholder relations committee's duty is to manage issues that may arise with the communities or relevant government bodies in the areas of operation, coordinate nominated Community Assisted Projects (CAP) and employment issues.

Open forum in form of community engagements shall be periodically held with the stakeholder relations committee membership participation during the course of the seismic survey operation. During such meetings, issues such as contractor's company's policy vis-à-vis community's interest as it relates to the seismic activities in the area and demands shall be discussed. Community Elders, Chiefs, Youths, Women leaders and NGOs would be invited to attend such forum. Information on the seismic activities would also be disseminated to Government agencies and NGOs. Employment opportunities shall be extended to the communities by the contractor with due regards to the contract and bearing in mind the 60% community employment ratio that would be prescribed by the contract. The stakeholders' Community relations committee members (with the permanent members in attendance) would share this employment quota amongst the various communities within the prospect area and thereafter communicate the information to the communities. The communities would carry out internal selection and present their employment quota list to the contractor for employment. The contractor's Community Affairs Department would interview the selected people. Successful candidates would be medically certified fit, swim tested, given safety induction, technical training and issued with personal protective equipment (PPE) before they commence work. The lists of communities so far identified that would be impacted by the proposed Project are shown on **Table 3.1.**

Table 3.1 Communities to be traversed in OML 28/31

S/N	**Bayelsa State**				**Rivers State**	
	Sagbama	**Kolokuma/Opokuma**	**Yenegoa**	**Ogbia**	**Abua/Odua**	**Ahoada West**
1	Odoni	Sampou	Ikarama-1	Otuegwe 2	Odau	Akinima
2	Agbere	Kalama	Ikarama- 2	Ibelebiri	Obedum	Enito-3
3	Anibeze	Amatu-Odi	Freetown	Otuasega		Enito-1
4	Adagbabiri	Ebereze-Odi	Kalaba	Oruma		Oruama/Akieo niso
5	Obuware-Sagbama	Amakiriebiama-Odi	Ayamabele	Elebele		Mbiama
6	Indiamazi-Sagbama	Agiama-Odi	Akomoni	Emeyali		Odhioluogboji
7	Oweinamazi -Sagbama	Ifidiama-Odi	Agbobiri	Opuemeya		Ele-Uma
8	Aduwezi-Sagbama	Bolouama-Odi	Nyambiri	Kala Emeya		Odhiogbor
9	Amoyan-Sagbama	Obaka-Ama-Odi	Zarama-Epie	Opu Kolo		Odiopiti
10	Aziawozi-Sagbama	Ogboloma-Odi	New-Jerusalem	Kaka Kolo		Ishiayi
11		Isonbiri-Odi	Akenfa-Epie	Atuagbo		Odiete-Ugbobi

S/N	Bayelsa State				Rivers State	
	Sagbama	**Kolokuma/Opokuma**	**Yenegoa**	**Ogbia**	**Abua/Odua**	**Ahoada West**
12		Oboribangha-Odi	Igbogene	Otueke		Ikodu
13		Kaiama	Yenegwe	Otuabo		Kunusha
14		Olobiri	Agbia			Okparaeki
15		Okorotom	Akenfa			Igovia
16		Ekpuwari	Agudama-Ekpetiama			Akiogbologbo
17		Ofonubiri	Akenpai			Okarki
18		Ayakoroama	Edepie			
19		Gbaran-Ama	Etegwe			
20		Gbanranbiri 1 & 2	Okotiama			
21		Iyibiabiri	Ayama			
22		Akanranbiri	Ogboloma			
23		Oyobou	Nedugo			
24		Abuwari	Okolobiri			
25		Igbainiwari	Okutukutu			
26		Orubiri	Opolo			
27		Sabagreia	Biogbolo			
28		Igbedi	Yenezue-Gene			
29		Okoloba	Asaingbene			
30		Agorogbene	Obunagha			
31			Kumboama			
32			Koroama			
33			Kpansia			
34			Onopa			
35			Okaka			
36			Yenezue-Epie			
37			Amarata			
38			Ekeki			
39			Swali -2 (Ikpenda)			
40			Polaku			
41			Agudama-Epie			
42			Tombia			
43			Gbarantoru			
44			Akabiri			
45			Bomundi			
46			Bomadi-Gbene			
47			Bebelebiri-1			
48			Bebelebiri-2			
49			Yenaka			
50			Ovom			

S/N	Bayelsa State				Rivers State	
	Sagbama	**Kolokuma/Opokuma**	**Yenegoa**	**Ogbia**	**Abua/Odua**	**Ahoada West**
51			Yenegoa			
52			Swali-1			
53			Obogoro			
54			Akaba			
55			Ogu			
56			Ikolo			
57			Ikibiri			
58			Fangbe			
59			Ogunbiri-Ama			
60			Obolomabiri-Ama			

Note: If a community previously unidentified is encountered during the execution phase of the seismic operations, normal process of verification with the relevant Government authorities shall be carried out and the community list updated.

3.4.3: Mobilization of Contractor to Site

Seismic data acquisition survey activities last for relatively short period of time and do not involve the establishment or use of long-term facilities and structures. The contractor shall mobilize all necessary personnel, materials and equipment to site after obtaining consent for the campsites and jetties (where required). Where SPDC sites shall be used, permission shall also be obtained in addition to obtaining formal SPDC's work order for the project. Prior to mobilization, SPDC shall carry out pre-mobilization inspection of all items and personnel after which pre-mobilisation certificate would be issued. All equipment and personnel that would be involved in the seismic data acquisition activities shall be certified fit for the purpose and approved by SPDC before deployment to site. About 1,500 personnel shall be used for the seismic operation, 60% of which shall come from the communities.

3.4.4: Land Clearing - For Campsites, Fuel Dumps/Generator House, Vehicle Parking Lots and Explosives/ Magazine Sites

This process involves manual clearing for camp sites (including vehicle parking lots), fuel dumps, generator house, recording truck positions and explosives magazine sites. The crew would use either porta-cabins (trailer camps) or existing structures as office, mess and residential accommodation. This would largely minimize fresh cuttings. Although, activities in the camp site require running of generator sets as source of power, the noise level from the power-generating sets shall be routinely checked to ensure that it does not exceed 85dB(A) around the generator sets by lagging the place and providing earmuffs for staff who shall maintain the equipment.

Although all attempts would be made to re-use previously occupied sites wherever possible so as to minimize impact on the environment, suitable sites for base and field camps among other considerations will be selected/chosen with due regards to the planned seismic data production rate and the best access to the seismic lines within the project area. Established camps will accommodate the project supervisors and will be equipped with standard living and office accommodations, recreational facilities and logistics facilities including maintenance workshop, clinic, and water treatment facility and telecommunication systems.

Pictures of campsites would be taken before occupation and also after remediation and documented. Maintenance of vehicles, generator sets and line equipment would be done within the base and field camps. The campsites and locations would be proposed and SPDC agreement obtained before being put to use. Plate 3.1 shows a typical trailer camp set up.

Plate 3.1: showing a typical trailer camp set up

Plates 3.2: Examples of improvised Jetties for the purpose of workmen boat embarkation and disembarkation for water borne activities

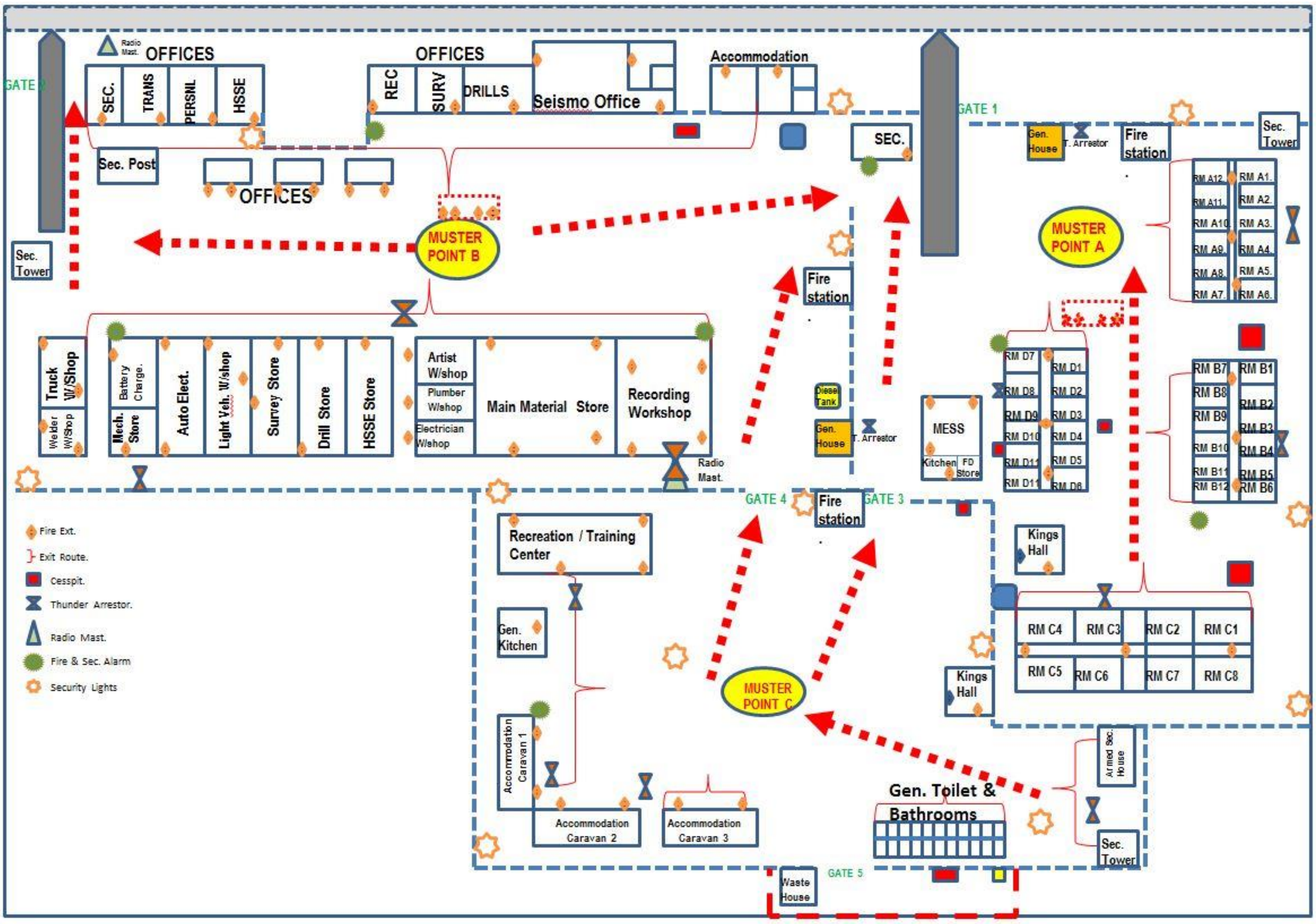


Fig 3.3: The proposed site layout of the Adibawa-Gbaran 3D Seismic Reshoot Project

On land, transportation will be by diesel powered 4 x 4 pick-ups and Bedford personnel carriers (Plate 3.3).

Pl [illegible] **picl**

In Swamp environment, transportation will be by diesel or petrol powered outboard engine (aluminium and fibre) boats (**Plate 3.4).**

Plate 3.4: Example of diesel or petrol powered outboard engine boat

3.4.5: Surveying Activities

The main tasks during survey exercise include correct positioning of shot points and receiver stations for use by the Drilling and Recording sections. This would be done by the conventional survey methods. Cutting activities for the control, receiver and source lines shall be done manually with a machete. In open areas and farmlands where there is clear line of sight between the instrument man and the man with the pole for measurements, no cutting shall be done. The planned approximate distances to be cut in linear kilometers are presented in Table 3.2.

Table 3.2: Approximate distances to be cut in linear kilometres for the survey lines

Survey lines	Distances (km)
Control lines	0.00 (These lines would be converted into Source and Receiver lines)
Receiver lines	1454.00
Source lines	4362.00

In order to minimize damage to the environment, satellite imagery maps of the area shall be used during the survey planning. Tree branches/shrubs with girth more than 15cm shall not be cut except where they pose threats to lives and equipment. The crew's Party Chief and SPDC's Company Site Representative or Operations Geophysicist shall give approval before the cutting of any tree above the approved girth size. Overhanging branches may be cut where necessary to enable workers move safely along the receiver and source lines. These seismic lines cut would create avenue for movement of men and equipment throughout the prospect. The lines will also serve as path for preparing shot holes and laying of recording equipment. The line width is usually one meter wide. The line clearers shall be supervised to ensure that the lines are not cleared to ground level. By adopting this procedure, vegetation is expected to regenerate within a short period of time. Efforts through awareness campaigns, appropriate warning signs etc. shall be made to discourage communities from converting such traverses into access routes. All forms of survey cutting in farms shall be minimized and buntings shall be used to indicate the line (traverse) direction in order to prevent seismic workers from wandering across farms. Areas of interest such as sacred areas, forest reserves, burial grounds, shrines etc. shall be identified and avoided (Plate 3.5).

Plate 3.5: Shows a typical seismic line width

Equipment Calibration

All equipment would be calibrated, tested and maintained from mobilisation phase to project completion so as to meet set tolerances.

Global Positioning System (GPS)

The Global Positioning System (GPS) is a satellite-based positioning system operated by the USA Department of Defence (DOD). This system provides all-weather, worldwide, 24-hours positioning and time information. The satellite’s broadcast signals can be tracked by receivers for positioning and navigation purposes, Global Positioning System points are required to control the entire survey network to ensure homogeneity and accuracy of the traverses. Carefully spaced out GPS stations shall be chosen to ensure easy access and freedom from other elevated obstructions such as huts, houses, trees and areas devoid of electro-magnetic interferences. GPS control positions with two witnesses each shall be used and monuments emplaced at desired positions.

Control Lines

Control lines would be cut to link up the established GPS positions. The control lines would be designed to either coincide with receiver or source lines. These control lines would then be used as receiver and source lines to minimize line cutting.

Receiver Lines

Receiver lines would be positioned using L*eica* TC1100/1001/1103 Total Station survey instruments. Receiver lines would be spaced 350m apart over the surface area from a minimum of two control points or from existing control lines. Receiver lines contain geophone and hydrophone stations (receiver stations). Receiver stations would be positioned using Total Station survey instruments. Receiver station positions along receiver lines would be spaced at an interval of 50m. The orientation of the receiver lines would be 90^0 North/South.

Source Lines

Source lines would be established in the same manner as the receiver lines using the same survey instruments. The source lines orientation would be 0^0 East/West. This means that the source lines would be established at positions perpendicular to the receiver lines. The source lines would be spaced at 350m intervals (Fig. 3.3) while the shot positions (shot points) would be spaced at 50m intervals. Shot points would be acquired using dynamite sources. Air guns will be used in the marine portion of the survey area. Shot points that fall within water bodies shall be moved to land location and explosives (dynamite and caps) used as the energy source.

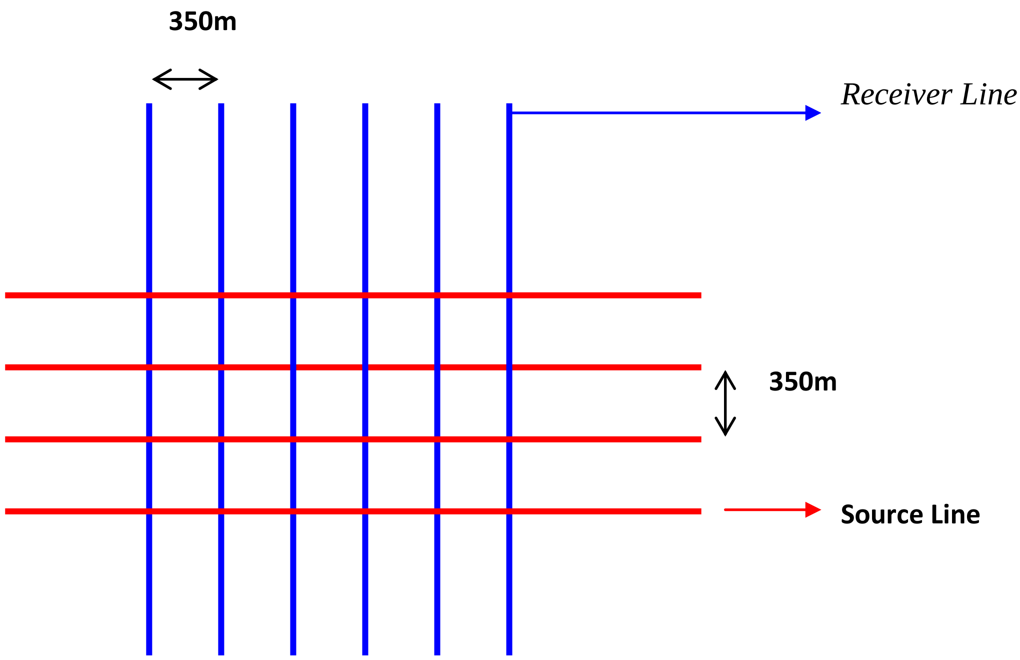


Fig. 3.3: A source and receiver line grid 350m apart that will be used during the seismic survey

Topographic Map Generation

Topographic maps are post-plot topographical maps, showing details of natural features, man-made features, vegetation and terrain conditions existing along the lines within the prospect area. In addition, the map shows the final actual position of receiver stations and shot points used in the seismic acquisition operations. On daily basis, each survey crew would submit complete and accurate line trace/omission and hazard report from both source and receiver lines. The report would clearly indicate pipeline, oil/water well, village/settlement, fish ponds, power lines, house, river, sacred/forbidden bush, roads, bridges, etc. actual position and distance to the seismic lines. The information supplied would be used to produce a topographic map at the end of the seismic campaign.

Hazard Map Generation

Hazard maps are produced from the same line trace/omission's report indicating positions where unsafe conditions or hazards were noted on the seismic lines. Features such as dangerous pits, structures and forbidden areas etc. are represented on this map and given to all sections for forward planning and distribution to the workers so that they can identify and avoid such obstacles and dangers.

3.4.6: Drilling of Shot Holes

Shot points (shot positions) shall be spaced at 50m intervals on the source lines. The drilling activity will involve clearing of shot points in some cases to a radius of about 1m. Three shot holes drilling techniques are commonly used. Thumping with steel casing and Hand augering are carried out on dry land terrain while in flooded areas and on edges of rivers, flushing technique using drilling engine would be used.

NOTE: For this campaign only single deep hole SDH rotary drilling/flushing will be done

Flushing Technique

Flushing technique utilizes the rotary drilling principle. The equipment used in this technique are, water pump, drill casings, swivel heads, clamps and hoses. The casing is fixed with a clamp at a reasonable height where it is possible for the drillers (two turners) to hold the clamp firmly, press the casing vertically down and at the same time turning it in the same direction (Plate 3.8). The casing is connected to the swivel head while the swivel head is linked to the water pump via a hose. Another hose link the water pump to the sucking mud pit. Two pits shall be made, sucking pit (0.7m x 0.7m) and cutting collector pit (0.5m x 0.5m). Environmentally friendly water based mud will be mixed with water in the sucking pit thus becoming mud (mud water). The pump will suck mud water from the sucking pit and pump it to swivel head from where it will enter the casing. The mud water being under pressure from the pump, wheel burrows into the earth as it comes into contact with it. The positioning of the casing ensures that the mud jet is directly at the point where the hole cutting is required to be made while the turning of the clamp by the drillers impact the effect of the rotary table in rotary drilling technique.

The earth material that is cut by the mud jet will be flushed out by the incoming mud through the annular space between the casing and the shot hole bore. This flushed materials mixed with the mud will flow to the cutting collecting pit. The cuttings will naturally be separated from the mud by gravity and the clean mud will flow back into the mud sucking pit. The cycle is repeated until the required depth is achieved. Water would be taken from nearby creeks and other water bodies around the area of operation for flushing. Single deep hole SDH drilling method will be adopted for the entire survey, drilled to 40 – 45m using the manual or mechanized rotary drilling machines.

Plate 3.8: A typical Single deep hole SDH rotary flushing method

Uphole logging positions would be located and acquired at 4km x 4km grid over the prospect areas. Uphole points would be flushed to 63m depths and logged to 60m depths. Where necessary to prevent hole collapse, the uphole hole would be lined with plastic casings. A harness of 11 hydrophones would be lowered into the hole. The spacing of the hydrophones on the harness would be at sampling interval of 1m, 3m, 5m, then at 5m, intervals is 5m to 30m, and 10m thereafter up to the 60m depth from the surface. A shot hole of 1m depth at 2m away from the uphole survey hole would be thumped and used for energy source. Explosive caps would be used as the source . Plastic casings where used would be recovered from the holes after logging. In situations where upholes cannot be carried out due to lack of water, Low Velocity Layer (LVL) data acquisition would be carried out using the same charge size and depth of source hole. In this case, geophones would be spaced on the ground.

The only significant difference between 6m, 40m and 60m holes flushing is the use of drilling mud in the deeper holes (40 and 60m) for holes stability. Environmentally friendly water based mud is the hole stabilizer that would be used. It would be mixed in the mud pit which will serves as a mixing tank. The mud pits would be properly back-filled and covered after flushing the holes, logging and loading as the case maybe. Human presence, noise and vibration from the pumping machine during drilling, flushing and detonation of explosive activities temporarily scare away animals within the vicinity. At the end of the activities, the animals would return to carry on with their normal life.

3.4.7: Recording Activities

This involves laying of links of Field Digitization Units (FDUs), Geophones, Hydrophones and other line equipment on the receiver lines and detonating explosives on the perpendicular source lines to generate minor energy, which is reflected and recorded on magnetic tapes via the recording instrument. The recording instrument that would be used is Sercel 428XL installed inside a recording truck (Sercel 428XL Recording System).

Geophones (Land Detectors)

Geophones are used on land to detect signals. They consist of a sensor element with coil resistance and a damping resistor sealed in a marsh case. They would be laid along the already cut and established receiver lines. Geophones are sensitive to particle motion. Two strings of geophones (18 jugs) per receiver station would be laid in a linear array centered on the surveyed peg and the plug connected in parallel to the FDU (Plate 3.10). A typical Geophone is shown in **Plate 3.9.**

Plate 3.9: A typical Geophone used for detecting signals on land

Plate 3.10: A Field Digitisation Unit

Hydrophones

This equipment measures changes in pressure as opposed to geophone that is sensitive to particle motion. Hydrophones would be used in water environment. They shall be deployed as single hydrophone units in river crossings, minor creeks and ponds of water or marshy environment. A single hydrophone unit would be placed at each peg position (receiver station). In deepwater the hydrophones would be weighted with chain links to avoid drifting. A typical hydrophone is shown in Plate 3.11.

Plate 3.11: A typical Hydrophone proposed to be used during the Seismic survey

Shooting Distances

Safe shooting distances based on Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) / Department of Petroleum Resources (DPR) shall be maintained to avoid any damage to structures. Surveyors, drillers and shooters shall be supervised to ensure compliance with minimum distances. Flagmen would be used to keep off trespassers from straying to the shot sites and control traffic on the highways and roads. Table 3.3, showed the accepted industry minimum shooting distances as defined in Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) which is published by Department of Petroleum Resources (DPR).

Table 3.3: DPR safe distances (meters) against vibration impact resulting from seismic detonations

Objects to be protected	Up to 1kg Detonation (m)	1 to 3kg Detonation (m)	3 to 6kg Detonation (m)
Pipes of any type	30	60	120
Pumping station with pipes of any type	40	60	120
Water wells of any type	100	200	$V_i$max = 12mm/sec
Dyke Structures	50	100	$V_i$max= 25mm/sec

Table 3.4: DPR minimum distances between shot point and radio transmitters

Power (Watts) From	Power (Watts) To	Minimum distances (m) from the nearest shot point
0	50	75
50	250	150
250	1,000	300
1,000	10,000	750
10,000	50,000	1,500
50,000	100,000	2,300

Explosives and Detonation of Explosives

Explosives

Standard explosives for seismic data acquisition shall be used. All shot holes shall be properly tamped to the surface after loading. In flooded terrain, charges shall be anchored in shot holes. Only seismic caps shall be utilized (Seismic Electric Detonators). Caps shall be water tight, radio proof, and have shunted lead wires. Cap bursting time shall not exceed one-fourth of the recording sampling interval, and to assure this is possible the cap specifications shall conform to the Blaster type, output energy, and signal. The seismic crew on-site storage facility shall be licensed (crew based) by Federal Ministry of Mines and Power. Specially modified vehicles (four wheel drive) and certified personnel shall be used to transport explosives to the seismic crew lines from crew storage facility.

Detonation of Explosives

Each shooting crew shall be deployed with a decoder radio shot firing system. Dynamite 2kg would be loaded into each single deep holes except Uphole points and some few cases were lower charge size might be used. Shot hole firing would be executed by MACHA® shooting system (MACHA is the product name of Macha International Incorporation, a company based in Houston, Texas, USA). This will be carried out remotely from the recording instrument via radio link using encoders. The acquisition system initiates the shooting cycle by signalling the encoder radio shot firing unit (on the recording platform) to transmit the shot release code to the shooters decoder unit in the field. The decoder and the encoder synchronize once both sides are on arm and the same privacy. After a programmed delay, the encoder issues a time-break pulse, to the acquisition system, which starts recording. At the same time the decoder unit issues a firing pulse to the blaster, which detonates the dynamite and sends Confirmatory Time Break (CTB) signal to the acquisition system.

Bad shots are shots that are fired but could not be recorded by the recording instrument in the recording truck due to break in transmission (line breaks) along the recording cables on the receiver lines. Such shot hole positions shall be moved about a meter, re-drilled and re-taken. Theoretical planned shot point positions that cannot be taken either due to obstruction (buildings, pipelines, etc) or creeks/rivers shall be moved in multiples of 50m, 100m, 150m, etc. until a safe shooting location is achieved. Proper tamping technique shall be employed to avoid blowouts. Contractual penalties for shot blowouts shall be used to ensure that proper tamping is enforced. In case of any blow out (pumping out of loosely tamped soil), deployed environmental crews shall ensure that the shot hole area is restored, cap wires etc. removed and taken to the base camp for re-cycling. Blow outs and misfires if any shall be documented and reported to DPR and NAPIMS.

Sercel 428XL Recording System

The Sercel 428XL recording system shall be used to record the generated seismic signals. Plates 3.12 and 3.13 show a recording truck and recording instrument respectively.

Plate 3.12: Picture showing a recording truck

Plate 3.13: Picture showing a recording instrument

3.5: Road Repairs and Community Assisted Projects (CAPS)

The OML 28/31 3D seismic re-shoot survey will be planned to minimize impact on existing track and farm roads within the communities. During the course of the operation, any track or farm road that is destroyed by the movement of operational heavy-duty trucks shall be repaired. Community assisted projects shall be identified and agreed upon through participatory rural appraisal. Existing stakeholder relations committee or Project Advisory Committee shall facilitate the implementation process for the projects.

3.6: Crops and other Economic trees damage Assessment and Compensation

Vegetation and any other asset inevitably damaged during the course of survey line cutting, drilling and recording operations, shall be assessed and compensation paid using Oil Producers' Trade Section (OPTS) industry recommended rate. Compensation will also be paid for inadvertently trespassed shrines and forbidden areas.

3.7: Environmental Restoration and demobilization

At the end of seismic activities, all used sites shall be restored to their pre-occupied state and documented. A site restoration certificate would be issued by SPDC to the contractor upon satisfactory restoration of the environment. Department of Petroleum Resources, Federal and State Ministries of Environment as well as local Government shall monitor the site restoration process. Cut vegetation on land and fresh water area (tropical rain forest) re-grow naturally within six months. Cut vegetation in mangrove swamps shall be re-planted through experts and community labour immediately after the seismic data acquisition campaign. The re-planted seedlings shall be monitored for a period of time.

Post Impact Assessment (PIA) will be conducted after the seismic data acquisition campaign. The above activities will involve human and equipment presence at sites. All waste handling during project execution will be in line with existing statutory and SPDC Waste Management guidelines. The existence of environmentally sensitive areas such as forest reserves, undisturbed forests, historical sites, shrines, river crossings, human settlements, farms, etc will be put into consideration during project execution. Both the contractor and SPDC will undertake continuous engagements with the communities in accordance with the well-established practices and procedures.

Demobilization: After restoration the contractor will be demobilized.

3.8: Waste Management

Wastes will be generated from the various project activities. However, the bulk of waste generated will be from logistics, offices and the Base camp area. The anticipated wastes from these activities include domestic wastes (e.g. food and trash), sanitary wastes. Details of waste types, estimated quantities that will be generated and corresponding waste management methods that will be used are provided in Table 3.5.

Table 3.5: Waste Types, Estimated Quantities and approved disposal options

Waste type	Major source	Estimated Quantities	Approved Disposal options
	SOLIDS		
Maintenance Wastes (Oil rags, Oil and fuel filters air filters)	Maintenance workshops	Varies	Shell IA Incineration yard, Port harcourt
Batteries	Maintenance workshops	130 units /year	Recycle/Reuse
Cables	Electrical maintenance	120kg/year	Recycle/Reuse
Cans and tins	Catering services	600kg/year	Eneka Landfill
Food waste	Catering services	600kg/year	Eneka composting yard
Garbage	Office/Domestic	300kg/year	Eneka waste dump
Medical waste	Site clinic	20kg/year	Shell IA Incineration yard, Port harcourt
Paper waste	Office operation	50kg/year	Reuse/Recycle
Tyres and tubes	Maintenance	Varies	Reuse/Recycle
Printer, cartridges and toners	Office operation	30kg/year	Reuse/Recycle
Shrubs/vegetation	Bush clearing	142390 Nos	Allow to biodegrade *insitu*
Trunks/stumps	Site stripping	-	Chop and stockpile
Scraps	Cut-offs/Damages	70 tons	Segregate into usable & non-usable & return to yard
	LIQUIDS		
Sewage	Domestic/Office	5000litres/month	Sewage Treatment Plant (Biological treatment)
Spent lube oil	Maintenance, logistics	960 litres/year	Reuse/Recycle
	GASES		
Emission	Generators, boat and vehicle exhaust	Varies	Reduce emission
Noise	Engines, piling	78-106 dB(A)	Wear ear protectors

3.9: Project Schedule

Mobilization to site is expected to commence by end Q4, 2015 while seismic activities are scheduled to be completed by December 2016. The project schedule is presented in Fig. 3.4.

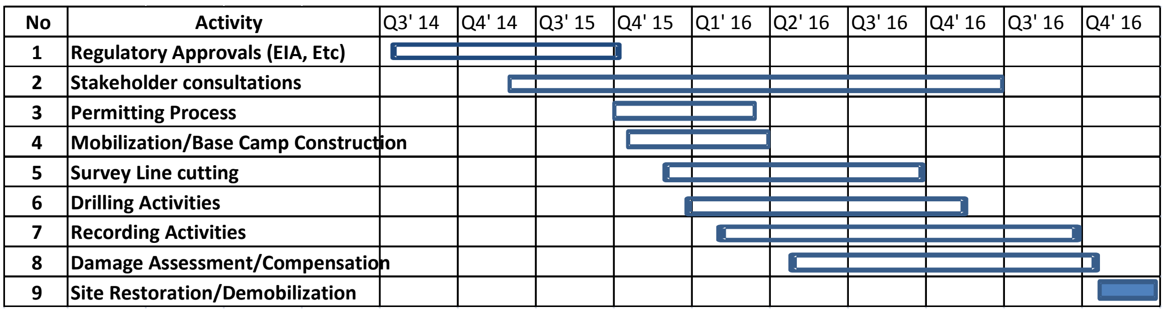


Fig. 3.4: Project plan for Adibawa-Gbaran 3D Reshoot Seismic Seismic Data Acquisition Project

CHAPTER FOUR
DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 General Study Approach

The purpose of the baseline data acquisition is to establish, before the execution of the project, the status of the various environmental components that are likely to be affected by the proposed project. The environmental components evaluated comprised biophysical, social and health. The status and sensitivities of the various ecological components of the study area were assessed from review of existing reports on baseline and Environmental Impact Assessment studies, conducted in recent times by Shell Petroleum Development Company (SPDC) for other projects within the area, and published literature.

A multi-disciplinary approach was adopted for data acquisition and ecological characterization which included climate/air quality, noise and vibration, soil, land use and agriculture, vegetation, wildlife and biodiversity, aquatic, geology and hydrogeology, socio-economics and community health status. Each of these components of the environment was sampled in accordance with DPR EGASPIN (2002) (Part VIII) D (2) Guidelines and Standards for sampling and handling of samples.

The baseline data used for the description of the environment in this report were obtained from the following documents.

- Environmental Impact Assessment (EIA) Process Manual – a manual for EIA execution in SPDC – 2000
- Previous EIA, EER and PIA studies including:
    - Environmental Impact Assessment For Gbaran Field Logistics Base (FLB)/Jetty For Gbaran/Ubie Integrated Oil & Gas Project, Final Report, July 2007;
    - Environmental Impact Assessment for The Drilling of two new Wells (E2/ E4) In Gbaran Field, June 2007;
    - Post Impact Assessment of Etegwe-Tombia Road (Final Report), April, 2008;
    - Environmental Impact Assessment of Gbaran Ubie Phase 2 Integrated Oil And Gas Project (EIA Cluster 1 – Koroama, Gbaran And Kolo Creek Fields) Final Report, October 2009;
    - Environmental Impact Assessment of Gbaran Ubie Phase 2 IOGP (EIA Cluster 3), 2010;
    - Environmental Evaluation (EE) - Based EIA Study of Gbaran Ubie Node Integrated Oil & Gas Project, 2012;
    - Environmental Impact Assessment (With Revalidated Baseline Data) of Gbaran Ubie Phase 2 Integrated Oil and Gas Project (EIA Cluster 2 – Epu Field), Final Report, March 2015;
    - Environmental Impact Assessment of Kolo Creek NAG Manifold to Soku Gas Plant Pipeline Project Final Report, July 2012;
- Library and archival documents from both SPDC and other relevant sources; and

- Accompanying Guidelines for SPDC EIA process. Data Collection III – 2004.

The entire study area was divided into four (4) Zones as in Table 4.1 (See Figure 4.1) for the purpose of sourcing data to adequately describe the existing environmental conditions in the study area.

Table 4.1: Study Zones and Past Reports Consulted

ZONE	PAST REPORTS SOURCED	YEAR
1	• Environmental Impact Assessment (With Revalidated Baseline Data) of Gbaran Ubie Phase 2 Integrated Oil and Gas Project (EIA Cluster 2 – Epu Field), Final Report	2015
2	• Environmental Impact Assessment of Gbaran Ubie Phase 2 Integrated Oil and Gas Project (EIA Cluster 1 – Koroama, Gbaran and Kolo Creek Fields) Final Report	2009
	• Environmental Impact Assessment of Gbaran Ubie Phase 2 IOGP (EIA Cluster 3)	2010
3	• Environmental Impact Assessment of Gbaran Ubie Phase 2 Integrated Oil and Gas Project (EIA Cluster 1 – Koroama, Gbaran and Kolo Creek Fields) Final Report	2009
	• Environmental Evaluation (EE) - Based EIA Study of Gbaran Ubie Node Integrated Oil & Gas Project	2012
4	• Post Impact Assessment of Etegwe-Tombia Road (Final Report)	2008
	• Environmental Impact Assessment For Gbaran Field Logistics Base (Flb)/Jetty For Gbaran/Ubie Integrated Oil & Gas Project, Final Report	2007a
	• Environmental Impact Assessment for the Drilling of two New Wells (E2/ E4) in Gbaran Field	2007b
	• Environmental Impact Assessment of Kolo Creek NAG Manifold to Soku Gas Plant Pipeline Project Final Report	2012

Figure 4.1 shows the sampling clusters for data acquisition for the description of the baseline status of the area.

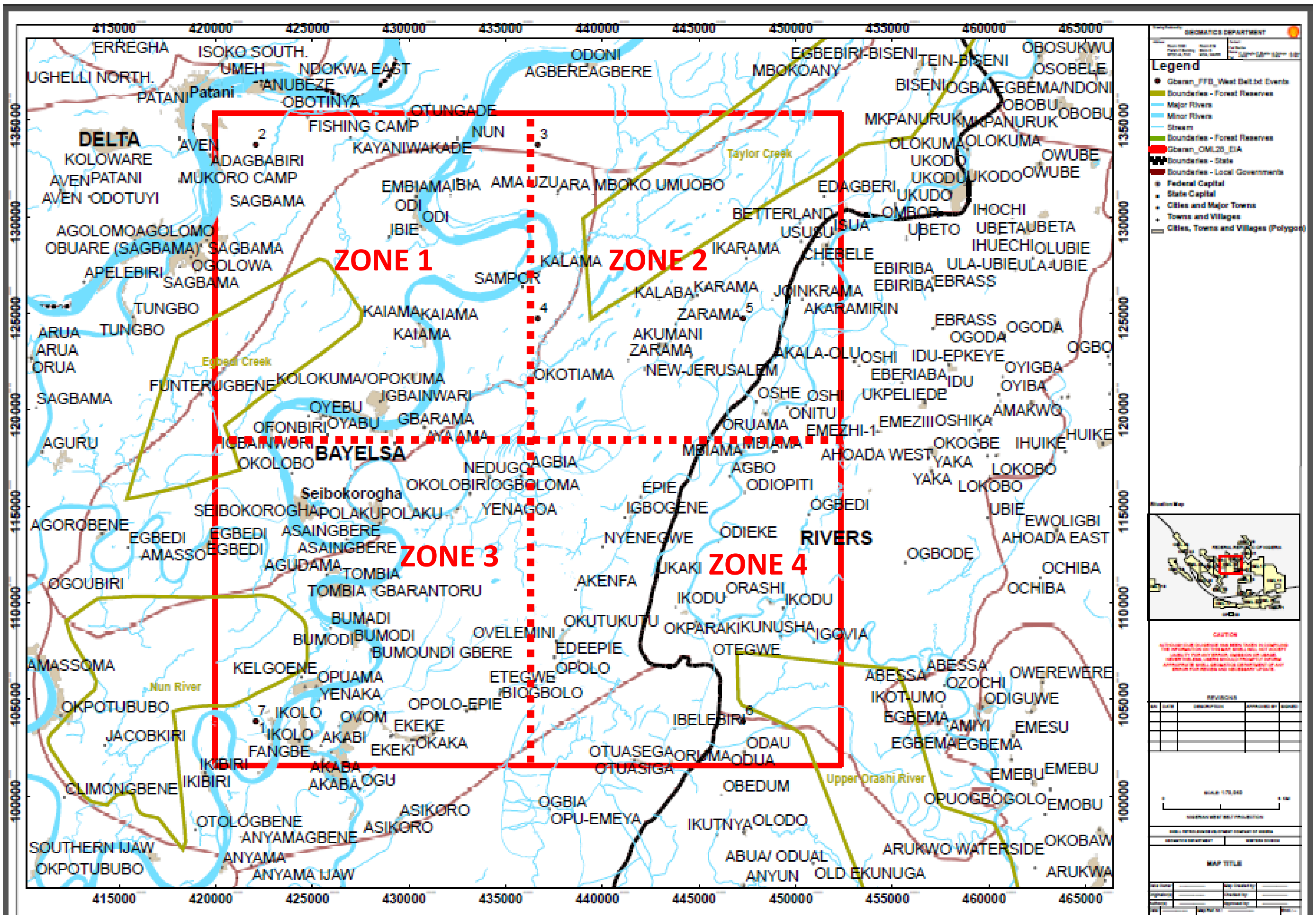


Fig. 4.1: Map of the study area showing the sampling stations from various studies (The Red Square covers the EIA Area)

Quality Assurance/Quality Control

The Quality Control (QC)/Quality Assurance (QA) programmes for all the reports used covered all aspects of the study, including sample collection and handling, laboratory analyses, coding, storage, data analyses and report preparation. The quality assurance programme employed in the fieldwork and laboratory analyses were in accordance with the recommendations by DPR (2002) and FMEnv (1991).

4.2: Baseline Data Acquisition Methods

Table 4.2 summarises the methods and instruments used for sampling and analyzing the various environmental components identified.

Table 4.2: Environmental Components and Methods/Instruments used for Sampling/measurement/analysis

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
METEOROLOGY	Temperature	ThermoAnemometer	°C
	Windspeed & Direction	ThermoAnemometer and windvane	m/s,
	Rainfall Pattern/Distribution	CIBA-CORNING hygrometer	%
AIR QUALITY	Suspended Particulate Matter	Microdust pro Monitor	Mg/m^3
	Nitrogen Oxides	ToxiRae	ppm
	Sulphur Oxides	ToxiRae	ppm
	Carbon Monoxides	Gastella Monitor	ppm
	VOC/HC	Photoionization Detector	ppm
	Heavy Metals		
NOISE	$L_{Aeq,90}$	Sound Level Meter	dB(A)
SOIL	Fixed Methodology	Sampling with a stainless steal auger	
	pH	pH meter	
	Electrical conductivity	Hilgar portable conductivity meter.	µS/cm
	Mechanical Analysis	Hydrometer method	
	Organic carbon	Wet combustion method	%
	Available Phosphorus	Ascorbic and acid-molybdenum blue colour method	mg/kg
	Total Nitrogen	Micro-kjeloahl digestion method.	mg/kg
	Exchangeable Bases	By Extraction within ammonium acetate	
	Exchangeable Acidity (EA)	KCL method	
	Effective Cation Exchange Capacity (ECEC)	By summation of exchangeable cation and exchangeable acidity	
	Base Saturation	% B.Sat. = $\frac{(ECEC - EA) X 100}{ECEC}$	
	Ammonium (NH_4)	Alkaline Pherate method	
	Nitrate and Nitrite	Brucine method and Alpha-naphthol method respectively.	mg/kg
	Sulphate	Turbidometric method	mg/kg
	Heavy metals	Agemcan and chan method	mg/kg
	Hydrocarbon content	Extraction with carbon tetrachloride	mg/kg
VEGETATION		Reconnaisance survey and Ground – truthing, Sampling with quadrant, information from existing literature and oral interviews.	
SURFACE/GROUND WATER		Water sampling with hydrobios water sampler	

ENVIRONMENTAL COMPONENT	**PARAMETER**	**EQUIPMENT**	**UNIT**
	Temperature	*In situ* Measurement with Mercury - in-glass thermometer for surface water and temperature probe for sub surface water from the bottom.	^{o}C
	pH	*In situ* Measurement with a HACH-one pH meter	
	Total, Dissolved and Suspended Solid	Gravimetric method for total solids (TS), *In situ* measurement with HACH dissolved solid meter for dissolved solids (DS) and TS-DS gives suspended solids	mg/l
	Total Alkalinity	HACH Digital Titration method	mg/l
	Dissolved Oxygen	Azide modification of Winkler method	mg/l
	Biological oxygen Demand (BOD_5)	Winkler method	mg/l
	Total Hydrocarbon Content (THC)	Extraction with CCL_4	mg/l
	Conductivity	*In situ* measurement with a HACH Portable Conductivity Meter.	
	Salinity	*In situ* measurement with oceanographic salinity measuring Bridge or Laboratory measurement using Harvey's titrimetric method	‰
	Sulphate	Modified Turbidometric method	mg/l
	Available Reactive Phosphorus	Stannous chloride method	mg/l
	Nitrate and Nitrite	Hach modification of the Cadmium reduction method	mg/l
	Sodium and Potassium	Flame Photometry	mg/l
	Calcium	EDTA Titration method	mg/l
	Heavy metals	Flame Atomic Absorption Spectrophotometry	mg/l
SEDIMENTS	Colour, Texture, Temperature, pH, Redox potential, THC, Oil & Grease , Sediment geochemistry (Fe, Ni, V, Cd, Cr, Pb, Zn, Hg), Sediment microbiology	Composite grab samples for laboratory analysis (Extraction, AAS)	
MICROBIOLOGY	Total heterotrophic bacteria, fungi, Total	Composite samples for laboratory analysis	

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
	hydrocarbon bacteria and fungi, total and faecal coliforms.		
HYDROBIOLOGY/ECOLOGY	Species composition, distribution, diversity and abundance and seasonality of Phytoplankton, Zooplankton, Benthos, Aquatic macrophytes, Macrophyte-associated macrofauna	Composite samples collected by plankton nets and Ekman grab for laboratory analysis	
FISHERIES	Species composition, catch-composition, Fisheries activities (including aquaculture) catch-per-unit of effort and price, fishing gears/methods, population in fisheries, spawning grounds, migration routes and patterns, productivity and pathology.	Direct observations/interview, *In situ* measurements, composite samples for laboratory analysis	
WATER USE	Traditional use of rivers and water bodies (navigation, sand mining, food processing, aquaculture, domestic etc)	Direct observation/ interviews	
BIODIVERSITY STATUS & ISSUES RELEVANT TO BIODIVERSITY **Conservation**	Conservation status (rare, threatened and endangered species), conservation areas (forest reserves etc), environmentally sensitive areas – wetlands and swamps), local conservation practices.	*In situ* observation, interviews, secondary data	
SOCIO-ECONOMIC STUDIES	Socio-economic Parameters		
Social Environment	Social Infrastructure Cultural Properties,	Key informant interviews, Focus Group Discussion (FGD), direct	

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
	Natural Resources and Land Use, Perception of the project, The role of women and children, Physically Challenged, Social Structure and Organisation, Vehicular Traffic Analysis, Sex Trade	observation, Administration of structured questionnaires and Collection of secondary data.	
Health Studies	Demographic profile of the Communities, Morbidity/Mortality Patterns, Healthcare facilities, Nutritional Status of Under-fives and the general population, Maternal and Child Health, Knowledge, Attitude Practice and Behaviour (KAPB), Environmental health factors,	Key informant interviews, FGD, Administration of structured questionnaire and interviews, Physical examination of volunteers, Walk-through survey and Collection of secondary data.	

The details of the methodology of data acquisition for each of the environmental components listed above are discussed in Appendix 4.1.

4.3 Baseline Environmental Conditions

4.3.1 Climate and Air Quality

The study area traverses Bayelsa State and Rivers State, situated in the Niger Delta region, which falls within the typical humid tropical climatic zone which is influenced by two dominant seasons, the wet or rainy and dry seasons. The two climate regimes depend on the two dominant air masses: the tropical continental air mass of Saharan origin, and the tropical maritime air mass blowing from the Atlantic at different times of the year. Meteorological data presented in the following sub-sections is based on literature review/desktop study and in situ measurements conducted during the two-season data gathering exercise.

Rainfall

Rainfall in the study area was monitored from the Port Harcourt Meteorological centre of the Nigerian Meteorological Agency (NIMET) from 1990 to 2010. Table 4.3.1.1 summarizes the mean monthly rainfall in the study area and reveals that there was precipitation in each of the months of the year, while Figure 4.3.1.1 illustrates the mean monthly values for the period, which ranged between 23.1 mm and 365.6 mm. Two distinct seasons can be distinguished: the high rainfall /wet season (April – October) and the low rainfall/dry season (November – March). The rainfall intensity peaks in July (365.6 mm) and abates significantly from December to January (24.7 mm – 23.1 mm), the so-called harmattan period.

Table 4.3.1.1: Monthly Maximum Rainfall (mm) in the study Area

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1991	0	80.9	105	107.5	432.1	256.5	360.2	310.1	139.1	171.6	111.1	20.3
1992	61.1	0	178	89.9	178.8	170.2	388.5	271.1	260.3	271.5	87.9	13.7
1993	0	43	158	247.5	138.5	326.8	438.5	426	368.7	266.8	147	20.9
1994	37.4	66.8	80.9	128.9	372.6	256.3	462.3	314.3	342	218.8	93.9	0
1995	79.6	15.6	118.3	120.1	362.5	246.6	393.6	333.6	319.6	413.1	72.9	53
1996	0	130.4	113.9	320.9	373.6	160.5	241.3	229.4	478	272.8	22.8	5.9
1997	23.3	18.6	96.4	174.5	380.1	353.1	360	305.6	207.4	133.2	247.7	29.9
1998	22.6	36.9	87.6	188	279.1	414.6	369.8	247.3	489.1	265.4	136.7	32
1999	40.9	52.1	106.6	186.4	291.6	232.9	294.1	257.4	453.5	510.6	73.5	0
2000	11.6	7.2	59.2	190.2	202.3	181.5	420.4	245.4	454.9	153.1	51.6	16.9
2001	31.3	2.4	156.2	118.2	314.7	245.2	336.9	309.9	365.3	137.2	108.1	28.1
2002	0	79	75.8	103.3	117.5	324	285.4	556.7	265.4	283.5	67	28.1
2003	17.3	86.2	93	169.3	174.2	254.7	480.9	206.4	535.3	239.6	98.6	4.1
2004	1.8	46.5	50.7	120.7	132.8	243.7	399.6	210.1	352.4	218.1	95.7	5.4
2005	17.1	85.9	170.8	121.4	247.3	383.4	253.9	228.6	284.2	195.2	28.7	38.7
2006	39.7	103.7	95.6	58.6	407.4	360.3	392.6	267.8	557.3	291.4	4.5	0.0
2007	0.0	78.0	93.2	168.8	290.1	445.9	500.9	455.1	366.9	299.2	145.1	105
2008	2.4	0.0	142.4	228.4	196.6	194.8	285.1	389.2	375.5	142.4	63.5	87.5
2009	61.3	67.6	120.1	156.9	312.9	351.1	440.3	391.9	213.5	372.2	77.6	0.0
2010	14.6	102.0	42.8	202.6	239.9	366.4	208.2	247.5	454.1	178.5	105.9	4.2
Mean	**23.1**	**55.1**	**107.2**	**160.1**	**272.2**	**288.4**	**365.6**	**310.2**	**364.1**	**251.7**	**92.0**	**24.7**

Source: Nigerian Meteorological Agency (NIMET) Station, Port Harcourt, 2011

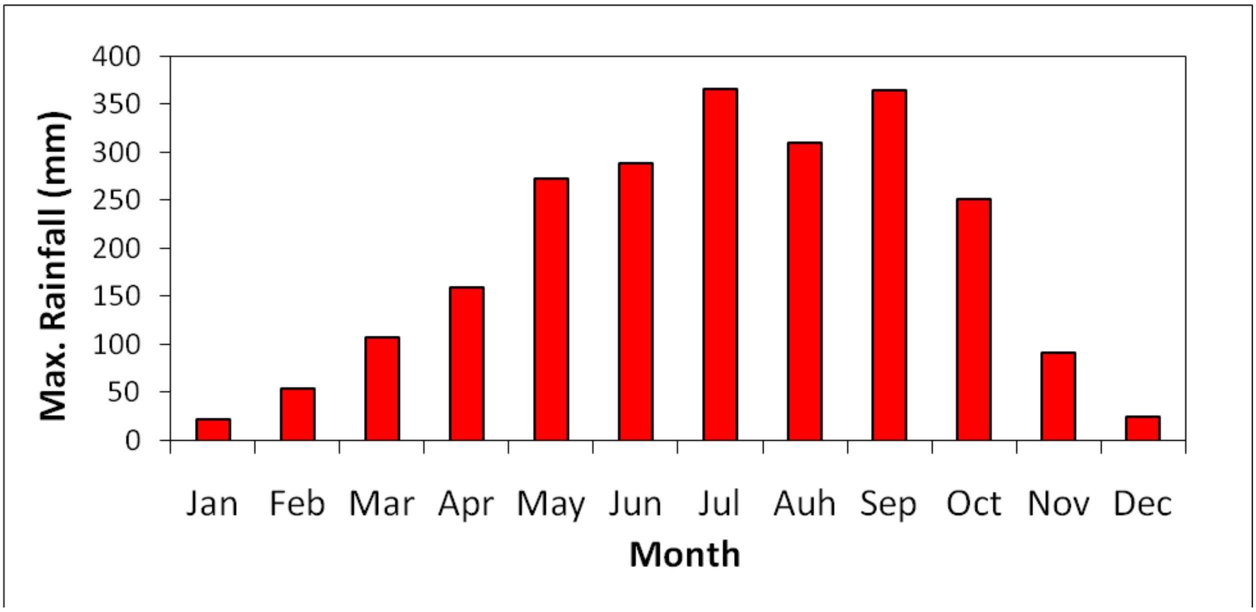


Fig. 4.3.1.1: Mean monthly rainfall in the study area

Source: Nigerian Meteorological Agency (NIMET) Station, Port Harcourt, 2011

Temperatures

Data on the monthly temperature variations within the Adibawa-Gbaran Seismic reshoot area were again obtained from NIMET (2011). Table 4.3.1.2a and 4.3.1.2b illustrate the monthly minimum and monthly maximum temperatures in the study area.

Table 4.3.1.2a: Monthly Minimum Temperatures (^oC) in the Study Area

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1994	22.5	24.7	24.8	24.6	23.7	23.3	23.2	23.3	23.5	23.3	23.7	20.8
1995	23	24.5	24.9	24.8	23.6	23.7	23.7	22.7	23.1	22.6	23.5	23.3
1996	23.9	24.9	24.9	24.2	24.3	23.7	23	23	22.8	23.1	24	24.3
1997	23.7	21.2	24.2	23.5	23.5	23.6	22.7	23.3	23.7	23.2	23.9	99.9
1998	21.1	21.9	23.5	23.4	23.6	23.4	22.8	23.4	23.5	23.4	32.7	23.1
1999	22.7	24.4	24	24.6	23.6	23.3	22.9	23.1	22.9	22.8	24.4	23.5
2000	24.1	23	24.7	24.4	24.1	24.1	22.9	22.9	23.1	22.9	24.5	23.4
2001	22.2	23.4	24.3	24.2	24.2	24	23.4	23.1	23.5	23.1	24.5	23.3
2002	22.6	23.5	25	24.4	24	23.2	23.4	23.1	23.2	23.4	24.4	22.9
2003	24	25.4	24.7	24.5	24.2	23.3	-	-	25.2	23.7	24.3	23.5
2004	24	24.4	25.5	24.8	23.9	23.9	23.3	23.3	23.1	-	23.2	23
2006	24	24	23	24	23	23	23	23	22	-	23	22

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2007	20	24	24	23	23	23	23	23	23	22	23	22
2008	21	22	23	23	23	22	22	23	23	22	24	22
2009	23	23	24	24	24	23	23	23	23	23	23	23
2010	23	24	24	24	24	24	23	23	23	23	23	22
Mean	**23**	**24**	**24**	**24**	**24**	**23**	**23**	**23**	**23**	**23**	**24**	**28**

Source: Nigerian Meteorological Agency (NIMET) Station, Port Harcourt, 2011

Table: 4.3.1.2b: Monthly Maximum Temperatures (^oC) in the Study Area

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1994	33	34.2	34.2	33.2	33	31.1	29.2	28.9	29.8	31.6	31.1	33.7
1995	33.4	34.4	34.2	33.4	32.4	31.3	29.1	29.4	30.1	30.8	33.2	32.8
1996	32.7	33.1	33.3	32.9	32.5	30.9	29.1	29	28.8	30.5	33.2	32.7
1997	32.8	34.1	32.8	32	31.8	30.1	28.8	29.4	30.4	31.2	33.3	32.6
1998	32.5	34.2	33.3	32.2	31.5	31.1	29.1	29.6	30.1	32.4	32.7	32.3
1999	32.2	32.6	33.5	33	32.5	30.8	28.1	29.5	28.7	29.7	32.5	33.5
2000	33	33.8	34.7	33.2	32.5	30.6	28.4	28.1	29.7	29.9	32.6	33.3
2001	32.8	34.1	33.9	32.7	32.3	30.6	29.7	27.9	29.7	30.1	32.8	33.4
2002	33.1	34.6	33.2	32.5	32.3	30.5	29.2	28.7	28.9	30.3	32.6	33.4
2003	33.1	34.7	33.8	33.1	32.5	30	-	-	30	32.1	32.9	32.4
2004	32.8	34.2	34.5	32.7	31.6	30.9	28.7	28.5	30.4	-	31.4	33.2
2006	34	34	34	34	32	32	30	29	29	31	32	34
2007	35	35	34	32	32	30	30	30	30	30	31	32
2008	32	36	34	33	32	30	30	30	30	31	33	33
2009	33	33	34	32	32	31	29	28	30	31	32	34
2010	35	35	34	34	32	30	30	29	30	31	32	33
Mean	**33**	**34**	**34**	**33**	**32**	**31**	**29**	**29**	**30**	**31**	**32**	**33**

Source: Nigerian Meteorological Agency (NIMET) Station, Port Harcourt, 2011

Figure 4.3.1.2 compares the mean minimum and mean maximum temperatures within the study area. The plots show that the temperature maxima peaked at 34 ^{o}C in February-March and dropped to 29^{o}C in the wet season (July and August).

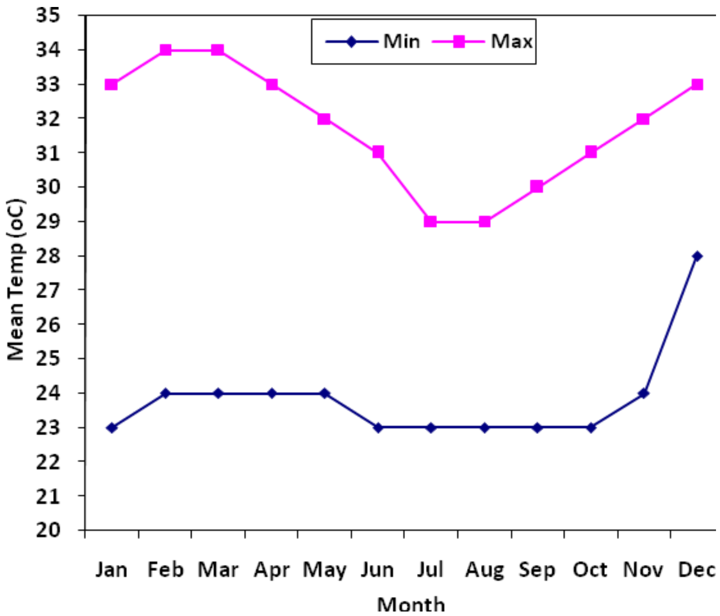


Fig. 4.3.1.2: Mean monthly minimum - maximum temperatures in the study area
Source: Nigerian Meteorological Agency (NIMET) Station, Port Harcourt, 2011

Relative Humidity

Other climatic data for the period 2002-2011 are presented in Table 4.3.1.3. These include the relative humidity, wind speed, wind direction, cloud cover and atmospheric pressure.

Table 4.3.1.3: Long-term Climatic Data for the Study Area (2002-2011)

S/No	Month	R/H(%)	Wind Speed (m/s)	Wind Dir.	Cloud Cover (oktas)	Pressure (mbar)
1	January	74	2.94	NE	6.9	1006.3
2	February	77	2.6	E	6.8	1005.7
3	March	80	3.5	SW	6.9	1005.5
4	April	83	3.3	SW	6.9	1005.7
5	May	86	4.2	SW	6.9	1007.1
6	June	88	4.2	SW	7	1008.7
7	July	90	4.9	SW	7	1009.6
8	August	90	4.8	SW	7	1009.2

S/No	Month	R/H(%)	Wind Speed (m/s)	Wind Dir.	Cloud Cover (oktas)	Pressure (mbar)
9	September	90	4.2	SW	7	1008.8
10	October	89	3.6	SW	6.9	1007.5
11	November	85	2.6	NE	6.8	1006.6
12	December	78	2.8	NE	6.8	1006.5

Source: Nigerian Meteorological Agency (NIMET) Station, Port Harcourt, 2011

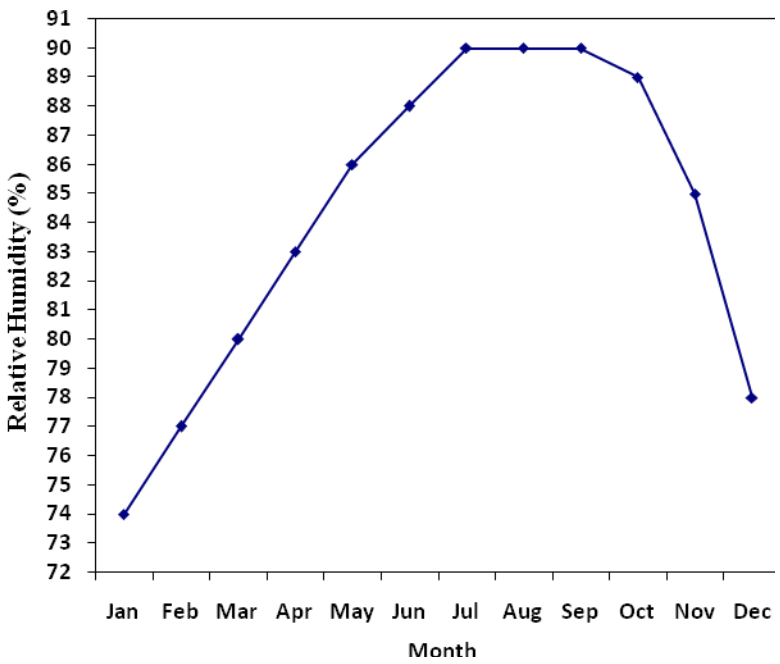


Fig. 4.3.1.3: Mean monthly relative humidity in the study area for the period 2002-2011
Source: Nigerian Meteorological Agency (NIMET) Station, Port Harcourt, 2011

Relative humidity measures the quantum of moisture in the atmosphere, with high relative humidity corresponding to high atmospheric moisture content. The plot in Figure 4.3.1.3 shows succinctly that the monthly relative humidity values peaked at 90% in the cooler wet season months of July - September and dropped in the warmer dry season. Relative humidity is normally highest around dawn and lowest in the afternoon.

Wind Speed/Wind Direction

Table 4.3.1.3 shows wind speeds to be fastest in July (4.9 m/s) slowest in February and November (2.6 m/s). This implies that fast winds are associated with the wet months (May-September) and slower wind speeds occur during the dryer months (November – March). Wind speed measured in the in situ in the study area (January, 2015) ranged from 0.7 - 5.3

m/s, with mean speed of 1.39 m/s. In terms of wind direction, the south-westerly wind dominated between March-October, with the north-easterly winds becoming more pronounced around November-February (Fig. 4.3.1.2).

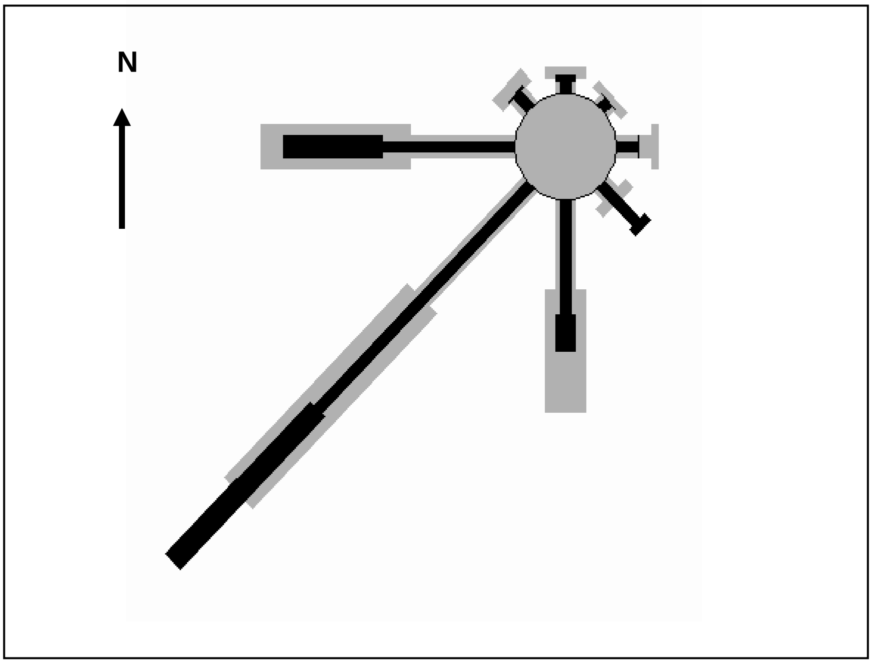


Fig. 4.3.1.4: Wind Rose of the Study Area
Source: SPDC (2009, 2015)

Air Quality Parameters
Increasing amounts of potentially harmful gases and particles are continuously emitted into the atmosphere resulting in damage to human health and the environment globally. With increasing environmental awareness and the urgent need to develop more environmentally friendly processes, it has become important to establish the ambient atmospheric condition of an area prior to commencement of any development project in order to monitor any changes or future environmental impacts of the project.

Field measurements of the ambient air quality often considers such parameters as suspended particulate matter (SPM), carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulphide (H_2S), ammonia (NH_3), volatile organic compounds (VOCs) and methane (CH_4) etc. Suspended particulate matter (SPM), are finely divided solid or liquid particles with diameter 0.01 to 100 µm. These could be either organic or inorganic species, including ultra-fine grained particles, dust, sand, metals, wood particles, diesel exhaust, coal fly ash, etc. They are considered very critical air pollutants. SPM are categorised into PM-10 and PM-2.5, corresponding to mean particle sizes 10 µm 2.5 µm respectively. These particles, when present above tolerable limits in the atmosphere can irritate the mucous membranes and may initiate a variety of respiratory diseases.
Sulphur dioxide (SO_2) and sulphur trioxide (SO_3) are the two oxides of sulphur of most interest in air quality studies. The SO_2 is often measured during environmental assessments since it is relatively stable in the atmosphere unlike SO_3. Moreover, SO_2 in the atmosphere

reacts with moisture to produce acid rain. It is a colourless gas that is produced from volcanoes, oceans, biological decay and forest fires releases. SO_2 can also be released into the atmosphere via fossil fuel combustion, smelting, manufacture of sulphuric acid, incineration of refuse and production of elemental sulphur (Ukpebor *et al.*, 2004). Health effects associated with this oxide includes breathing problems, respiratory illness, alterations in pulmonary defences and aggravation of existing cardiovascular disease.

Carbon II oxide (CO) also calledcarbon monoxide is a colorless, odourless, tastelessand toxic gas. Carbon monoxide is formed in nature by photochemical reactions in the troposphere, as well as from volcanoes, brush fires, and other forms of incomplete combustion of carbonaceous materials or fossil fuels. A significant proportion of atmospheric CO comes from fuel combustion engines. Its adverse health effect results from replacing oxygen in the bloodstream and forming carboxyhemoglobin (COHb).

Oxides of nitrogen (NO_x) are also produced by the oxidation of atmospheric molecular nitrogen N_2 at high temperature in the presence of oxygen. (Ukpebor&Okolo, 2002). Nitric oxide (NO) and nitrogen dioxide (NO_2) are the two major toxic oxides of interest. NO is rapidly formed by partial oxidation of nitrogen and is usually emitted from the combustion engine exhaust. It is however unstable and quickly oxidizes to NO_2. Nitrogen dioxide (NO_2) is a reddish-brown gas with a pungent and irritating odour and acts mainly as an irritant affecting the mucosa of the eyes, nose, throat, and respiratory tract. It transforms in the air to form gaseous nitric acid and toxic organic nitrates.

The results of the air-quality measurements made at the various zones within the study area are shown in Tables 4.3.1.4a – 4.3.1.4d. More detailed data can be found in Appendix 4.3.1a.The results indicate that SPM concentrations in the ambient air of the study area for both wet and dry seasons range between 3.0 and 10.0 $\mu g/m^3$, whereas the indoor values varied from 4.0 to 8.0 $\mu g/m^3$. The mean concentration recorded (8.0$\mu g/m^3$; outdoor and 6.38 $\mu g/m^3$; indoor) all fall below Nigerian ambient air quality standards (NAAQS) of 250 $\mu g/m^3$ (daily average of hourly values) and 600 $\mu g/m^3$ (concentration not to be exceeded for more than once a year) (FEPA, 1991). The observed ambient (<0.1$\mu g/m^3$ and 19.9 $\mu g/m^3$) and indoor (0.1$\mu g/m^3$ and 39.7 $\mu g/m^3$) concentrations of SO_2 measured in the study area for wet and dry seasons were well below DPR daily mean values of 100 – 150 $\mu g/m^3$. Hence the area had negligible SO_2 concentration at the time of sampling. NO_x was not detected in the ambient environment within the study area, while small amounts (<1.0 - 14.2 $\mu g/m^3$) were detected in some indoor locations. All of the parameters tested were also found to be within the FMEnv and DPR permissible limits listed in Table 4.3.1.5.

4.3.1.1 ZONE 1

Typical air quality parameter levels in Zone 1 area are listed in Table 4.3.1.4a. Oxides of sulphur in the outdoor ranged from 0.10 – 19.9 µg/m^3 across both seasons, while oxides of nitrogen only occurred in the indoor environment in the dry season. Suspended particulate matter ranged from 3.0 – 10 µg/m^3 outdoors and 4.00 – 5.50 µg/m^3 indoors.

Table 4.3.1.4a: Some Air Quality Parameter Levels in the Zone 1 Area

Sample Station	Season	Sample Station	SO_x (µg/m^3)	NO_x (µg/m^3)	CO (µg/m^3)	H_2S (µg/m^3)	C_xH_x (µg/m^3)	O_2 (µg/m^3)	SPM (µg/m^3)	Noise dB(A)
ZONE 1	**Wet Season**	**Outdoor**	**12.46**	**<0.1**	**<0.1**	**0.53**	**<0.1**	**21.12**	**8.0**	**63.15**
		SD	10.25	<0.1	<0.1	0.56	<0.1	0.03	2.32	5.45
		Minimum	0.10	<0.1	<0.1	0	<0.1	21.10	3.0	52.1
		Maximum	19.90	<0.1	<0.1	1.10	<0.1	21.18	10.0	69.8
		Indoor	**22.38**	**3.55**	**7.60**	**1.08**	**<0.1**	**21.14**	**6.38**	**63.59**
		SD	7.00	6.57	21.50	1.14	<0.1	0.05	1.41	6.03
		Minimum	19.90	0	0	0	<0.1	21.10	4.00	58.00
		Maximum	39.70	14.20	60.80	3.20	<0.1	21.20	8.00	75.90
ZONE 1	**Dry Season**	**Outdoor**	**19.90**	**<0.1**	**<0.1**	**<0.1**	**<0.1**	**21.08**	**7.00**	**61.97**
		SD	0	<0.1	<0.1	<0.1	<0.1	0.03	1.00	6.30
		Minimum	19.90	<0.1	<0.1	<0.1	<0.1	21.04	6.00	55.8
		Maximum	19.90	<0.1	<0.1	<0.1	<0.1	21.10	8.00	68.4
		Indoor	**19.90**	**<0.1**	**<0.1**	**<0.1**	**<0.1**	**21.05**	**5.25**	**63.10**
		SD	0	<0.1	<0.1	<0.1	<0.1	0.07	0.35	2.40
		Minimum	19.90	<0.1	<0.1	<0.1	<0.1	21.00	5.00	61.40
		Maximum	19.90	<0.1	<0.1	<0.1	<0.1	21.10	5.50	64.80
		FMEnv limits	26	75-113	11.4				250	90
		WHO limits	100-150	150	10				150-230	

Source: SPDC, 2015

4.3.1.2 ZONE 2

Typical air quality parameter levels in the Zone 2 area are listed in Table 4.3.1.4b. Oxides of sulphur ranged from 2.6 – 19.9 µg/m^3 across both seasons, while oxides of nitrogen were not detected in this zone. Suspended particulate matter ranged from 1.15 – 1.95 µg/m^3 outdoors and 0.13 – 1.10 µg/m^3 indoors.

Table 4.3.1.4b: Range of Air Quality Parameter Levels in the Zone 2 Area

Sample Station	Season	Sample Station	SO_x ($\mu g/m^3$)	NO_x ($\mu g/m^3$)	CO ($\mu g/m^3$)	VOC ($\mu g/m^3$)	SPM ($\mu g/m^3$)	Noise dB(A)
ZONE 2	Dry Season	**Outdoor**	**3.12**	**<0.1**	**<0.1**	**<0.1**	**1.51**	**61.84**
		SD	1.16	<0.1	<0.1	<0.1	0.23	17.37
		Minimum	2.6	<0.1	<0.1	<0.1	1.26	49.56
		Maximum	5.2	<0.1	<0.1	<0.1	1.85	76.50
		Indoor	**<0.1**	**<0.1**	**<0.1**	**<0.1**	**0.63**	**61.49**
		SD	<0.1	<0.1	<0.1	<0.1	0.38	3.83
		Minimum	<0.1	<0.1	<0.1	<0.1	0.13	57.60
		Maximum	<0.1	<0.1	<0.1	<0.1	1.08	69.40
ZONE 2	Wet Season	**Outdoor**	**19.90**	**<0.1**	**<0.1**	**<0.1**	**1.55**	**43.42**
		SD	0	<0.1	<0.1	<0.1	0.35	18.9
		Minimum	19.90	<0.1	<0.1	<0.1	1.15	27.00
		Maximum	19.90	<0.1	<0.1	<0.1	1.95	70.50
		Indoor	**19.90**	**<0.1**	**<0.1**	**<0.1**	**0.70**	**47.77**
		SD	0	<0.1	<0.1	<0.1	0.33	15.30
		Minumum	19.90	<0.1	<0.1	<0.1	0.3	27.40
		Maximum	19.90	<0.1	<0.1	<0.1	1.1	66.80
		FMEnv limits	26	75- 113	11.4	160	250	90
		WHO limits	100-150	150	10		150-230	

Source: SPDC, 2010

4.3.1.3 ZONE 3

Typical air quality parameter levels in Zone 3 area are listed in Table 4.3.1.4c. Oxides of sulphur ranged from 0 – 5.20 $\mu g/m^3$ across both seasons, while oxides of nitrogen were undetected in the area. Suspended Particulate Matter ranged from 1.26 – 21.0 $\mu g/m^3$ outdoors and 0.13 – 1.18 $\mu g/m^3$ indoors.

Table 4.3.1.4c: Range of Air Quality Parameter Levels in the Zone 3 Area

Sample Station	Season	Sample Station	SO_x ($\mu g/m^3$)	NO_x ($\mu g/m^3$)	CO ($\mu g/m^3$)	VOC ($\mu g/m^3$)	SPM ($\mu g/m^3$)	Noise dB(A)
ZONE 3	Dry Season	**Outdoor**	**3.12**	**<0.1**	**<0.1**	**<0.1**	**9.10**	**59.61**
		SD	1.16	<0.1	<0.1	<0.1	5.84	11.64
		Minimum	2.6	<0.1	<0.1	<0.1	3.60	46.50
		Maximum	5.2	<0.1	<0.1	<0.1	21.0	83.10
		Indoor	**<0.1**	**<0.1**	**<0.1**	**<0.1**	**0.63**	**61.49**
		SD	<0.1	<0.1	<0.1	<0.1	0.38	3.83
		Minimum	<0.1	<0.1	<0.1	<0.1	0.13	57.60
		Maximum	<0.1	<0.1	<0.1	<0.1	1.08	69.40
ZONE 3	Wet Season	**Outdoor**	**0.01**	**<0.01**	**<0.1**	**0.79**	**1.51**	**74.12**
		SD	0.007	<0.01	<0.1	0.23	0.23	2.72
		Minimum	0	<0.01	<0.1	0.58	1.26	70.50
		Maximum	0.02	<0.01	<0.1	1.06	1.85	76.65
		Indoor	**<0.1**	**<0.1**	**<0.01**	0.16	0.72	61.49

		SD	<0.1	<0.1	<0.1	0.06	0.34	3.83
		Minumum	<0.1	<0.1	<0.1	0.08	0.16	57.6
		Maximum	<0.1	<0.1	<0.1	0.28	1.18	69.4
		FMEnv limits	26	75- 113	11.4	160	250	90
		WHO limits	100-150	150	10		150-230	

Source: SPDC (2009, 2015)

4.3.1.4 ZONE 4

Typical air quality parameter levels in Zone 4 area are listed in Table 4.3.1.4d. Oxides of sulphur ranged from 0.05 – 0.7 μg/m^3 across both seasons, while oxides of nitrogen only occurred in the outdoor environment in the dry season (0.05 – 1.5 μg/m^3). Suspended particulate matter ranged from 0.015 – 85.6 μg/m^3 outdoors and 0.03 – 1.16 μg/m^3 indoors.

Table 4.3.1.4d: Range of Air Quality Parameter Levels in the Zone 4 Area

Sample Station	Season	Sample Station	SO_x (μg/m^3)	NO_x (μg/m^3)	CO (μg/m^3)	VOC (μg/m^3)	SPM (μg/m^3)	Noise dB(A)
ZONE 4	Dry Season	**Outdoor**	0.34	0.41	<0.1	**<0.1**	**11.94**	**59.61**
		SD	0.21	0.5	<0.1	<0.1	29.95	11.64
		Minimum	0.05	0.05	<0.1	<0.1	0.015	46.50
		Maximum	0.7	1.5	<0.1	<0.1	85.6	73.10
		Indoor	<0.1	<0.1	<0.1	**<0.1**	**0.63**	**61.49**
		SD	<0.1	<0.1	<0.1	<0.1	0.38	3.83
		Minimum	<0.1	<0.1	<0.1	<0.1	0.13	57.60
		Maximum	<0.1	<0.1	<0.1	<0.1	1.08	69.40
ZONE 4	Wet Season	**Outdoor**	0.01	<0.01	<0.1	**0.79**	**9.95**	**50.49**
		SD	0.007	<0.01	<0.1	0.23	2.75	8.53
		Minimum	0	<0.01	<0.1	0.58	5.3	38.00
		Maximum	0.02	<0.01	<0.1	1.06	14.30	64.00
		Indoor	<0.1	<0.1	<0.01	**0.16**	**0.37**	**38.99**
		SD	<0.1	<0.1	<0.1	0.06	0.44	3.76
		Minumum	<0.1	<0.1	<0.1	0.08	0.03	33.47
		Maximum	<0.1	<0.1	<0.1	0.28	1.16	43.93
		FMEnv limits	26	75- 113	11.4	160	250	90
		WHO limits	100-150	150	10		150-230	

Source: SPDC, 2007a; 2007b; 2008; 2012

Table 4.3.1.5: DPR National Air Quality Guidelines For Maximum Exposure

Pollutant	1-Hour Mean (μgm^{-3})	8-Hour Mean (μgm^{-3})	Daily Mean (μgm^{-3})	Annual (μgm^{-3})
Total Suspended Particulates (TSP)	150 - 230		60 - 90	
Carbon monoxide(CO)	30		10	
Sulphur dioxide (SO_x)	350		100 - 150	40 - 60
Nitrogen dioxide(NO_x)	400		150	
Lead				0.5 – 1.0

Source: DPR, 2002

4.3.2 Noise

Noise is a periodic fluctuation of air pressure (in cycles per second), which is seldom recognized as a source of pollution, but constitutes a danger to people's health through physical, physiological and even psychological stresses. Common source of noise in the study are include operation of generators and vehicles plying the roads. Sudden loud noise can cause discomfort, including temporary hearing loss and may even instill fear in the young, as well as stress the biodiversity in the area.The results of the noise survey conducted in indoor and outdoor environments within the project are presented in Tables 4.3.1.4a – d, while the noise exposure limits for Nigeria are listed in Table 4.3.2.1.

Table 4.3.2.1: Noise Exposure Limits for Nigeria

Duration per Day, Hour	Permissible Exposure Limit dB(A)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Source: FEPA 1991

4.3.2.1: ZONE 1

The mean outdoor and indoor noise levels at all stations within the Zone 1 areaare illustrated in Figure 4.3.2.1. The mean outdoor levels were63.15 and 63.59dB(A) for dry and wet season respectively, while indoor levels were 61.97 and 63.10 db(A) for both seasons. The noise levels were below 90dB, the permissible noise level for an 8-hour working period as listed in Table 4.3.2.1 (FMEnv, 1992).

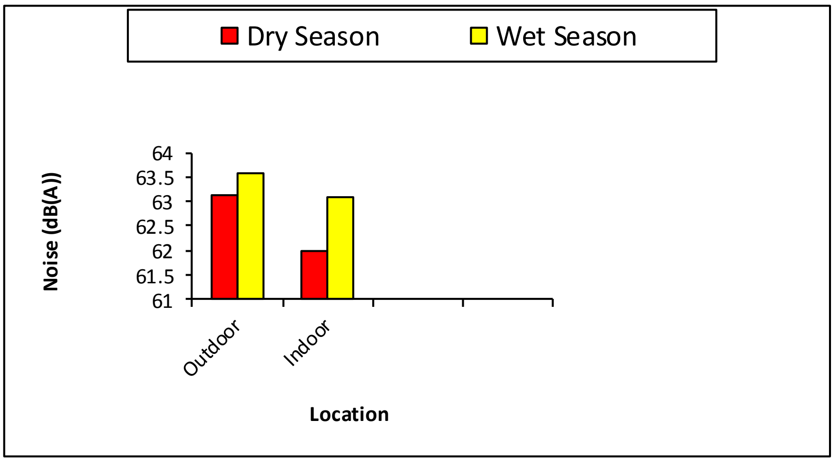


Fig. 4.3.2.1: Mean indoor and outdoor noise levels in Zone 1 area

4.3.2.2: ZONE 2

The mean outdoor and indoor noise levels at all stations within the Zone 2 area are illustrated in Figure 4.3.2.2. The mean outdoor levels were 61.84 and 61.49 dB(A) for dry and wet season respectively, while indoor levels were 43.42 and 47.78 db(A) for both seasons. The noise levels were below 90 dB, the permissible noise level for an 8-hour working period.

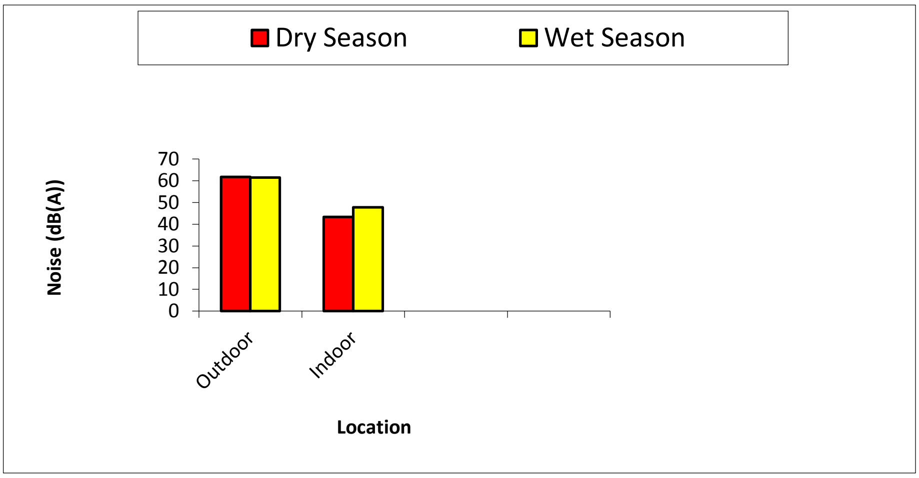


Fig. 4.3.2.2: Mean indoor and outdoor noise levels in Zone 2 area

4.3.2.3: ZONE 3

Figure 4.3.2.3 illustrates the mean outdoor and indoor noise levels in the Zone 3 area. The mean outdoor levels in this zone were 59.61 and 72.14 dB(A) for dry and wet season respectively, while indoor levels for dry and wet seasons maintained a value of 61.49 dB(A). The noise levels were below 90 dB, the permissible noise level for an 8-hour working period.

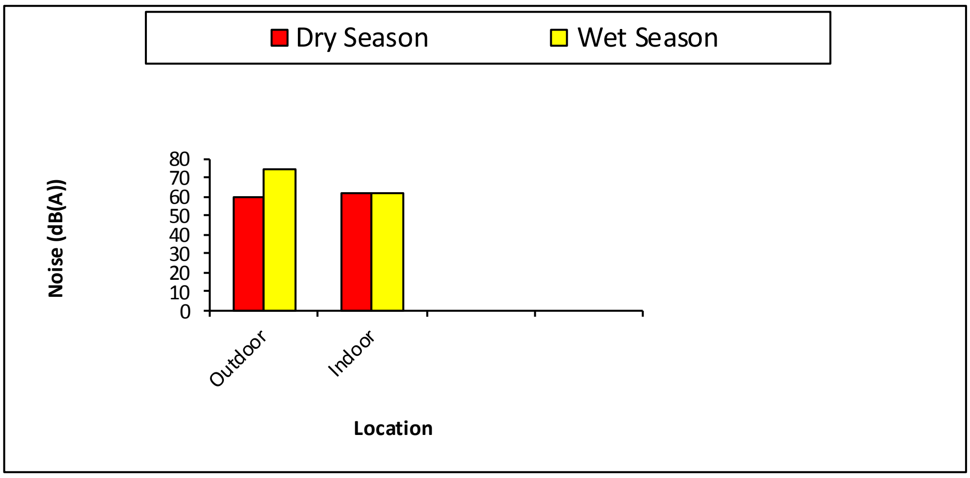


Fig. 4.3.2.3: Mean indoor and outdoor noise levels in Zone 3 area

4.3.2.4: ZONE 4

The mean outdoor and indoor noise levels at all stations within the Zone 4 area are illustrated in Figure 4.3.2.4. The mean outdoor levels were 59.61 and 50.49dB(A) for dry and wet season respectively, while indoor levels were 61.49 and 38.99db(A) for both seasons. The noise levels were below 90 dB, the permissible noise level for an 8-hour working period.

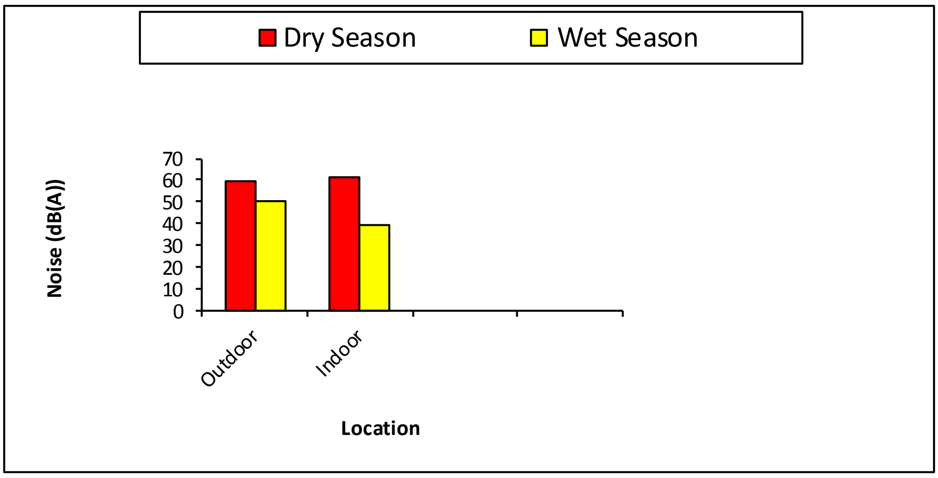


Fig. 4.3.2.4: Mean indoor and outdoor noise levels in Zone 4 area

4.3.3 Soil

The soil study of the proposed project area was carried out to establish the physical and chemical conditions (baseline) of the area. The established baseline data shall form the bench mark upon which subsequent deviations (if any) as a result of the project effects on the soil of the project area shall be assessed. Soil contamination at any site may arise from waste handling practices, underground storage tanks and past materials (chemicals and petroleum products) handling practices. Such contamination results from spills, leaks and seepages. Accordingly, the data generated concerning the soil condition shall be adapted for future quantification and evaluation of the environmental impacts associated with the Adibawa-Gbaran Seismic reshoot project. This will enable implementation mitigation measures to ameliorate the adverse impacts of the seismic survey, or enhance the beneficial impacts.

Soil Physical and Chemical Characteristics

The results of some key physical and chemical properties of the soil within the different locations in the study area are summarized in Tables 4.3.3.1 and 4.3.3.2. More detailed information can be found in Appendix 4.3.3.

Soil Colour and Texture

The soils of the proposed project and study area varied in colour (moist soils – using the Munsell Soil Colour Chart) from brown superficial (7.5YR 5/3) to light brown (7.5 6/3) at the subsurface level (SPDC, 2010, 2015). The dark brown coloration of the surface soil is attributable to decomposition of dead organic matter.

The texture of the soil of the proposed project area can be described as varying from Sandy Clay Loam to Loamy Sand from the surface to subsurface soil levels. This description is the general terminology used in soil descriptions by the United States Department of Agriculture. Table 4.3.3.1 shows sand-sized particles to be predominant across the entire study area (46.5 to 83.1% - surface soil) and (27.0 to 83.1% - subsurface soil). Clay-sized particles occupied 11.5 – 38.0% (surface) and 7.92 – 39.0% (subsurface). Silt was the least significant particle size in the mechanical analysis.

Table 4.3.3.1: Summary of Physical Parameters of Soils in the Study Area

Sample code	Soildepth cm	ZONE 1			ZONE 2			ZONE 3			ZONE 4		
		Min	max	mean	min	Max	mean	min	max	Mean	min	max	Mean
Sand %	0 – 15	30.0	50.0	38.6	47.02	57.02	53.82	47.02	57.02	53.82	60.22	74.99	65.16
	15 – 30	17.0	40.0	30.0	45.02	59.02	45.89	45.02	59.02	45.89	41.80	74.89	52.84
Silt %	0 – 15	2.0	3.0	9.8	11.52	37.52	25.02	11.52	37.52	25.02	12.36	17.43	14.06
	15 – 30	8.91	79.45	14.0	17.52	37.52	28.75	17.52	37.52	28.75	8.6	17.39	11.54
Clay %	0 – 15	18.0	38.0	26.2	11.46	31.46	21.96	11.46	31.46	21.96	7.56	15.14	12.61
	15 – 30	25.0	39.0	31.1	11.46	31.40	18.70	11.46	31.40	18.70	7.92	16.95	13.94

Source: SPDC(2007a,b; 2008; 2009; 2010; 2012; 2015)

Soil Physico-Chemical Characteristics

The site – specific soil physico-chemical data for the select locations (Zones) traversing the entire Adibawa-Gbaran Seismic reshoot area in the dry and wet seasons are summarized in Tables 4.3.3.2a and b. More detailed data is available in Appendix 4.3.3. The values of soil reaction (pH) in all locations across seasons ranged from strongly acid (pH 3.70) to near neutral (pH 7.6).

Table 4.3.3.2a: Summary of Physico-Chemical Characteristics of Soil within Adibawa-Gbaran 3D reshoot Seismic Project area (Dry Season)

Parameter	Depth	ZONE 1		ZONE 2		ZONE 3		ZONE 4	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
pH	0 – 15	5.9 – 6.5	6.13	5.3-5.75	5.53	4.64-5.78	5.02	3.88 – 4.54	4.28
	15 – 30	5.6 – 6.3	5.98	5.2-5.85	5.49	4.60-5.32	4.95	3.84 – 4.52	4.21
Org. Matt %	0 – 15	0.80-2.40	1.54	0.42-2.03	1.14	0.90-5.24	2.33	0.42 – 3.22	12.5
	15 – 30	0.80-1.90	1.41	0.30-1.81	0.97	1.07-2.56	1.38	0.35 – 1.96	12.0
Avail .P mg/kg	0 – 15	ND	ND	16.7-28.9	22.3	ND	ND	1.98 – 4.98	3.63
	15 – 30	ND	ND	16.34-2.26	20.5	ND	ND	0.60 – 3.22	2.5
E.C μS/cm	0 – 15	93.0 – 168	129.38	20-260	80	30.0-620	178.1	93.0 - 168	129.4
	15 – 30	78.0 – 147	114.49	20-120	47.5	20.0-150	110	78.0 – 147	114.5
Ca^{2+} meq/100g	0 – 15	1.5 – 8.2	4.28	28.1-79.3	50.7	0.10-0.39	0.23	28.3 – 50.2	38.7
	15 – 30	0.16 – 8.60	4.62	18.3-66.9	48.8	0.06-0.21	0.23	20.3 – 41.4	31.8
Na^{+} meq/100g	0 – 15	ND	ND	10.1-36.1	21.9	0.91-3.16	1.71	12.7 – 35.9	23.9
	15 – 30	ND	ND	11.1-28.1	20.5	0.39-1.94	1.16	11.9 – 30.4	18.9
K^{+} Meq/100g	0 – 15	3.54 – 5.20	4.26	16.1-45.6	28.8	0.43-1.14	0.82	18.8 – 42.4	31.3
	15 – 30	3.86 – 5.01	4.4	10.3-40.0	24.2	0.40-0.99	0.67	12.6 – 30.3	19.8
Phosphate mg/kg	0 – 15	18.5 – 23.5	20.74	28.3-42.2	35.7	ND	ND	20.2 – 31.7	26.5
	15 – 30	17.2-22.1	19.14	30.3-42.2	35.9	ND	ND	20.2 – 31.2	26.1
Nitrate mg/kg	0 – 15	3.6 - 6.4	5.26	10.2-12.8	11.4	ND	ND	0.60 – 1.40	1.32
	15 – 30	3.6 - 8.9	5.03	10.3-12.6	11.3			0.24 – 1.26	1.08
Ni mg/kg	0 – 15	0.23 - 1.15	0.48	0.35-8.95	4.8			0.35- 8.95	4.8
	15 – 30	0.29 - 0.79	0.45	0.68 -9.64	4.7			0.68 – 9.64	4.70
Pb mg/kg	0 – 15	0.14 - 0.61	0.29	0.367-1.22	0.7			0.12 –0.20	0.15
	15 – 30	0.12 - 0.52	0.26	0.029-1.76	0.8			0.10 – 0.24	0.15
Cr mg/kg	0 – 15	1.02 - 12.00	3.52	0.24-2.18	1.5			0.12 – 0.19	0.16
	15 – 30	1.06 - 14.3	3.85	0.36-2.37	1.6			0.09 – 0.17	0.14
Zn mg/kg	0 – 15	1.18 - 10.2	4.07	2.98-53.7	20.5			0.18 – 0.44	0.3
	15 – 30	0.17 - 6.76	2.41	4.29 -47.2	18.2			0.14 – 0.69	0.44
Mn mg/kg	0 – 15	290 – 450	372.9	6.45-566.5	116.0			0.13 – 0.22	0.17
	15 – 30	45.7 – 474	371.7	3.60 -304.2	72.7			0.14 – 0.26	0.18
Fe mg/kg	0 – 15	512.1 - 1261.9	918.7	297.87-1481	780.9			834.5 – 1023.0	993.7

Parameter	Depth	ZONE 1		ZONE 2		ZONE 3		ZONE 4	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
	15 – 30	613.1 - 1262.9	978.7	330.78-1634	965.1			609.4 – 1025.3	976.8

Source: SPDC, 2007a,b; 2008; 2009; 2010; 2012; 2015

Table 4.3.3.2b: Summary of Physico-Chemical Characteristics of Soil within Adibawa Gbaran Seismic reshoot area (Wet Season)

Parameter		ZONE 1		ZONE 2		ZONE 3		ZONE 4	
	Depth	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Ph	0 – 15	5.9 – 6.5	6.21	4.75-6.17	5.46	3.7-6.0	4.97	4 - 7.6	6.22
	15 – 30	5.7 – 6.3	5.88	5.30-6.43	5.86	4.08-6.55	4.86	4.3-7.6	5.79
Org. Matt %	0 – 15	0.9-1.7	1.35	0.88-6.89	2.14	4.08-6.55	4.86	0.9 - 5.59	3.12
	15 – 30	1.0-1.80	1.40	0.53-6.63	1.89	1.35-2.61	1.78	0.58-4.26	2.33
Avail .P mg/kg	0 – 15	18.5 – 23.5	20.7	0.001-7.96	4.18	1.25-2.03	1.67	1.19-19.2	1.79
	15 – 30	0.01-7.88	3.75	0.01-7.88	3.75	0.07-7.96	4.71	0.84-1.85	1.25
E.C µS/cm	0 – 15	73.6 – 810	595.6	359.6-670	453.13	0.024-7.35	3.84	20-260	80
	15 – 30	63.9 – 124.5	79.8	74.8-607.2	444.56	359.6-438.8	412.4	20-120	47.5
Ca^{2+} meq/100g	0 – 15	26.4 - 89.6	17.8	2.01-31.7	13.62	74.8-590	402.9	1.37-4.63	2.93
	15 – 30	24.9 - 91.6	18.4	0.81-33.7	14.49	5.26-14.3	10.9	1.29-4.61	12.75
Na^{+} meq/100g	0 – 15	17.5 - 45.9	29.5	24.2-143.8	82.97	0.81-15.8	10.5	12.6 – 35.7	23.6
	15 – 30	15.2 - 41.8	27.7	22.46-163.5	87.04	24.2-131.2	79.9	11.9 – 30.1	18.92
K^{+} Meq/100g	0 – 15	24.9 - 63.4	38.1	35-1354	479.53	22.5-163.5	80.8	18.8 – 42.1	31.3
	15 – 30	21.7 - 56.7	36.5	2-9864.5	7404.06	41.4-426.3	239.8	12.6 – 30.2	19.8
Phosphate mg/kg	0 – 15	18.5 – 23.5	20.7	28.3-42.2	35.7	45.3-398.5	234.4	11.3 - 21.4	16.52
	15 – 30	17.2-22.1	19.1	30.3-42.2	35.9	9.1-43.2	25.2	8.4-14.6	11.40
Nitrate mg/kg	0 – 15	3.6 - 6.4	5.3	10.2-12.8	11.35	5.75-28.3	19.8	70.9-88.4	79.03
	15 – 30	3.6 - 8.9	5.03	10.3-12.6	11.29	1.92-17.6	6.88	54.8-79.2	67.96
Ni mg/kg	0 – 15	0.25 - 1.15	0.48	4.32-11.5	7.46	1.88-16.6	6.82	3.85-9.24	6.43
	15 – 30	0.29 - 0.79	0.44	4.32-8.96	6.29	4.32-6.48	5.31	4.32-5.92	6.28
Pb mg/kg	0 – 15	0.14 - 0.61	0.13	0.245-1.79	0.49	4.22-8.44	6.03	0.55-3.08	1.61
	15 – 30	0.12 - 0.52	0.10	0.025-2.15	0.47	0.25-0.29	0.26	0.51-2.80	1.52
Cr mg/kg	0 – 15	1.05 - 12	3.92	2.23-21.0	13.92	0.06-2.15	0.83	0.01-0.84	0.38
	15 – 30	1.1 - 14.3	3.71	0.26-20.4	13.89	12.5-19.3	15.56	0.008-0.310	0.35
Zn mg/kg	0 – 15	1.18 - 10.2	4.07	29.49-298.1	92.06	11.4-19.9	16.5	0.32-0.82	0.56
	15 – 30	0.17 - 6.76	2.40	22.44-187.1	87.74	72.7-107.3	87.4	0.28-0.69	0.51
Mn mg/kg	0 – 15	290 - 450	372.9	142.36-6209	3189.65	80.0-174.9	101.9	20.29-92.63	48.52
	15 – 30	45.7 - 474	371.7	125.38-5589	3112.75	142.4-5067	2054	20.10-85.77	44.20
Fe mg/kg	0 – 15	3848 - 6099	4972.05	1478-24660	10886	125.4-5318	1478	3848 - 6099	1339.554
	15 – 30	1071 - 6438	4935.118	15322-20491	9976.64	1478-13584	5812	1071 - 6438	811.474

Source: SPDC, 2007a,b; 2008; 2009; 2010; 2012; 2015

Figure 4.3.3.1 illustrates the mean soil pH values in different locations within Adibawa-Gbaran Seismic reshoot area as a function of pre ailing seasonal conditions and soil depth. The plots show clearly that the mean pH values did not vary greatly with soil depth and season. The studied soils can be considered predominantly acid soils. Generally, pH 4.8 is set as the lower limit for optimum growth of crops; conversely, pH 9.5 is regarded as the extreme alkalinity of which crops can still grow.

The soil organic matter is derived from dead or living residues of plants and soil organisms, including other organic materials. Soil organic matter in the study area ranged from 0.42% to 3.22% in the dry season and from 0.53% to 6.13% in the wet season (Table 4.3.3.2). As expected, the range for organic matter was lower during the dry season. Organic matter is considered crucial in soils because important soil properties such as soil water absorption and retention, capacity to supply nitrogen, phosphorus and other elements vital to growing plants, and adequacy of aeration, are dependent to some degree on the quality of organic matter present in soils.

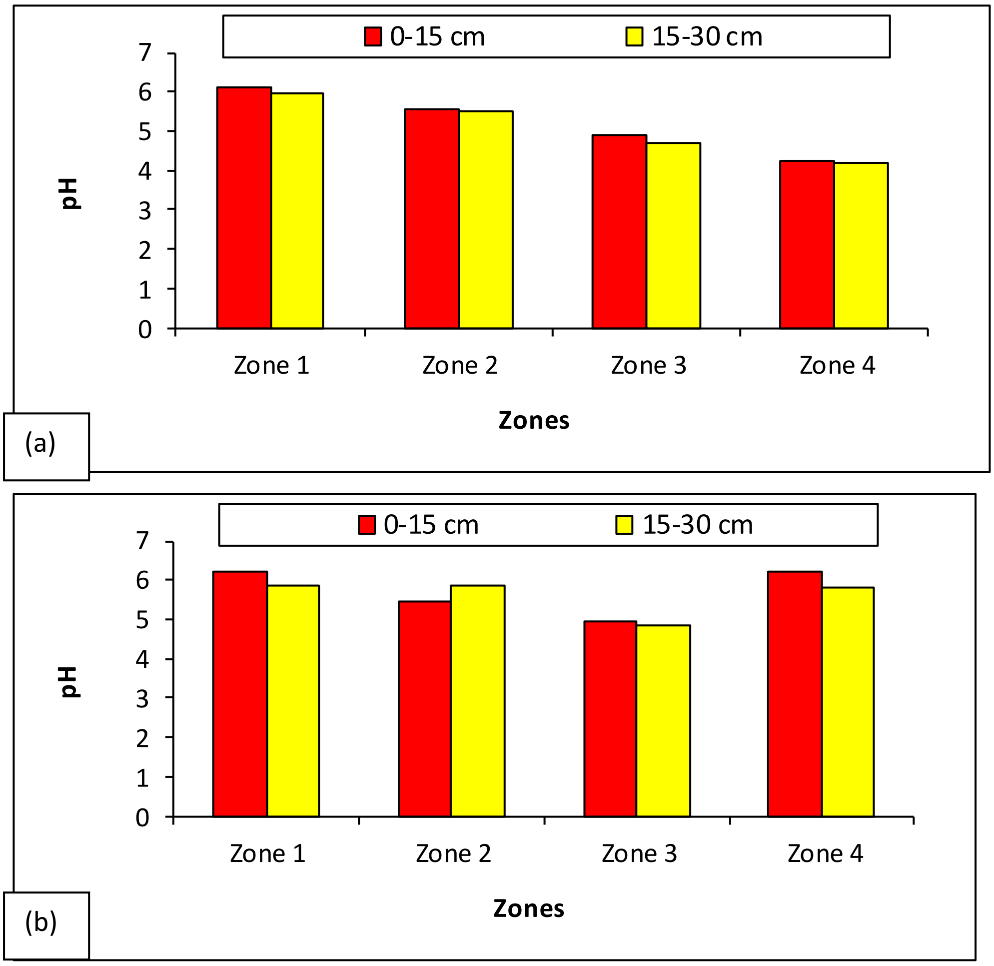


Fig. 4.3.3.1: Mean pH values in the soil at different locations within Adibawa-Gbaran Seismic reshoot area for (a) dry and (b) wet seasons
Source: SPDC (2007a,b; 2008; 2009; 2010; 2012; 2015)

The soil organic matter is derived from dead or living residues of plants and soil organisms, including other organic materials. Soil organic matter in the study area ranged from 0.42% to 3.22% in the dry season and from 0.53% to 6.13% in the wet season (Table 4.3.3.2). As expected, the range for organic matter was lower during the dry season. Organic matter is considered crucial in soils because important soil properties such as soil water absorption and retention, capacity to supply nitrogen, phosphorus and other elements vital to growing plants, and adequacy of aeration, are dependent to some degree on the quality of organic matter present in soils.

Figure 4.3.3.2 illustrates the mean values of some nutrients and heavy metals; namely Ca^{2+}, phosphate, lead and nickel in the different locations within the study area. The plots also no significant variations of the parameters with soil depth, apart from Ca^{2+} and nickel in Zone 4. The soil macronutrients that significantly control plant growth include nitrogen and phosphorous. The more available forms of nitrogen in soil are nitrate (NO_3^-), ammonium (NH_4^+). Nitrate content of soils in the study area for both dry and wet seasons ranged from 5.03 mg/kg and 79.0 mg/kg. Available phosphorus in the studies soils ranged from 0.001 to

7.96 mg/kg in the wet season and 16.3 – 28.9 mg/kg in the dry season. The phosphate contents of the sampled soils varied from 6.81 mg/kg to 35.9 mg/kg in the dry season and 11.5 mg/kg to 35.9 mg/kg in the wet season. Electrical conductivity of the studied soils, which expresses its total ionic strength varied from 20 µS/cm to 260µS/cm during the dry season and 20.0 – 810.0 µS/cm during the wet season. The exchangeable bases of sampled soils across the study area in the rainy season are dominated by K^+, followed by Na^+ and Ca^{2+}, with 479.0 meq/100g, 82.9 meq/100g and 17.8 meq/100g respectively. The dry season values in the same order were 31.5 meq/100g, 23.9 meq/100g and 50.7 meq/100g respectively, indicating predominance of Ca^{2+}.

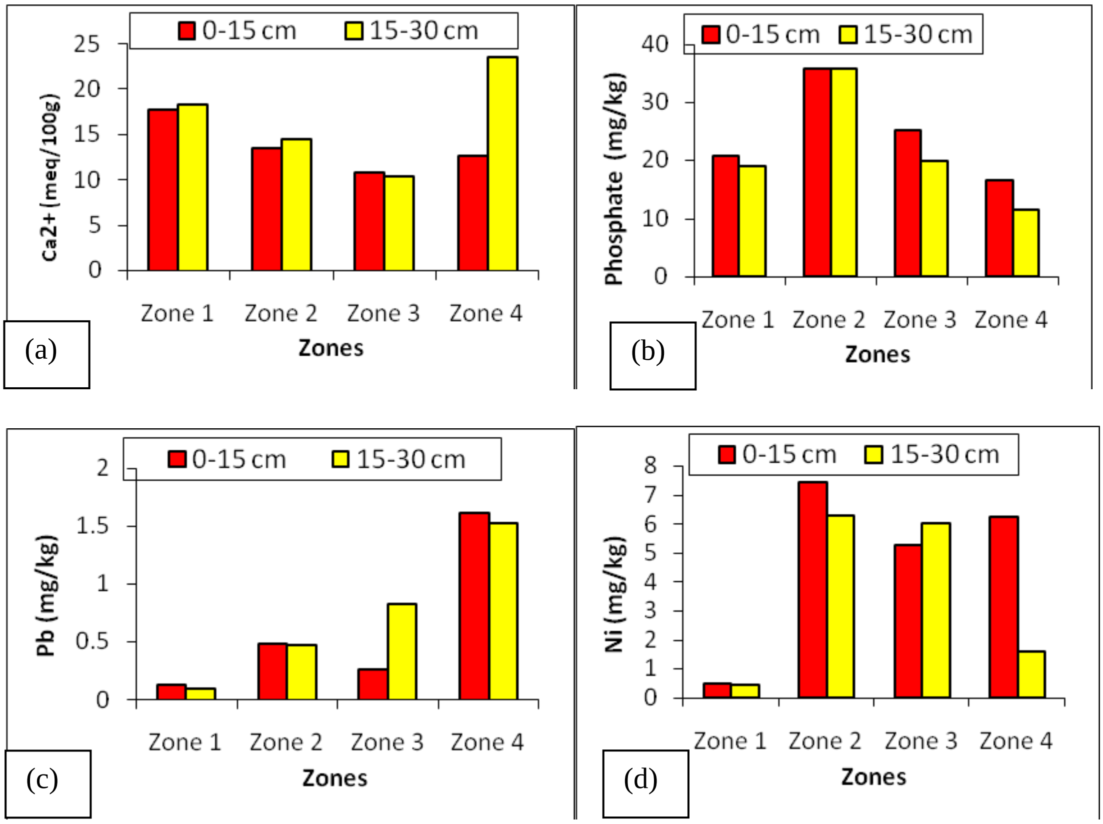


Fig. 4.3.3.2: Mean values of soil nutrients and heavy metals in the different locations within Adibawa-Gbaran Seismic reshoot area: (a) Ca^{2+} (b) phosphate (c) lead and (d) nickel.

Source: SPDC, 2007a,b; 2008; 2009; 2010; 2012; 2015

For heavy metal content, iron concentration was markedly higher than the other heavy metals in the area, which is a well-known occurrence in the Niger Delta region. The mean concentrations of iron in the dry and wet seasons were 993 mg/kg and 10,886 mg/kg. The dry/wet season trends for the other heavy metals were as follows; manganese – 373/2054 mg/kg; zinc – 20.5/92.1 mg/kg; chromium – 3.52/15.6 mg/kg; lead – 0.70/1.61 mg/kg; nickel – 4.80/7.46 mg/kg. All the studied metals recorded significantly higher values in the wet season compared to the dry season values.

Soil Microbiological Properties

Data on soil microbiological properties in the Adibawa-Gbaran Seismic reshoot area are contained in Tables 4.3.3.3 to 4.3.3.6 and Figures 4.3.3.3 to 4.3.3.5.

4.3.3.1 ZONE 1

Soil Physicochemical Properties

Somephysico-chemical properties of the soil in Zone 1 are highlighted in Table 4.3.3.2 and Figures 4.3.3.1 and 4.3.3.2. The dry season soil pH values in the Zone 1 area ranged from 5.9 – 6.5 (surface soil) and 5.6 – 6.3 (subsurface soil), while the wet season values were 5.9 – 6.5 and 5.7 – 6.3 respectively. The mean maximum electrical conductivity values in dry and wet season were 168 µS/cm and 810 µS/cm (surface) and 147 µS/cm and 124.5 µS/cm (subsurface). Surface and subsurface mean concentrations of heavy metal were: Ni (0.48/0.44 mg/kg), Pb (0.13/0.10 mg/kg), Cr (3.92/3.71 mg/kg) and Fe (4972/4935 mg/kg) in the wet season and Ni (0.48/0.45 mg/kg), Pb (0.29/0.26 mg/kg), Cr (3.52/3.85 mg/kg) and Fe (918.7/978.7 mg/kg) in the dry season.

Soil Microbiology

The microbiological characteristics of the soil samples are summarized in **Table 4.3.3.3**.

Table 4.3.3.3: Summary of Soil Microbiology in the Zone 1 Study Area

PARAMETERS		WET SEASON 2008			WET SEASON 2014		
	Depth (cm)	Mean	StdDev	Range	Mean	StdDev	Range
THB (cfu/g)($x10^6$)	0 - 15	4.94375	0.268251	4.3 - 5.4	0.792059	0.585964	0.12 - 1.97
	15 - 30	4.86875	0.375444	4.2 - 5.5	1.126176	1.134848	0.215 - 4.9
THF (cfu/g) ($x10^4$)	0 - 15	4.4875	0.43031	3.4 - 4.9	1.885882	1.576904	0.52 - 4.2
	15 - 30	4.59625	0.362158	3.9 - 4.9	2.026471	2.359158	0.48 - 6.3
HUF (cfu/g)	0-15	NO DATA	NO DATA	NO DATA	5.788235	1.840137	3 - 9.1
	15-30	NO DATA	NO DATA	NO DATA	4.782353	1.666297	1 - 7.3
HUB (cfu/g)	0-15	NO DATA	NO DATA	NO DATA	6.14375	2.120682	3.1 - 8.9
	15-30	NO DATA	NO DATA	NO DATA	6.0875	2.252665	1.1 - 9.9

Source: Field Work 2008 and 2014

The total heterotrophic bacterial (THB) count ranged from $0.12x10^6$cfu/g – 1.97 x 10^6cfu/g in top soil to 0.22 x 10^6 – 4.9 x 10^6cfu/g in bottom soil. The 2008 wet season study recorded 4.30 x 10^6 - 5.40 x 10^6cfu/g and 4.2 x 10^6 – 5.5 x 10^6 cfu/g for top soil and bottom soil respectively.

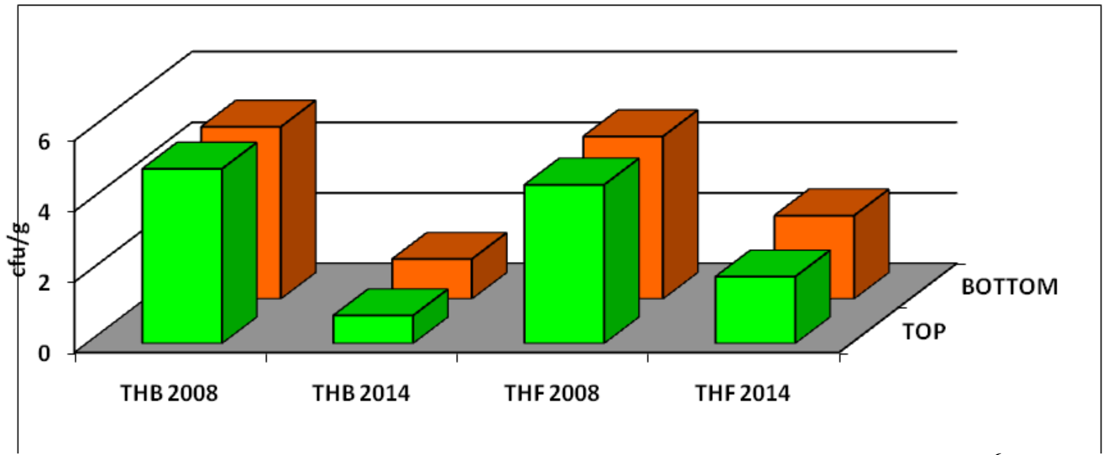


Fig. 4.3.3.3: Microbial counts in the wet season of 2008 and 2014 (TFB x 10^6; THF x 10^4)

Total heterotrophic fungal (THF) count ranged from 0.52 x 10^4 – 4.2x10^4cfu/g and 0.48 x10^4 – 6.3 x 10^4 for top and bottom soils respectively which is much lesser than the mean population of 4.5 x 10^4 and 4.6 x 10^4cfu/g in the top and sub-soils, respectively (**Table 4.3.3.3, Fig. 4.3.3.3**). Counts of heterotrophic bacteria and fungi were generally high in all soil samples which suggested normal microbial growth and absence of stressed conditions. The hydrocarbon utilising bacteria population count ranged from 3 x 10^3 - 9.1x 10^3cfu/g for top soil and 1.0 x 10^3 – 7.3 x 10^3 cfu/g for bottom soil. Population counts for hydrocarbon utilising fungi had a range of 3.1 x 10^2 cfu/g – 8.9 x 10^2cfu/g for top soil.

4.3.3.2 ZONE 2

Soil Physicochemical Properties

Soil physico-chemical properties in Zone 2 are summarized in Table 4.3.3.2a and b, as well as Figures 4.3.3.1 and 4.3.3.2. The dry season mean pH values for surface and subsurface soil were 5.53 and 5.49, while the corresponding conductivity values were 80 and 47.5 µS/cm. Soil organic matter was 1.14 and 0.97%, while exchangeable calcium was 50.7 and 48.8 meq/100g. The corresponding values in the wet season were: Soil pH (5.46 and 5.86), conductivity (3.75 and 453.1 µS/cm), organic matter (1.14 and 1.89%), exchangeable calcium (13.6 and 14.5 meq/100g).Wet season surface and subsurface mean concentrations of heavy metal were: Ni (7.46/6.29 mg/kg), Pb (0.49/0.47 mg/kg), Cr (13.9/13.9 mg/kg) and Fe (10,886/9976mg/kg), while corresponding dry season values were Ni (4.80/4.70 mg/kg), Pb (0.70/0.80 mg/kg), Cr (1.50/1.60 mg/kg) and Fe (780/965 mg/kg).

SoilMicrobiology

The bacterial count varied from 1.0 x 10^3 to 7.78x10^5cfu/g, while the fungi count of the soils of the study area varied from 1.8 x 10^3 to 1.22x10 10^5cfu/g. The variations in microbial load due to season and due to soil depth are shown in Table 4.3.3.4 as well as Figure 4.3.3.4. All values were higher in the top soil and in the dry season for all parameters. The level of PUB and PUF did not indicate petroleum pollution in the study area. The HDB in the soil samples can therefore be considered as pristine levels. However, this conclusion is at variance with Atlas (1981) who considered pristine levels of HDB to be less than 1%. This variance may be attributed to hydrocarbon contamination in the soil (via anthropogenic activities, accidental spills, leakages etc) (Zaihan and Tuah, 2008).

Table 4.3.3.4: Microbial characteristics of soil in Zone 2

Sample code	Soildepth cm	Rainy season			Dry season		
		Min	Max	mean	min	max	mean
Total bacteria (x 10^5cfu/g)	0 -1 5	0.1	7.78	4.5	4.9	8.9	7.2
	15-30	0.1	6.24	3.2	3.1	6.8	4.8
Total fungi (x 10^5cfu/g)	0 -1 5	0.18	1.22	1.04	1.2	1.9	1.6
	15-30	0.15	1.20	1.06	0.9	1.6	1.2
Pet. Ut.Bact (x 10^3cfu/g)	0 -1 5	0.01	0.8	0.41	1.2	2.6	3.5
	15-30	0.01	0.2	0.1	1.2	2.8	1.8
Pet. Ut. Fungi (x 10^3cfu/g)	0 -1 5	0.01	0.14	0.06	0.2	1.4	0.8
	15-30	0.01	0.12	0.05	0.2	1.2	0.5

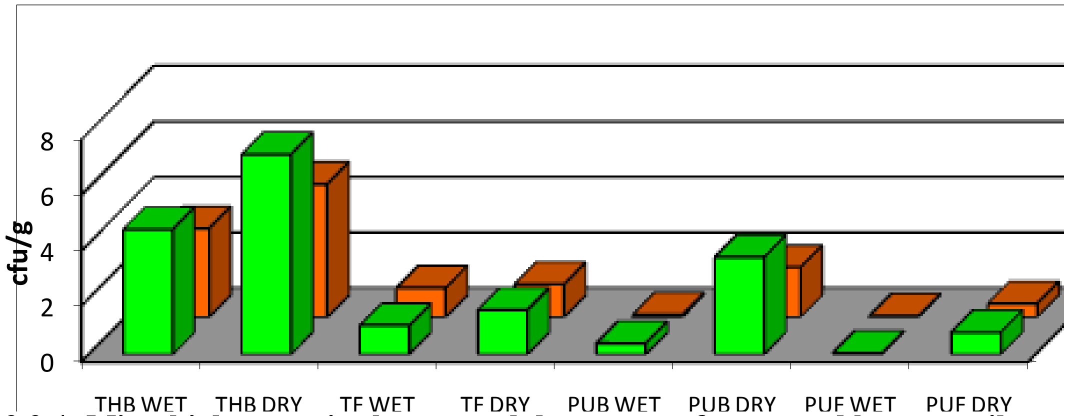


Fig. 4.3.3.4: Microbial counts in the wet and dry seasons for top and bottom soils

The high numbers of bacteria and fungi in the project area is a reflection of the eutrophic (high nutrient) nature of the environment. Furthermore, nine bacterial genera *Pseudomonas, Arthrobacter, Acinetobacter, Norcadia, Klebsiella, Enterococci, Enterobacter, Vibrio, Micrococcus, Bacillus* were identified from the soils. Some of the genera were less frequently isolated. The fungal isolate mainly belonged to the genera *Aspergillus, Saccharomyces, Mucor, Fusarium, Candida* and *Penicillium*.

4.3.3.3 ZONE 3

Soil Physicochemical Properties

Typicalphysico-chemical properties of the soil in Zone 3 are as well highlighted in Table 4.3.3.2 and Figures 4.3.3.1 and 4.3.3.2. The dry season mean pH values for surface and subsurface soil were 5.02 and 4.95, while the corresponding conductivity values were 178 and 110 µS/cm. Soil organic matter was 2.13 and 1.38%, while exchangeable calcium was 0.23 meq/100g at both soil depths. The corresponding values in the wet season were: Soil pH (4.97 and 4.86), conductivity (3.84 and 412.4 µS/cm), organic matter (4.86 and 1.78%), exchangeable calcium (402 and 10.9meq/100g). Wet season surface and subsurface mean concentrations of heavy metal were: Ni (6.82/5.31 mg/kg), Pb (6.03/0.26 mg/kg), Cr (0.83/15.6 mg/kg) and Fe (1478/5812mg/kg).

Soil Microbiology

The bacterial count varied from 1.0 x 10^3 to 7.78x10^5cfu/g, while the fungi count of the soils of the study area varied from 1.8 x 10^3 to 1.22x10 10^5cfu/g. The variations in microbial load due to season and due to soil depth are shown in Table 4.3.3.5 and illustrated in Figure 4.3.3.5. All values were higher in the top soil and in the dry season for all parameters. The level of PUB and PUF did not indicate petroleum pollution in the study area. The HDB in the soil samples can therefore be considered as pristine levels. However, this conclusion is at variance with Atlas (1981) who considered pristine levels of HDB to be less than 1%. This variance may be attributed to hydrocarbon contamination in the soil (via anthropogenic activities, accidental spills, leakages etc) (Zaihan and Tuah, 2008).

Table 4.3.3.5: Microbial characteristics of soil in Zone 3

Sample code	Soildepth cm	Rainy season			Dry season		
		Min	max	mean	min	max	mean
Total bacteria (x 10^5cfu/g)	0 -1 5	0.1	7.78	4.5	4.9	8.9	7.2
	15-30	0.1	6.24	3.2	3.1	6.8	4.8
Total fungi (x 10^5cfu/g)	0 -1 5	0.18	1.22	1.04	1.2	1.9	1.6
	15-30	0.15	1.20	1.06	0.9	1.6	1.2
Pet. Ut.Bact (x 10^3cfu/g)	0 -1 5	0.01	0.8	0.41	1.2	2.6	3.5
	15-30	0.01	0.2	0.1	1.2	2.8	1.8
Pet. Ut. Fungi (x 10^3cfu/g)	0 -1 5	0.01	0.14	0.06	0.2	1.4	0.8
	15-30	0.01	0.12	0.05	0.2	1.2	0.5

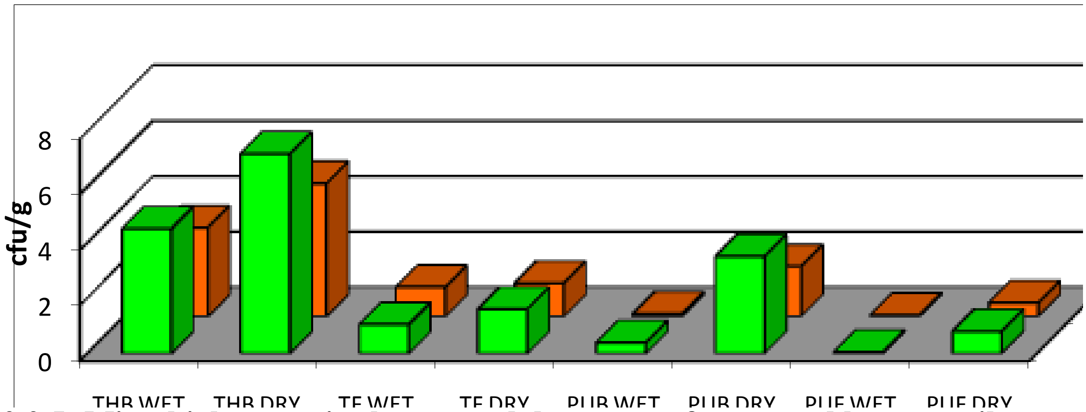


Fig. 4.3.3.5: Microbial counts in the wet and dry seasonsfor top and bottom soils

The high numbers of bacteria and fungi in the project area is a reflection of the eutrophic (high nutrient) nature of the environment. Furthermore, nine bacterial genera *Pseudomonas, Arthrobacter, Acinetobacter, Norcadia, Klebsiella, Enterococci, Enterobacter, Vibrio, Micrococcus*, *Bacillus* were identified from the soils. Some of the genera were less frequently isolated. The fungal isolate mainly belonged to the genera *Aspergillus, Saccharomyces, Mucor, Fusarium, Candida* and *Penicillium*.

4.3.3.4 ZONE 4

Soil Physicochemical Properties

Some soil physico-chemical properties in Zone 4 are as well summarized in Table 4.3.3.2a and b, as well as Figures 4.3.3.1 and 4.3.3.2. The dry season mean pH values for surface and subsurface soil were 4.28 and 4.21, while the corresponding conductivity values were 129 and 114 µS/cm. Soil organic matter was 12.5 and 12.0%, while exchangeable calcium was 38.7 and 38.1 meq/100g. The corresponding values in the wet season were: Soil pH (6.22 and 5.79), conductivity (8.0 and 47.5 µS/cm), organic matter (3.12 and 2.33%), exchangeable calcium (2.93 and 12.8 meq/100g). Surface and subsurface mean concentrations of heavy metal were: Ni (6.43/6.28 mg/kg), Pb (1.52/0.38 mg/kg), Cr (0.38/0.35 mg/kg) and Fe (1339/811 mg/kg) in the wet season.

Soil Microbiology
Summary of the microbial load of the soil samples are presented in Table 4.3.3.6.

Table 4.3.3.6: Summary of the Microbial Properties in the Soil Samples of the Gbaran FLB/Jetty Area

	MicrobialProperties	SoilDepth (cm)	Range	Mean
	Total Heterotrophic Bacteria (THB) (X10^6) cfu/g	0-15 15-30	4.9-8.9 3.1-6.8	7.2 ± 14.4 4.8 ± 1.1
	Hydrocarbon Utilising Bacteria (HUB) (X10^5) cfu/g	0-15 15-30	1.2-3.6 1.2-2.8	2.5 ± 0.8 1.8 ± 0.5
	Percent HUB	0-15 15-30	2.44-6.10 0.25-5.16	3.51 ± 1.20 3.37 ± 1.24
	Total Heterotrophic Fungi (THF) (10^6) cfu/g	0-15 15-30	1.2-1.9 0.9-1.6	1.6 ± 0.4 1.2 ± 0.2
	Hydrocarbon Utilising Fungi (HUF) (10^5) cfu/g	0-15 15-30	0.2-1.4 0.2-1.2	0.8 ± 0.4 0.5 ± 0.4
	Percent HUF	0-15 15-30	1.00-10.00 0.83-10.00	4.98 ± 3.18 3.85 ±3.35

Source: Field Survey, November 2005.

The soil samples in the study area had rich total hetérorophic bacteria load ranging from 3.1 x 10^6cfu/g to 6.8 x 10^6cfu/g in the bottom layer and from 4.9x10^6cfu/g to 8.9x10^6cfu/g in the topsoil layer. The mean heterotrophic bacteria load for the top and bottom soil layers were 7.2 x 10^6cfu/g and 4.8 x 10^6cfu/g, respectively. The hydrocarbon degrading bacteria load ranged from 1.5 x 10^5cfu/g to 3.6 x 10^5cfu/g for the top soil layer and 1.2 x 10^5cfu/g to 2.8 x 10^5cfu/g for the bottom layer. The mean hydrocarbon degrading bacteria load for the top and bottom soil layers were 2.5 x 10^5cfu/g and 1.8 x 10^5cfu/g, respectively. These results indicate that the environment have rich heterotrophic bacteria load that is capable of responding to any possible oil pollution.

The total fungal count for the topsoil layer ranged from 1.2 – 1.9 x 10^6cfu/g with a mean of 1.6 x 10^6cfu/g, whilst the bottom layer fungal load ranged from 0.9 – 1.6 x 10^6cfu/g with a mean of 1.2 x 10^6cfu/g. These high microbial densities in the soil may be indicative of the fact that the soil contained high concentration of nutrients which supported their growth.

4.3.4: Vegetation and Land use

4.3.4.1 Floristics

Vegetation characteristics of the study area are compiled from the different reports of field studies carried out recently in the study area by SPDC. The vegetation cover is observed to be homogenous across the four sampling zones.

Ecology

The study area is located within the tropical fresh water swamp forest ecological zone of the Niger Delta (SPDC, 2007b). Perennial heavy rainfalls, seasonal flooding, and unstable marshy terrain are characteristic of the area. The seasonal flooding is occasioned by the swelling and overflow of the river Niger and its distributaries and numerous creeks including Nun River, Orashi River, Taylor Creek and Egbedi creeks (SPDC, 2012). Flooding occurs across much of the area during the peak of the rains. The terrain is further kept totally or partially inundated, perennially, by the soil structure and shallow depth of the water table which impedes drainage. Inland lakes and rivers are scattered across the area and occur where the shallow ground water table hits the surface. Abundant water supply and inundation of the area is therefore guaranteed nearly all year round. The vegetation ecology (especially structure and species composition) is thus restricted by the challenges posed by the hydrology for which the peculiar species assemblage in fresh water swamp vegetation, have the natural adaptation to cope with.

Species Composition and Taxonomic Diversity

Taxonomic diversity is the same across the four zones within the study area and is represented by 119 species belonging to 52 plant families. Diversity at the rank of family is dominated by 6 families which account for a total of 56 species. These families in decreasing order of their number of representative species are: Fabaceae (15), Euphorbiaceae (12), Annonaceae (9), Poaceae (7), Rubiaceae (7) and Moraceae (6). The checklist of species and their classification are provided in Table 4.3.4.1.

Table 4.3.4.1: Checklist of Plant Species of the Study Area

SPECIES NAMES	FAMILY	COMMON NAME	HABIT	ETHNOBOTANY
Acacia sp.	FABACEAE (Mimosoideae)		Shrub	
Aframomum sceptrum	ZINGIBERACEAE	Alligator Pepper; Fisani	Herb	Condiment, Weaving
Afzelia bipindensis	MORACEAE	Igbengi	Tree	Food
Albizia ferruginea	FABACEAE (Mimosoideae)		Tree	Fuel wood/Timber
Albizia zygia	FABACEAE (Mimosoideae)	*Yanyan*	Tree	Canoe Carving
Alchornea cordifolia	EUPHORBIACEAE	Christmas bush	Herb	
Allophylus africanus	SAPINDACEAE		Shrub	

SPECIES NAMES	**FAMILY**	**COMMON NAME**	**HABIT**	**ETHNOBOTANY**
Alstonia boonei	APOCYNACEAE	Stool Wood	Tree	Timber / Soft Wood
Anthocleista nobilis	GENTIANACEAE	Boundary Plant	Tree	
Anthostema aubryanum	EUPHORBIACEAE		Tree	
Antiaris africana	MORACEAE	False Iroko	Tree	Timber / Hard Wood
Antidesma vogelianum	EUPHORBIACEAE	*Ingolo golo*	Tree	Medicine
Aspilia africana	ASTERACEAE	Hemorrhage plant	Herb	Medicine
Asplenium africanum	ASPLENIACEAE		Tree Fern	
Bambusa vulgaris	POACEAE	Bamboo	Tree	
Baphia nitida	FABACEAE (Faboideae)	Camwood	Shrub / Tree	
Berlinia grandiflora	FABACEAE (Faboideae)	*Berlina*	Tree	Timber
Blighia sapida	SAPINDACEAE	Akee Apple	Tree	Fuel wood
Bosqueia angolensis	MORACEAE		Tree	Timber
Bridelia grandis	EUPHORBIACEAE	*Igbara gbara*	Tree	Medicine
Calamus deeratus	ARECACEAE / PALMAE	Rattan Palm; *Apie*	Liana	Fish Trap; Handicraft
Canarium schweinfurthii	BURSERACEAE		Tree	Oleoresin / Food
Carapa procera	MELIACEAE		Tree	Canoe Carving
Carpolobia lutea	POLYGALACEAE		Shrub	Medicine
Ceiba pentandra	BOMBACACEAE	Silk Cotton	Tree	Timber / Medicinal
Christella dentata	THELYPTERIDACEAE		Fern	
Chromolaena odorata	ASTERACEAE	Awolowo; Siam weed	Herb	Medicine
Cissus aralioides	VITACEAE	Ibiabia	Liana	Medicine
Cissus arguta	VITACEAE	Iguasi	Climber	
Clappertonia ficifolia	MALVACEAE(Grewioideae)		Shrub	
Cleistopholis patens	ANNONACEAE	Canoe Carving	Tree	Timber / Soft Wood
Clerodendrum umbellatum	LAMIACEAE	Medicinal	Climber	Medicine
Combretum paniculatum	COMBRETACEAE		Shrub	
Combretum racemosum	COMBRETACEAE		Liana	
Commelina spp	COMMELINACEAE		Herb	
Costus afer	COSTACEAE	Ogbodo	Herb	Fibre; Medicine
Craterispermum cerinanthum	RUBIACEAE		Tree	Food
Ctenolophon englerianus	CTENOLOPHONACEAE		Tree	
Cyclosorus dentatus	PTERIDOPHYTA		Fern	
Cyrtosperma senegalensis	AGAVACEAE	Bou Ake	Herb	Medicine
Dracaena arborea	ASPARAGACEAE		Tree	

SPECIES NAMES	FAMILY	COMMON NAME	HABIT	ETHNOBOTANY
Eichhornia crassipes	PONTEDERIACEAE	Water Hycinth	Herb	Invasive plant
Elaeis guineensis	ARECACEAE / PALMAE	Palm Tree	Tree	Food, Handicraft
Erythrophleum ivorense	FABACEAE(Caesalpinioideae)	Sass wood	Tree	Timber
Ficus exasperata	MORACEAE	Sand paper tree; Ikoronsi	Shrub / Tree	Medicine
Ficus ovata	MORACEAE		Liana	
Fleroya ledermannii	RUBIACEAE	Abura	Tree	Timber / Soft Wood
Fleurya aestuans	URTICACEAE		Herb	
Funtumia africana	APOCYNACEAE	Lagos Rubber	Tree	Rubber
Garcinia kola	CLUSIACEAE	Bitter Cola tree	Tree	Medicine
Gongronema latiflolium	APOCYNACEAE		Climber	Food / Medicine
Greenwayodendron suaveolens	ANNONACEAE		Tree	Timber
Hannoa klaineana	SIMAROUBACEAE		Tree	Medicine
Harungana madagascariensis	HYPERICACEAE		Shrub	Medicine
Hekistocarpa minutiflora	RUBIACEAE		Shrub	
Hevea brasiliensis	EUPHORBIACEAE	Rubber	Tree	Rubber
Homalium africanum	FLACOURTIACEAE		Shrub / Tree	
Irvingia gabonensis	IRVINGIACEAE	Ogbono; Bush Mango	Tree	Timber / Hard Wood
Klainedoxa gabonensis	IRVINGIACEAE		Tree	Canoe; Furniture
Laccosperma secondiflorum	ARECACEAE / PALMAE	Rattan Palm	Liana	Fish Trap; Handicraft
Lannea sp	ANACARDIACEAE		Tree	Medicine
Leucaena leucocephala	FABACEAE(Mimosoideae)		Tree	Domestic Fuel wood
Lonchocarpus griffonianus	FABACEAE(Faboideae)		Tree	
Lophira alata	OCHNACEAE	Efenfen Afanfan; Ekki	Tree	Timber / Hard Wood
Macaranga barteri	EUPHORBIACEAE		Tree	
Macaranga heudelotii	EUPHORBIACEAE		Shrub/Tree/ Liane	
Maesobotrya barteri	EUPHORBIACEAE		Tree	Timber
Mallotus oppositifolius	EUPHORBIACEAE		Herb	
Mammea africana	GUTTIFERAE		Tree	Timber/Hard/Medicine
Mangifera indica	ANACARDIACEAE	Mango	Tree	
Manihot esculenta	EUPHORBIACEAE	Cassava	Shrub	
Marantochloa purpurea	MARANTACEAE		Herb	
Microdesmis puberula	PANDACEAE		Herb	
Mimosa invisa	FABACEAE		Straggling	

SPECIES NAMES	FAMILY	COMMON NAME	HABIT	ETHNOBOTANY
	(Mimosoideae)		Herb	
Mimosa pudica	FABACEAE(Mimosoideae)		Straggling Herb	
Monodora myristica	ANNONACEAE	Calabash Nutmeg	Tree	Condiment
Musanga cecropioides	EUPHORBIACEAE	Umbrella tree	Tree	Timber / Soft Wood
Nauclea diderrichii	RUBIACEAE	Opepe	Tree	Timber / Hard Wood
Nephrolepis biserrata	NEPHROLEPIDACEAE	Giant Sword Fern	Fern	
Neptunia oleracea	FABACEAE(Mimosoideae)		Straggling Herb	
Newboulda laevis	BIGNONIACEAE	Boundary tree	Construction	
Olax spp.	OLACACEAE			
Oleandra distenta	OLEANDRACEAE		Tree Fern	
Ouratea calantha	OCHNACEAE			
Palisota hirsuta	COMMELINACEAE		Herb	
Panicum maximum	POACEAE		Grass	
Paspalum vaginatum	POACEAE		Grass	
Pennisetum purpureum	POACEAE			
Pentaclethra macrophylla	FABACEAE (Faboideae)	Oil bean tree	Tree	
Pentadesma butyracea	CLUSIACEAE		Tree	Timber / Hard Wood
Pentodon pentandrus	RUBIACEAE		Herb	
Phymatodes scolopendria	POLYPODIACEAE		Tree Fern	
Piptadeniastrum africanum	FABACEAE (Mimosoideae)			
Platycerium stemaria	POLYPODIACEAE		Tree Fern	
Psydrax palma	RUBIACEAE		Tree	Hard wood
Pterocarpus santalinoides	FABACEAE (Faboideae)			
Raphia hookerii	ARECACEAE / PALMAE	Wine Palm	Tree	Sap Wine; Handicraft
Rauvolfia vomitoria	APOCYNACEAE		Shrub	Medicine
Rhigiocarya racemifera	MENISPERMACEAE			
Rothmannia hispida	RUBIACEAE			Medicine
Sacciolepis africana	POACEAE		Grass	
Selaginella myosurus	SELAGINELLACEAE		Fern	
Setaria megaphylla	POACEAE		Grass	
Smilax kraussiana	SMILACACEAE		Straggling Herb	
Spondianthus preussii	EUPHORBIACEAE	Okolota	Tree	Hard/hand dug canoe
Spondias mombin	ANACARDIACEAE	Iginein	Tree	Food/Medicine
Symphonia globulifera	CLUSIACEAE		Tree	Chewing stick

SPECIES NAMES	FAMILY	COMMON NAME	HABIT	ETHNOBOTANY
Syzygium guineense	MYRTACEAE		Tree	
Terminalia ivorensis	COMBRETACEAE	Idigbo; Black Afara	Tree	Timber / Hard Wood
Terminalia superba	COMBRETACEAE	White Afara	Tree	Timber / Hard Wood
Tetrapleura tetraptera	FABACEAE (Faboideae)		Tree	Condiment/Medicine
Treculia africana	MORACEAE	African Bread Fruit	Tree	Food
Triumfetta cordifolia	MALVACEAE		Herb	
Uapaca guineensis	PHYLLANTACEAE		Tree	Food / Timber
Urena labata	MALVACEAE		Herb	
Vitex grandifolia	LAMIACEAE		Tree	Timber
Vossia cuspidata	POACEAE		Grass	
Xylopia aethiopica	ANNONACEAE		Tree	Boat making, Condiment
Xylopia staudtii	ANNONACEAE		Tree	Timber/Soft/Food/Condiments

Source: SPDC (2007a,b; 2008, 2009, 2010, 2012, 2015).

Structure and Physiognomy

Fresh water swamp vegetation system as observed within the study area is differentiated according to the level and extent of wetness in all the zones. This relativity within the swamp vegetation ecosystem is a natural function of presence and proximity to perennial water sources and other variables including water table depth, ground elevation, and reach/duration of flooding. Several anthropologically induced factors especially road construction, sand filling activities and forest encroachment for community expansion, result in the interruption of the natural ecosystem and the consequent alteration of its species composition. The predominant sub ecological differentiation of the vegetation cover is mostly natural, and observed in the species composition and physiognomy of the vegetation. The structure of the vegetation cover across the four sampling zones is divided into two major categories:

1. Fresh Water Swamp Forest
2. Agricultural Farmlands and Home Gardens

- **Fresh Water Swamp**

Riparian forests are characterized by plants that have morphological and physiological adaptations to water - logging (Steentoft, 1986; Richards, 1970). Two major types of the Fresh water swamp were identified in this habitat based on species composition and dominance patterns, they are: the Flood forest and Raffia swamp.

Flood Forest: According to Raunkiaer (1934) life form spectrum, the vegetation structure of this ecosystem is observed to be predominantly Mesophanerophytic. Mature, secondary forest vegetation is observed in zone 1 (SPDC, 2007a; SPDC, 2010). The profile of the secondary forest is fairly unstratified: although there is a layer of tall emergent species supported by elaborate buttress and stilt roots; and the canopy layer. The emergent layer constitutes over

60 % of the vegetation cover, and reaches a height of 20 metres. Dominant tree species in the upper canopy included *Alstonia boonei*, *Elaeis guineensis*, *Ceiba pentandra*, *Cleistopholis patens,* and *Irvingia gabonensis.* Palm dominated areas are however more common as well as open canopy areas in tree gaps around perennial water sources, being dominated by aquatic macrophytes of which near homogenous populations of *Paspalum species,* and *Sacciolepis africana* occur (Plate 4.3.4.1a). Tree canopy is fairly populated with tree ferns associated with the oil palms including *Phymatodes scolopendria, Oleandra distenta, Platycerium stemaria,* and *Asplenium africanum*; and lianas including: *Macaranga heudelotii, Ficus ovate, Cissus aralioides, Combretum racemosum*. Generally, the undergrowth vegetation is sparse because of the predominant flood condition, consisting mainly of tree saplings including oil palm (Plate 4.3.4.1b). In drier terrain, open canopy areas resulting from lumbering and agricultural activities were observed (Plate 4.3.4.1c).

Plate 4.3.4.1: Profile of Flood Forest Vegetation in the study area. a: Secondary Swamp Forest; b: Flooded forest floor; c: Open Canopy forest during dry season
Source: SPDC (2014; SPDC 2007a).

Generally the vegetation is mostly open canopy forest as the seasonally flooded freshwater swamp forest area is under considerable anthropogenic pressure from indigenous sources (SPDC, 2007b).

Raffia Swamp: The Raffia Swamp is a fresh water swamp sub ecosystem circumscribed on the basis of species dominance. It exists as a near homogenous population of Raffia species. This community within the study area is observed to be dominated by *Raphia hookerii.* The raffia swamp is dominant around Adibawa area located in sampling Zone 2 (SPDC, 2010); and around Koroadaba located in sampling Zone 1 (SPDC, 2007b); while smaller communities are present around Zarama (Zone 2) (SPDC, 2014). Generally, the *Raphia hookerii* population is found to occur along with a few other plants including *Anthocleista vogelii*, *Alstonia boonei*, *Ficus* sp and *Fleroya ledermannii* (Abura).

According to the Raunkiaer (1934) life form classification scheme, this habitat is Mesophanerophytic. Average height of vegetation is 16 metres and there is an emergent vegetation layer above the Raphia palm canopy occupied by *Alstonia boonei* and *Symphonia globulifera.* The Raffia swamp vegetation in the study area was generally luxuriant.

Plate 4.3.4.2: Raffia Swamp fringe at Koroadaba: open canopy area dominated by aquatic macrophytes. SOURCE: SPDC (2007a).

Aquatic macrophytes were common within the fresh water swamp ecosystem across the zones of the study area. Dominant species include rooted aquatic macrophytes: *Cyclosorus striatus*, *Sacciolepis africana*, *Cyrtosperma senegalensis*, and *Sagittaria sagittifolia.* Floating aquatic macrophytes were also present which included *Nymphaea lotus*, *Lemna paucicostata*, and *Wolffia arrhiza.* The invasive Water Hyacinth (*Eichhornia crassipes*) was observed to be a menace along most of the water courses (Plate 4.3.4.3).

Plate 4.3.4.3: Creek rendered almost closed up by Water hyacinth.

Source: *SPDC (2010).*

- **Agricultural Farmlands and Home Gardens**

Agricultural farmlands and bush fallows are the predominant vegetation systems in Zone 2 area, as much of the original vegetation has been removed for agricultural purposes (SPDC, 2010). Agricultural activity is however common across the study area and consist mainly of annuals which are cultivated during the short dry spell (SPDC, 2014). Cropping is mainly mixed farming dominated by any two or three of Maize, Yam, Cassava, Okra, Groundnut and Melon carried out on a subsistence level (mostly less than an acre per holder). It is non-mechanised and is characterised by slash and burn shifting cultivation system. All of these crops are also cultivated in home gardens. Much of the food staples and vegetables consumed within the area are cultivated locally on small farm holdings and home gardens (Plate 4.3.4.4). A total of 32 species in 21 families were identified in this vegetation system. The relative species composition of the five major categories of crops cultivated within the study area is: Edible Fruits/Seeds/Stems (17) > Vegetables (7) > Staples (5), Medicine (5) > Condiments (3) (The medicinal plant category is made up of species drawn from the other groups). Table 4.3.4.2 shows the list of common crops cultivated in the area.

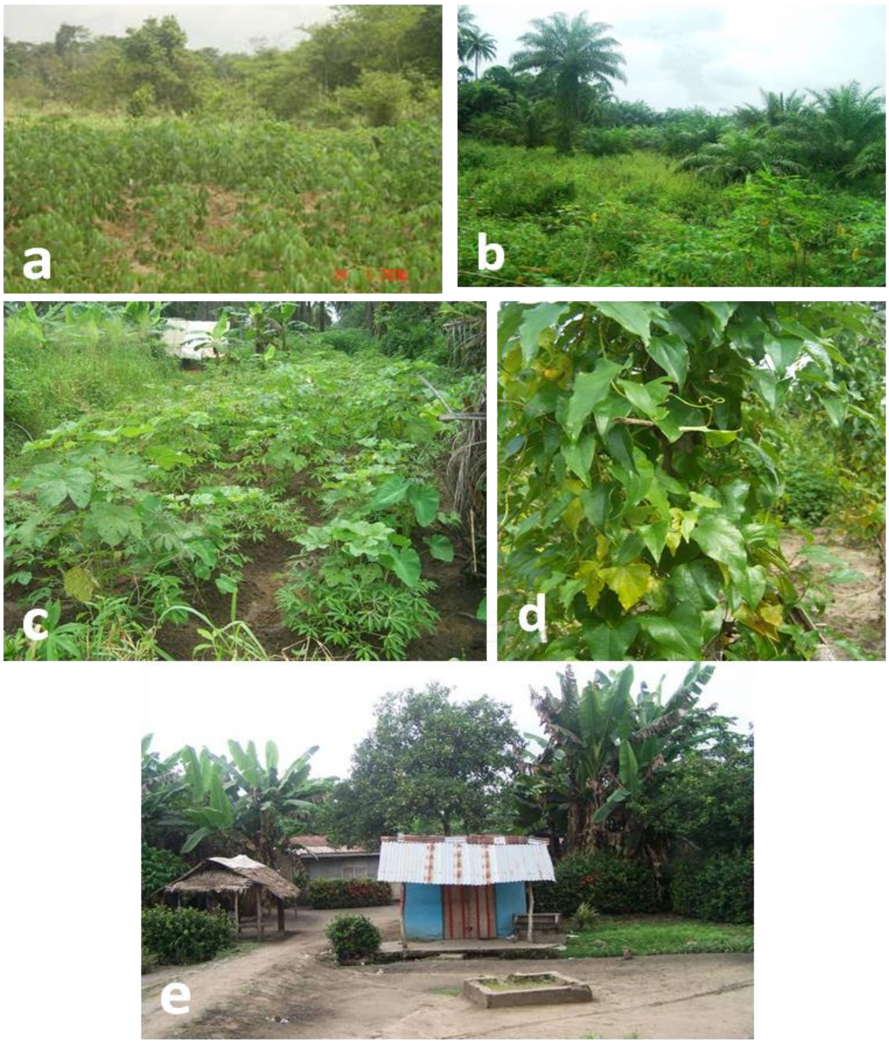


Plate 4.3.4.4: Typical agricultural farms found within the study area. a: Cassava farm; b: Oil palm plantation; c: Mixed cropping of Cassava, Okro and Cocoyam; d: Yam farm; e: typical home garden.

Source: SPDC (2007b; 2010)

Table 4.3.4.2: Crops of agricultural farmlands and home gardens, in the study area

S/No	Scientific Name	Family	English name	Habit	Economic Use
1	*Musa paradisiaca*	Musaceae	Plantain	Herb	Staple
2	*Dacryodes edulis*	Burseraceae	African pear	Tree	Edible Fruit
3	*Dioscorea alata*	Dioscoreaceae	Water yam	Climber	Staple
4	*Ipomoea batatas*	Convolvulaceae	Sweet potatoe	Creeper	Staple
5	*Abelmoschus esculenta*	Malvaceae (Malvoideae)	Okra	Herb	Vegetable
6	*Colocasia esculenta*	Arecaceae	Cocoyam	Herb	Staple
7	*Carica papaya*	Caricaceae	Pawpaw	Tree	Edible Fruit
8	*Artocarpus communis*	Moraceae	African Bread fruit	Tree	Edible Fruit
9	*Mangifera indica*	Anacardiaceae	Mango	Tree	Edible Fruit/ Medicine
10	*Ananas comosus*	Bromeliaceae	Pineapple	Herb	Edible Fruit
11	*Cola acuminata*	Malvaceae (Sterculioideae)	Colanut	Tree	Edible Seeds
12	*Saccharum officinarum*	Poaceae	Sugarcane	Grass	Edible Stems
13	*Manihot esculenta*	Malvaceae (Malvoideae)	Cassava	Shrub	Staple Tuber
14	*Zea mays*	Poaceae	Maize	Herb	Edible Fruit
15	*Musa sapientum*	Musaceae	Banana	Herb	Edible Fruit
16	*Vernonia amygdalina*	Asteraceae	Bitter leaf	Shrub	Vegetable
17	*Capsicum spp*	Solanaceae	Pepper	Herb	Vegetable
18	*Telfairia occidentale*	Cucurbitaceae	Pumpkin leaf	Climber	Vegetable
19	*Amaranthus*	Amaranthaceae	Green	Herb	Vegetable

S/No	Scientific Name	Family	English name	Habit	Economic Use
	spp		vegetable		
20	*Spinacia oleracea*	Spinaceae	Spinach	Climber	Vegetable
21	*Talinum triangulare*	Amaranthaceae	Water leaf	Herb	Vegetable
22	*Cocos nucifera*	Arecaceae	Coconut	Tree	Edible Fruit
23	*Persea americana*	Lauraceae	Pear	Tree	Edible Fruit
24	*Psidium guajava*	Myrtaceae	Guava	Tree	Edible Fruit/Medicine
25	*Arachis hypogaea*	Fabaceae (Faboideae)	Groundnut	Herb	Edible Seeds
26	*Monodora myristica*	Annonaceae	Calabash nutmeg	Tree	Condiment
27	*Ocimum gratissimum*	Lamiaceae	Sweet Basil	Herb	Condiment/Medicine
28	*Cymbopogon citratus*	Poaceae	Lemon grass	Herb	Condiment
29	*Citrullus lanatus*	Cucurbitaceae	Melon	Creeper	Edible Fruit
30	*Annona muricata*	Annonaceae	Soursop	Tree	Edible Fruit
31	*Citrus sinensis*	Rutaceae	Orange	Tree	Edible Fruit
32	*Citrus aurantifolia*	Rutaceae	Lime	Tree	Edible/Medicine

Source: SPDC (2007a,b; 2008; 2010; 2012; 2015).

Abandoned agricultural farmlands result in bush fallows dominated by common weeds (Hopkins, 1981; Akobundu, 1988). Typical species present include *Chromolaena odorata, Aspilia africana*, *Clappertonia ficifolia*, and *Alchornea cordifolia*. The vegetation is stratified into two layers: the shrub layer with average height of less than 2 metres and the tree layer. Its physiognomy is defined by the few scattered vestiges of trees emerging above the shrub layer; dominated by Oil palms, and includes *Irvingia gabonensis* (Plate 4.3.4.5). Pioneer tree species/saplings of degraded swamp vegetation including *Musanga cecropioides*, *Anthocleista nobilis*, and *Alstonia boonei* are common in this habitat.

Plate 4.3.4.5: Typical profile of bush fallow vegetation in the study area.
Source: SPDC (2008).

4.3.4.2 Phytochemistry

Table 4.3.4.3a,b shows the summary of the results of heavy metal analysis of plants in the study area. The concentration of the potentially toxic heavy metals (Ni, Cr, Pb, V, Zn, Mn, Fe and Cu) which were assessed fall within the range for normal concentrations in plant tissue.

Table 4.3.4.3: Summary of Heavy Metal Concentration in Plants of the Study Area

Species	V	Ni	Pb	Cr	Zn	Cd	Fe	Mn	Cu	Hg
Costus afer (Ginger lily)	BDL	0.24	BDL	0.002	2.1	BDL	5.15	3.7	5.61	BDL
Diplazium sammanti	0.05	0.46	0.02	0.015	8.55	BDL	4.9	2.15	4.91	BDL
Raphia hookeri (Raffia palm)	0.02	0.16	0.03	0.008	25.7	BDL	7.1	5.1	5.8	BDL
Alchornea cordifolia (Christmas bush)	0.04	0.37	0.03	BDL	29.65	BDL	2.7	34.45	6.82	BDL
Antocleista vogeli (Cabbage tree)	0.03	0.32	BDL	0.029	19.6	BDL	4.4	5.5	7.34	BDL
Pterocarpus santalinoides	BDL	0.06	0.05	BDL	8.55	BDl	6.05	6.45	5.81	BDL
Manihot spp.	0.03	0.27	BDL	0.003	26.2	BDL	5.8	8.15	6.84	BDL

SPDC (2015)

Table 4.3.4.3b: Summary of Heavy Metal Concentration in Plants of the Study Area

S/No.	Scientific Name	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	Cr	Cd	Ni	V	Pb
		%						ppm								
1a	*Manihot esculenta*	1.63	0.38	0.56	0.37	0.45	0.01	0.22	0.01	1.44	0.30	0.30	0.1	0.01	0.01	0.16
1b	*Manihot esculenta*	1.86	0.35	0.54	0.42	0.43	0.06	0.18	0.01	0.99	0.04	0.33	0.1	0.01	0.01	0.04
2a	*Dioscorea alata*	1.72	0.35	0.52	0.32	0.43	0.02	0.10	0.10	0.81	0.04	0.03	0.2	0.02	0.02	0.04
2b	*Dioscorea alata*	1.70	0.20	0.56	0.85	0.24	0.32	0.86	0.07	2.84	1.00	0.43	0.0	0.01	0.01	0.11
3a	*Raphia hookeri*	1.72	0.28	5.70	2.60	0.27	0.33	0.33	0.02	4.45	1.66	0.05	0.1	0.02	0.02	0.06
3b	*Raphia hookeri*	1.90	0.26	4.87	2.54	0.34	0.31	0.36	0.02	4.30	1.65	0.04	0.0	0.01	0.02	<0.01
4a	*Abemoschus esculenta*	1.72	0.25	5.30	2.40	0.24	0.32	0.86	0.07	2.84	1.0	0.03	0.0	0.01	0.01	0.11

S/No.	Scientific Name	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	Cr	Cd	Ni	V	Pb
		%						ppm								
4b	*Abemoschus esculenta*	1.84	0.28	5.28	2.62	0.26	0.36	0.84	0.06	2.90	1.02	0.02	0.05	0.01	0.01	0.10
5a	*Elaeis guineensis*	1.78	0.23	1.55	0.82	0.42	0.44	0.13	0.03	0.42	0.03	0.02	0.03	0.02	0.03	<0.01
5b	*Elaeis guineensis*	1.86	0.25	1.58	0.88	0.46	0.54	0.16	0.04	0.44	0.03	0.01	0.02	0.02	0.01	<0.01
6a	*Musa* sp.	2.43	0.26	1.04	0.89	0.54	0.31	0.46	0.02	0.70	0.05	0.02	0.05	0.01	0.02	<0.01
6b	*Musa sp*	2.54	0.28	1.06	0.90	0.62	0.43	0.49	0.03	0.82	0.04	0.02	0.06	0.01	0.02	<0.01
7a	*Telfaria occidentalis*	2.51	0.61	2.3	1.72	0.63	0.21	0.09	0.01	1.88	1.04	0.18	0.06	0.01	0.01	0.01
7b	*Telfaria occidentalis*	2.58	0.65	2.50	1.84	0.70	0.26	0.10	0.01	1.98	1.50	0.121	0.08	0.01	0.01	0.01
8a	*Saccharum Officinarum*	2.68	0.58	2.4	1.65	0.58	1.2	0.54	0.02	3.90	0.02	0.10	0.14	0.02	0.01	0.10
8b	*Saccharum officinarum*	2.56	0.54	2.6	1.72	0.61	1.5	0.58	0.01	2.81	0.02	0.10	0.13	0.02	0.01	0.10

SPDC (2010)

4.3.4.3 Ethnobotany

The vegetation cover supports the livelihood of the people in providing timber which is harvested in commercial quantities and sold to timber merchants. They are also used for furniture making, construction of huts/houses, and fishing canoes: Typical timber species present include *Lophira alata, Ceiba pentandra, Fleroya ledermannii*. Twigs and non-economically useful timber are used for fuel wood, and stakes for yam cultivation. Non timber forest resources include medicine and food. In Koroadaba area (sampling zone 1), like in most of the study area, the tapping of raffia sap is a key preoccupation which provides the raw material for the distillation of local gin (Plate 4.3.4.6) providing jobs', and refreshment for the locals. Details of the economic value of plants in the project area are listed in Table 4.3.4.1.

Plate 4.3.4.6: A typical palm wine tapper in the study area
Source: SPDC (2007a)

4.3.4.4 Phytopathology

The pathological conditions encountered in the area include leaf spots, necrosis, chlorosis, defoliation and leaf variegation. Close examination of plants with variegated leaves shows that the causal organisms are insect pests (Beetles, Aphids, Lepidopteran larvae and Grasshoppers). The severity of disease incidence is generally mild or moderate. The list of disease symptoms present in plant populations including agricultural farms in the study area is presented in Table 4.3.4.4.

Table 4.3.4.4: Disease symptoms and causative organisms isolated from leaf samples

Disease Symptoms	**Causative organisms**	**Group of Organism**
Leaf Spots	*Cercospora* sp.	Fungi
Kernel rot Maize	*Fusarium moniliforme*	Fungi
Mosaic / Chlorotic patches on leaves	African cassava mosaic virus (*Begomovirus* sp)	Virus
Chlorotic to Necrotic spots	*Xanthomonas campestris*	Bacteria
Necrosis and wilting (Maize)	*Pseudomonas* sp	Bacteria
Inner Root Rot	*Phomopsis* sp.	Fungi
Soft rot: Root	*Erwinia* sp.	Bacteria
Leaf Spot	*Nigrospora* sp.	Fungi
Variegated leaves	Ants	
Powdery dew	*Aspergillus flavus*	Fungi

SOURCE: SPDC (2007a,b; 2008; 2010; 2012; 2015).

4.3.4.5 Ecologically Sensitive Areas

The study area is around four Forest Reserves. The Forest Reserves and their gazetted sizes are (UNDP, 2013): Taylor Creek (22.57 km^2) (Bayelsa State), Upper Orashi 47.67 km^2 (Rivers State), Nun River 122.5 km^2 (Bayelsa State), Egbedi 66.32 km^2 (Bayelsa State).

The terrain is typically seasonally flooded fresh water swamp forest which belongs to the sensitive wetland ecosystem housing diverse flora and fauna. Its swamp character defines and sustains the entire ecosystem, providing water and energy for the unique organisms that inhabit the habitat including plants. It is important to note that this highly unstable soil environment is held in place by the trees which by their root system, and ground cover, provide protection against coastal erosion and adverse flooding. The ecosystem greatly depends on the natural surface water flow dynamics across the terrain which can be hindered by industrial activities. These form the bulk of concern that underscores the sensitivity of this ecosystem.

Land Use/Cover

The main land-use and cover types of the study area in order of prominence is forestry/agriculture > built-up areas (settlement and industrial), and water bodies.The built-up areas consist of communities within the study area **(see SOCIO ECONOMICS SECTION 4.3.8)** and access roads; SPDC well sites, pipelines and manifolds; SPDC access roads leading to well sites and locations**.** Other industrial fingerprints include Flowline/pipeline right-of-ways (ROWs) and a ROW being established by Power Holding Company of Nigeria (PHCN) (formerly National Electric Power Authority (NEPA)). An extensive refuse dump operated by the Bayelsa State Government is located in Zone 1.

Agricultural land use is quite substantial within the study area. Arable crops are grown in cassava-based shifting cultivation systems. Also, perennial crops like plantain and banana are cultivated especially in home gardens. Fallow lands characterized by sparse vegetation are abundant. Patches of oil palm bush or forest and Raphia swamps are located within the study area. These areas are managed for harvesting of wild palm-fruits and palm wine tapping, respectively. There are indications that the forests are also managed for other non-timber forest products (NTFPs) like giant snails and rattan cane. Notable water bodies for transport and fishing activities at the proposed project area include Osumu Creek, Odidie Creek, Onopa Creek, Abambule Lake and Okubidi Lake, Taylor Creek, Egbedi Creek, River Nun, and Upper Orashi River. Also, seasonal lakes and fish ponds abound within the forest.

4.3.5 Wildlife

4.3.5.1 Ecology

The study area is situated in the wet rainforest ecosystem. The freshwater swamp forest belt is bounded on the southern margins by the coastal swamps and on the northern margin by the tropical rainforest. This kind of ecosystem sustains a large assemblage of wildlife because of the near perennial availability of water which is essential for wildlife survival. The diversity of swampy terrains is enhanced by the presence of reptiles because reptiles are more adapted to the wet terrains being the immediate descendants of the amphibians. Generally, Mammals, and particularly herbivorous species find a nearly all year round availability of food and are mostly ungulates which are also well adapted to the swampy terrain. Elevated areas of the vegetation system encourage traditionally rainforest species especially during dry spells. There is thus a seasonal migration of wildlife to the margins of the tropical rainforest during the wet season and back to the swamps during the short dry spells.

4.3.5.2 Species Inventory

A total of 84 wildlife species was identified in the study area. The major Classes of wildlife in order of the number of species reported are: Aves (29 species belonging to 15 families), Mammals (27 species from 12 families) and Reptiles (22 species spread across 11 families). A checklist of wildlife species identified in the study area is presented in Appendix 4.3.5.1 Amphibians had the least number of 6 belonging to 4 families.

4.3.5.3 Conservation Concerns

Interview sessions with hunters about last kill, usual kills, or sighting by hunters deduced in the course of interview reveal that most of the animals listed (including the African elephant which was killed in 2010 around Zarama, Taylor Creek forest reserve area (Zone 2)) have been encountered in the recent times. This suggests that some relic populations of endangered species are still present in the wild in this area. According to SPDC (2015), the bulk of the wildlife in Zone 1 sample area, is resident in the riparian forests marking the shores of the Nun River between Kaiama, and the Egbedi Creek area. All the previous reports reviewed from the area, show that there is a large concentration of wildlife especially in the margins of the forest reserves. According to the hunters, the greatest catches are recorded during the flood season, when most of the wildlife migrate locally from their habitats to dry grounds to escape rising flood. In the process they become susceptible or exposed to hunting. Hunting is rife and carried out by use of traps and native guns. During field surveys it was easy to come by game killed the same day (Plate 4.3.5.1).

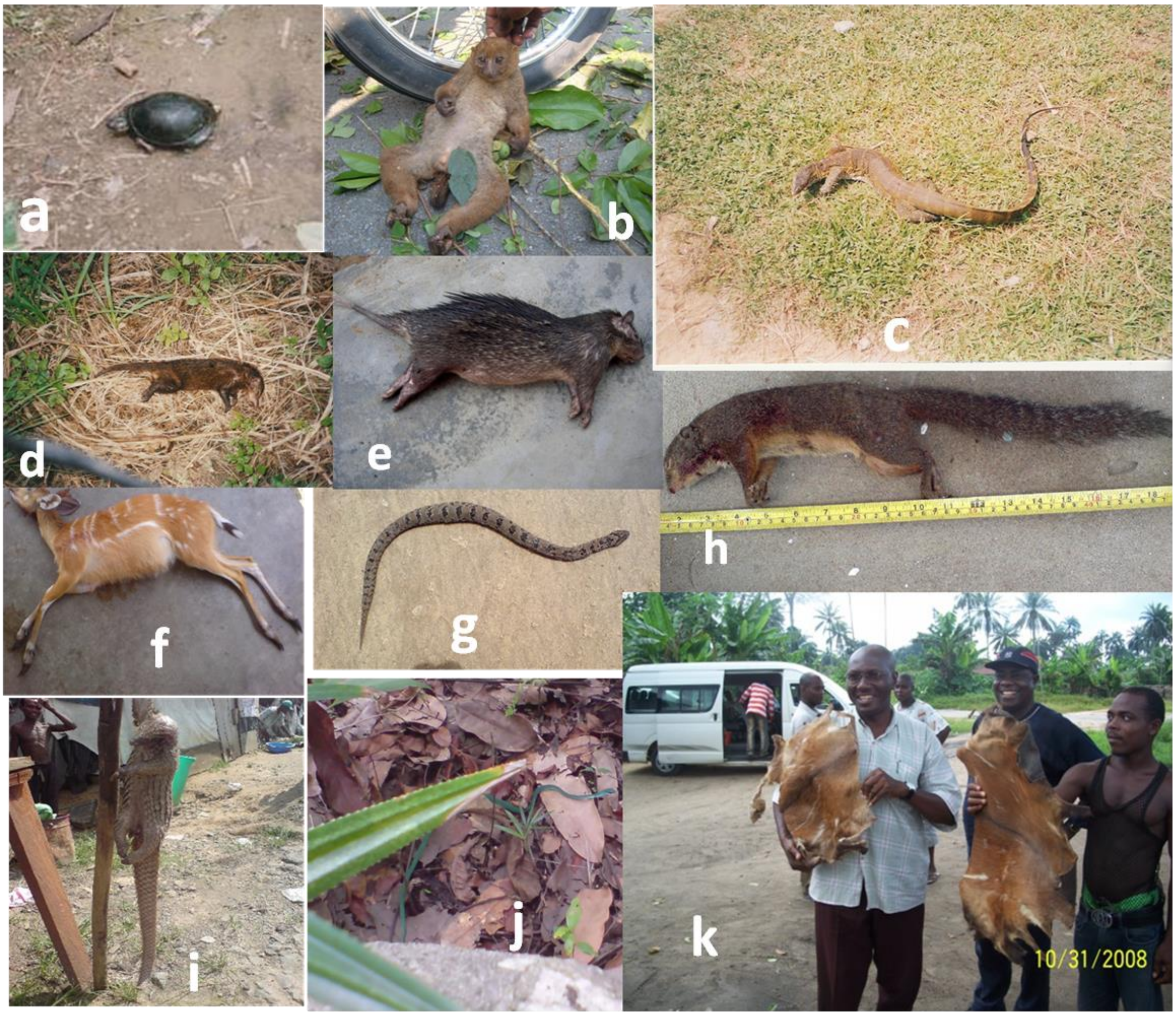


Plate 4.3.5.1: Game encountered during field survey: a, Black forest turtle; b, Bosmann's Potto; c, Forest Monitor; d, Cusimanse; e, Brush tailed porcupine; f, Sitatunga; g, Night Adder; h, Squirrel; i, Tree pangolin; j, green snake; k, Bush buck.
Source: SPDC (2007, 2008, 2009, 2010).

A summary of the sensitive wild life species associated with the study area along with their local and IUCN status is presented on Table 4.3.5.1. Status of wildlife is categorized into five by the IUCN:

i. Extinct (Organisms without any living specimen left, or thought to be wiped out).
ii. Endangered (deemed to be in immediate danger of extinction).
iii. Threatened (a generic term for animals whose populations face any level of depletion).
iv. Vulnerable (taxa with populations that have been seriously depleted; and taxa with populations that are still abundant but are under threat from severe adverse factors).
v. Rare (taxa with naturally small world populations).

Table 4.3.5.1: Some of the sensitive wildlife species within the study area and their local and IUCN status

	Common Name	Species	IUCN / LOCAL STATUS
Mammals	White-throated Guenon	*Cercopithecus erythrogaster*	Endangered
	Sclater's Guenon	*Cercopithecus Sclateri*	Vulnerable
	Spot-necked otter	*Lutra maculicollis*	Vulnerable
	Maxwell's duiker	*Cephalophus maxwelli*	Locally threatened
	African manatee	*Tricheus senegalansis*	Vulnerable
	Brush-tailed porcupine	*Atherurus africanus*	Locally threatened
	African Elephant	*Loxodenta africana*	Locally Rare / Threatened
	Calabar angwantibo	*Arctocebus calabarensis*	Locally Vulnerable
	Sitatunga	*Tragelaphus spekei*	Vulnerable
	Water chevrotain	*Hyemoschus aquaticus*	Locally Vulnerable
	White-nosed monkey	*Cercopithecus nictitans*	Locally Vulnerable
	Niger Delta Red Colobus monkey	*Procolobus epieni*	Critically Endangered/Vulnerable
	Bosmann's Potto	*Perodicticus potto*	Locally Threatened
	Crested genet	*Genetta cristata*	Vulnerable
Reptiles	Dwarf Crocodile	*Osteolaemus tetraspis*	Vulnerable
	Serrate hingeback tortoise	*Kinixys erosa*	Threatened
	Nile Monitor lizard	*Varanus niloticus*	Threatened
	Nile Crocodile	*Crocodylus niloticus*	Threatened
	Rock Python	*Python sebae*	Locally Vulnerable
	Long tailed/Black-bellied pangolin	*Phataginus tetradactyla*	Vulnerable
	Tree/White Bellied Pangolin	*Phataginus tricuspis*	Vulnerable
Birds	Black Kite	*Milvus migrans*	Locally Common
	African Harrier Eagle	*Polyboroides typus*	Locally Common

Source: SPDC (2007a,b; 2008, 2009, 2010, 2012, 2015).

The unique location of the study area, which is bounded on the four angles by Forest Reserves, makes the area a buffer zone for wildlife as they cross from one Forest Reserve to the other. The sensitivity of the area is further strengthened by the presence of endemic species. Seven (7) species have a conservation status of being locally and globally threatened e.g. African elephant. Twelve (12) other species (including the Nile monitor, Calabar Angwantibo, Bosmann's Potto, African manatee and Putty nosed monkey) are particularly locally vulnerable. The monkeys include Nigeria's only two endemic species (White throated and Sclater's Guenon). This is because the study area occupies the broad boundary between two geographic assemblages: eastern species (Sclater's guenon, Angwantibo and Fire footed rope squirrel) and the western species (White throated guenon and the Redless rope squirrel). The Crested porcupine (*Hystrix cristata*) and Chimpanzee (*Pan troglodytes*) are reported to be present in the Fangbe end of Zone 3 around the Nun River, particularly known for both species of the crocodiles.

4.3.6 Geology/Hydrogeology

Regional Geology

The study area lies within the Niger Delta sedimentary Basin. This Basin was formed in the Tertiary Period from the interplay between subsidence and deposition arising from a succession of transgressions and regressions of the sea (Hosper, 1965). This phenomenon gave rise to the deposition of three lithostratigraphic units in the Niger Delta. These are Akata, Agbada, and Benin Formations in order of decreasing age (Short and Stauble, 1965). The overall thickness of these Tertiary sediments is about 10,000 metres. The oldest of the units is the Akata Formation which is Paleocene in age. It consists of plastic, low density, under compacted, high pressured, shallow marine to deep water clays, shales and limestones. Its approximate thickness is about 1000 metres. The Akata Formation is known to be the source rock of petroleum in the Niger Delta. The Agbada Formation overlies the Akata Formation. It is made up of alternation of marine shale and sandstones and has an overall thickness of 3000 metres. It is the reservoir rock for petroleum in the Niger Delta. The youngest unit in the Delta is the Benin Formation (Coastal Plain Sands) which consists primarily of coarse sands with occasional clay/clayey intercalations. It is the major aquifer in the Delta, and the bearing medium for most of the engineering structures. The Formation outcrops on the surface in the Niger Delta.

Lithologic Logs/Local Geology

The project site shares the characteristic low lying topography of the Niger Delta. Lithologic logs of the boreholes drilled (Fig 4.3.6.1) show that the site (within the depth of investigation) is made up of three main lithologies. These include clay, clayey sand, and sand. The first two lithologies are collectively called clayey layer and are found from the surface to a maximum depth of 7 meters in BH2. This layer is followed by the sandy layer. The sands are commonly fine to medium grained, poorly sorted, and brown to white in colour and constitute the major aquiferous layer in the area. The permeability of these lithologies was determined to know the rate with which pollutants would flow through the ground to the aquifer, and within the aquifer also. Results (Table 4.6.3.1) show that the upper clayey unit has permeability values of $3.025X10^{-3}$ cm/s in BH3 1m to 9.6×10^{-3} in BH2 1m, while the aquiferous sand has slightly higher values of 1.21 x 10^{-2} cm/s in BH 4,8m to 2.56 x 10^{-2} cm/s in BH5, 3 -5m. If there is pollution in the area, the pollutants would flow through these layers at the permeability values stated. The flow rate would be faster within the aquifer than through the ground into the aquifer. The lithologic logs in the study area also show that the aquifers in the Gbaran location are confined by 1m to 4m of clay.

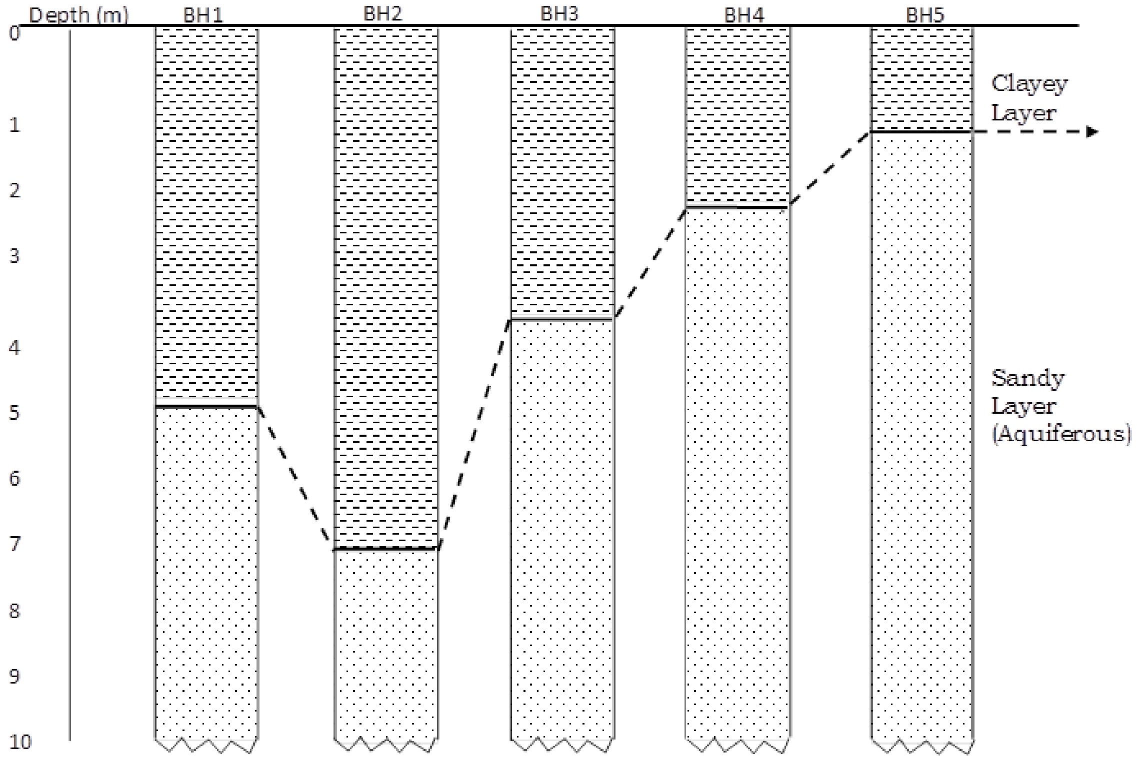


Fig 4.3.6.1: Lithologic Logs of Boreholes in the Study Area

Table 4.3.6.1: Permeable Values for Different Lithologies

Borehole code	Borehole Location		Soil type	Sample depth (m)	Particle Size Distribution (% passing sieve No)						K (cm/s)
	N	E			2mm	1mm	0.425mm	0.250mm	0.150mm	0.063mm	
BH1	04.75468°	007.10119°	Clay	1	99.7	98.1	85.3	51.2	23.8	10.5	3.6 x 10^{-3}
			Clay	2	99.6	97.5	89.3	50.5	27.3	8.5	4.9 x 10^{-3}
			Clayey sand	4	98.5	94.1	73.9	31.1	11.6	0.9	1.96 x 10^{-2}
			sand	6	97.3	94.8	71.8	39.5	13.2	1.8	1.69 x 10^{-2}
			Sand	8	99.2	92.3	70.4	33.6	12.5	1.0	1.96 x 10^{-2}
			sand	10	97.4	93.2	70.5	38.5	13.1	1.3	1.96 x 10^{-2}
BH2	04.76317°	007.10689°	Clay	2	99.4	97.1	81.3	53.2	20.8	9.5	9.6 x 10^{-3}
			Clay	4	99.7	97.1	83.3	54.2	22.8	8.6	4.9 x 10^{-3}
			Clayey sand	6	97.8	94.2	71.2	30.5	10.3	0.7	5.6 x 10^{-3}
			Sand	8	99.2	91.3	70.4	31.6	12.5	0.9	1.96 x 10^{-2}
			sand	9	99.2	90.3	70.1	30.6	11.5	1.0	2.25 x

Borehole code	Borehole Location		Soil type	Sample depth (m)	Particle Size Distribution (% passing sieve No)						K (cm/s)
	N	E			2mm	1mm	0.425mm	0.250mm	0.150mm	0.063mm	
											10^{-2}
BH3	04.76017°	007.09816°	Clay	1	99.1	96.3	81.5	49.8	25.6	12.5	3.025×10^{-3}
			Clay	2	99.1	97.3	88.1	50.1	24.3	11.2	3.6×10^{-3}
			Sand	6	98.2	91.3	69.4	31.2	11.5	0.9	2.25×10^{-2}
			Sand	8	99.1	90.3	71.2	30.6	12.0	0.8	1.96×10^{-2}
			sand	10	99.2	92.3	70.1	33.3	9.5	1.0	2.89×10^{-2}
BH4	04,76375°	007.09992°	clay	1	99.5	97.2	80.5	55.3	21.6	10.5	3.6×10^{-3}
			Sand	4	97.4	92.2	70.3	38.5	11.1	1.0	2.56×10^{-2}
			Sand	6	99.1	90.2	70.5	36.1	13.1	0.9	1.96×10^{-2}
			Sand	8	98.5	91.5	71.5	34.8	15.6	0.8	1.21×10^{-2}
			sand	10	99.6	89.7	69.6	31.5	14.8	0.9	1.32×10^{-2}
BH5	04.76182°	007.09728°	Clay	0.5	99.9	98.8	88.5	57.9	28.5	12.5	3.6×10^{-3}
			Sand	2	98.3	91.0	71.2	32.5	11.3	1.2	2.89×10^{-2}
			Sand	3	99.3	90.5	67.5	38.5	10.9	0.8	2.56×10^{-2}
			sand	5	99.1	90.2	71.5	38.2	11.4	1.0	2.56×10^{-2}

Source: Fieldwork 2014.

Groundwater Flow Direction

Groundwater flow direction in the study area as determined from the hydrogeological data generated during this study (Table 4.3.6.2) is from Northeast to Southwest (Fig. 4.3.6.2). The implication is that if there is pollution of groundwater in the area, the pollutants would flow from northeast to southwest from the point of pollution. The hydrogeological data also show that Static Water Level in the area is very high (very close to the surface) (Table 4.3.6.2). Pollutants should not be dumped on the ground surface in view of the closeness of groundwater to the surface.

Table 4.3.6.2: Hydrogeological Data in Gbaran area

Borehole code	Borehole location		Borehole Elevation(m)	Static Water Level (SWL), m	Hydraulic Head (m)
	N	E			
BH1	04.75468°	007.10119°	10.1	-	-
BH2	04.76317°	007.10689°	7.0	0.81	6.19
BH3	04.76017°	007.09816°	5.0	0.62	4.38
BHC1	04.76375°	007.09992°	5.3	0.1	5.20
BHC2	04.76182°	007.09728°	6.0	0.43	5.57

Source: Fieldwork, 2014

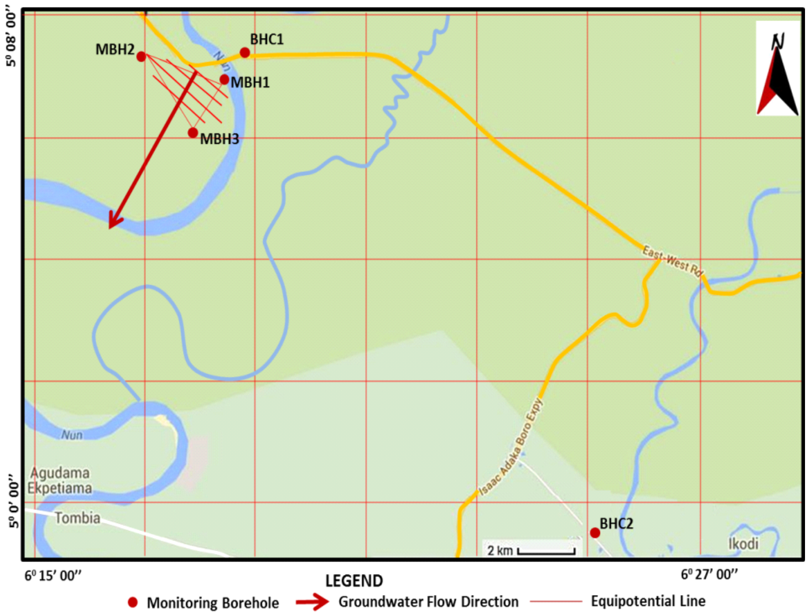


Fig. 4.3.6.2: Groundwater Flow Direction in Gbaran

Groundwater Physicochemistry

The results of the analyses of water samples from boreholes in in the different zones of the study area are summarized in Tables 4.3.6.3 and 4.3.6.4 and illustrated pictorially in Figures 4.3.6.2 and 4.3.6.4. The detailed data can be found in Appendix 4.3.6. The sample numbers in the previous studies are as follows:

- Environmental Impact Assessment (With Revalidated Baseline Data) of Gbaran Ubie Phase 2 Integrated Oil and Gas Project (EIA Cluster 2 – Epu Field), Final Report (2015) – five (5) boreholes.
- Environmental Impact Assessment of Gbaran Ubie Phase 2 Integrated Oil and Gas Project (EIA Cluster 1 – Koroama, Gbaran and Kolo Creek Fields) Final Report (2009) – Six (6) boreholes.
- Environmental Impact Assessment of Gbaran Ubie Phase 2 IOGP (EIA Cluster 3) (2010) – Six (6) boreholes.

The pH values of the groundwater range from 6.88 to 9.45. These values show near neutral to slightly basic groundwater in the study area. These values fall outside the FMEnv (1993) recommended pH range of 6.5 to 8.5. The mean conductivity values in the zones ranged from 126 µS/cm to 579 µS/cm. Mean BOD values ranged from 1.10 mg/l to 5.18 mg/l, while mean nitrate values ranged from 0.16 mg/l to 4.52. The heavy metal common in all the zones include Fe (0.44 – 11.9 mg/l) and zinc (0.02 – 8.5 mg/l). All of the parameters were within FMEnv/WHO guideline limits. The groundwater therefore met the WHO chemical quality requirements of water meant for human consumption.

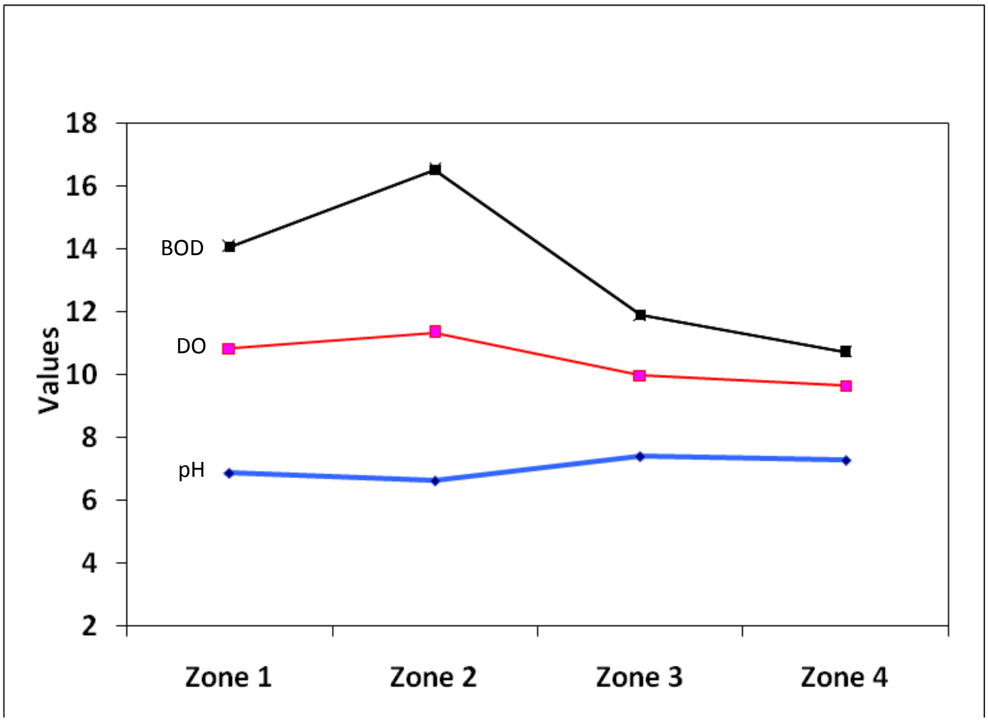


Fig. 4.3.6.3: Mean values of BOD, DO and pH for groundwater in the different Zones in the study area

Source: SPDC (2007a,b; 2008; 2009; 2010; 2012; 2015)

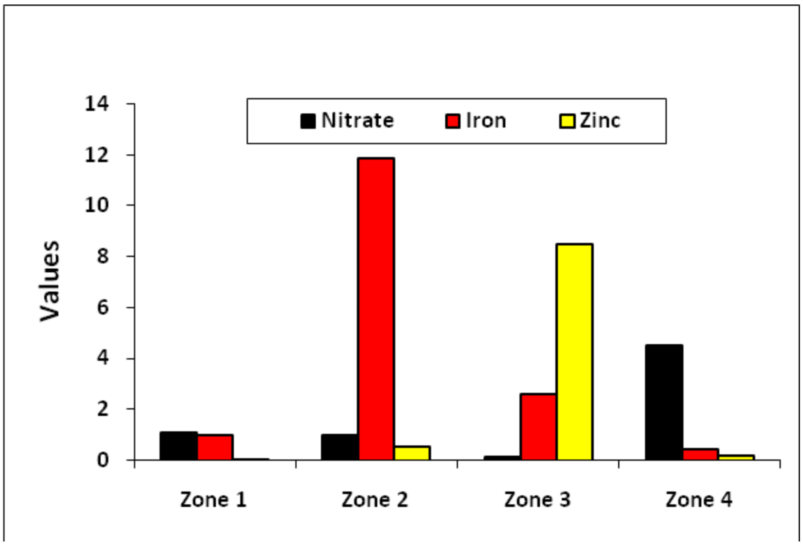


Fig. 4.3.6.4: Mean values of nitrate, iron and zinc for groundwater in the different Zones in the study area

Source: SPDC (2007a,b; 2008; 2009; 2010; 2012; 2015)

4.3.6.1 ZONE 1

Groundwater Physicochemical Properties

Some physicochemical characteristics of groundwater samples from Zone 1 are listed in Tables 4.3.6.3and 4.3.6.4 as well as Figures 4.3.6.3 and 4.3.6.4. The pH ranged from 6.88 to 7.30, with a mean value of 6.89. These pH values comply with the FMEnv limits for drinking water. Electrical conductivity ranged from 5.56 to 160.3 µS/cm, while dissolved oxygen was between 0.34 and 4.41 mg/l. Biochemical oxygen demand, chemical oxygen demand and total dissolved solids ranged from 0.43 – 3.69 mg/l, 1.77 – 11.7 mg/l and 1.83 – 78.2 mg/l respectively. Iron and zinc were the only heavy metals detected in the groundwater in Zone 1.

Table 4.3.6.3: Physicochemical characteristics of groundwater in the Zone 1 and Zone 2 Areas

Parameters	Zone 1				Zone 2				
	Min	Max	Mean	SD	Min	Max	Mean	SD	DPR/ *FMEnv
pH	6.88	7.30	6.89	7.3	5.30	6.64	5.96	0.59	6.5-8.5
Electric Conductivity, µs/cm	5.56	160.3	155	168	70.3	197.4	126.0	44.5	
DO, mg/l	0.34	4.41	3.96	4.78	3.48	6.8	4.7	1.22	7.5*
Total Hardness, mg/l					12	48	27	13.1	600/ 250*
TSS, mg/l	4.89	26.2	21.7	32.1	125.0	2136	727.8	748.18	<10*
TDS, mg/l	1.83	78.2	76.1	80.1	37.26	104.6	66.79	23.6	1500/ 500*
Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	
Bicarbonate, mg/l					25.6	92.72	50.8	25.4	
Alkalinity, mg/l	15.4	171.8	155.0	190.0	20.9	75.99	41.7	20.8	0.3
BOD, mg/l	0.43	3.69	3.13	4.15	3.7	7.1	5.82	1.24	
Salinity as Chloride					3.33	10	6.66	2.11	
COD, mg/l	1.77	11.7	9.14	13.2	6.3	9.32	8.53	1.18	
Ammonium, mg/l	0.13	0.52	0.39	0.68	1.55	8.41	4.81	3.19	
Nitrite , mg/l	0.09	0.11	0.01	0.18	--	--	--	--	
Nitrate, mg/l	0.58	1.43	1.1	2.1	0.25	2.01	1.03	0.85	10*
Chromium, mg/l	<0.001	<0.001	0	0	0.28	0.395	0.33	0.06	
Cadmium, mg/l	<0.001	<0.001	0	0	<0.001	<0.001	0	0	1.0*
Copper, mg/l					0.02	0.109	0.078	0.05	0.01*
Lead, mg/l	<0.001	<0.001	0	0	<0.001	<0.001	0	0	
Iron, mg/l	1.12	2.19	0.99	3.48	1.18	26.98	11.9	9.82	0.05*
Nickel, mg/l	<0.001	<0.001	0	0	0.30	0.98	0.55	0.37	15/5.0*
Vanadium, mg/l	<0.001	<0.001	0	0	<0.001	<0.001	0	0	1/1*
Zinc, mg/l	0.04	0.12	0.06	0.15	0.013	1.17	0.57	0.50	0.05*
Arsenic, mg/l	<0.001	<0.001	0	0	<0.001	<0.001	0	0	0.01*
Mercury, mg/l	<0.001	<0.001	0	0	<0.001	<0.001	0	0	0.2*

Source: SPDC (2010; 2015)

4.3.6.2 ZONE 2

Physicochemical characteristics of groundwater samples from Zone 2 are also listed in Table 4.3.6.2 and Figures 4.3.6.3 and 4.3.6.4. The pH ranged from 5.30 to 6.64, while the electrical conductivity ranged from 20.3 to 197.4 µS/cm. Dissolved oxygen was between 3.48 and 6.8 mg/l, biochemical oxygen demand (3.7 – 7.1 mg/l), chemical oxygen demand (6.3 – 9.32 mg/l) and total dissolved solids ranged from 37.3 to104.6 mg/l. Heavy metals detected in Zone 2 include iron, nickel and zinc.

4.3.6.3 ZONE 3

Physicochemical characteristics of groundwater samples from Zone 3 are listed in Table 4.3.6.4 as well as Figures 4.3.6.3 and 4.3.6.4. The pH ranged from 7.01 to 8.04, with a mean value of 7.41. These pH values comply with the FMEnv limits for drinking water. Electrical conductivity ranged from 170 to 400 µS/cm, while dissolved oxygen was between 2.13 and 3.3 mg/l. Biochemical oxygen demand, total dissolved solids and turbidity ranged from 1.71 – 2.14 mg/l, 89.0 – 229.0 mg/l and 18.2 – 75.2 NTU respectively. Iron and zinc were the only heavy metals detected in the groundwater in Zone 3.

4.3.6.4 ZONE 4

Physicochemical characteristics of groundwater samples from Zone 4 are listed in Table 4.3.6.4 as well as Figures 4.3.6.3 and 4.3.6.4. The pH ranged from 5.67 to 9.45, with a mean value of 7.28. The upper pH limit falls outside the FMEnv limit for drinking water. Electrical conductivity ranged from 24 to 1915 µS/cm, while dissolved oxygen was between 0.7 and 4.95 mg/l. Biochemical oxygen demand, total dissolved solids and turbidity ranged from 0.10 – 3.04 mg/l, 10.8 – 695 mg/l and 1.00 – 8.00 NTU respectively. Iron, lead and zinc were the heavy metals detected in the groundwater in Zone 4.

Table 4.3.6.4: Physicochemical characteristics of groundwater in the Zones 3 and 4 (Wet Season)

Parameter	Zone 3				Zone 4				
	Min	Max	Mean	SD	Min	Max	Mean	SD	**DPR/ *FMEnv**
pH	7.01	8.04	7.41	0.4159	5.67	9.45	7.28	1.26	
Cl^- (mg/l)	19.7	48.2	31.1	12.1	7.1	159.8	42.74	48.09	
Cond. (µS/cm)	170	400	262	102.6	24	1915	579.2	761.30	
Turb (NTU)	18.2	75.2	35.6	23.3	1.00	8	3.11	2.00	*10
DO (mg/l)	2.13	3.3	2.57	0.48	0.7	4.95	2.36	1.21	
TDS (mg/l)	89	229	144.8	57.9	10.8	695	232	287.67	1500/500*
SO_4 (mg/l)					2.8	8.75	5.06	1.43	500/200*
TOC (mg/l)					0.005	0.08	0.04	0.024	
BOD_5 (mg/l)	1.71	2.14	1.92	0.16	0.10	3.04	1.10	0.80	

Parameter	Zone 3				Zone 4				
	Min	Max	Mean	SD	Min	Max	Mean	SD	**DPR/ *FMEnv**
NH_4 – N (mg/l)					0.27	0.83	0.45	0.18	
NO_2 - (mg/l)					0.01	0.04	0.03	0.01	
NO_3 - (mg/l)	0.1	0.34	0.16	0.10	0.12	5.41	4.52	1.49	10*
TSS (mg/l)					0.02	1.9	0.36	0.53	
PO_4(mg/l)	0.12	0.28	0.194	0.06	0.26	0.7	0.39	0.12	
Ni (mg/l)	<0.001	<0.001	0	0	<0.001	<0.001	0	0	15/5.0*
V (mg/l)	<0.001	<0.001	0	0	<0.001	<0.001	0	0	1/1*
Pb (mg/l)	0.01	0.01	0.01	--	0	0.01	0.002	0.003	
Mn (mg/l)	<0.001	<0.001	0	0	<0.001	<0.001	0	0	1.5/0.1*
Fe (mg/l)	1.11	4.76	2.60	1.44	0.01	2.2	0.44	0.76	0.05*
Zn (mg/l)	0.29	41	8.51	18.2	0	0.3	0.05	0.10	0.05*

Source: SPDC, (2007a,b; 2008; 2009; 2015)

4.3.7 Aquatic Studies

Surface Water Characteristics

Surface water quality data is very vital as these are used to describe the suitability of a given water body to sustain humans and biodiversity within the vicinity of the water body. The surface water bodies traversing the Adibawa-Gbaran Seismic reshoot area include; Nun river, Orashiriver, Taylor creek, as well as several other creeks and lakes. The physico-chemical characteristics of surface water bodies within the different study zones delineated in the Adibawa-Gbaran Seismic reshoot area were determined over two seasons (dry and wet seasons).Summary of some typical wet season physical and chemical characteristics of the surface water samples from the different zones are presented in Table 4.3.7.1, while the detailed results for all seasons are given in Appendix 4.3.7.

Table 4.3.7.1: Summary of Physico-Chemical Characteristics of Surface Water (Wet season)

Parameter	ZONE 1			ZONE 2			ZONE 3			ZONE 4			
	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	**DPR/ *FMEnv**
pH	6.98 - 7.85	7.45	0.35	6.58-7.49	7.02	0.304	7.13-8.80	7.95	0.34	5.7-7.61	6.66	1.35	6.5-8.5
Conductivity, µS/cm	98.5 - 136	113.3	11.81	31.3-72.8	46.0	12.318	40-250	91.9	42.73	52.5-190	121.3	97.2	
Bicarbonate, mg/l	12.35-16.65	14.20	0.72	6.2-16.34	12.3	3.293	3.5-10.1	6.89	1.76	ND	ND		
Alkalinity, mg/l	50 - 80	9.23	0.30	5.08-13.39	10.1	2.706	11.0-14.0	12.3	0.67	1.08-2.16	1.52	0.41	0.3
Biochemical Oxygen Demand mg/l	5.08 - 6.84	5.96	0.53	3.6-5.0	4.37	0.524	1.40-3.80	2.26	6.62	1.9-3.47	2.69	1.11	
Dissolved Oxygen mg/l	3.48 - 5.01	4.49	0.54	5.7-6.93	6.25	0.493				4.61-5.3	4.96	0.49	7.5*
Chemical Oxygen Demand, mg/l	ND	ND	ND	5.1-8.3	6.69	1.233	42.0-350.0	199.3	123.5	14.0-768.0	128.5	180.0	
Salinity as Chloride, mg/l	3.55 – 7.1	5.99	1.62	6.66-10.0	7.40	1.473	7.09-35.5	13.82	8.09	16.9-17.51	17.2	0.43	
Total Hardness, mg/l	16.5 - 18.9	21.0	1.83	1.4-16	11.7	4.685	89.4-250.0	186.6	42.24	14.0-28.0	17.9	3.24	
Ammonium, mg/l	0.28-0.52	0.41	0.12	0.003-5.5	2.62	1.931	ND	ND	ND	0.20-0.59	0.40	0.28	
Nitrite , mg/l	0.95 - 1.95	1.49	0.35	0.001-0.001	0.001	0.000	ND	ND	ND	0.04-4.76	2.4	3.34	
Nitrate, mg/l	0.1 - 0.6	0.22	0.21	0.28-0.38	0.35	0.032	0.51-2.51	1.21	0.47	0.04-0.40	0.22	0.26	10*
Phosphorus, mg/l	ND	ND	ND	0.04-0.50	0.16	0.142	4.87-8.53	6.06	0.83	0.005-0.47	0.24	0.33	<5*

Source: SPDC (2007a,b; 2008; 2009; 2010; 2012; 2015)

Surface water temperatures recorded in the area during the study ranged between 27.10 ^{o}C and 29.70 ^{o}C, indicating a generally optimal condition for the survival of aquatic life. This is consistent with temperatures recorded in surface water bodies in the tropics (Ayoade, 1988).

The pH of surface waters in the area range from slight acidic to moderate basic with a pH range of 5.70-8.8. However, these values comply with the WHO limit of 6.0 to 9.0 for pH of good quality water. Dissolved oxygen (DO) levels ranged from 3.84 – 6.93 mg/l. Biological oxygen demand (BOD_5) ranged from 1.9 – 6.84 mg/l; alkalinity from 5.08 – 80 mg/l while conductivity was from 31.3 – 190 µS/cm. The total hydrocarbon (THC) and total petroleum hydrocarbon (TPH) concentrations in all the surface water samples were <0.01 mg/l indicating absence of hydrocarbon contamination of the surface water. The concentration of nitrate was 0.01 – 2.31 mg/l. It is observed that the values of some parameters like temperature, pH, bicarbonate, chloride, magnesium increased during the wet season, whereas some other such as potassium and alkalinity decreased. The recorded concentrations however, suggest optimum condition for survival of aquatic life and necessary for algal growth. The pH and turbidity of the water samples do not comply with FMEnv standards for drinking water.

Table 4.3.7.2a: Dry season heavy metal content of the surface waters of the study area

Metal	ZONE 1			ZONE 2			ZONE 3			ZONE 4			
	Range	MEAN	SD	Range	MEAN	SD	Range	MEAN	SD	Range	MEAN	SD	DPR/ *FMEnv
Chromium, mg/l	<0.001 - 0.47	0.18	0.21	<0.001	<0.001		0.001-1.28	0.34	0.39	<0.001	<0.001	0	
Cadmium, mg/l	<0.001 - 0.024	0.006	0.000	<0.001	<0.001		0.002-0.24	0.04	0.08	<0.001	<0.001	0	1.0*
Copper, mg/l	<0.001 - 0.48	0.30	0.19	0.007-0.025	0.0195	0.005	0.012-0.66	0.20	0.24	<0.001	<0.001	0	0.01*
Lead, mg/l	<0.001 - 0.002	0.002	0.000	<0.001	<0.001		0.002-0.55	0.05	0.15	<0.001	<0.001	0	
Iron, mg/l	0.15 - 3.01	1.99	0.813	<0.001	<0.001		0.30-2.61	0.92	0.62	0.08-5.04	0.7	1.3	0.05*
Nickel, mg/l	<0.001 - 0.21	0.036	0.070	<0.001	<0.001		0.001-0.49	0.13	0.18	<0.001	<0.001	0	15/5.0*
Vanadium, mg/l	<0.001	<0.001	0.000	<0.001	<0.001		<0.001	<0.001	0	<0.001	<0.001	0	1/1*
Zinc, mg/l	0.291 - 0.417	0.33	0.039	<0.001	<0.001		0.001-0.62	0.21	0.17	<0.001	<0.001	0	0.05*
Arsenic, mg/l	<0.001	<0.001	0.000	<0.001	<0.001		<0.001	<0.001	0				0.01*
Mercury, mg/l	<0.001	<0.001	0.000	<0.001	<0.001		<0.001	<0.001	0	<0.001	<0.001	0	0.2*

Source: SPDC (2007a,b; 2008; 2009; 2010; 2012; 2015)

Table 4.3.7.2b: Wet season heavy metal content of the surface waters of the study area

Metal	ZONE 1			ZONE 2			ZONE 3			ZONE 4			
	Range	MEAN	SD	Range	MEAN	SD	Range	MEAN	SD	Range	MEAN	SD	DPR/ *FMEnv
Chromium, mg/l	<0.001	<0.001		0.20-0.43	0.34	0.077	0.18-2.15	1.01	0.74	0-0.01	0.005	0.0070	
Cadmium, mg/l	<0.001	<0.001		0.005-0.005	0.005	0.000	0.001-0.84	0.26	0.24	<0.001	<0.001	0	1.0*
Copper, mg/l	<0.001-0.007	0.0195	0.005	0.016-0.24	0.11	0.088	0.02-1.43	0.53	0.39	<0.001	<0.001	0	0.01*
Lead, mg/l	<0.001	<0.001		0.002	0.002	0.000	0.11-0.11	0.11	0	0.01-0.07	0.04	0.042	
Iron, mg/l	1.18 - 7.73	3.04	2.37	2.34-9.95	4.70	2.12	0.79-8.34	3.79	2.01	0.30-14.64	2.01	3.3845	0.05*
Nickel, mg/l	0.001 – 0.151	0.051	0.067	0.21-0.97	0.49	0.31	0.001-2.34	0.40	0.68	0-0.03	0.015	0.021	15/5.0*
Vanadium, mg/l	<0.001	<0.001		0.001-0.001	0.001	0.000	<0.001	<0.001	0	0-0.03	0.015	0.021	1/1*
Zinc, mg/l	<0.001	<0.001		0.028-0.314	0.17	0.093	0.003-4.82	0.47	1.12	0-0.40	0.2	0.28	0.05*
Arsenic, mg/l	<0.001	<0.001		<0.001	<0.001	0.000	<0.001	<0.001	0	<0.001	<0.001	0	0.01*
Mercury, mg/l	<0.001	<0.001		<0.001	<0.001	0.000	<0.001	<0.001	0	0.01-0.1	0.055	0.064	0.2*

Source: SPDC (2007a,b; 2008; 2009; 2010; 2012; 2015)

The heavy metal contents of surface water in the study area in the dry and wet seasons are summarized in Table 4.3.7.2a and b. Interestingly, most of the heavy metals had concentrations below analytical instrument detection limit (<0.01 mg/l) in Zones 2 and 4 during the dry season. The concentrations of vanadium, arsenic and mercury were not detected in any location, whereas mercury was only detected in the wet season within Zone 4 (mean concentration = 0.064 mg/l). The mean maximum concentrations recorded for iron, lead and copper were 3.79 mg/l, 0.11 mg/l and 0.5 mg/l respectively. The high concentrations of iron could be attributed to concentrations in soils and rock formations, as well as industrial sources. This also correlates with the trend observed for soils as discussed above. The heavy metal content of the surface water in the study area was generally higher in the wet season.

Surface Water Microbiology

The microbiological properties of surface water in the study area are presented in Tables 4.3.7.3, 4.3.7.6, 4.3.7.8 and 4.3.7.12as well as Figures 4.3.7.1.

Sediment Physicochemical Characteristics

Details of the physico-chemical characteristics of sediments in the study area are given in Appendix 4.3.7 and summarized in Tables 4.3.7.4, 4.3.7.9, 4.3.7.13. Sediment samples were moderately acidic with a global mean pH range of 5.10 to 6.39 and conductivity 1.36 to 100.7 µS/cm. Total organic carbon content ranged from 39.4% to 86.9%, while chloride content was from 17.2 to 27.6 mg/kg. Polycyclic aromatic hydrocarbons (PAH) and BTEX were not found in the sediments. Seasonal trends in selected sediment properties are depicted in Figures 4.3.7.2 and 4.3.7.5 for Zones 1 and 3 respectively. The values of such parameters as electrical conductivity, chloride, total organic carbon and total organic matter were generally higher in the wet season. Heavy metals such as mercury, vanadium, arsenic were not detected within the entire study area, whereas cobalt, copper, lead, zinc, chromium and iron were detected at varying concentrations in the different zones. The significantly higher concentrations of iron in the sediment samples correlates with the trends in surface water and soil, showing that they may have been mobilized from crustal rocks by natural geochemical processes. Flocculation of these metals by adsorption to particulates is a source of incorporation into sediments. Thus leaching of soil particles from land into the aquatic environment as run-off could have contributed to the increase.

Sediment Microbiology

The microbiological properties of sediment in the study area are presented in Tables 4.3.7.5, 4.3.7.7, 4.3.7.10 and 4.3.7.11, as well as Figures 4.3.7.3 and 4.3.7.6.

4.3.7.1 ZONE 1

Surface Water Physicochemical Properties

Typical physicochemical characteristics of surface water samples from Zone 1 are listed in Table 4.3.7.1. The mean pH value was7.45, while the mean value of the electrical conductivity was 113.3 µS/cm. The mean values of alkalinity, BOD, DO and nitrate were respectively 9.23 mg/l, 5.96 mg/l, 4.49 mg/l, 0.22 mg/l. Heavy metals detected in surface water in the Zone 1 area during the dry season include chromium, cadmium, copper, lead, iron, nickel and zinc. For these, iron, copper and zinc exceeded the regulatory limits.

Surface Water Microbiology

The microbial counts observed in the surface water of the study area is summarised in Table 4.3.7.3. The total heterotrophic bacterial (THB) and total heterotrophic fungal counts (THF) in the surface water samples ranged from 2.60 x 10^4cfu/ml to 3.60 x 10^4cfu/ml in the wet season (2008) and 39 - 2700 x 10^4cfu/ml in the dry season of 2012.

Table 4.3.7.3: Summary of Surface water Microbiology

	2008 Wet Season			**2012 Dry Season**			**2014 Wet Season**			**FMEnv limits**
Parameters	**Mean**	**Range**	**Standard Deviation**	**Mean**	**Range**	**Standard Deviation**	**Mean**	**Range**	**Standard Deviation**	
Total Heterotrophic Bacteria (x10^4) cfu/ml	3.21	2.60 – 3.60	0.38	510	39 - 2700	2.55	3.18	1.2 - 7.4	2.26	
Total Heterotrophic Fungi (x10^2) cfu/ml	3.13	2.90 - 3.40	0.22	2525	450 - 8500	2.73	5.88	3.6 - 9.1	2.54	
Total Coliform (MPN/100ml) (x10^3)	2.54	1.9 – 3.2	0.44	26	9.0 - 64		256.44	172 – 326	57.36	0
Petroleum utilizing Bacteria (x10^4)cfu/ml	ND			5.3	0 – 9.8	3.03	4.13	1 - 7.2	1.69	
Petroleum utilizing Fungi(x10^3)cfu/ml	ND			5.56	0 - 9.9	2.96	3.71	0 - 7.2	2.95	
Faecal Coliform Count (MPN/100mL)	ND						54.67	11.0 - 53	112.79	0

Source: Fieldwork July 2008; Fieldwork January 2012 and Fieldwork 2014
ND = Not Data

KEY: THB = Total Heterotrophic Bacteria, HUB = Hydrocarbon Utilizing Bacteria, THF = Total Heterotrophic Fungi, HUF = Hydrocarbon Utilizing Fungi

Relating these figures with the 2014 (1.2 – 7.4 x10^4cfu/ml) indicates a reduction in the microbial load of the surface water in terms of the total heterotrophic bacteria. THF counts for wet and dry seasons ranged from 2.90 to 3.40 x 10^2cfu/ml and from 850 to 8500 cfu/ml, respectively. The total heterotrophic fungi in surface water showed higher microbial load of (3.6 – 9.1 x 10^3cfu/ml) in 2014 with respect to counts obtained in 2008 (Fig. 4.3.7.1). These depict seasonal variations in THB and THF in the study area. Statistical analysis did not give a significant difference (P>0.05) in THB counts but was significantly different (P<0.05) with regards to THF counts between 2008 and 2014. Petroleum utilizing bacteria (PUB) (determined in the dry season only) ranged from 0 to 9.8 x 10^4cfu/ml representing 0 – 3.16 % of the bacterial count. Petroleum Utilizing Fungi (PUF) ranged from 0 to 9.9 x 10^3cfu/ml representing 0 – 9.7 % of the fungal count. The current (2014) PUB count range from 1.0 – 7.2 x 10^2cfu/ml with a mean of 4.13 x 10^2cfu/ml while those of PUF varied from 0.0 – 7.21 cfu/ml with a mean of 3.71 x 101 cfu/ml suggesting their spatial variation in the area of study. Presence of petroleum degraders and percentage degraders of values greater than 1.0% may reveal traces of crude petroleum in the water samples; however, petroleum degraders also occur in nature.

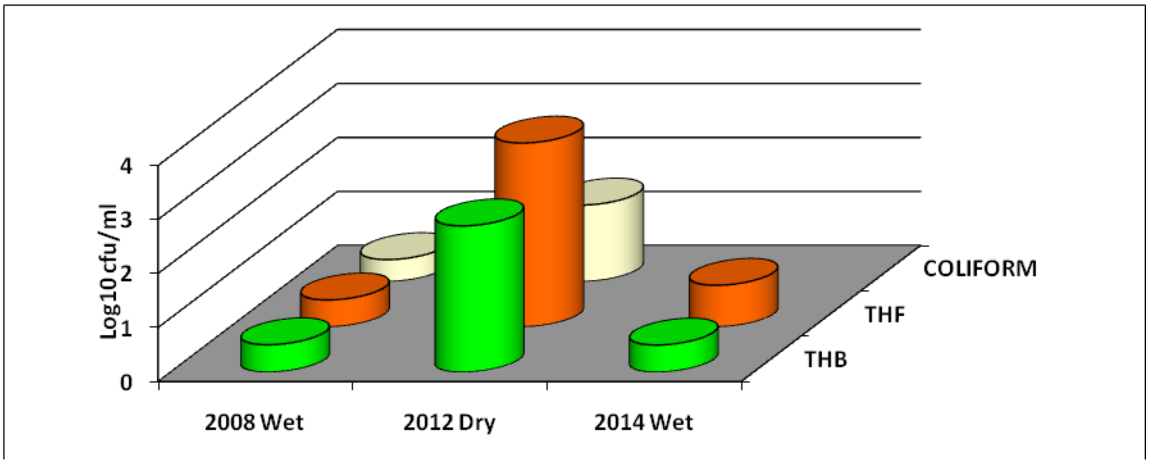


Fig. 4.3.7.1: Microbial counts during 2008, 2012 and 2014

The presence of the bacterial sub-group, coliform, in the aquatic environments indicates that the water is contaminated with coliform bacteria which could be of faecal origin. Total coliform counts recorded in the surface water ranged from 1900 to 3200 MPN/100ml in the wet season and 9000 to 64000 MPN/100ml in the dry season of 2012. There is a decrease in the total coliform count in the study area. This is indicated by the range of values recorded in 2014 (172 – 326 MPN/100ml) relative to 2008. Statistical analysis also gave a significant variation ($P<0.05$) in total coliforrm count in terms of the two years compared. Faecal coliform counts differed between 11 – 53 MPN/100ml with a mean of 54.67 MPN/100ml.These indicate the presence of faecal contamination in the water, and this is mainly due to the fact that communities in the area defecate into the rivers and creeks.

Sediment Physicochemical Properties

Typical dry and wet season data for some sediment parameters determined in Zone 1 are illustrated in Figures 4.3.7.2. Some other physicochemical characteristics of the Zone 1 sediment samples in the wet season are listed in Table 4.3.7.4. The mean pH value was 5.83, while the mean value of the electrical conductivity was 59.5 µS/cm. The mean values of organic matter content, phosphate, calcium, nitrates, total hydrocarbon content were respectively 1.39%, 8.64 mg/kg, 2.72 mg/kg, 0.04 mg/kg and 1.79 mg/kg. Heavy metals detected in the sediment include zinc and iron.

Table 4.3.7.4: Some wet season physicochemical characteristics of sediments from the Zone 1 and Zone 2 areas

	ZONE 1			ZONE 2		
PARAMETERS	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
pH	5.37	6.26	5.83	4.4	5.68	5.11
Electrical Conductivity µS/cm	54.0	68.0	59.5	33.7	174.6	100.7
Organic matter (Organic Carbon) %	1.06	2.01	1.39	1.82	3.93	2.75
Phosphate, mg/kg	6.20	15.0	8.64	0.01	14.0	6.51

	ZONE 1			ZONE 2		
PARAMETERS	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
Sulphate, mg/kg	0	5.0	4.67	68.2	90.1	75.9
Calcium, mg/kg	2.16	4.80	2.72	12.4	39.2	29.6
Sodium, mg/kg	21.9	32.2	27.14	201.4	920.5	333.8
Potassium, mg/kg	5.19	6.01	5.48	82.9	858.0	424.3
Nitrate, mg/kg	0	0.04	0.04	5.39	14.5	8.97
Total Hydrocarbon mg/kg	0.02	3.14	1.79	1.00	9.04	3.01
Heavy Metals						
Vanadium, mg/kg	<0.001			<0.001		
Nickel, mg/kg	<0.001			8.42	11.9	10.26
Lead, mg/kg	<0.001			0.002	1.46	0.16
Chromium, mg/kg	<0.05			22.9	30.3	25.8
Zinc, mg/kg	0.74	2.55	1.33	109.5	168.4	129.4
Cadmium, mg/kg	<0.001			0.005	0.005	0.005
Iron, mg/kg	432.0	794.0	669.2	4964	7642	5741

Source: SPDC (2010; 2015)

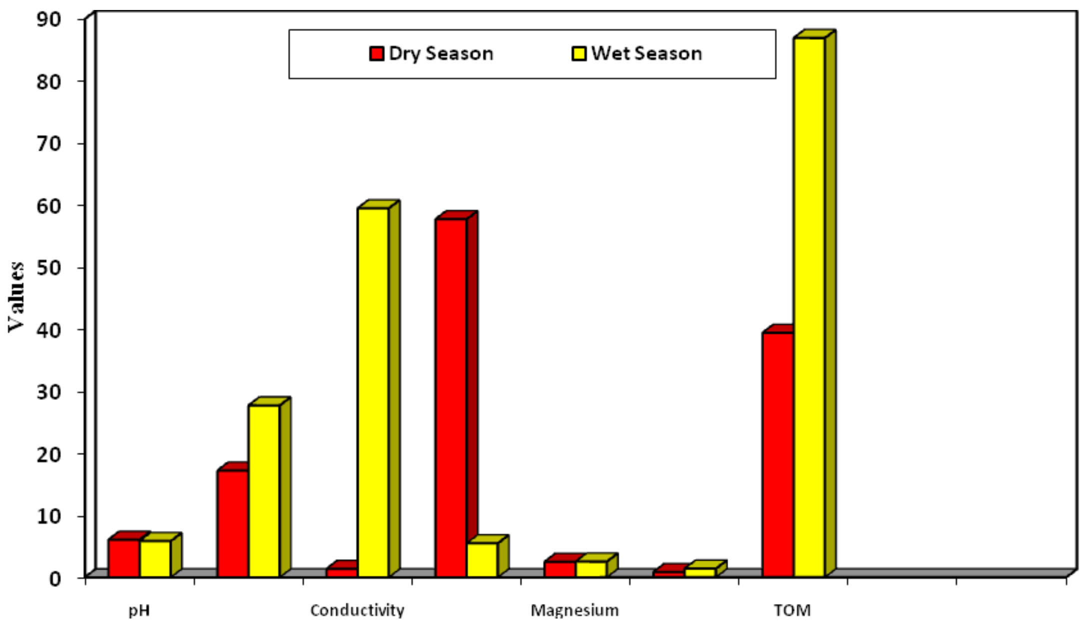


Fig. 4.3.7.2: Dry and wet season data for some sediment parameters determined in Zone 1 (Parameter units are as outlined in Table 4.3.7.4)
Source: SPDC (2015)

Sediment Microbiology

The microbiological characteristics of sediments of the study area are summarized in Table 4.3.7.5. The total heterotrophic bacterial (THB) and total heterotrophic fungal (THF) counts recorded in the sediment ranged from 4.80 x 10^6 cfu/g to 7.40 x 10^6 cfu/g and from 2.30 x10^4cfu/g to 4.70 x10^4cfu/g, respectively during the wet season, while dry season values were 0.11 – 0.91 x 10^6cfu/g for THB and 0.59 – 7.7x 10^4cfu/g for THF (Fig. 4.3.7.3).

Table 4.3.7.5: Summary of Sediment Microbiology in the Study Area

	2008 Wet Season			2012 Dry season			2014 Wet Season		
Parameters	**Mean**	**Range**	**Standard Deviation**	**Mean**	**Range**	**Standard Deviation**	**Mean**	**Range**	**Standard Deviation**
THB x 10^6 (cfu/g)	6.31	4.80–7.40	0.99	4.86	0.11 – 0.91	3.31	3.6	1.19 - 9.0	2.60
THF x10^4 (cfu/g)	3.29	2.30 – 4.70	0.79	3.25	0.59 - 7.7	2.28	6.79	4.3 - 9.2	1.78
HUB x 10^3cfu/g		ND			0		3.2	1.0 - 8.7	2.77
HUF x 10^2cfu/g		ND			0		4.8	3.0 - 4.8	0.67

Source: Fieldwork July 2008; Fieldwork Janurary 2012 and Fieldwork 2014
ND = Not Determined

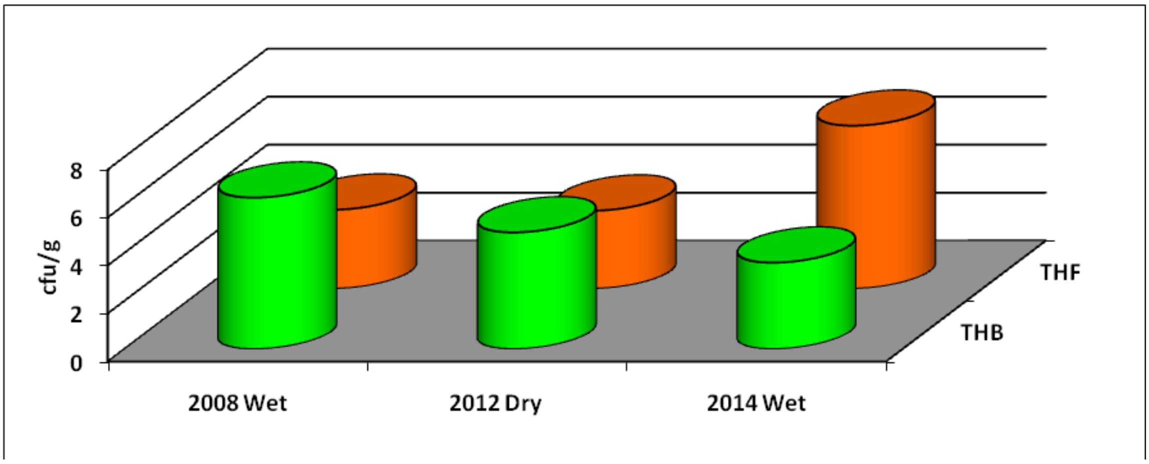


Fig. 4.3.7.3: Microbial counts during 2008, 2012 and 2014

Total heterotrophic counts for bacteria in 2014 ranged from 1.19 x 10^5cfu/g to 9.0x 10^5cfu/g while total heterotrophic fungi was in the range of 4.3 x 10^3cfu/g to 8.9 x 10^3cfu/g indicating a reduction in the THB and THF load in the area. Statistical analysis of microbial counts between 2008 and 2014 gave a significant difference ($p<0.05$) for both THB and THF. Hydrocarbon utilizing bacteria were not determined in the wet season, but dry season samples showed no growth of HUB in sediment samples. This is indicative of the absence of hydrocarbon pollution in sediment. The counts of HUB in 2014 ranged from 1.00 x 10^3cfu/g to 8.7 x 10^3cfu/g while HUF counts was in the range of 3.0 x 10^2cfu/g to 5.2 x 10^2cfu/g. This result indicates seasonal variation in the HUB and HUF values of sediments in the study area

Hydrobiology

Phytoplankton

The phytoplankton taxonomic data are summarized in Table 4.3.7.6, while the detailed results are given in Appendix 4.3.7.4. The phytoplankton community was represented by four divisions, Bacillariophyceae (diatoms), Chlorophyceae (green algae), Cyanophyceae (blue green algae) and Dinophyceae (dinophytes), but these were dominated by the diatoms (Fig. 4.3.7.4) except in the dry season of 2012 when the blue greens were dominant. The dominance of Bacillariophyceae is characteristic of the phytoplankton community structure in the Niger Delta of Nigeria and this has been severally reported by Ogamba *et al*. (2004), Davies *et al*. (2009), Emmanuel and Onyema (2007), and Allison and Otene (2012). Current data obtained in 2014 shows inclusion of two new divisions of phytoplankton (Dinophyceae and Euglenophyceae) which were not reported in 2008. The most common species amongst the Centrales were *Melosira* and *Cylindrotheca gracilis* while for the Pennate diatoms were *Gyrosigma acuminatum* and *Bacillaria*. Others are *Closteruim* and *Richterella*, and *Oscillatoria* for Chlorophyceae, Cyanophyceae respectively. There was a statistically significant difference ($P<0.05$) in the abundance of Bacillariophyceae, Cyanophyceae and Chlorophyceae between 2008 and 2014.

The numbers of species in the phytoplankton communities were 33, 16 and 60 for 2008, 2012 and 2014 respectively. The species number was higher in 2014 with values indicating an

Table 4.3.7.6: Abundance and diversity of Phytoplankton in Zone 1

	2008 WET	2012 DRY	2014 WET
BACILLARIOPHYCEAE			
No of species	22	8	24
Abundance	12007	1030	4389
CHLOROPHYCEAE			
No of species	7	3	12
Abundance	1900	640	2730
CYANOPHYCEAE			
No of species	4	5	15
Abundance	1560	1530	3733
DINOPHYCEAE			
No of species			5
Abundance			1247
EUGLENOPHYCEAE			
No of species			4
Abundance			692
Taxa_S	33	16	60

	2008 WET	2012 DRY	2014 WET
Individuals	15467	3200	12791
Dominance_D	0.03818	0.124	0.019
Shannon_H	3.374	2.332	4.016
Menhinick	0.2653	0.2828	0.5305
Margalef _d	3.317	1.859	6.239
Equitability_J (Evenness)	0.9651	0.8411	0.9807

improvement in the phytoplankton species number. However, the generally low species numbers of the green algae (Chlorophyceae) in the study area indicated that the aquatic system was

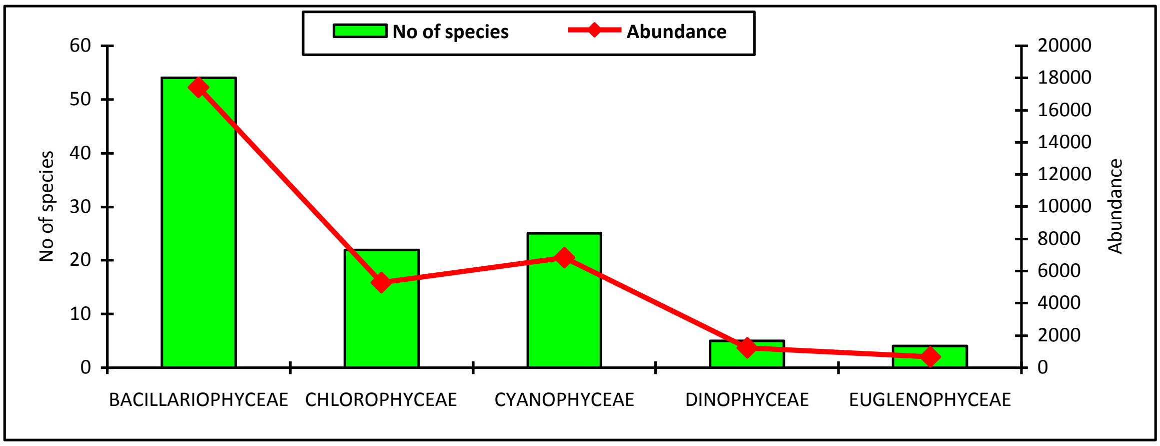


Fig. 4.3.7.4: Abundance and number of species among phytoplankton divisions

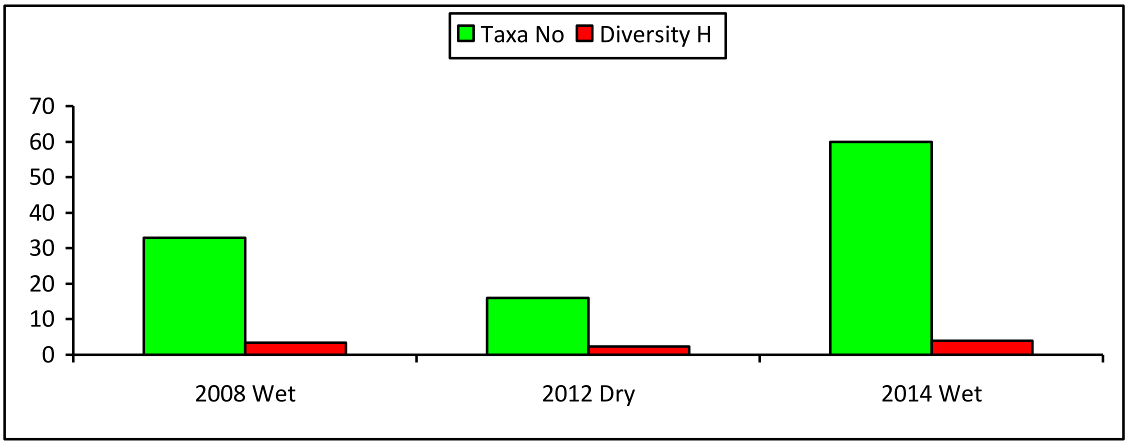


Fig. 4.3.7.5: Temporal trend in Taxa number and Shannon diversity (H')

unpolluted. Abundance values ranged from 3200 in the dry season of 2012 to 15467 in 2008. The diversity of phytoplankton was assessed using several indices of diversity and community stability. These were the Margalef's species richness (d), Shannon Wiener diversity (H^1), Equitability (Evenness), and Dominance index (D). Generally, the higher the Shannon diversity, the more stable a community is. Evenness and Dominance measure the equitable spread of individuals among the species. The data over the years show the phytoplankton community to be stable (Shannon diversity values 2.332 to 4.016), reflecting an unpolluted environment (Fig. 4.3.7.5). The evenness was high in all the samples, just as the dominance was low, indicating good representation of individuals among the species. The observed variation in the diversity indices are statistically significant (P<0.05).

Zooplankton
The adult and larval zooplankton assemblage was a mixed and poorly diverse community. The Zooplankton community was represented by Rotifera, Copepoda, Cladocera, meroplanktonic larvae and Protozoa (Table 4.3.7.7). Detailed results are given in Appendix 4.3.7.5. The Copepoda dominated the community with mostly calanoids and cyclopoids. This was followed by the Rotifera (Fig. 4.3.7.6). Temporally, the total number of species and abundance of zooplankton were highest in the wet season of 2014. This represented marginal increase with respect to previous data obtained in the study area. This is validated by the statistical analysis with no significant variation (p>0.05) in the major zooplankton taxa between the periods covered. The relationship between 2008 and 2014 with respect to zooplankton abundance is presented in Table 4.3.7.7.

Table 4.3.7.7: Abundance and diversity of Zooplankton in Zone 1

	2008 WET	2012 DRY	2014 WET
ROTIFERA			
No of species	3	3	7
Abundance	850	220	419
COPEPODA			
No of species	6	2	7
Abundance	910	50	665
CLADOCERA			
No of species		2	3
Abundance		50	442
MEROPLANKTONIC LARVAE			
No of species	2		2
Abundance	130		26
PROTOZOA			
No of species		1	
Abundance		40	

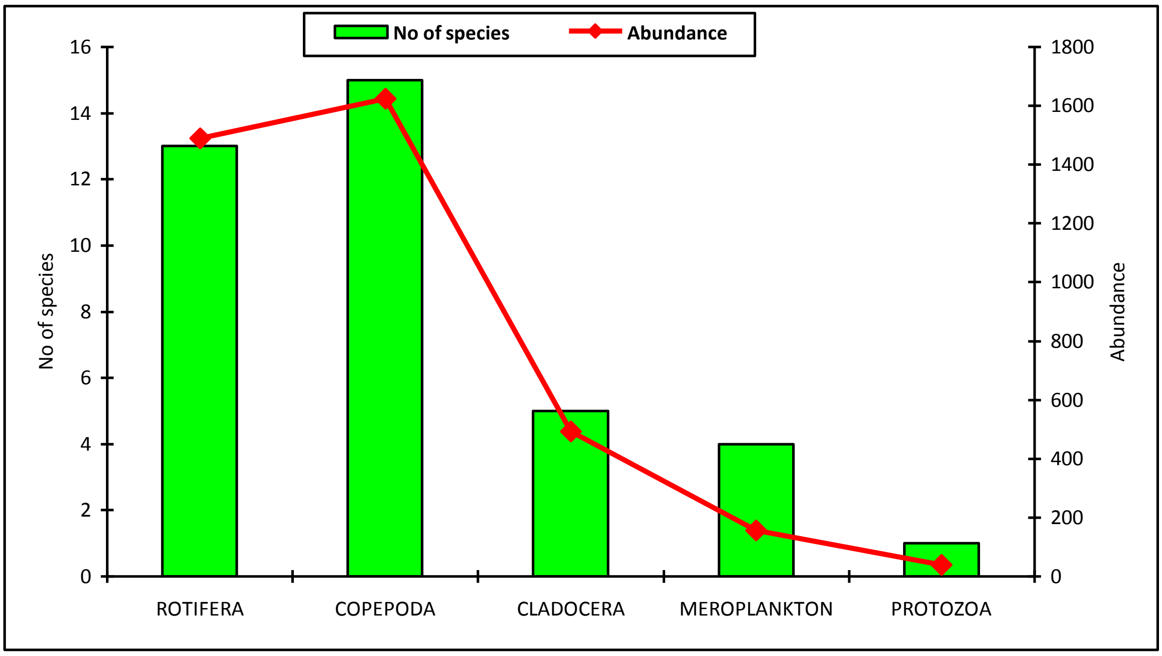


Fig. 4.3.7.6: Abundance and number of species among zooplankton groups

With respect to 2008, maximum species number of 11 was obtained for zooplankton while current (2014) figures of species number reached a maximum of 19 representing an improvement in zooplankton species number. In 2008 the variation in Margalef's Species Richness index was between 0.341 and 1.68 while the Shannon-Weiner diversity Index varied between 0.0 and 0.96. Analysis of the recent data (2014) shows that Margalef's Species Richness index was in the range of 1.58 to 2.45 while Shannon-Wiener diversity index varied between 2.162 and 2.705 suggesting an increase with respect the periods under review. These diversity indices were significantly different ($p<0.05$) between the two years compared.

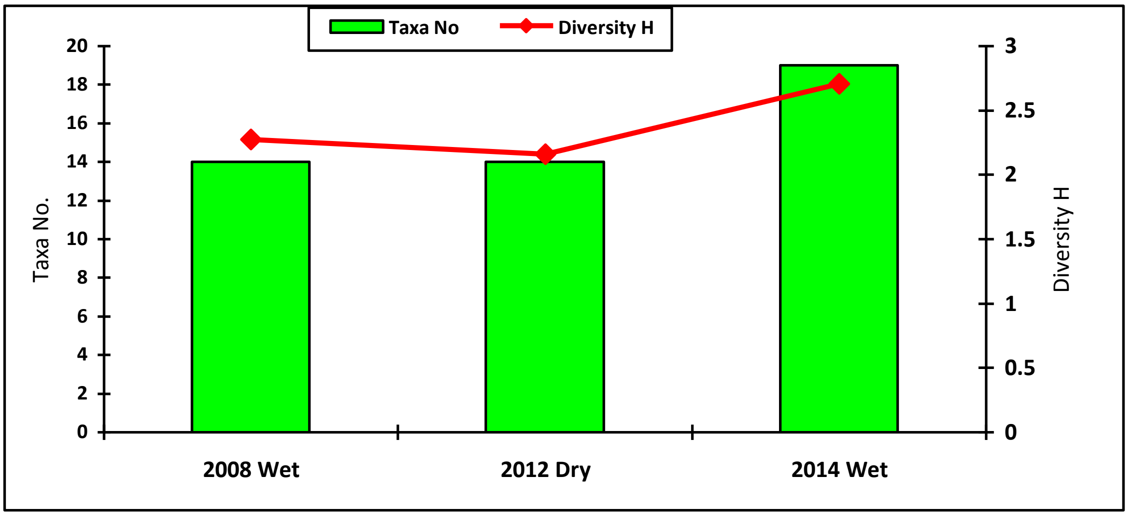


Fig. 4.3.7.7: Temporal trend in Taxa number and Shannon diversity (H^1)

Benthic Fauna

The Macrobenthic fauna comprised the Oligochaetes, Molluscs, Insect Larvae, Crustaceans and Nematodes (Table 4.3.7.8). The detailed results are given in Appendix 4.3.7.6). The Benthic community was composed predominantly of Oligochaetes and Gastropods in the wet season of 2008, while the dry season samples consisted of *Oligochaetes, Insects, Crustaceae* and *Nematodes*. In comparison with figures obtained in 2014, six major groups were obtained including *Annelids, Decapods, Gastropod Ephemeroptera, Hemiptera, Coleoptera, Odonata* and *Diptera.*

Table 4.3.7.8: Abundance and diversity of benthos in Zone 1

	2008 WET	2012 DRY	2014 WET
OLIGOCHAETA			
No of species	3	6	4
Abundance	72	225	17
MOLLUSCA			
No of species	2		
Abundance	66		
INSECTA			
No of species		4	14
Abundance		13	45
CRUSTACEA			
No of species		2	3
Abundance		5	15
NEMATODE			
No of species		1	
Abundance		4	

The percentage make up of Oligochaetes was 52.0% and that of gastropods was 48% in 2008 but in 2014 annelids and decapods were the dominant benthic fauna contributing up to 25 % of benthos each (Fig.4.3.7.8). The dominance of the Oligochaetes during both seasons did show statistically significant difference ($P<0.05$) between the two years tested. The total number of occurring species ranged from 1 to 5 for the wet season and 3 to 6 for the dry season respectively. These wet season value is consistent with the range (1- 5) obtained for species number in 2014. This suggests a relatively stable species number in the study area with respect to the periods under review.

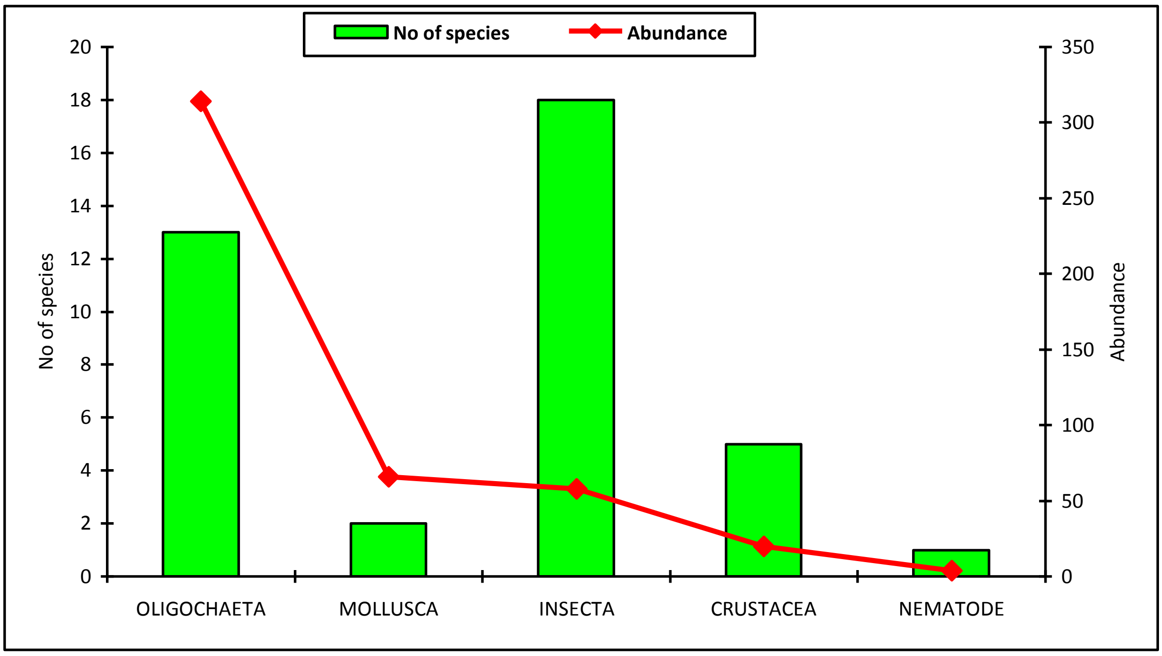


Fig. 4.3.7.8: Abundance and number of species among benthic groups

The benthic diversity was assessed using several diversity indices. The temporal variation in diversity is shown in Figure 4.3.7.9. The variations observed in the diversity indices were also significantly different ($P<0.05$) between 2008 and 2014. The most common species during the wet season were *Stylaria* spp. (Oligochaeta) and *Pleurocera sp* (river snail) while dry season samples were dominated by *Tubifex* sp, *Enchytraeus* sp (Oligochaeta) and insect larvae. These species are freshwater organisms that have been reported in several reports in Nigeria (Victor and Ogbeibu, 1985; Ogbeibu and Victor, 1989; Ogbeibu and Egborge, 1995; Ogbeibu and Oribhabor 2002: Ogbeibu *et al.*, 2010; Omoigberale and Ogbeibu, 2010). Tubifex is known to be good indicator of organic pollution (Ogbeibu and Egborge, 1995).

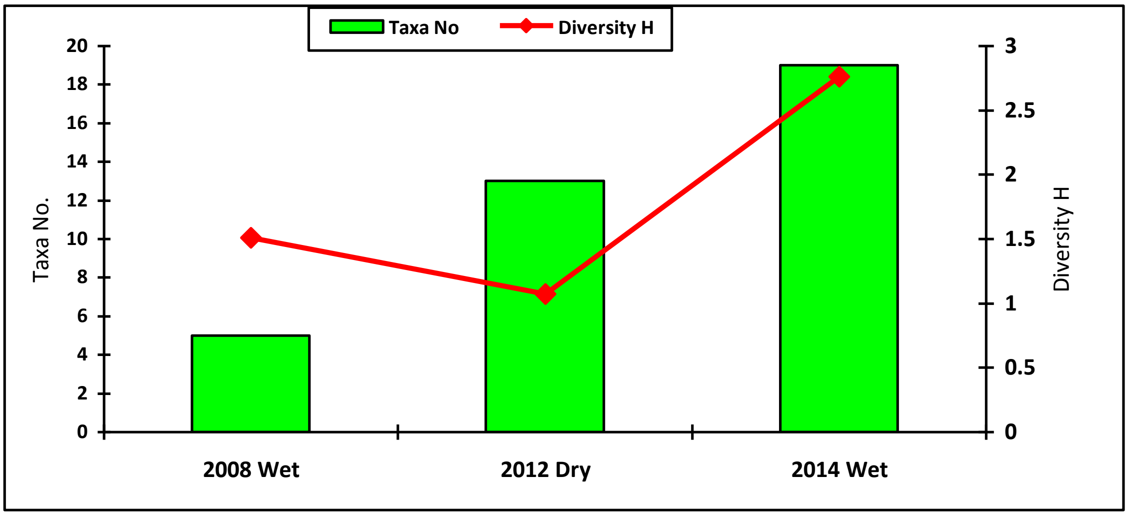


Fig. 4.3.7.9: Temporal trend in Taxa number and Shannon diversity (H^1)

Fish and Fisheries

Species Composition

Thirty five (35) fish families made up of 120 species were identified in the study area (Table 4.3.7.9). Out of these, 61 species are pure river dwellers at the adult life, 29 dwell in swamps and 30 species thrive in both habitats**.** Most of the purely fresh water river dwelling fishes pass their larval and juvenile stages in the floodplain or backwater swamps and lakes. The adults also carry out lateral migration into the floodplain during the high flood for reproduction or to avoid swift river flow (Otobo, 1996). Fisherfolks in the area reported that One Bagrid catfish (*Arius gigas)* has disappeared in the project area while two members of the Citharinidae (*Citharinops distichodoide*s and *Citharinus latus*) are very difficult to find. Also *Polyprerus ansorgii* and *P. endlicheri* (Polypteridae) which were once common in the area are now hardly seen in the swamps.

Migrant species from coastal/brackish water such as *Ethmalosa fimbriata* (Clupeidae), *Polynemus quadrifilis* (Polynemidae) and *Liza falcipinus* (Mugilidae) occur occasionally in the area during the dry season. The members of the Eleotridae, Elopidae and Gobidae are also found as occasional inhabitants of the area. Shellfish of the area are the fresh water shrimps including *Macrobrachium macrobrachion* and *M. vollenhovenii* which form important fisheries in the flood channels. *Caridina africana* also occur in the swamps and backwaters in the area. Few numbers of the fresh water turtle (*Pelusis niger*) is found in swamps.

Fishing Gears and Methods

Fishing gears of the area were many and varied as shown by previous survey (Otobo, 1995) and similar to those recorded for Nigeria by Udolisa (1994). The fishing gears found during the survey were relatively less varied and fewer in number when compared with previous records. The gears used in the area include gillnets, tow nets, cast nets, beach seines, lift nets, traps, hooks and lines, fences and stakes as well as wounding implements. Bailing of ponds to collect stranded fish in swamps is an age-old traditional fishing method.

Gill Nets

Gill nets were of different designs and sizes ranging from large nets of more than 100m long are rigged with lead and floats. These were observed to be deployed in the main channels of the Nun River and Taylor Creek. Small pieces of netting walls are usually tied to sticks and stretched out along river banks, backwaters and floodplain lakes. The net design and mesh sizes differ according to fishing area and target fish and may change with seasons. Gill nets were used in capturing a wide variety of fish species. Typical of these nets were those targeting small sized pelagic fishes such as fresh water clupeid, *Pellonula* Spp. and glass fish, *Parailia pellucida* which are mainly exploited by women.

Tow Nets

Tow nets of various dimensions were operated in the main channels of both the Nun River and Taylor Creek. They are tapering bags with wings, body and cod end similar to trawl nets and are towed by two canoes to keep the mouth open in course of fishing operation.

Constructed from small meshed netting materials, they are efficient in capturing both bottom and shoaling fishes.

Table 4.3.7.9: Fish Families and the Number of Species occurring in the Area

S/N	Fish family	Number of Species
1	*Amphilidae*	2
2	*Anabantidae*	1
3	*Arridae*	1
4	*Bagridae*	10
5	*Centropomidae*	1
6	*Channidae*	2
7	*Cichlidae*	10
8	*Characidae*	8
9	*Citharinidae*	3
10	*Clariidae*	6
11	*Clupeidae*	6
12	*Cynoglosside*	1
13	*Cyprinidae*	4
14	*Cyprinodontidae*	6
15	*Dasyatidae*	1
16	*Distichodontidae*	8
17	*Eleotidae*	3
18	*Eleopidae*	1
19	*Gobiidae*	1
20	*Gymnarchidae*	1
21	*Hepsetidae*	1
22	*Malapteruridae*	2
23	*Mochokidae*	9
24	*Mormyridae*	15
25	*Mugilidae*	1
26	*Nanidae*	1
27	*Notopteridae*	2
28	*Osteoglossidae*	1
29	*Pantodontidae*	1
30	*Phractolaemidae*	1
31	*Polynemidae*	1
32	*Protopteridae*	4
33	*Protopteridae*	1
34	*Schilbeidae*	3
35	*Sciaenidae*	1

Cast Nets

Cast nets were cone-shaped devices constructed from netting materials with a lead line at the bottom and attached to a rope at the distal head. They were operated from canoes or on the ground along the shore line. The operation of cast nets requires skilful throwing to obtain maximum spread to enclose fish in the vicinity of throw. Cast nets were exclusively operated by men owing to the skill and strength needed in operating them. The gear is not selective of fish types but the size of fish caught may depend on the mesh size of the netting material.

Beach Seines

Seine nets generally are designed to surround fish and gather them in the cause of dragging or towing to a central area for collection. In the study area, beach seines were operated in the low water period (dry season). In the Nun River section, beach seines were dragged from shallow waters to the shores of the sand bank. The catch is non-selective of fish type and size as the mesh sizes are small. Most beach seines in the area are walls of netting material rigged with floats at the head rope and lead at the foot rope. The ends are attached to sticks and tied with strong ropes that provide aid in dragging the net.

Lift Nets

Lift nets are devices set fixed or allowed to drift through the water column and designed to lift fish out of water when required. The size of fish taken by lift nets is only limited by the size and strength of the gear. One frequently used gear in the study area is 'atala' lift net, a rectangular piece of netting framed by bamboo poles. It was operated from a canoe either in a stationary position or drifting along the river and periodically raised to collect fishes contained in it. Recently, the use of mosquito-proof netting materials has enabled this gear to capture the smallest known clupeid fish, *Sierrathrissa leonensis* which were abundant from April through June around Polaku, a confluence town of the Nun River and Taylor Creek. The importance of this modification is that this fish cannot be taken by other commercial fishing gear owing to its small size. Its capture through this gear makes available a cheap protein source which otherwise will be unavailable.

Traps

Traps are reputed to be the most sophisticated of all fishing gear (Reed *et al.,* 1967). In the project area several kinds of traps were used in fishing, ranging from small purse-like devices for juveniles to large structures that are several metres long and broad capable of taking aquatic mammals and reptiles. Some traps have non-returnable valves to retain fish while some retain fish by water pressure or when they are stock to the extreme narrow end of a seeming alley. Traps that operate by trigger mechanism which closes the mouth to prevent escape were also common. Some of the traps were used together with fish fences where creek channels were blocked and the traps strategically placed to collect fishes. This is especially in the swamps during the recession of the flood to capture fish returning to the main river channels.

Traps were made from forest materials, but few introductions and innovations have brought about the use of synthetic netting materials. For instance the *gura* trap which is prepared from nylon netting material was introduced by Hausa fishermen. Traps were operated by both males and females as well as by all age groups depending on type and size of trap. They contributed substantially to the fish catch of the area in the flood period.

Hooks and Lines

Hooks and lines used in the area varied from the pole and line with a single hook to long lines carrying many hooks and of different sizes and designs. Hooks were usually baited with assorted baits depending on target fish species and may be set stationary or allowed to drift along the river. An introduced long line (*meri meri*) constructed with close-set hooks was set without baits, fishes swimming close to these hooks were hooked on any part of the body. One peculiar type is the trigger hook which operates by a mechanism that lifts fish out of the water after it had been caught and it hangs on a line attached to a flexible stake. Hooks were operated by all gender and age groups.

Wounding gear

Almost every kind of sharp implement served as a wounding gear. Spears, machetes, and sticks were used in killing fish at different places. Children waded in shallow waters and walked along shorelines searching edges and holes for fish while using the above gears. In silted swamp lakes, women used machetes to cut out dense vegetation to collect fish from the mud. Spears were used in assisting hooks to impale struggling fish.

Pond Bailing

Local fish ponds constructed in swamps and by the sides of swamp lakes were sources of fish supply to all communities in the study area. Pond bailing was done during the dry season when pond margins were clearly exposed and ground water was low enough to prevent excessive seepage into the ponds. The water remaining in the pond was bailed out with buckets and all fish contained in it collected. Thereafter, the pond was dressed and left to be filled with the next flood water. Several ponds existed in the study area.

4.3.7.2 ZONE 2

Surface Water Physicochemical Properties

Physicochemical characteristics of surface water samples from Zone 2 are also listed in Table 4.3.7.1 and 4.3.7.2. The mean pH value was 7.02, while the mean value of the electrical conductivity was 46.0 µS/cm. The mean values of alkalinity, BOD, DO, COD and nitrate were respectively 10.1 mg/l, 4.37 mg/l, 6.25 mg/l, 6.69 mg/l and 0.22 mg/l. The prominent heavy metal detected in surface water in the Zone 2 area in the dry season was copper.

Surface Water Microbiology

The result of the microbiological analysis of the water samples collected from the various sampling stations is summarized in Table 4.3.7.10. The microbial population were in the order of more than 10^6cfu/ml. The coliform bacteria in the wet and dry season ranged from 130 to ≥2400 MPN/100ml and 170 to ≥2400 MPN/100ml, an indication of poor sanitary condition in the project area. Also, the Total Heterotrophic and Hydrocarbon degrading Bacteria in the wet season ranged from 0.42×10^7 to 0.91×10^7cfu/ml and 0.23×10^7 to 0.74×10^7cfu/ml respectively. In the dry season, the values ranged from 0.34×10^7 to 1.47×10^7cfu/ml and 0.14×10^7 to 0.98×10^7cfu/ml respectively.

The composition of the Hydrocarbon degrading bacteria relative to the Total heterotrophic bacteria in the wet and dry season ranged from 41.79 to 81.32% and 41.18 to 83.72%. This reflects the hydrocarbon burden of the project area (Atlas, 1981).

The Total Heterotrophic and hydrocarbon degrading fungal counts in the wet season ranged from 0.31 x 10^7 to 0.88 x 10^7cfu/ml and 0.11 x 10^7 to 0.49 x 10^7cfu/ml. In the dry season, the microbial counts ranged from 0.23 x 10^7 to 1.09 x 10^7cfu/ml and 0.09 x 10^7 to 0.59 x 10^7cfu/ml. These microbial populations are considered high and above recorded studies in the Niger Delta.

Moreover, the percentage of the hydrocarbon degrading fungal counts in the wet and dry season ranged from 20.34 to 61.22% and 39.13 to 70.59%. The Bacterial isolates identified in the water sample include *Escherichia coli, Serratiasp, Bacillus sp, Staphylococcus sp, Enterococci sp, Bacillus sp, Micrococcus sp, Pseudomonas sp, Vibrio sp, Klebsiellasp, Enterobactersp*and*Arthrobacter sp.* The fungal isolates belonged to the genera*Aspergillus, Mucor, Fusarium, Penicillium* and *Candida.*

Table 4.3.7.10: Summary of the population densities of surface water microbes in the project area

Parameters	Coliforms (MPN/100ml)	THB (Population density x 10^7cfu/ml)	THF (Population density x 10^7cfu/ml)	HDB (Population density x 10^7cfu/ml)	HDF (Population density x 10^7cfu/ml)	HDB (%)	HDF (%)
			WET SEASON				
Range	130.0-≥2400.0	0.42-0.91	0.31– 0.88	0.23– 0.74	0.11– 0.49	41.79 – 81.32	20.34 – 61.22
			DRY SEASON				
Range	170.0-≤2400.0	0.34-1.47	0.23-1.09	0.14 -0.98	0.09– 0.59	41.18 – 83.72	39.13 – 70.59

Sediment Physicochemical Properties

Typical physicochemical characteristics of the Zone 2 sediment samples in the wet season are listed in Table 4.3.7.4. The mean pH value was 5.11, while the mean value of the electrical conductivity was 100.7 µS/cm. The mean values of organic matter content, phosphate, calcium, nitrates, total hydrocarbon content were respectively 2.75%, 6.51 mg/kg, 29.6 mg/kg, 8.97 mg/kg and 3.01 mg/kg. Heavy metals detected in the sediment include zinc, cadmium and iron.

Sediment Microbiology

The result of the microbiological analysis of the sediment samples is shown in summarized in Table 4.3.7.11. Sediments are usually the ultimate sink of contamination in any water body. The total heterotrophic and hydrocarbon degrading bacteria count in the wet season ranged from 0.54 x 10^7 to 1.91 x 10^7cfu/g and 0.24 x 10^7 to 0.81 x 10^7cfu/g respectively. In the dry season, the bacterial count ranged from 0.29 x 10^7 to 1.32 x 10^7cfu/g and 0.15 x 10^7 to 0.99 x 10^7cfu/g respectively. The ubiquitous nature of bacterial isolates may be responsible for their presence in high numbers.

The proportion of the hydrocarbon degrading bacteria counts (%) in the wet and dry season ranged from 17.2 to 70.4% and 36.6 to 75.0% respectively. The heterotrophic and hydrocarbon degrading fungal count ranged from 0.41 x 10^7 to 1.01 x 10^7cfu/g and 0.16 x 10^7 to 0.72 x 10^7cfu/g respectively in the wet season. The dry season values ranged from 0.29 x 10^7 to 1.32 x 10^7cfu/g and 0.11 x 10^7 to 0.82 x 10^7cfu/g respectively.

The percentage composition of the hydrocarbon degrading fungal counts in the wet and dry season ranged from 25.81 to 70.37% and 36.59 to 75.00%. A summary of the proportion of the hydrocarbon fungal counts (%) of the sediment sample is shown in Table 4.3.7.11. Bacterial genera isolated in the sediment sample include *Serratia*, *Staphylococcus*, *Bacillus*, *Micrococcus*, *Pseudomonas*, *Arthrobacter* and *Klebsiella.* The fungal isolate mainly belonged to the genera *Aspergillus, Mucor, Fusarium*and *Candida.*

Table 4.3.7.11: Summary of the population densities of sediment microbes in the project area

Parameters	THB (Population density x 10^7cfu/g)	THF (Population density x 10^7cfu/g)	HDB (Population density x 10^7cfu/g)	HDF (Population density x 10^7cfu/g)	HDB (%)	HDF (%)
WET SEASON						
Range	0.54 – 1.91	0.41 – 1.01	0.24 – 0.81	0.16 – 0.72	25.81–70.37	27.87 – 75.61
DRY SEASON						
Range	0.29 – 1.32	0.23 – 1.27	0.15 – 0.99	0.11 – 0.82	36.59–75.0	30.95 – 65.22

Phytoplankton

The phytoplankton are unicellular (exceptionally multicellular) microscopic algae which are either solitary or colonial, and whose movements are dependent on water currents and waves. They represent primary producers in the aquatic ecosystem, since they are autotrophs, fixing solar energy for photosynthesis, and using carbon dioxide, water and mineral nutrients to produce organic matter and oxygen. A great diversity of phytoplankton exists in both fresh and brackish/marine water. The types commonly found in the fresh and brackish waters include members of the division Chlorophyta (green algae), Cyanophyta (blue –green algae or Cyanobacteria) and the Bacillariophyta (diatoms) (Opute, 1991).

Distribution and abundance of Phytoplankton

In this study, 34 phytoplankton taxa were recorded (Appendix 4.3.7.7), (slightly lower than the dry season record of 37 taxa). These comprised 15 species of Bacillariophyta (diatoms), 14 species of Chlorophyta (green algae), 2 species of Cyanophyta (blue greens) and 3 species of Euglenophyta (euglenoids). The diatoms were dominated by Coscinodiscus and Flagillaria construens, while the green algae were dominated by Closterium spp. and Spirogyra spp. During the dry season, 94 species of phytoplankton comprising three Divisions, Bacillariophyta, Chlorophyta and Cyanophyta were reported. Of these, Bacillariophyta was dominant (Fig. 4.3.7.10).

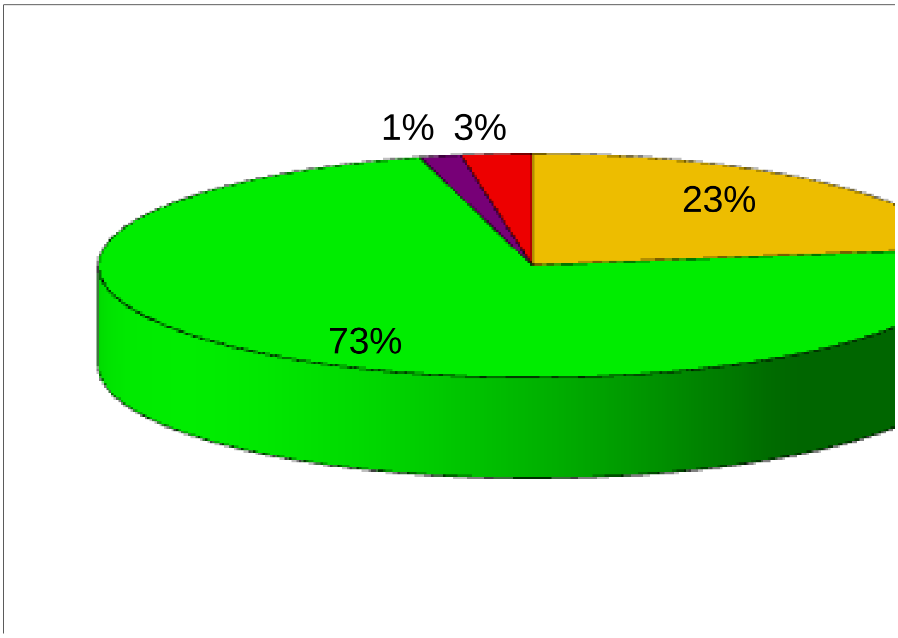


Fig. 4.3.7.10: Percentage Composition of Different Phytoplankton Divisions in the study

The division Chlorophyta dominated the phytoplankton population density, contributing 72% of the total density. This was followed by the Bacillariophyta which contributed 23% of the total density. The other divisions recorded were not significant. The dominance of Spirogyra contributed remarkably to the total abundance and dominance of Chlorophyta in the study area. Bacillariophyta however had the highest number of species (Fig. 4.3.7.11).

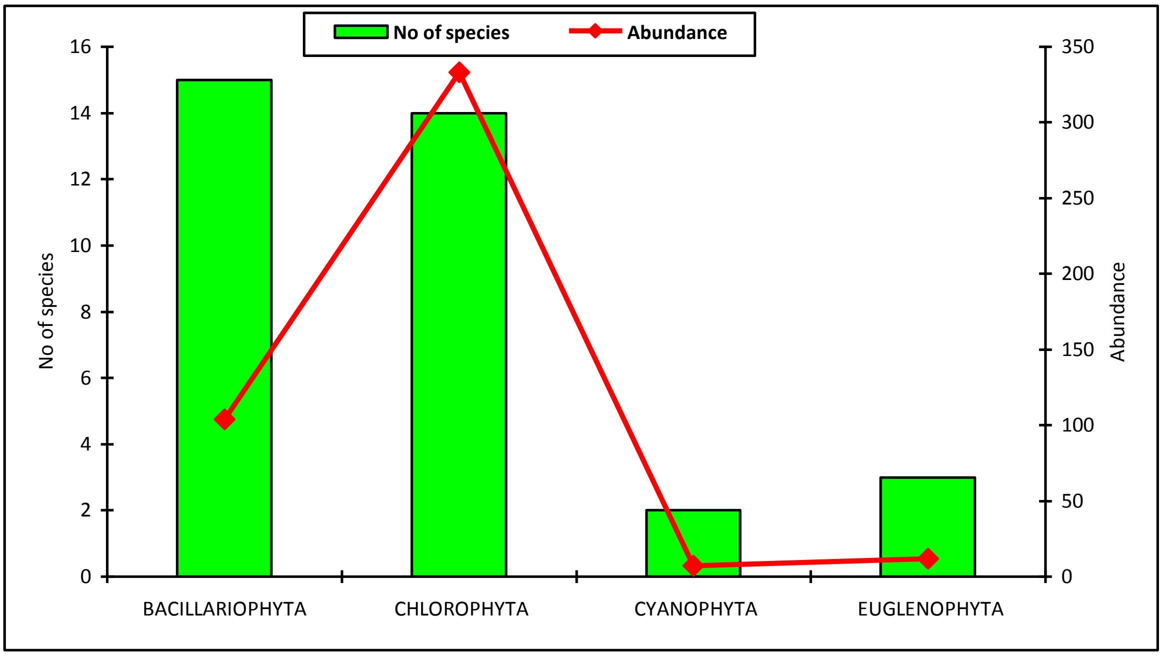


Fig. 4.3.7.11: Abundance and number of species among Phytoplankton divisions

Diversity and Evenness Indices

The diversity indices for phytoplankton in Zone 1 are shown in Figure 4.3.7.12. The dominance index was low (0.25) and equitability (evenness) moderately high (0.65). The Shannon diversity value (2.28) was moderately high and indicates a slightly perturbed environment. The higher the evenness, the lower the dominance, and the higher the overall diversity. Margalef's species richness index (d) was high because of the high number of species and relatively low abundance.

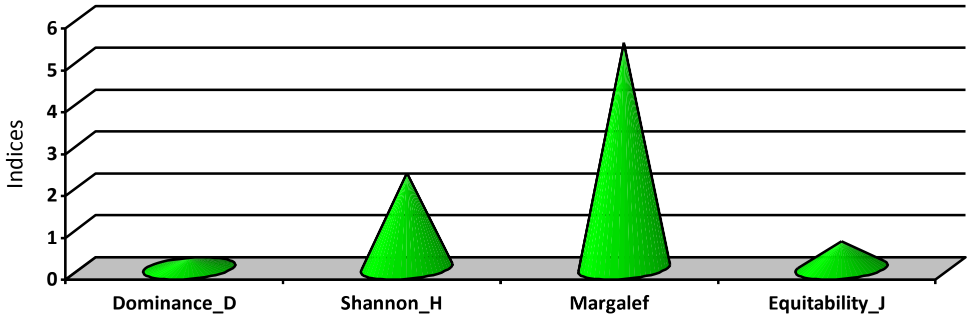


Fig. 4.3.7.12. Diversity indices for phytoplankton

Zooplankton

Zooplanktons are microscopic animals found mainly in the pelagic zone of water bodies where they depend on water currents and waves for motion (Ross, 1970; Davis, 1972). Zooplankton communities in the tropics consist of the Rotifera, Cladocera, Copepoda and meroplanktonic larvae of benthic and nektonic organisms (Egborge, 1994; Ogbeibu & Egborge, 1995). They are good biological indicators of water quality. Their sensitivity to environmental factors, both natural and artificial, makes them of considerable significance in pollution and environmental impact assessment studies.

The zooplankton community is subdivided according to its life history patterns as follows:
Holoplankton: Those that spend their entire life cycle as zooplankton, e.g., copepods, rotifers.
Meroplankton: Those that spend part of their life cycle as plankton, e.g., larvae forms of fish, shrimp, crabs and molluscs.

Composition, Abundance and Distribution of Zooplankton

In this rainy season study, 12 zooplankton taxa were recorded, (compared to the 14 taxa recorded during the dry season). These comprised 4 species of Rotifera, 5 species of Cladocera and 3 Copepod taxa (Appendix 4.3.7.8). Cladocera dominated the zooplankton with 41.7% composition, followed by Rotifera (33.3%) while copepod constituted 25% (Fig. 4.3.7.12). Cladocera which had the highest abundance also had the highest number of taxa (Fig. 4.3.7.13). The zooplankton density ranged from 32 individuals per m3 to 1 individual per m^3. The dry season study reported the dominance of Copepoda (62%) followed by Cladocera (20%) and Rotifera (14%).

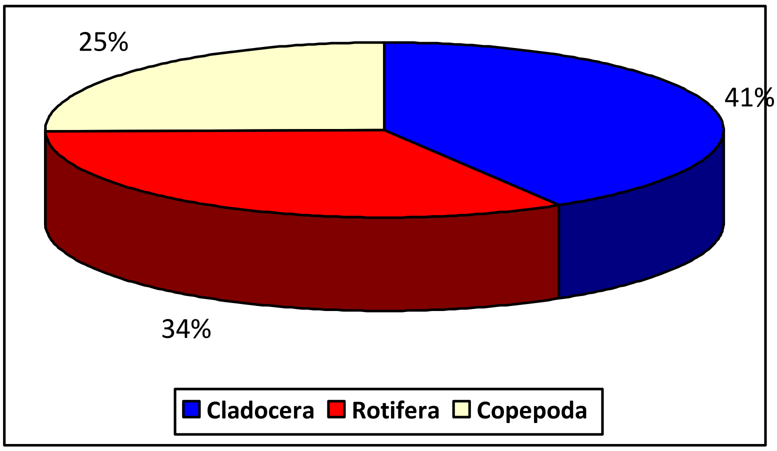


Fig. 4.3.7.12: Percentage Composition of Different Zooplankton Divisions in the study area

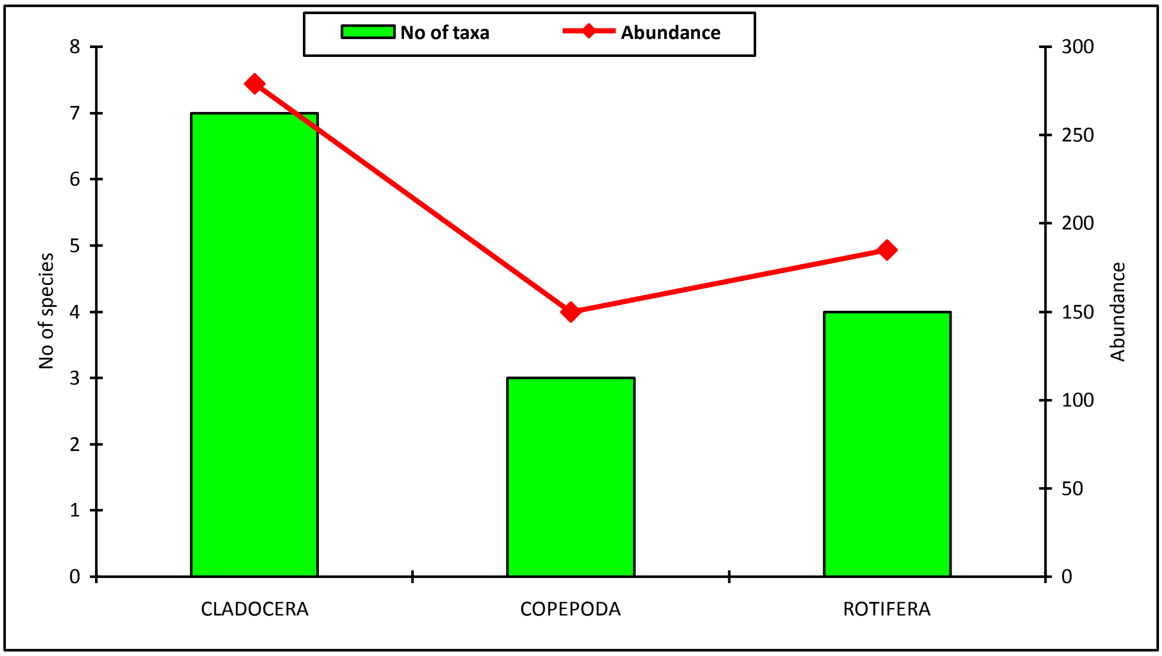


Fig. 4.3.7.13: Abundance and number of species among Zooplankton groups in Zone 2

Diversity and Evenness Indices

The diversity indices for zooplankton in Zone 1 are shown in Figure 4.3.7.14. The dominance index was low (0.11) and equitability (evenness) moderately high (0.93). The Shannon diversity value (2.32) was moderately high and indicates a slightly perturbed environment. The higher the evenness, the lower the dominance, and the higher the overall diversity. Margalef's species richness index (d) was low because of the low number of species and relatively high abundance.

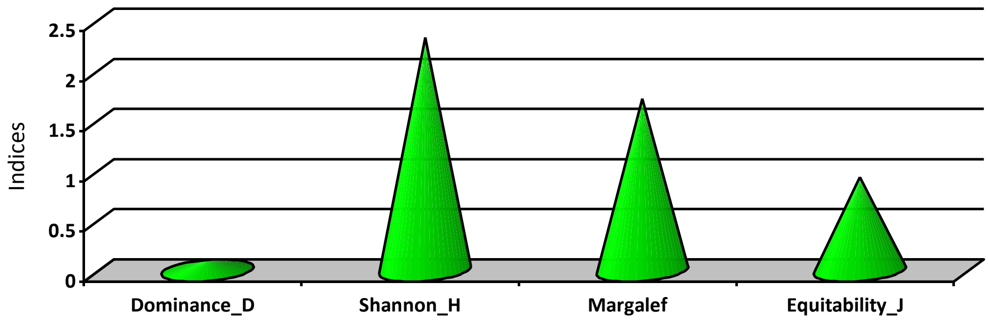


Fig. 4.3.7.14: Diversity indices for Zooplankton

Benthic Macrofauna

Macrobenthic fauna are bottom dwelling animals (mainly invertebrates) over 1.0 mm in size. They are either classified as infauna i.e. living wholly or partially buried in soft or hard substrates e.g. bottom dwelling annelids (segmented worms) or epifauna i.e. living on the surface, either crawling (mobile benthic fauna) or attached to hard substrates, roots of floating plants (sessile). Examples are crabs, barnacles and oysters (Egborge, 1994). In Nigerian inland waters, the major benthic components include the Oligochaeta (Annelida), the water mites (Hydrachnellae), insect larvae/nymphs (Diptera, Coleoptera, Ephemeroptera, Hemiptera, Odonata and Trichoptera) and few molluscs and decapod crustaceans (Ogbeibu, 1991; Ogbeibu & Egborge, 1995; Olomukoro, 1996; Egborge et al, 2003). The coastal and marine benthic fauna comprise mainly the Polychaeta (Annelida), Crustacea (crab and prawns), Mollusca (mostly bivalves and gastopod perwinkles), echinoderms and fishes.

Species Composition, Density and Distribution

Twenty-four taxa comprising 6 oligochaetes, 1 crustacean, 15 Insecta, 1 amphibian and fish fingerlings were recorded (Appendix 4.3.7.9). The Insecta alone (which had the highest number of taxa) accounted for 62.5% of the total benthic fauna with the crustacean recording the least (Figs. 4.3.7.15, 4.3.7.16). The most abundant and widespread taxa were *Nais communis* (Oligochaeta); and *Chironomus fractilobus* and *Chironomus transvaalensis* (Diptera).

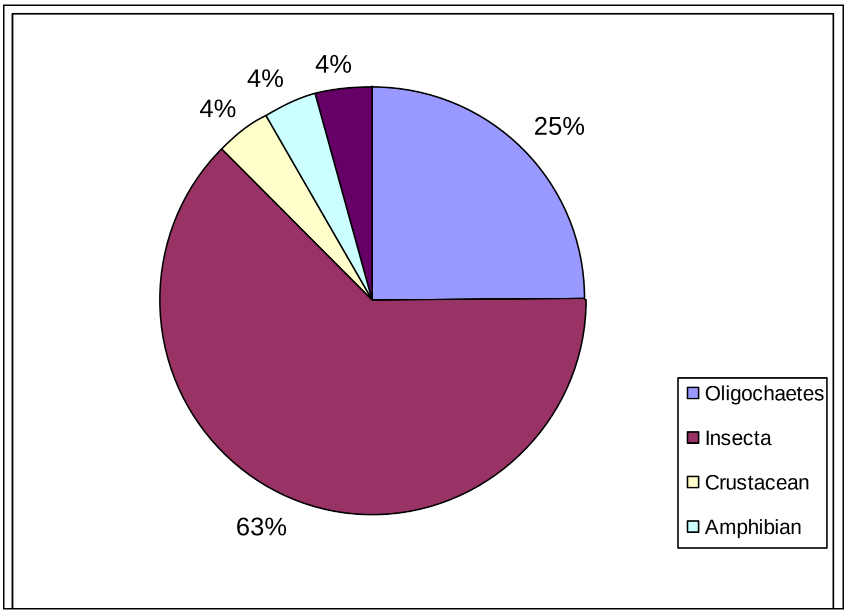


Fig. 4.3.7.15: Relative % Composition of Different Macrobenthic Fauna

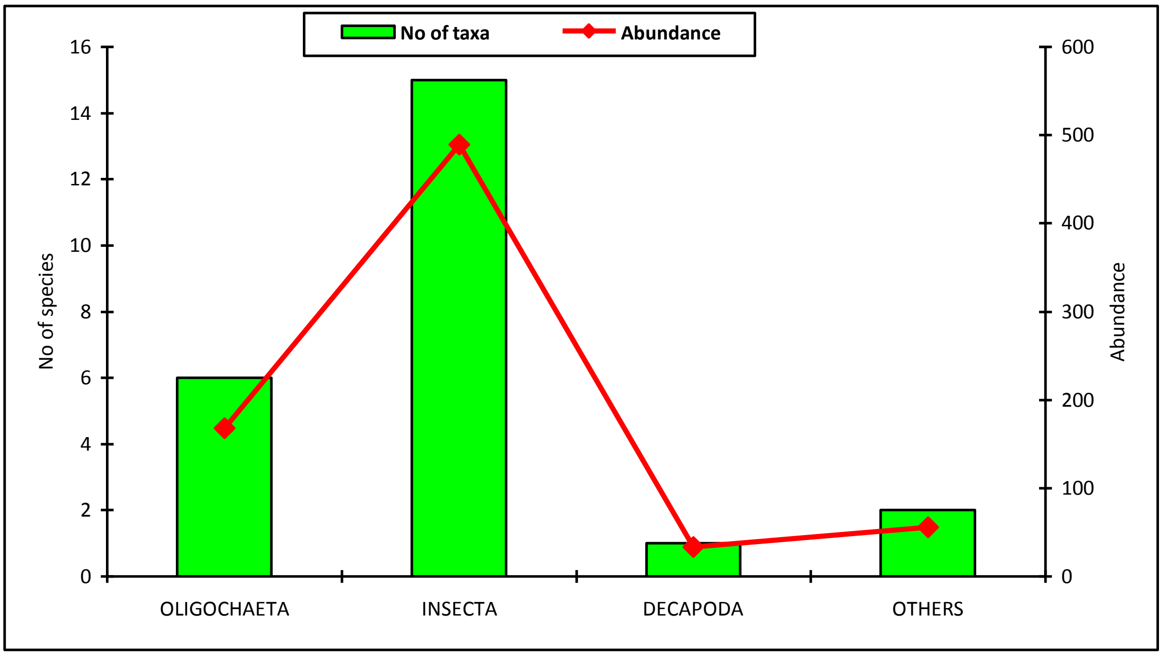


Fig. 4.3.7.16: Abundance and number of species among Benthic groups in Zone 2

Diversity and Evenness Indices

The diversity indices for benthos in Zone 1 are shown in Figure 4.3.7.117. The dominance index was low (0.12) and equitability (evenness) moderately high (0.81). The Shannon diversity value (2.57) was moderately high and indicates a slightly perturbed environment. The higher the evenness, the lower the dominance, and the higher the overall diversity. Margalef's species richness index (d) was low because of the low number of species and relatively high abundance.

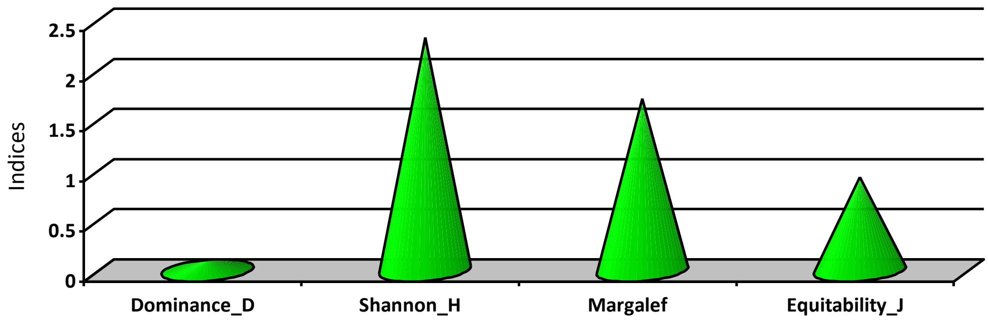


Fig.4.3.7.17. Diversity indices for Benthos

Fisheries

The summary of the fish checklist in the project area is highlighted in Table 4.3.7.12. Fishing practise in the project area is entirely subsistence in nature. A total of 27 fishery resources were identified in the project area. The fishing gear employed includes cast nets, floating and stationary hooks and long lines via wooden canoes especially around Orashi River and its tributaries. Further more, morphometric measurements of the fish sample (*Distichodus* sp) was carried out in the laboratory. It was observed that the fish species, though large – sized, had no pathological conditions. Seasonal changes in temperature reflect on the growth pattern in fishes. This information has been used in the study of distribution, age and growth of fishes by Fagade (1974), van Der Waal and Schoonbee (1975), Ikisemiju (1976), Araoye, (2002). The abundance of fish species during wet season was attributed to successful spawning and the presence of an unlimited food supply from the decay of the flooded vegetation which in turn encouraged rapid multiplication of insect diets for several fish species (Banks *et al*., 1965). The distortion of the stratified conditions of the river around the project area as a result of heavy down pour and water current during the wet season influenced the type of fishing gear used in the project area as gill nets used by artisan fishermen were minimized. In the dry season, due to periodic stratification, higher fish catch are inevitable as a result of the relative stability and low levels of the river around the project area. Table 4.3.7.13 shows the morphometric measurements of the three fish samples (*Distichodus* sp) caught in Mbiama (along the Orashi River).

Plate 4.3.7.1: Fishing gears used within communities in the project area

Plate 4.3.7.2: *Distichodus* sp used for morphometric measurement

Table 4.3.7.12: Checklist of Fishery resources of the project area

	TAXA	
S/N	**FAMILY**	**GENUS/SPECIES**
1	Polypteridae	*Erpitoichthys calabaricus*
2	Pantodontida	*Pantdon buchholzi*
3	Notopteridae	*Papyrocranus afa*
		Xenomystus nigri
4	Mormyridae	*Breinomyrus brachyistius*
		Isichthys henryi
		Petrocephals bovei
		Petrocephalus simus
5	Phractolamidae	*Phractolomu ansorgii*
6	Hepsetidae	*Hepsetus odoe*
7	Characidae	*Brycinus nurse*
		Hydrocynus forscali
		Arnoldicthys spilopterus
8	Distichodontidae	*Distichodus rostratus*
		Neolebia ansorgii
		Nannocharax fasciatus
9	Gyprinidae	*Labeo parvus*
10	Bagridae	*Chrysichthys nigrogiditatus*
		Chrysichthys auratus
		Parauchenogonis auratus
		Parauchenogonis ekiri
11	Schibeidae	*Parailia physalia*
12	Clariidae	*Clarias buthopogon*
		Clarias gariepinus
		Clarias agboyensis
13	Mochokidae	*Sysnodontes nigrita*
14	Malapteruridae	*Malapterurus electricus*
15	Mochokidae	*Synodontis clarias*
16	Cyprinodontidae	*Epiplatys sexfasciatus*
		Epiplatys senegalensis
		Epiplatys biafranus
		Epiplatys grahami
17	Channidae	*Parachanna obscura*
		Parachanna africana

	TAXA	
S/N	**FAMILY**	**GENUS/SPECIES**
18	Lutjanidae	*Lutjanus gorensis*
19	Eleotridae	*Eleotris senegalensis*
20	Anabantidae	*Ctenopoma sp.*
21	Anabantidae	*Ctenopoma petherici*
22	Cichlidae	*Chromidotiapia guntheri*
		Pevicachromis pulcher
		Hemichromis sp
		Hemichromis elongates
		Hemicromis bimaculatus
		Tilapia zilli
		Tilapia guineensis
		Oreochromis niloticus
23	Nanadidae	*Polycentropsis abbreviata*
24	Mastacembelidae	*Mastercembelus erhenbergii*
25	Palaemonidae (crustaceans)	*Macrobrachium macrobracion*
		Macrobrachium volenhovenii
		Desmocaris trispinosa
26	Fresh water crab (Potamidae)	*Sudananatus africana*
27	Ampularidae (molluscs)	*Pila ovata*
		Lanistes libyanus

Plate 4.3.7.3: *Cithrarinus citherus, Synodontis claris* and *Distichodus sp* caught by a fisherman along Orashi River

Table 4.3.7.13: Morphometric measurements of *Distichodus sp*

S/N	Fish species	Length (cm)	Width (cm)	Pectoral fin (cm)	Caudal fin (cm)	Pelvic fin (cm)	Body weight (g)
1	*Distichodus sp* A	560	210	120	120	120	3000
2	*Distichodus sp* B	540	200	100	100	120	2800
3	*Distichodus sp* C	540	200	120	120	120	2800

4.3.7.3 ZONE 3

Surface Water Physicochemical Properties

Physicochemical characteristics of surface water samples from Zone 3 are also listed in Tables 4.3.7.1 and 4.3.7.2, whileFigure 4.3.7.4 compares dry and wet season data for some parameters determined in the zone. The mean pH value was 7.95, while the mean value of the electrical conductivity was 91.9 µS/cm. The mean values of alkalinity, BOD, COD and nitrate were respectively 12.3 mg/l, 2.26 mg/l, 199.3 mg/l and 1.21mg/l. The heavy metals in the surface water samples during dry season include chromium, cadmium, copper, lead, iron, nickel and zinc.

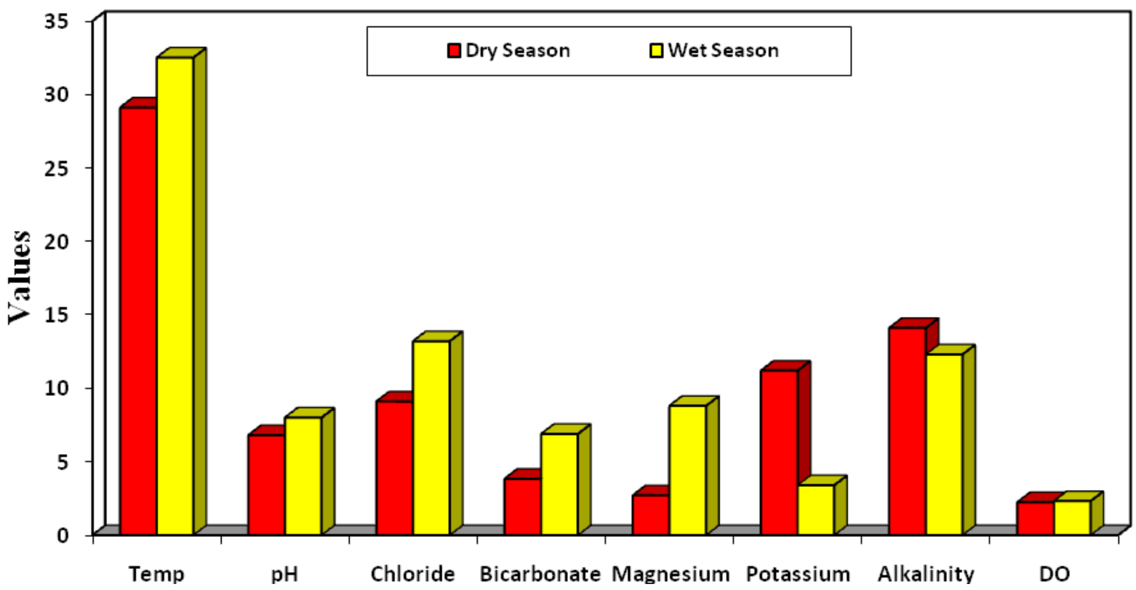


Fig. 4.3.7.18: Dry and wet season data for some surface water parameters determined in Zone 3 (Parameter units are as outlined in Table 4.3.7.1)

Source: SPDC (2009; 2015)

Surface Water Microbiology

The result of the microbiological analysis of the surface water samples collected from the various sampling stations is summarized in Table 4.3.7.14 and details in Appendix 4.3.7.10. Fourteen (14) bacterial isolates were identified in the surface water samples. These include *Enterobacter* spp., *Escherichia coli*, *Pseudomonas* spp., *Micrococcus* spp., *Staphylococcus* spp., *Achromobacter* spp., *Vibrio* spp., *Serratia* spp., *Klebsiella* spp., *Flavobacterium* spp., *Acinetobacter* spp., *Bacillus spp.*, *Proteus* spp. And *Norcardia* spp. Seven (7) fungal isolates were identified including *Fusarium* spp., *Aspergillus* spp., *Candida* spp., *Mucor*s pp., *Torulopsis* spp., *Saccharomyces* spp. and *Sporobolomyces* spp.

Table 4.3.7.14: Summary of microbiological characteristics of surface water

	Dry season (2012)							Rainy season (2012)						
	Coliforms (MPN/100ml)	THB (cfu/ml)	THF (cfu/ml)	HUB (cfu/ml)	HUF (cfu/ml)	%HUB	%HUF	Coliforms (MPN/100ml)	THB (cfu/ml)	THF(cfu/ml)	HUB (cfu/ml)	HUF (cfu/ml)	%HUB	%HUF
Min	7	3.9×10^5	4.5×10^4	0	0	0	0	15	$4.8x10^7$	$5.7x10^6$	0	0	0	0
Max	210	9.1×10^7	9.7×10^6	$7.7x10^5$	$7.1x10^4$	3.38	42.2	460	$1.09x10^9$	$2.42x10^8$	$3.1x10^3$	$4.7x10^2$	3	2.1
Mean	35.5	1.57×10^7	1.90×10^6	$1.25x10^5$	$7.96x10^3$	1.13	3.69	65	$1.69x10^9$	$5.8x10^8$	$2.3x10^3$	$1.03x10^2$	2.4	1.52
SD	51.2	2.39×10^7	3.0×10^5	$2.14x10^5$	$1.44x10^4$	0.99	9.25	33	$1.03x10^8$	$2.7x10^7$	$1.07x10^2$	$2.1x10^1$	1.9	1.20

The coliform bacteria counts ranged from 7 to 210 MPN/100ml in the dry season and 15 to 460MPN/100ml in the rainy season. The higher density in the rainy season may be attributed to input from surface runoff associated with the wide-scale flooding. The flood experienced during the mid July rains overflowed the river banks and washed off most make shift toilets along the river banks. Total Heterotrophic bacteria and fungi count ranged from 3.9 $x10^5$ to 9.1 x 10^7 cfu/ml and 4.5 x 10^4 to 9.7 x 10^6 cfu/ml in the dry season. During the rainy season total heterotrophic bacteria and fungi ranged from $4.8x10^7$ to $1.09x10^9$ cfu/ml and $5.7x10^6$ to $2.42x10^8$ cfu/ml respectively. The increase in the microbial counts is attributed to increase in organic material input to the surface water bodies via surface runoffs and flooding. This is in agreement with the high concentrations of BOD and COD during the rainy season. The results are however, within the upper limits of surface water bodies in the Niger Delta (NDES, 1997, RPI, 1985).

The density of hydrocarbon utilizing bacteria and fungi ranged from 0 to $7.7x10^5$ cfu/ml and 0 to 7.1 x 10^4 cfu/ml respectively in the dry season and from 0 to 3.1 x 10^3 cfu/ml and 0 to $4.7x10^2$ cfu/ml respectively in the rainy season. Rainy season levels were significantly lower than dry season values. This may be attributed to dilution of hydrocarbons and the microbial densities by rain and floods. The percentage composition of the hydrocarbon utilizing bacteria and fungi ranged from 0 to 4.22% and 0 to 3.3% in the dry season and from 0 to 3.0% and 0 to 2.1% respectively in the rainy season. According to Atlas (1981) pristine levels of hydrocarbon utilizing bacteria should be <1%. The observed levels were generally >1%, indicating that the environment is not devoid of hydrocarbons.

Sediment Physicochemical Properties

Typical dry and wet season data for some sediment parameters determined in Zone 3 are listed in Table 4.3.7.15 and illustrated in Figure 4.3.7.18. Heavy metals detected in the sediment include zinc, cadmium, copper, cobalt, lead, nickel, chromium and iron.

Table 4.3.7.15: Some dry and wet season physicochemical characteristics of sediments from the Zone 3 area

	Dry Season				Wet Season			
	Min	Max	Mean	STD	Min	Max	Mean	STD
pH	5.68	7.09	6.14	0.44	5.94	7.11	6.39	0.38
Temperature (oC)	27.4	32.8	29.6	1.59	27	28.4	27.7	0.44
Conductivity (µs/cm)	0.8	2.12	1.40	0.45	18	28.0	22.3	4.02
Chloride (mg/kg)	5.68	31.2	16.2	7.37	5.1	26.3	14.9	6.24
Nitrogen (mg/kg)	6.57	8.94	7.39	0.66	4.56	12.10	7.04	2.46
Phosphorus (mg/kg)	1.6	11.30	6.36	2.41	1.82	6.31	3.13	1.43
Alkalinity (mg/kg)	6	14.00	10.11	2.24	7.5	11.1	9.31	1.25
Potassium (K) (mg/kg)	72.3	1059	193.1	304.7	82.5	124.2	100.3	13.1
Magnesium (Mg) (mg/kg)	123	162.0	147.8	11.3	110	200.0	168.9	30.8
Calcium (Ca) (mg/kg)	198.0	381.0	289.5	49.9	240.0	415.0	359.6	51.9
TPH (mg/kg)	0	0.00	0.00	0.00	0.25	1.25	0.58	0.36
PAH (mg/kg)	0	0.00	0.00	0.00	0	0.00	0.00	0.00
BTEX (mg/kg)	0	0.00	0.00	0.00	0	0.00	0.00	0.00
Total Organic carbon (mg/kg)	33.4	73.8	57.8	11.6	45.2	72.1	59.8	9.76
Vanadium (Vn) (mg/kg)	0	0.00	0.00	0.00	0	0.00	0.00	0.00
Barium (Ba) (mg/kg)	0.1	3.22	1.52	0.95	0.01	0.04	0.02	0.02
Cobalt (Co) (mg/kg)	0.07	8.15	3.00	3.07	0.02	0.04	0.03	0.01
Mercury (Hg) (mg/kg)	0	0.00	0.00	0.00	0	0.00	0.00	0.00
Copper (Cu) (mg/kg)	0.12	0.86	0.51	0.25	0.04	0.08	0.05	0.02
Lead (Pb) (mg/kg)	0.001	13.2	1.62	4.35	0.02	0.67	0.14	0.20
Zinc (Zn) (mg/kg)	1.87	40.6	16.7	13.5	5.9	11.1	8.61	2.10
Iron (Fe) (mg/kg)	874	3009	1450	646.2	755.9	2879	1735	744.6
Cadmium (Cd) (mg/kg)	0.002	0.12	0.04	0.04	0	0.00	0.00	0.00
Arsenic (mg/kg)	0	0.00	0.00	0.00	0	0.00	0.00	0.00
Nickel Ni (mg/kg)	0.03	86.5	14.5	35.3	0.33	41.1	16.18	11.63
Chromium Cr (mg/kg)	0.10	197.0	31.7	73.3	1.67	65.1	16.9	23.9

Source: SPDC (2009; 2015)

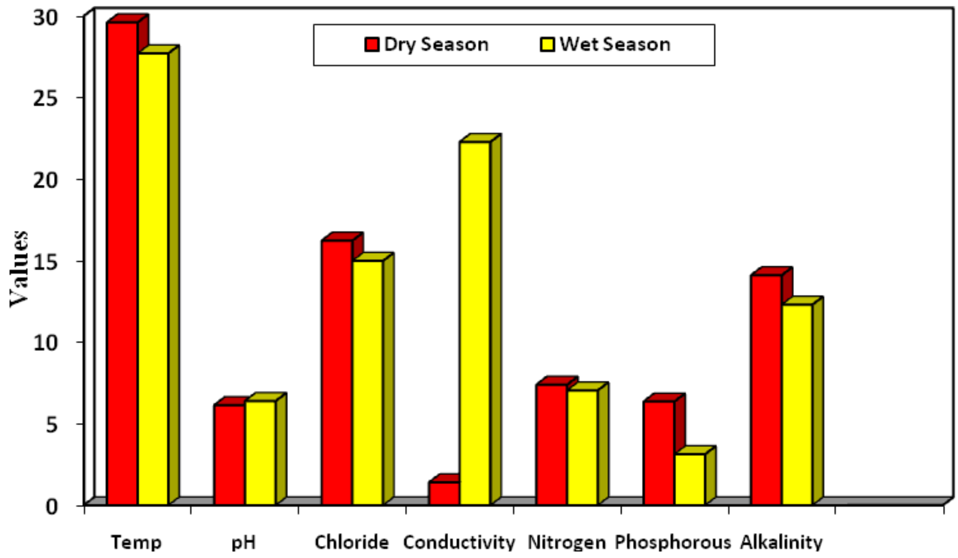


Fig. 4.3.7.18: Dry and wet season data for some sediment parameters determined in Zone 3 (Parameter units are as outlined in Table 4.3.7.3)
Source: SPDC, 2009; 2015

Sediment Microbiology

The results of the sediment microbiological studies are summarized in Table 4.3.7.16. Detailed results are presented in Appendix 4.3.7.10.

Table 4.3.7.16: Summary of microbiological measurements in sediments of the study area

	Dry Season				Rainy Season			
	SD		DP		SD		DP	
	THB ($x10^5$ cfu/g)	THF ($x10^4$ cfu/g)	THB ($x10^5$ cfu/g)	THF ($x10^4$ cfu/g)	THB ($x10^5$ cfu/g)	THF ($x10^4$ cfu/g)	THB ($x10^5$ cfu/g)	THF ($x10^4$ cfu/g)
Min	1.08	0.11	1.02	1.01	1.1	0.59	1.1	0.57
Max	9.3	9.4	9.5	8.1	9.2	7.7	9.8	8.1
Mean	4.96	3.52	5.75	3.94	4.32	3.23	6.15	3.74
SD	3.02	3.38	2.76	2.26	3.36	2.28	2.86	2.35

Total heterotrophic bacteria (THB) ranged from 1.08 x 10^5 to 9.3 x 10^5cfu/g outside the CPF and from 1.02 to 9.5 x 10^5cfu/g around the CPF during the dry season. During the rainy season the levels ranged from 1.1 to 9.2 x10^5cfu/g outside the CPF and from 1.1 to 9.8 x 10^5cfu/g around the CPF discharge area.

Total heterotrophic fungi (THF) ranged from 0.11 to 9.4 x 10^4 cfu/g outside the CPF and from 1.01 to 8.1 x 10^4 cfu/g within the CPF discharge area during the dry season. During the rainy season, THF ranged between 0.59 and 7.7 cfu/g outside the CPF and from 0.57 to 8.1 cfu/g within the CPF discharge area. THB and THF were relatively higher around the CPF discharge area (DP) of the Nun River compared with stations outside the area (SD) during the dry and rainy seasons (Fig. 4.3.7.19). The levels of THB within the CPF were higher during the rainy than dry season but the opposite was true of THF. The relatively higher levels of bacteria and fungi around the CPF may be associated with the level of human activities associated with the CPF.

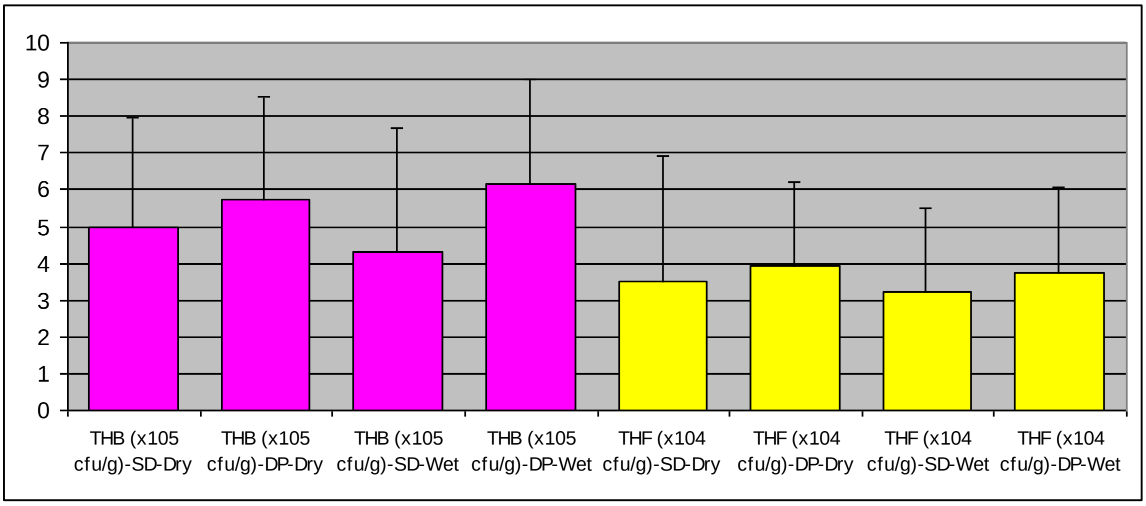


Fig. 4.3.7.19: Distribution of bacteria and fungi in sediments of the study area (mean ± SD)

Heterotrophic bacterial isolates identified in the sediment include *Klebsiella* spp., *Acinetobacter* spp., *Bacillus* spp., *Pseudomonas* spp., *Flavobacterium* spp., *Achromobacter* spp., *Staphylococcus* spp., *Proteus* spp. *Serratia* spp., *Micrococcus* spp. The fungal isolates identified include *Candida* spp., *Saccharomyces* spp., *Mucor* spp., *Fusarium* spp., *Sporobolomyces* spp., *Torulopsis* spp. and *Aspergillus* spp. Hydrocarbon utilizing bacteria and fungi were not isolated from the sediment samples during both dry and rainy seasons. This is in agreement with the absence of petroleum hydrocarbon in the sediments. Table 4.3.7.17 compares the pre-commissioning bacterial and fungal population density in 2004 with the conditions in 2012.

Table 4.3.7.17: Comparison between microbial density in sediments of the study area in 2004 and 2012

Parameter	2004			2012		
	3	7	11	WSC1	WS3	WS4
THB (cfu/g)	2.54×10^8	2.03×10^8	1.72×10^6	2.3×10^5	7.8×10^5	1.24×10^7
TF(cfu/g)	1.22×10^8	2.35×10^8	1.43×10^6	1.01×10^4	2.9×10^3	7.9×10^6
HUB (cfu/g)	0.46×10^4	1.13×10^4	0.54×10^6	0	0	0
HUF (cfu/g)	0.24×10^4	0.53×10^4	0.14×10^6	0	0	0

Total heterotrophic bacteria (THB) was 10 to 1000 fold higher in 2004 compared to 2012, total fungi (TF) was similarly markedly higher in 2004 than 2012. Hydrocarbon utilizing bacteria (HUB) and hydrocarbon utilizing fungi (HUF) which occurred widely in 2004 were not isolated in any station in 2012. This depicts improvement in environmental conditions in the area over the years.

Hydrobiology

Phytoplankton

The list of phytoplankton identified in the surface water bodies of the study area during the dry and rainy seasons is presented in Appendix 4.3.7.11. A total of 1347 organisms made up of 21 species were recorded during the dry season. These were made up of three divisions comprising 12 species of Bacillariophyta (diatoms), 6 species of Cyanophyta (blue green algae) and 3 of Chlorophyta (green algae). The diatoms dominated in terms of the number of species while the green algae dominated in terms of abundance. During the rainy season, 22 species in three similar divisions as in the dry season were recorded. They comprised 13 species of Bacillariophyta, 6 of Cyanophyta and 3 of Chlorophyta.

The green algae made up 39 % of the phytoplankton during the dry season but only 12 % during the rainy season. The *Spirogyra* dominated the population of the green algae. The diatoms became more dominant during the rainy season making up to 54% of the total abundance. Seasonal differences were also observed among the blue-green algae with higher abundance (34%) during the rainy season as against the dry season period (24%) (Fig. 4.3.7.20). Minor spatial differences were noticed in species number across the sites studied. The dominant diatom during the dry season was *Nitszchia* spp while *Cyclotella* spp dominated during the rainy season. The blue-green algae *Oscillatoria* spp was most dominant in both seasons; the same temporal trend was also observed for the green algae *Spirogyra* spp.

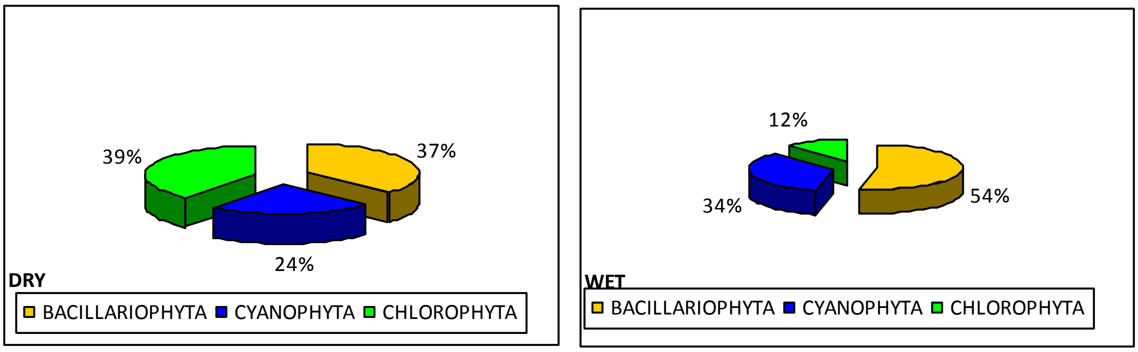


Figure 4.3.7.20: Percentage composition of phytoplankton in the study area.

Spatial and temporal variations were noticed in the phytoplankton diversity indices. Species were almost evenly distributed across sampling stations, with minimal variations in both seasons. The species richness was generally higher during the dry season than the rainy season period while species diversity was higher during the rainy season than the dry season. The higher species richness and abundance during the dry season is expected because of the higher photosynthetic activity during this period. The lower diversity recorded during the same period was probably due to the dominance of few species which reduced the general diversity.

There was no definite pattern in the spatio-temporal variation with respect to the diversity values computed to assess possible alterations due to effluent discharge in some locations. There are no observable changes in diversity indices that can be attributed to the effect of discharge

Zooplankton

The list of zooplankton identified in the study area is presented in Appendix 4.3.7.12. A total of 585 organisms made up of 16 species were observed during the dry season. These were made up of six classes, including the copepods, cladocerans, rotifers, protozoans, nematodes and insects as observed during the dry season but the nematodes were not recorded during the rainy season. The copepods constituted 36 % of the zooplankton examined while the cladocerans, rotifers, protozoans nematodes and insects contributed 46 %, 7%, 9%, and 1 % each respectively. During the rainy season, 14 species belonging to similar taxonomic groups were recorded. They comprised the cladocerans (41%) and the copepods which had the same percentage (24%) as the rotifers (Figure 4.3.7.21). Copepod nauplius, *Bosmina longirosbis, Epistilis* sp and *Keratella cochlearis* were among the most abundant zooplankton species during the study.

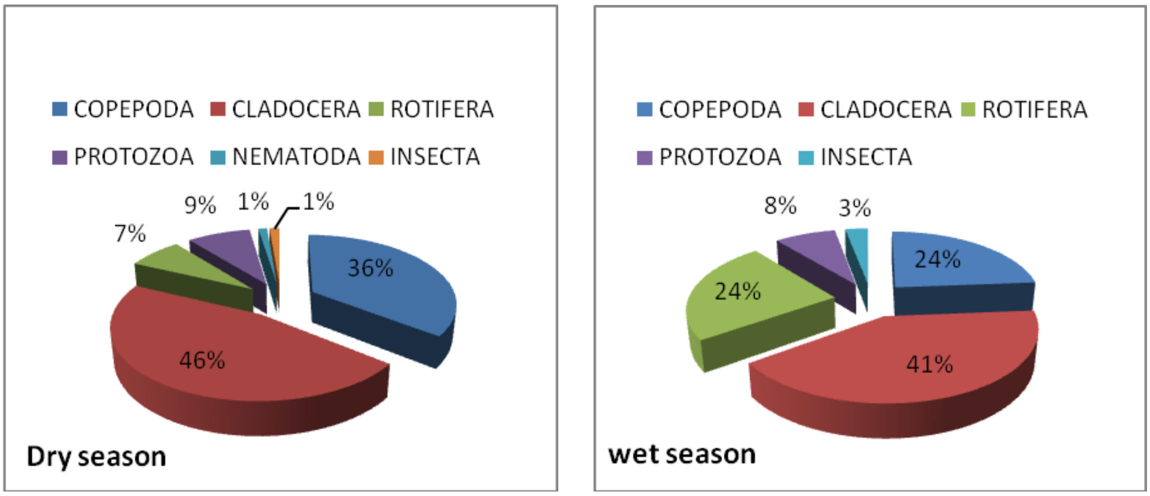


Figure 4.3.7.21: Percentage contribution of zooplankton taxonomic groups during the dry and rainy seasons.

Minimal spatio-temporal variation was observed in the evenness of the species while higher variations were observed for species richness in space and time. Species were generally richer during the rainy season than the dry season period. Also, a similar temporal trend was noticed for species diversity. There was no definite pattern in the spatio-temporal variation with respect to the diversity values computed to assess possible alterations due to effluent discharge. There are no observable changes in diversity indices that can be attributed to the effect of discharge. The species richness, however was slightly lower in the effluent discharge stations.

Benthic Macrofauna

Benthos refers to the invertebrate benthic communities that live on or in the bottom sediments of the aquatic habitat. The composition and abundance of the benthic fauna is presented in Appendix 4.3.7.13. A total of 13 taxa belonging to the Oligochaeta, Insecta, Crustacea and Nematoda were identified during the dry season. Similar numbers of taxa belonging to the same taxonomic groups as in the dry season were recorded during the rainy season. The oligochaetes were the most abundant group in both seasons. These worms constituted 83 % of the benthic fauna during the dry season and 61 % during the rainy season, suggesting a seasonal influence on the abundance of these worms. The insects made up 10% and 28 % during the dry and rainy seasons respectively of the benthic fauna. The abundance of the crustaceans were almost the same in during the two seasons while the nematodes were higher during the rainy season (5%) (Fig. 4.3.7.22). Tubifex spp were the most abundant and were observed in about 50 % of the stations examined. Their dominance reached 64% during the dry season and 33% during the rainy season. The worms were generally more than the arthropods which were more than the crustaceans and nematodes.

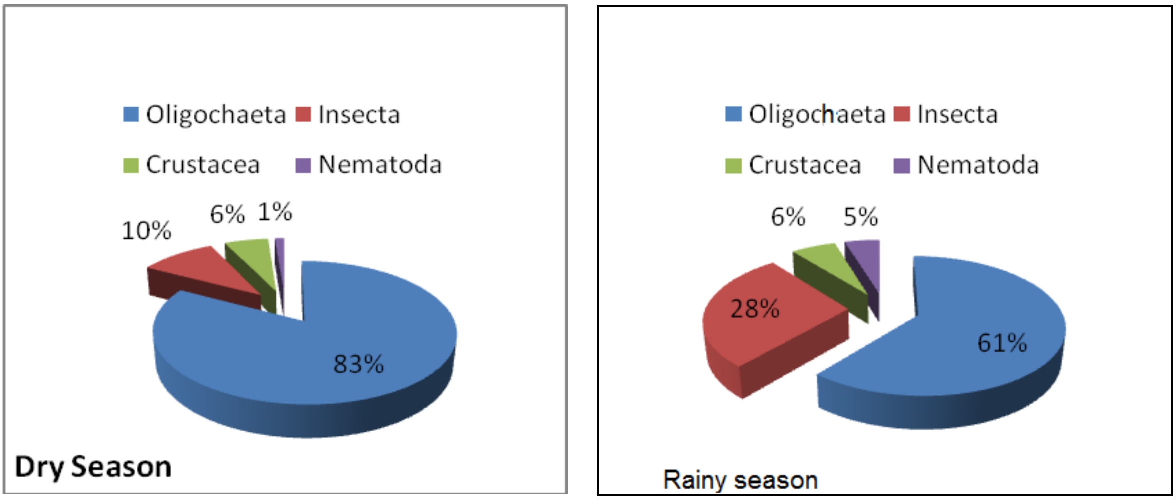


Figure 4.3.7.22: Percentage Composition of Benthic fauna.

There were also remarkable variations in species richness, evenness and ecological diversity of benthic fauna across all stations observed in both seasons. The species were generally richer during the dry season but more evenly distributed during the rainy season.

There was no definite pattern in the spatio-temporal variation with respect to the diversity values computed to assess possible alterations due to effluent discharge. There are no observable changes in diversity indices that can be attributed to the effect of discharge. However, the species richness was on the average lower around the effluent discharge stations during the dry season. The harmonizing and diluting effect of rainy season might have been responsible for the more or less uniform values during that season. In general, the benthic species diversity was moderately high (1.6 - 2.4) in the study area.

Fishery Resources

Fishing is an age old tradition in the study area and includes actual fishing to maintenance of fishing crafts and gear, fish processing and marketing. Several types of fishing gear are used interchangeably or complementarily to exploit a large number of fish species which could either be lotic or lentic. Furthermore, lotic fishes include those fishery resources from Taylor creek, Orashi River and Nun River. Similarly, the lentic fish resources include fish resources from lakes, ponds and swamps. A few lentic water bodies observed in the study area include but not limited to the following: You-uwon ororo, Egwebara and Osoko-adi.

Fish Catch

The fishes caught during the field data gathering exercise in the lotic and lentic water bodies were dominantly members of the family Clariidae (Clarias gariepinus), Mochokidae (Synodontis spp), Channidea (Parachana obscura, Parachana africana), Cichlidae (Tilapia zilli, Oreochromis niloticus), Polypteridae (Erpetoichthys spp) (Plates 4.3.7.5 and 4.3.7.6). However, members of the Clariidae and Channidae were most predominant in the lentic water bodies and constituted about 90% of the total fish catch observed in the study area (Figure 4.3.7.23, Table 4.3.7.18).

Plates 4.3.7.5 Species of *Parachana obscura* (Ijaw: Iyoro) caught by a fishing folk in Gbarantoru community

Plates 4.3.7.6: Species of *Clarias gariepinus* (Ijaw: Olomo) caught by a fishing folk in Okaki community

Table 4.3.7.18: Fish species composition of the study area

Family	Scientific Name	Habitat	AI
Clariidae	*Clarias buthupogon*	Demersal	C
	Clarias ebriensis	Demersal	C
	Clarias gariepinus	Benthopelagic	C
Cichlidae	*Tilapia guineensis*	Benthopelagic	C
	Tilapia zilli	Demersal	C
	Oreochromis niloticus	Benthopelagic	C
	Hemichromis bimaculatus	Benthopelagic	C
	Chromidotilapia guentheri	Benthopelagic	C
Channidae	*Parachanna obscura*	Demersal	C
	Parachanna africana	Benthopelagic	C
Gobiidae	*Periophthalmus barbarus*	Demersal	C
Citharinidae	*Nannocharax fasciatus*	Pelagic	C
	Neolebias ansorgii	Pelagic	C
Mormyridae	*Petrocephalus ansorgii*	Demersal	C
	Petrocephalus bovei bovei	Demersal	C
	Petrocephalus soudanensis	Demersal	C
Mochokidae	*Synodontis melanopterus*	Benthopelagic	C
	Synodontis nigrita	Benthopelagic	C
	Synodontis schall	Benthopelagic	C
Schilbeidae	*Schilbe brevianalis*	Demersal	C
	Schilbe intermedius	Pelagic	C
	Schilbe mystus	Pelagic	C

AI = Abundance Index, C = Common, R = Rare

Source: Fieldwork, 2012

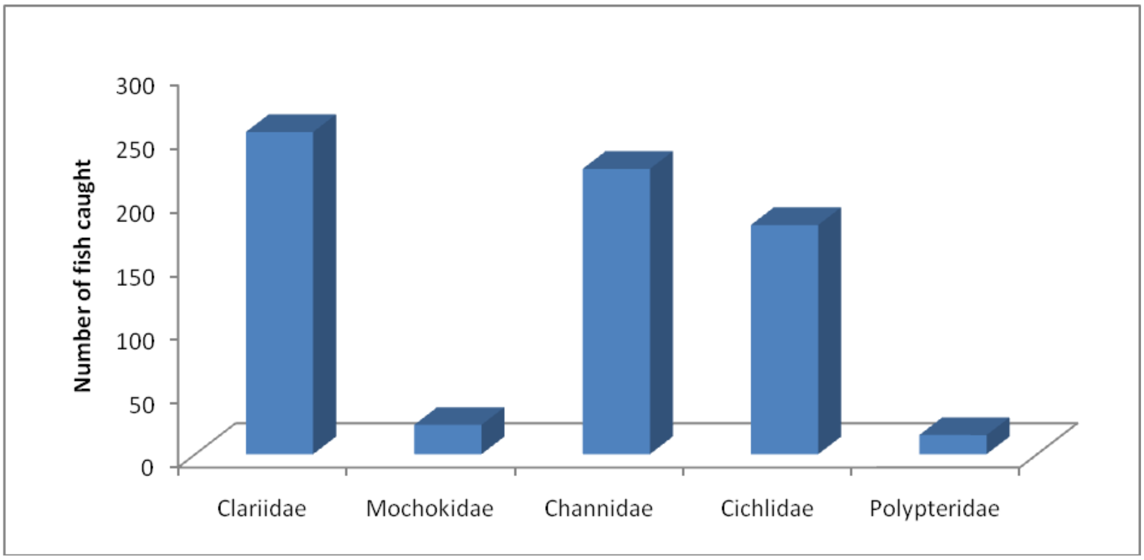


Fig. 4.3.7.23: Total fish catch by family as indicated by fishing folks during the field data gathering exercise

Fishing Gears

Fishing folks were observed to have a variety of fishing gears due to seasonal changes in both species and abundance status. There is linear relationship between the fish body breadth and gill net mesh size selectivity. Ita and Madahili (1997) reported a linear relationship between body breath and gill net mesh size selectivity. Survey of the fishing gear used in the study area indicates the use of traps (Plate 4.3.7.7), spear, cast nets, hook and lines, lifts nets, seine nets and gill nets. Fisher folks usually have variety of fishing gear because seasonal changes both in species diversity and abundance require varying fishing gear several times a year (Bankole et al. 2003). Table 4.28 highlights the various fishing gears observed in the study area and the target fish species. Similarly, the fishing gear composition in Figure 4.3.7.24 revealed that the commonest gear type in the study area were the Hook and lines, Gill nets, Traps and Cast nets comprised over 60% of the gear composition. A succinct description of the various gear types is presented below:

Gill nets

Gill nets are of assorted designs and sizes, and may be constructed to target particular fish group or groups of fish. Gill nets are commonly named after the target fish for which it was designed to catch and referred to as Eleli-dii or Ofoinmo dii in the study area. They may be set floating along with water current (drift net) or set stationary at the bottom or mid water with anchors and floats (set nets). The sizes of fish caught depend on the mesh size and design characteristics. Set over a period of several hours either at night or in the day, gill nets take a variety of fish. Nets are constructed from monofilament netting materials with meshes of 13mm to 140mm. Attached to the footrope of these nets (as sinkers) were lead, corked bottles, stones and batteries while Styrofoam/corks were used on the headrope as floats (Kingdom and Kween, 2009). These nets are light and are mainly set to drift so as to trap shoals of fish. Target fish species include but not limited to the following: Characids, Mochokids and Schilbeids.

Cast nets

Cast nets varied in design and size in the study area and commonly referred to as 'Igbo'. This gear is a cone-shaped device operated from canoes and requires skillful throwing to achieve maximum spread in order to trap fish in the vicinity of the throw. They are constructed with nets of stretched mesh size of 38mm and target mainly cichlids, characids and schilbeids. Gears are used all year round independent of seasons.

Hook and lines

Hooks and lines are constructed to form long lines, consisting of rope with snoods fastened at regular intervals and bearing hooks. The size of this gear type is dependent on the target fish species. Among the lines were the spring-loaded set line (fungu dayi), rod and line (poi dayi) and the longline (merimeri/sara dayi) all targeting the bagrids, schilbeids, clariids and mochokids (Kingdom and Tween, 2009).

Table 4.23.7.19: Fishing gears commonly used in the study area

Fishing gear	Local name	Target fish species
Spear	*Dumuo, Imbieye*	Channidae
Traps	*Eteu*	Palaemonidae
Cast nets	*Igbo*	Cichlids and characids
Hook and lines	*Meri meri, Sara dayi*	Clariids, mochokids
Lifts nets	*Atalla*	Distichodids
Seine nets	*Keli-keli*	Mochokids
Gill nets	*Eleli-dii, Ofoinmo dii*	Characids, mochokids and schilbeids

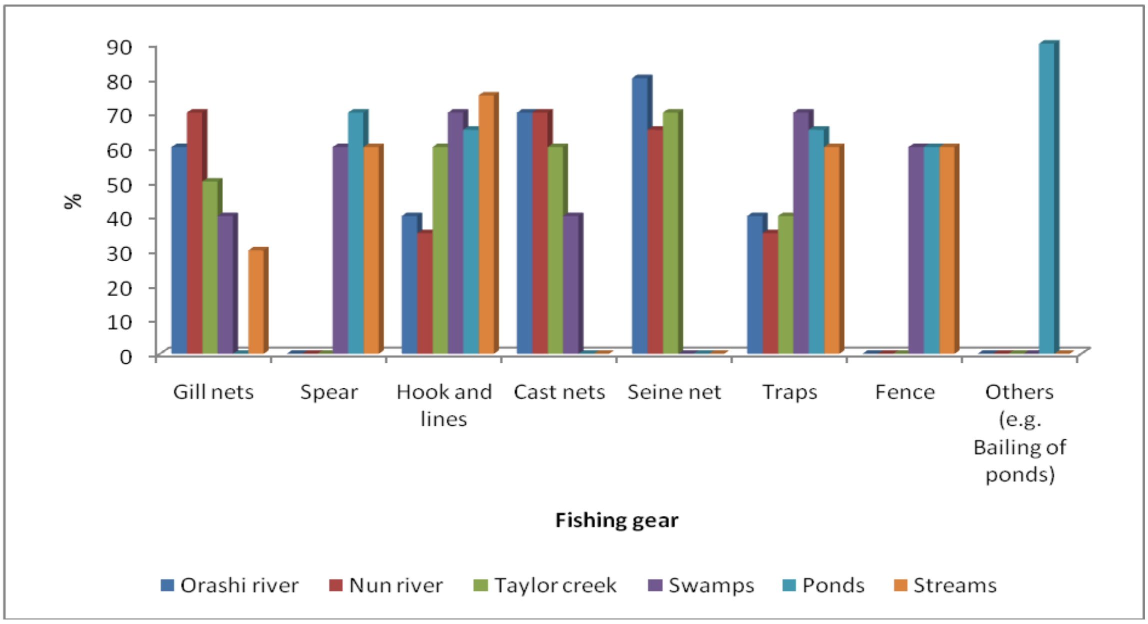


Figure 4.3.7.24: Fishing gear composition in the study area

Plate 4.3.7.7: Common fishing gears of the study area

Fishing Craft and Fishing Patterns
The dug-out canoes without engines were observed to be the most predominant fishing craft in the study area with sizes ranging from 2m to 5m usually carrying one to three persons and used to operate gill nets and lifts nets in the lotic surface water bodies i.e. Taylor Creek, Orashi River and Nun River. Dug-out canoes with outboard engines also exist but in relatively small numbers. The dugout canoes had relatively small free board and thereby displayed low reserved buoyancy and were observed to be less stable. These canoes are carved by skilled artisanal craftsmen from plants such as Afara (*Terminalia ivorensis*), White afara (*Terminalia superba*), red iron (*Lophira alata*), Obeche (*Alstonia sp*.) etc. The fishing craft characteristics of the study area are presented in Table 4.3.3.20 and Plate 4.3.7.8. Furthermore, fishing activities take place virtually throughout the year but may be influenced by lunar cycles, water currents and fish movements. The period of June through September are known with low fishing activities attributed to high river discharge and flooding.

Table 4.3.3.20: Characteristics of Dugout boats used in the study area

S/N	Characteristics	Nun/Orashi river	Taylor creek
1	Overall length (m)	8 – 13.3	3 - 7
2	Maximum width or moulded breadth (m)	0.85 – 1.60	0.63 – 1.00
3	Draft/ maximum Depth (moulded) (m)	0.71 – 0.90	0.15 – 0.44
4	Load water line (LWL) (m)	3.11 – 5.10	2.58 – 4.40
5	Volume (m3)	1.53 – 8.77	0.40 – 2.68
6	Free board ratio	1:2	2:1
7	Mode of Propulsion	Paddle/Engine	Paddle

Plate 4.3.7.8: Dug out canoes observed in the study area

Tissue Analysis

Chromium, Lead, Cadmium and Mercury were not detected in the tissues of the fish samples analysed in both seasons (Table 4.3.7.21). The concentration of Zinc was highest in the Liver of all the fish samples analysed. The zinc concentration in all the fish tissues analysed complied with 30mg/kg dry weight of FAO (1983) for safe consumption. Similarly, iron recorded the highest concentration in the liver of Oreochromis niloticus in the rainy season and dry season (5.59 and 5.41mg/kg) and maybe related to increased dissolved iron uptake. No significant difference ($p>0.05$) was observed in the concentration of metals in the tissues of all fish species analysed. The concentration of other heavy metals in various fish tissues were within acceptable limits (Table 4.3.7.21 and Table 4.3.7.22). There is therefore no evidence of heavy metal contamination in the fish tissues examined, and the fishes are fit for human consumption.

Table 4.3.7.21: Result of tissue analysis of fish samples obtained in the Rainy season

Parameters	*Clarias gariepinus*					*Parachanna obscura*					*Oreochromis niloticus*					WHO (1989)	FAO (1983)	USFDA (1993)
	Gills	Spleen	Liver	Gonads	Kidneys	Gills	Spleen	Liver	Gonads	Kidneys	Gills	Spleen	Liver	Gonads	Kidneys			
Cu (mg/kg)	0.76	1.72	2.31	0.08	1.45	3.64	0.02	3.9	0.53	0.45	0.31	2.45	3.39	0.14	0.10	1	30	
Mn (mg/kg)	1.05	3.2	5.76	0.99	2.52	1.90	0.81	2.32	0.51	0.92	0.10	0.53	1.31	0.45	0.19			
Cr (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.5		12 – 13
Zn (mg/kg)	9.81	7.61	15.95	6.87	11.82	9.20	10.31	17.21	9.91	12.11	6.97	10.24	13.115	8.82	9.20	10	30	
Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	2	0.5	
Cd (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	2	0.5	
Fe (mg/kg)	1.22	1.07	5.19	0.43	1.61	1.90	1.32	3.72	2.42	1.99	1.47	1.52	5.59	2.12	1.59			
Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			

Table 4. 3.7.22: Result of tissue analysis of fish samples

Parameters	*Clarias gariepinus*					*Parachana obscura*					*Oreochromis niloticus*					*Distichodus rostratus*					*Pellonula leonensis*					WHO (1989)	FAO (1983)	USFDA (1993)
	Gills	Spleen	Liver	Gonads	Kidneys	Gills	Spleen	Liver	Gonads	Kidneys	Gills	Spleen	Liver	Gonads	Kidneys	Gills	Spleen	Liver	Gonads	Kidneys	Gills	Spleen	Liver	Gonads	Kidneys			
Cu (mg/kg)	0.51	1.80	2.12	0.17	1.25	3.43	0.13	3.75	0.63	0.59	2.11	2.61	3.57	0.35	0.24	0.05	1.49	2.55	0.07	1.61	3.19	0.01	3.33	0.47	0.30	0.5		12 – 13
Mn (mg/kg)	0.95	2.83	5.20	0.61	2.30	2.39	0.68	2.33	0.58	0.87	0.92	0.62	1.39	0.52	0.19	1.33	3.10	4.19	0.77	3.28	1.39	0.51	2.35	0.47	0.87			
Cr (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
Zn (mg/kg)	7.20	7.45	9.05	6.50	11.52	9.54	10.97	15.28	9.76	11.93	6.53	10.74	12.24	7.21	9.01	6.61	4.37	19.70	7.75	12.62	6.91	10.72	14.35	7.35	11.19		30	
Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	2	0.5	
Cd (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Fe (mg/kg)	1.30	1.25	5.22	0.53	1.42	1.48	1.50	3.55	2.50	2.61	1.60	1.57	5.41	2.43	1.77	0.22	1.28	5.01	0.49	1.39	1.61	1.36	3.69	2.20	1.42			
Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			

4.3.7.4 ZONE 4

Surface Water Physicochemical Properties

Typical physicochemical characteristics of surface water samples from Zone 4 are listed in Tables 4.3.7.1 and 4.3.7.2. The mean pH value was 6.66, while the mean value of the electrical conductivity was 121.3 µS/cm. The mean values of alkalinity, BOD, DO, COD and nitrate were respectively 1.52 mg/l, 2.69 mg/l, 4.96 mg/l, 128.5 mg/l and 0.26 mg/l. The prominent heavy metal detected in surface water in the Zone 4 area during the dry season was iron.

Surface Water Microbiology

Data on the microbiology of the surface water samples collected from the Gbaran FLB/Jetty area are presented in Table 4.3.7.23. Total heteroptrophic bacterial load ranged from 1.25-1.84x10^7cful/ml with a mean of 1.46x10^7cfu/ml, while total fungal load on the other hand ranged from 0.7-3.8x10^6cfu/ml with a mean value of 1.9x10^6cfu/ml.

The percentage hydrocarbon utilizing bacteria ranged from 1.16-10.15% while that of fungi ranged from 0.60-3.33%. Comparing these figures to the results recorded for Gbarain Zone surface waters in 2003 (SPDC, 2004), these values are higher than those recorded Gbaran zone surface waters in 2003 by SPDC, 2004. This may be attributed to higher boat traffic and increase in organic materials resulting from the dredging of Koroama Appraisal well.

Table 4.3.7.23: Summary of Microbial Populations of Water Samples from River Systems and Back Waters.

MicrobialProperties	Range	Mean
Total heterotrophic bacteria (THB) (x10^7) cfu/ml	1.25-1.84	1.46 ± 0.2
Hydrocarbon utilising bacteria(HUB) (x10^6) cfu/ml	1.1-7.5	2.9 ± 1.9
Percent HUB	1.16-10.15	4.46 ± 3.23
Total heterotrophic fungi (THF) (x10^6)cfu/ml	0.7-3.8	1.9 ± 0.9
Hydrocarbon utilising fungi (HUF) x10^5cfu/ml	0.2-0.9	
Percent HUF	0.60-3.33	
Total coliform MPN/100ml	7-230	48.77 ± 78.65

Sediment Physicochemical Properties

Typical physicochemical characteristics of sediment samples from Zone 4 in the dry and wet seasons are listed in Table 4.3.7.24. The dry/wet season mean pH values were 5.21/5.38, while the mean values of the chloride content were 4.36/26.5 mg/kg. Similarly, the mean values of sodium, magnesium and nitrate were 20.4/15.3 mg/kg, 3.28/2.34 mg/kg and 0.04/78.2 mg/kg respectively. Heavy metals detected in the sediment include Zinc, Cadmium, Copper, Manganese, Lead, Nickel, Vanadium and Iron.

Table 4.3.7.24: Some dry and wet season physicochemical characteristics of sediments from the Zone 4 area

	Dry Season			**Wet Season**		
	Range	**Mean**	**SD**	**Range**	**Mean**	**SD**
pH	4.9-5.5	5.21	0.18	4.7-6.3	5.38	0.63
Chloride (mg/kg)	2.8-6.2	4.36	1.46	22.45-39.86	26.51	4.76
Na (mg/kg)	17.5-22.7	20.43	1.54	5.18-23.43	15.27	5.15
K (mg/kg)	2.7-4.5	3.66	0.62	1.09-8.12	3.58	2.17
Ca (mg/kg)	1.8-3.3	2.48	0.52	2.1-4.85	3.22	0.91
Mg (mg/kg)	2.3-4.1	3.28	0.54	0.43-8.63	3.91	2.34
NO_3 (mg/kg)	0.03-0.07	0.04	0.01	73.6-82.65	78.52	2.98
NO_2 (mg/kg)	< 0.01	< 0.01	< 0.01	0.1-0.4	0.28	0.10
NH_4- N (mg/kg)	<0.01-0.04	0.03	0.01	22.45-39.86	26.51	4.76
Heavy Metals						
Fe (mg/kg)	0.3-2.45	1.22	0.88	23.63-162.64	99.71	41.26
Pb (mg/kg)	<0.001-0.68	0.24	0.28	0.34-1.63	1.06	0.41
Zn (mg/kg)	0.05-1.32	0.58	0.46	0.02-0.062	0.04	0.01
Cu (mg/kg)	0.01-0.25	0.08	0.09	8.15-15.30	11.34	2.21
Mn (mg/kg)	0.05-0.5	0.23	0.13	16.73-59.63	34.37	14.98
Cr (mg/kg)	<0.001	<0.001	<0.001	0.01-0.034	0.02	0.01
Ni (mg/kg)	<0.001-0.03	0.02	0.01	<0.01 - 0.64	0.19	0.22
V (mg/kg)	<0.01-0.1	0.04	0.03	<0.01	<0.01	<0.01
Cd (mg/kg)	0.01-0.05	0.02	0.01	0.01-0.021	0.01	0.00
Hg (mg/kg)	<0.001			<0.01		

Sediment Microbiology

The total heterotrophic bacterial count (cfu/g) of the sediment ranged from 3.1 – 7.2 x 10^6 with a mean of 4.3 x 10^6, while the fungal load ranged from 0.5 – 2.9 x 10^6 (cfu/g) with a mean of 1.2 x 10^6 (Table 4.3.7.25). The percentage hydrocarbon utilising bacteria ranged from 1.8 – 6.3% while the values for hydrocarbon utilising fungi were 0.55 – 4.12%, hydrocarbon utilising fungi was recorded only in 3 out of the 12 sample stations. This observation coupled with the low percentage of hydrocarbon degrading bacteria suggests that the sediments have not been contaminated by crude oil.

Table 4.3.7.25: Summary of Microbial Properties of Sediments from the Water Systems

MicrobialProperties	Range	Mean
Total Heterotrophic Bacteria (THB) (X10^6) cfu/g	3.1-7.2	4.3 ± 1.7
Hydrocarbon Utilising Bacteria (HUB) (X 10^5) cfu/g	1.0-2.9	1.7 ± 0.6
Percent HUB	1.80-6.30	3.87 ± 1.36
Total Heterotrophic Fungi (THF) (X10^6) cfu/g	0.5-2.9	1.2 ± 0.7
Hydrocarbon Utilising Fungi (HUF) (X10^5) cfu/g	0.1-1.2	
Percent HUF	0.55-4.12	

Source: Field Survey, November 2005.

Hydrobiology

Phytoplankton

A total of 72 phytoplankton species was observed within the study area. Of these, Bacillariophyceae contributed 58%, followed by Cyanophyceae with 25%, Chlorophyceae (10%) and Euglenophyceae (6%). Dinophyceae had the least contribution of 1% (Fig. 4.3.7.25). The prominent species in the population were *Aulocosiera granulata, Melosira nummulodes, Synedra ulna, Diatoma hiemale, Anacystis aeuroginosa,* and *Phormedium uncinatum.* The species richness in different stations showed values ranging from 24 species to 44 species. The variation in the number of species among the divisions followed the same pattern as in abundance, being highest in Bacillariophyceae and lowest in Dinophyceae. The community structure showed a consistent pattern in all stations with Bacillariophyceae forming between 45–63%. The phytoplankton density ranged from 370 x10^3 l^{-1} to 1012 x10^3 l^{-1}.

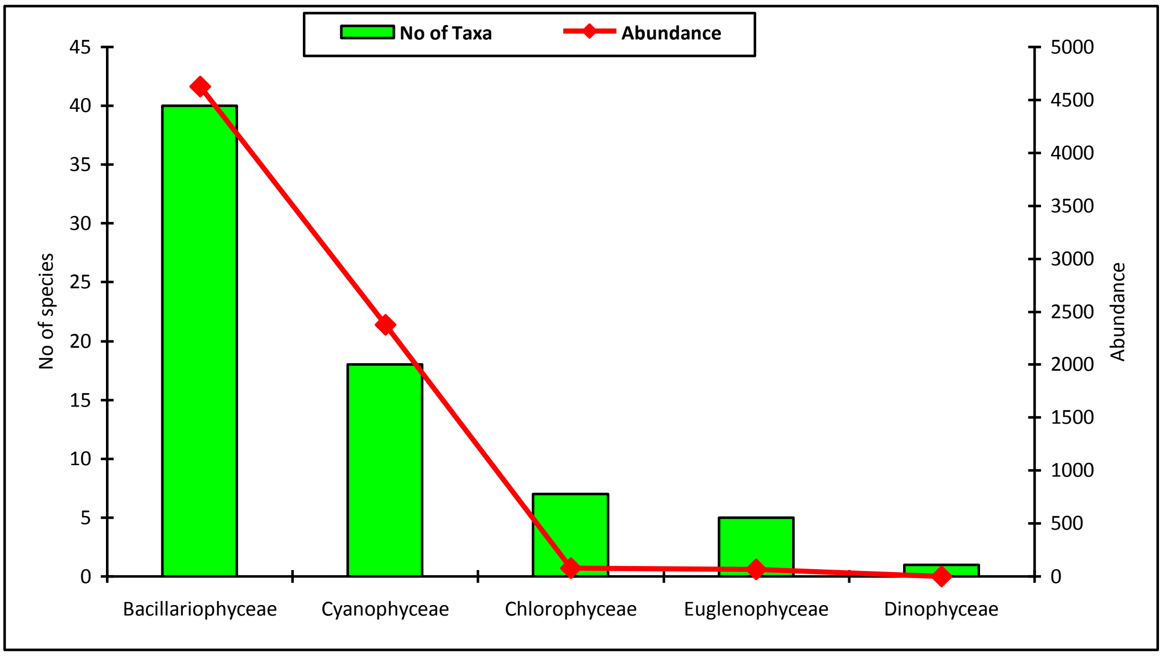


Fig. 4.3.7.25: Abundance and number of species among Phytoplankton divisions

Diversity and Evenness Indices

The diversity indices for phytoplankton in Zone 4 are shown in Figure 4.3.7.26. The dominance index was very low (0.12) and equitability (evenness) moderately high (0.64). The Shannon diversity value (2.74) was high and indicates a stable and undisturbed environment. The higher the evenness, the lower the dominance, and the higher the overall diversity. Margalef's species richness index (d) was also very high (7.89).

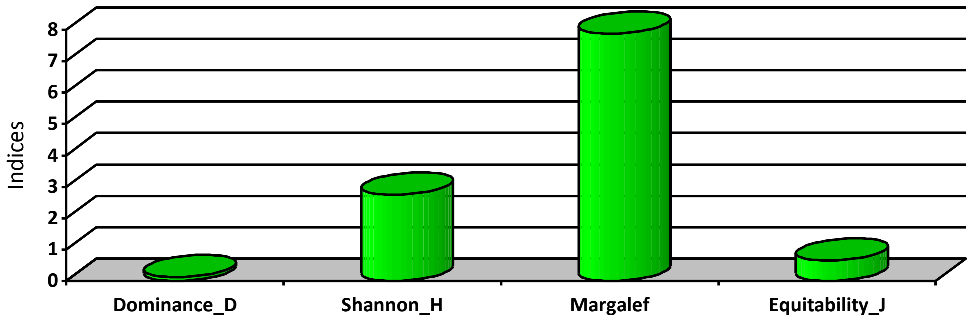


Fig.4.3.7.26: Diversity indices for phytoplankton

Zooplankton

The zooplankton densities found in the project area showed variation between stations with values ranging from 47 x 10^2 l^{-1} individuals to 96 x$10^2 l^{-1}$ (Appendix 4.3.7.14). The zooplankton comprised 64 species with the Rototaria constituting 58% followed by Rhizopoda (14%), Ciliata (11%), Copepoda (9%) and Cladocera (8%) as shown in Figure 4.3.7.27. The commonly occurring species were *B. quadridentatus, Keratella stipidata,* *Polyathra maior, Alona monacantha and* copepod nauplii. The species richness varied from a minimum of 5 species in Cladocera to a maximum of 37 species in Rotatoria (Rotifera). The community structure indicated that a higher proportion of the population were Rotatoria followed by Copepoda and Rhizopoda.

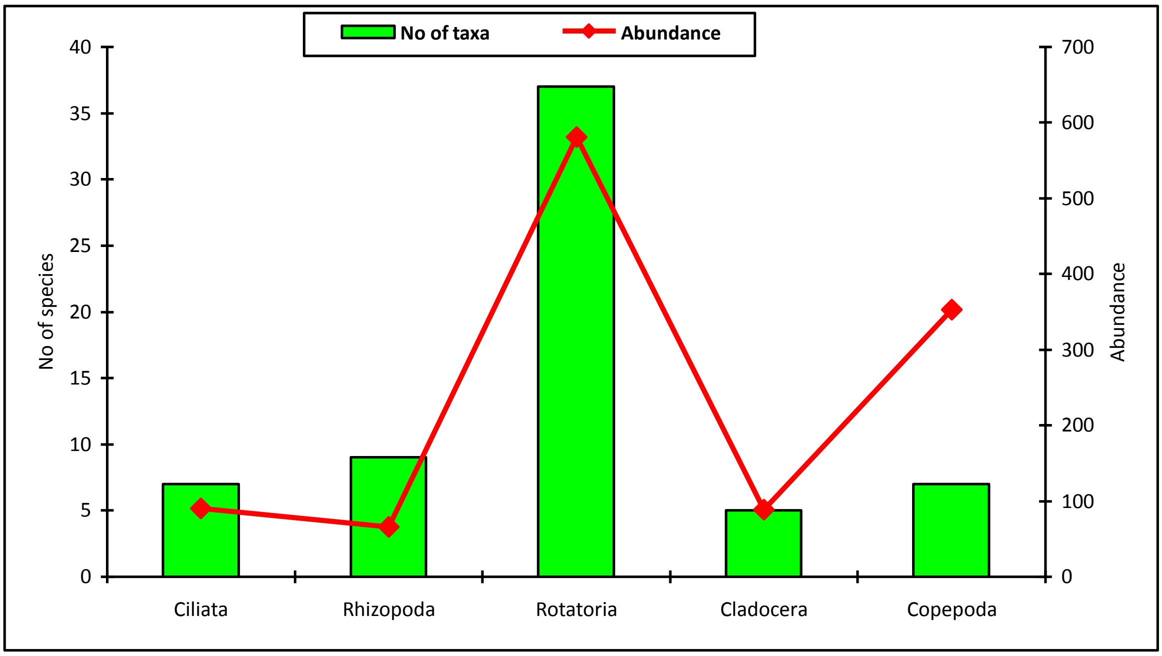


Fig. 4.3.7.27: Abundance and number of species among Zooplankton groups in Zone 4

Diversity and Evenness Indices

The diversity indices for zooplankton in Zone 4 are shown in Figure 4.3.7.28. The dominance index was low (0.068) and equitability (evenness) moderately high (0.857). The Shannon diversity value (3.576) was high and indicates a very diverse assemblage and ecologically stable community. The higher the evenness, the lower the dominance, and the higher the overall diversity. Margalef's species richness index (d) was also very high, indicating a very diverse community in an unperturbed environment.

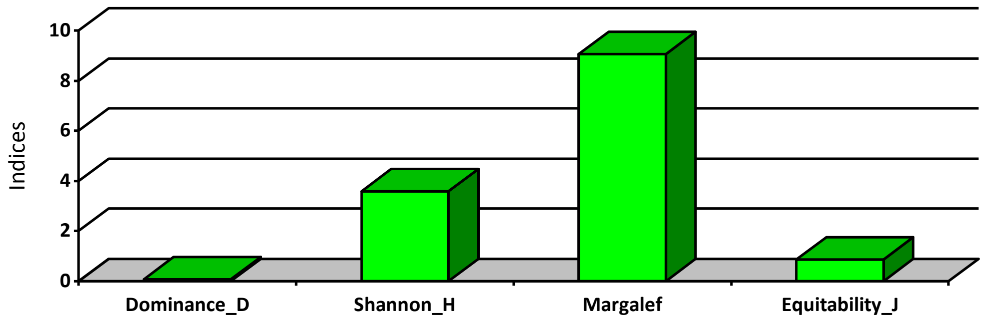


Fig. 4.3.7.28: Diversity indices for Zooplankton

Benthic Macrofauna

A total of 9 macroinvertebrate benthic fauna was observed in the project area (Appendix 4.3.7.15). Oligochaeta, Insecta and gastropod mollluscs were the bgroups contributed almost equal proportions of speciesenthic groups represented in the community. Of these, Oligochaeta were dominant, followed by Insecta (Fig 4.3.7.29). Of the 9 species observed, only three species (*Enchytraeussp* sp., *Lumbricillus* sp, *and Chironomus abblabiesmia*) had wide distribution while the others were relatively limited and occurred in less than 20% of the study stations.

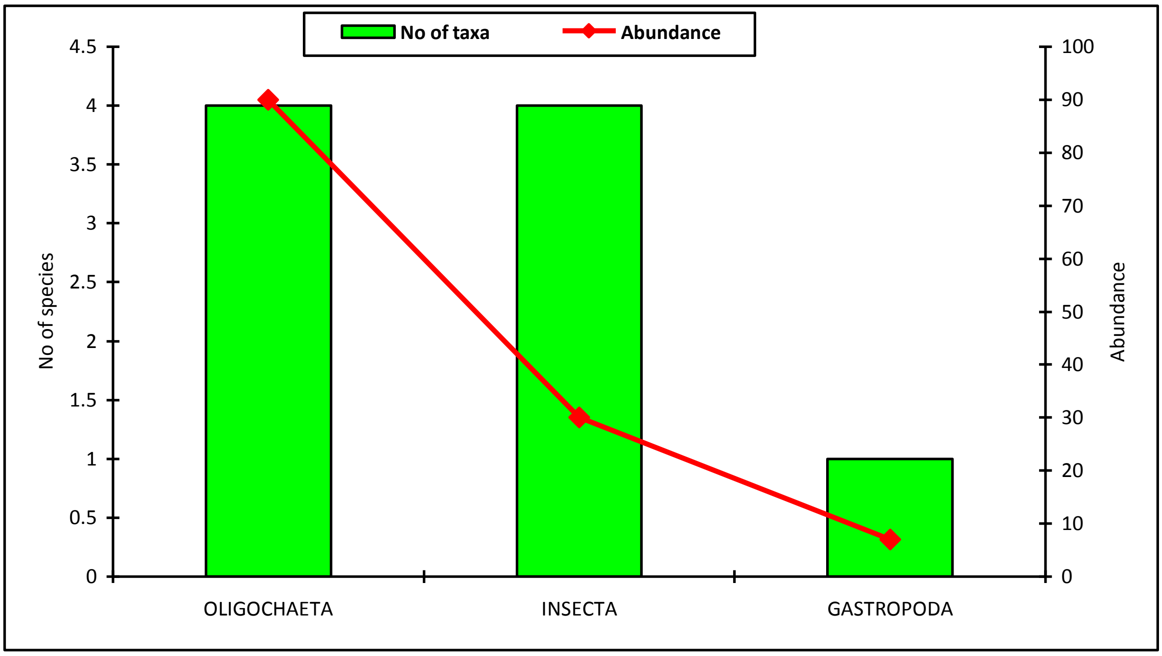


Fig. 4.3.7.29: Abundance and number of species among Benthic groups in Zone 4

Diversity and Evenness Indices

The diversity indices for benthos in Zone 4 are shown in Figure 4.3.7.30. The dominance index was low (0.24) and equitability (evenness) moderately high (0.76). The Shannon diversity value (1.697) was low and indicates a perturbed environment. The higher the evenness, the lower the dominance, and the higher the overall diversity. Margalef's species richness index (d) was also low because of the low number of species and abundance.

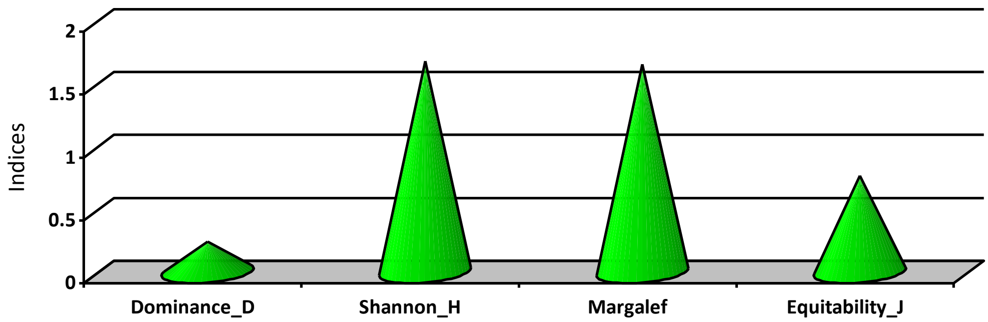


Fig.4.3.7.30. Diversity indices for Benthos

Fish and Fisheries

Fin Fishes and Shell Fishes of the Area

The study area had 35 families of fish made up of 120 species (Table 4.3.7.27). Out of these, 61 species are pure river dwellers at the adult life, 29 dwell in swamps and 30 species inhabit both habitats (Table 4.3.7.28). Most of the purely fresh water river dwelling fishes pass their larval and juvenile stages in the floodplain or backwater swamps and lakes. The adults also carry out lateral migration into the floodplain during the high flood for reproduction or to avoid swift river flow (Otobo, 1996). One bagrid catfish (*Arius gigas)* has disappeared in the project area while two members of the Citharinidae (*Citharinops distichodoide*s and *Citharinus latus*) are very difficult to find. Also *Polyprerus ansorgii* and *P. endlicheri* (Polypteridae) which were once common in the area are now hardly seen in the swamps.

Migrants species from coastal/brackish water such as *Ethmalosa fimbriata* (Clupeidae), *Polynemus quadrifilis* (Polynemidae) and *Liza falcipinus* (Mugilidae) occur occasionally in the area during the dry season. The members of the Eleotridae, Elopidae and Gobidae are also found as occasional inhabitants of the area.

Table 4.3.7.27: Fish families and the Number of Species occurring in the Area

S/N	Fish family	Number of Species
1	Amphilidae	2
2	Anabantidae	1
3	Arridae	1
4	Bagridae	10
5	Centropomidae	1
6	Channidae	2
7	Cichlidae	10
8	Characidae	8
9	Citharinidae	3
10	Clariidae	6
11	Clupeidae	6
12	Cynoglosside	1
13	Cyprinidae	4
14	Cyprinodontidae	6
15	Dasyatidae	1

S/N	Fish family	Number of Species
16	Distichodontidae	8
17	Eleotidae	3
18	Eleopidae	1
19	Gobiidae	1
20	Gymnarchidae	1
21	Hepsetidae	1
22	Malapteruridae	2
23	Mochokidae	9
24	Mormyridae	15
25	Mugilidae	1
26	Nanidae	1
27	Notopteridae	2
28	Osteoglossidae	1
29	Pantodontidae	1
30	Phractolaemidae	1
31	Polynemidae	1
32	Protopteridae	4
33	Protopteridae	1
34	Schilbeidae	3
35	Sciaenidae	1

Source: Field Suvey, November 2005.

Shellfish of the area are the fresh water shrimps including *Macrobrachium macrobrachion* and *M. vollenhovenii* which form important fisheries in the flood channels. *Caridina africana* also occur in the swamps and backwaters in the area. Few numbers of the fresh water turtle (*Pelusis niger*) is found in swamps.

Table 4.3.7.28: Annotated Checklist of Fishes in the Nun River and Taylor Creek around The FIB/Jetty Area

S/No.	Family	Scientific Name	River	Swamp	A I
1	Amphilidae	*Phractura ansorgii (Boulenger, 1901)*	X		R
2	Amphilidae	*Phractura clauseni (Daget & Staucher,1963)*	X		R
3	Anabantidae	*Ctenopoma kingsleyae (Guther,1896)*		X	C
4	Ariidae	*Arius gigas* (Boul.,1911)	X		D
5	Bagridae	*Auchenaglanis bicutatus* (G. St. Hilaire,1809)		X	C
6	Bagridae	*Auchenaglanis occidentalis* (Val., 1840)	X		C
7	Bagridae	*Bagrus bayad* (Forskal,1775)	X		C
8	Bagridae	*Bagrus docmak* (Forskal,1775)	X		C
9	Bagridae	*Chrysichthys auratus*(G. St. Hilaire,1809)	X		C
10	Bagridae	*Chrysichthys nigrodigitatus (Lacepede, 1803)*	X		C
11	Bagridae	*Clarotes laticeps* (Rupell,1829)	X		C
12	Bagridae	*Parauchenoglanis akiri (Risch, 1987)*		X	C
13	Bagridae	*Parauchenoglanis fascitus (Gras, 1960)*		X	C
14	Bagridae	*Parauchenoglanis guttatus (Gras, 1960)*		X	C
15	Centropomidae	*Lates niloticus (Linn., 1758)*	X		C
16	Channidae	*Parachanna africana (Steindachner, 1879)*		X	C
17	Channidae	*Parachanna obscura (Gunther, 1861)*		X	C
18	Characidae	*Alestes baremoze (de Joannis, 1835)*	X		C
19	Characidae	*Brycinus brevis (Boul., 1903)*	X		C
20	Characidae	*Brycinus longipinnis (Gunther, 1864)*	X		C
21	Characidae	*Brycinus macrolepidotus Val., 1849*	X		C
22	Characidae	*Brycinus nurse (Ruppell, 1832)*	X		C
23	Characidae	*Bryconaethiops quinquesquamae (Teugels & Thys v.d.A. 1990)*	X		C
24	Characidae	*Hydrocynus forskalii (Cuvier, 1819)*	X		C
25	Characidae	*Micralestes elongates (Daget, 1957)*	X		C
26	Characidae	*Micralestes occidentalis (Gunther, 1899)*	X		C
27	Characidae	*Rhabdalestes septentrionalis (Boul., 1911)*	X		C
28	Cichlide	*Chromidotilapia guntheri (Sauvage, 1882)*	X	X	C
29	Cichlidae	*Hemichromis bimaculatus (Gill, 1863)*	X	X	C
30	Cichlidae	*Hemichromis fasciatus (Peters, 1858)*	X	X	C
31	Cichlidae	*Oreochromis niloticus (Hasselquist, 1757)*	X	X	C
32	Cichlidae	*Sarotherodon galilaeus (Artedi, 1757)*	X	X	C
33	Cichlidae	*Thysochromis ansorgii (Boul., 1901)*	X	X	C
34	Cichlidae	*Tilapia mariae (Boul., 1899)*	X	X	C
35	Cichlidae	*Tilapia zillii (Gervais, 1848)*	X	X	C

S/No.	Family	Scientific Name	River	Swamp	A I
36	Citharinidae	*Citharinops distichodoides* (Pellegrin 1919)	X	X	R
37	Citharinidae	*Citharinus citharus (*G. Sint-Hilaire, 1809*)*	X	X	C
38	Citharinidae	*Citharinus latus (Muller & Troschel, 1845)*	X	X	R
39	Clariidae	*Clarias anguillaris (Linn., 1758)*		X	C
40	Clariidae	*Clarias buthopogon (Sauvage, 1879)*		X	C
41	Clariidae	*Clarias gariepinus (Burchell, 1822*		X	C
42	Clariidae	*Gymnallabes typus (Gunther, 1867)*		X	R
43	Clariidae	*Heterobranchus bidorsalis (G. Saint-Hilaire, 1809)*		X	C
44	Clariidae	*Heterobranchus longifilis (Val., 1840)*		X	C
45	Clupeidae	*Ethmalosa fimbriata (Bowdich, 1825)*	X		R
46	Clupeide	*Odaxothrissa ansorgei*	X		R
47	Clupeidae	*Odaxothrissa mento (Regan, 1917)*	X		R
48	Clupeidae	*Pellonula leonensis 9Boul., 1916)*	X		C
49	Clupeidae	*Pellonula vorax (Gunther, 1868)*	X		C
50	Clupeidae	*Sierrathrissa leonensis (Thys v.d. Audenaerde, 1969)*	X		C
51	Cynoglossidae	*Cynoglossus senegalensis (Kaup, 1858)*	X		R
52	Cyprinidae	*Barbus callipterus (Boul., 1907*	X		C
53	Cyprinidae	*Labeo parvus (Boul., 1902)*	X		C
54	Cyprinidae	*Labeo senegalensis (Val., 1842)*	X		C
55	Cyprinidae	*Raiamas senegalensis (Steindachner, 1870)*	X		C
56	Cyprinodontidae	*Aphyosemion gardneri (Boul., 1911)*		X	C
57	Cyprinodontidae	*Aplocheilichthys macrophthalmus Meinken, 1932*	X	X	C
58	Cyprinodontidae	*Epiplatys grahami (Boul., 1911)*	X	X	C
59	Cyprinodontidae	*Epiplatys sexfasciatus (Gill, 1863)*	X	X	C
60	Cyprinodontidae	*Foerschichthys flavipinnis (Meinken, 1932)*		X	C
61	Cyprinodontidae	*Procatopus aberrans (Ahl, 1927)*	X		C
62	Dasyatidae	*Dasyatis margaritella (Compagno & Roberts, 1984)*	X		R
63	Distichodontidae	*Distichodus brevipinnis (Gunther, 1864)*	X		C
64	Distichodontidae	*Distichodus engycephalus (Gunther, 1864)*	X		C
65	Distichodontidae	*Distichodus roastratus (Gunther, 1864)*	X		C
66	Distichodontidae	*Ichthyborus monody (Pellegrin, 1926)*	X		R
67	Distichodontidae	*Nannocharax fasciatus Gunther,1867)*	X	X	R
68	Distichodontidae	*Neolebias ansorgii (Boul., 1912)*	X	X	C
69	Distichodontidae	*Neolebias unifasciatus (Steindachner, 1894)*	X	X	C
70	Distichodontidae	*Phago loricatus (Gunther, 1865)*	X		R

S/No.	Family	Scientific Name	River	Swamp	A I
71	Eleotridae	*Eleotris daganensis (Steindachner, 1870)*	X		R
72	Eleotridae	*Eleotris senegalensis (Steindacher, 1870)*	X		R
73	Eleotridae	*Kribia nana (Boul., 1901)*	X		R
74	Eleopidae	*Elops lacerta (Val., 1846)*	X		R
75	Gobiidae	*Porogobius schiegeli (Gunther, 1861)*	X		C
76	Gymnarchidae	*Gymnarchus niloticus (Cuvier, 1829)*	X	X	C
77	Hepsetidae	*Hepsetus odoe 9Bloch, 1794)*	X	X	C
78	Malapteruridae	*Malapterurus electricus (Gmelin, 1789)*	X		C
79	Malapteruridae	*Malapterurus minjiriya Sagua, 1987*		X	C
80	Mochokidae	*Brachysynodontis batensoda 9Ruppell, 1832)*	X		C
81	Mochokidae	*Hemisynodontis membranaceus (G. Saint-Hilaire, 1809)*	X		C
82	Mochokidae	*Synodontis budgetti (Boul., 1911)*	X		C
83	Mochokidae	*Synodontis clarias (Linn., 1758)*	X		C
84	Mochokidae	*Synodontis eupterus (Boul., 1901)*	X		C
85	Mochokidae	*Synodontis nigrita (Val., 1840)*	X		C
86	Mochokidae	*Synodontis ocellifer (Boul., 1900)*	X		C
87	Mochokidae	*Synodontis schall (Bloch & Schneider, 1801)*	X		C
88	Mochokidae	*Synodontis sorex (Gunther, 1864)*	X		C
89	Mormyridae	*Campylomyrus tamandua (Gunther, 1864)*	X		C
90	Mormyridae	*Gnathonemus petersii (Gunther, 1862)*	X	X	C
91	Mormyridae	*Hippopotamyrus pictus (Marcusen, 1864)*		X	C
92	Mormyridae	*Hyperopisus bebe (Lac{p}de, 1803)*	X	X	C
93	Mormyridae	*Marcusenius abadii (Boul., 1901)*	X	X	C
94	Mormyridae	*Marcusenius cyprinoids (Linn., 1758)*	X	X	C
95	Mormyridae	*Mormyrops anguilloides (Linn., 1758)*	X	X	C
96	Mormyridae	*Mormyrus macrophthalmus (Gunther, 1866)*	X	X	C
97	Mormyridae	*Mormyrus rume (Val., 1846)*	X		C
98	Mormyridae	*Petrocephalus bane 9Lac{p}de, 1803*	X	X	C
99	Mormyridae	*Petrocephalus bovei (Val., 1846)*	X	X	C
100	Mormyridae	*Petrocephalus sauvagii (Boul., 1887)*		X	C
101	Mormyridae	*Petrocephalus soundanensis (Bigorne & Paugy, 1990)*		X	C
102	Mormyridae	*Pollimyrus adspersus (Gunther, 1866)*	X	X	C
103	Mormyridae	*Pollimyrus isidori (Val., 1846)*	X	X	C
104	Mugilidae	*Liza falcipinnis (Val., 1836)*	X		R
105	Nandidae	*Polycentropsis abbreviata (Boul., 1901)*		X	C
106	Notopteridae	*Papyrocranus afer (Gunther, 1868)*		X	C

S/No.	Family	Scientific Name	River	Swamp	A I
107	Notopteridae	*Xenomystus nigri (Gunther, 1868)*		X	C
108	Osteoglossidae	*Heterotis niloticus (Cuvier, 1829)*	X	X	C
109	Pantodonitdae	*Pantodon buchholzi (Peters, 1877)*		X	C
110	Phractolaemidae	*Phractolaemus ansorgii (Boul., 1901)*		X	C
111	Polynemidae	*Polynemus quadrifilis (Cuv., 1829)*	X		R
112	Polypteridae	*Erpetoichthys calabaricus (Smith, 1866)*		X	C
112	Polypteridae	*Polypterus ansorgei (Boul., 1910)*		X	C
114	Polypteridae	*Polypterus bichir (Geoffroy Saint-Hilaire, 1802)*		X	R
115	Polypteridae	*Polypterus senegalus (Cuvier, 1829)*		X	R
116	Protopteridae	*Protopterus annectens (Owen, 1839)*		X	C
117	Schilbeidae	*Parailia (Physailia) pellucida (boul., 1901)*	X		C
118	Schilbeidae	*Pareutropius buffei (Gras, 1960)*	X		R
119	Schilbeidae	*Schilbe (Eutropius) brevianalis (Pell., 1929)*	X		C
120	Sciaenidae	*Pseudotolithus elongatus (Bowdich,1825)*	X		R

Source: Field Survey, November 2005.

Key to Letters:

AI = Abundance Index: X = Occurrence: C = Common: R = Rare: D = Disappeared

Fishing Gears and Methods

Fishing gears of the area were many and varied as shown by previous surveys (Otobo, 1995) and similar to those recorded for Nigeria by Udolisa (1994). The fishing gears found during the survey were relatively less varied and fewer in number when compared with previous records. This was due to the short period of sampling in which several gears used in the floodplain had been withdrawn owing to the recession of the flood. The gear commonly used in the area include gillnets, tow nets, cast nets, beach seines, lift nets, traps, hooks and lines, fences and stakes as well as wounding implements. Bailing of ponds to collect stranded fish in swamps is an age-old traditional fishing.

Gill Nets:

Gill nets were of different designs and sizes ranging from large nets of more than 100m rigged with lead and floats and operated floating or set stationery in the main channels of the Nun River and Taylor Creek to small pieces of netting wall tied to sticks and stretched out along river banks, backwaters and floodplain lakes. The design and mesh sizes differ according to fishing area and target fish and may changed with seasons.

Gill nets were used in capturing a wide variety of fish species. Some were designed for special fisheries. Typical of these were those targeting small sized pelagic fishes such as fresh water clupeid, *Pellonula* Spp. and glass fish, *Parailia pellucida* which are mainly exploited by women.

Tow Nets:

Tow nets of various dimensions were operated in the main channels of both the Nun River and Taylor Creek. They are tapering bags with wings, body and cod end similar to trawl nets and were towed by two canoes to keep the mouth open in the course of operation. Constructed from small meshed netting materials, they are efficient in capturing both bottom and shoaling fishes.

Cast Nets:

Cast nets are cone-shaped devices constructed from netting materials with a lead line at the bottom and attached to a rope at the distal head. They are operated from canoes or on the ground along the shore line. The operation of cast nets requires skillful throwing to obtain maximum spread to enclose fish in the vicinity of throw. Cast nets were exclusively operated by men owing to the skill and strength needed in operating them. The gear is not selective of fish types but the size of fish caught may depend on the mesh size of the netting material.

Beach Seines

Seine nets generally are designed to surround fish and gather them in the cause of dragging or towing to a central area for collection. In the study area, beach seines were operated in the low water period (dry season). In the Nun River section, beach seines were dragged from shallow waters to the shores of the sand bank. The catch is non-selective of fish type and size as the mesh sizes are small. Most beach seines in the area are walls of netting material rigged with floats at the head rope and lead at the foot rope. The ends are attached to sticks and tied with strong ropes that provide aid in dragging the net.

Lift Nets

Lift nets are devices set fixed or allowed to drift through the water column and designed to lift fish out of water when required. The size of fish taken by lift nets is only limited by the size and strength of the gear. One frequently used gear in the study area is ‘atala’ lift net, a rectangular piece of netting framed by bamboo poles. It was operated from a canoe either in a stationary position or drifting along the river and periodically raised to collect fishes contained in it. Recently, the use of mosquito-proof netting materials has enabled this gear to capture the smallest known clupeid fish, *Sierrathrissa leonensis* which were abundant from April through June around Polaku, a confluence town of the Nun River and Taylor Creek. The importance of this modification is that this fish cannot be taken by other commercial fishing gear owing to its small size. Its capture through this gear makes available a cheap protein source which otherwise will be unavailable.

Traps

Traps are reputed to be the most sophisticated of all fishing gear (Reed, *et al*, 1967). In the project area several kinds of traps were used in fishing, ranging from small purse-like devices for juveniles to large structures that are several metres long and broad capable of taking aquatic mammals and reptiles. Some traps have non-returnable valves to retain fish while some retain fish by water pressure or when they are stock to the extreme narrow end of a seeming alley. Traps that operate by trigger mechanism which closes the mouth to prevent escape were also common. Some of the traps were used together with fish fences where creek channels were blocked and the traps strategically placed to collect fishes. This is especially in the swamps during the recession of the flood to capture fish returning to the main river channels.

Traps were made from forest materials, but few introductions and innovations have brought about the use of synthetic netting materials. For instance the *gura* trap which is prepared from nylon netting material was introduced by Hausa fishermen. Traps were operated by both males and females as well as by all age groups depending on type and size of trap. They contributed substantially to the fish catch of the area in the flood period. Various forms of basket traps are common in the area (Plate 4.3.7.9).

Plate 4.3.7.9: Crayfish Traps used in the Flood Plains

Hooks and Lines

Hooks and lines used in the area varied from the pole and line with a single hook to long lines carrying many hooks and of different sizes and designs. Hooks were usually baited with assorted baits depended on target fish species and may be set stationary or allowed to drift along the river. An introduced long line (*meri meri*) constructed with close-set hooks was set without baits, fishes swimming close to these hooks were hooked on any part of the body. One peculiar type is the trigger hook which operates by a mechanism that lifts fish out of the water after it had been caught and it hangs on a line attached to aflexible stake. Hooks were operated by all gender and age groups.

Wounding gear

Almost every kind of sharp implement served as a wounding gear. Spears, machetes, and sticks were used in killing fish at different places. Children waded in shallow waters and walked along shorelines searching edges and holes for fish while using the above gears. In silted swamp lakes, women used machetes to cut out dense vegetation to collect fish from the mud. Spears were used in assisting hooks to impale struggling fish.

Pond Bailing

Local fish ponds constructed in swamps and by the sides of swamp lakes were sources of fish supply to all communities in the study area. Pond bailing was done during the dry season when pond margins were clearly exposed and ground water was low enough to prevent excessive seepage into the ponds. The water remaining in the pond was bailed out with buckets and all fish contained in it collected. Thereafter, the pond was dressed and left to be filled with the next flood water. Several ponds existed in the study area.

Swamp Lake Fishinng

The swamps comprising backwaters and lakes are important sources of fish production in the study area. Some of such lakes included Opurusabagha, Osoko-adi, Bipremo, You-uwou ororo, Egeregere-Ogugu, Egwebara, Poi, Akarerei, Kalauba, Abadunou, etc. These lakes serve as reservoirs for fishes during the flood season and together with the seasonal channels are important to the freshwater shrimp fisheries of the area during the flood period.

These lakes are fished by women at the recession of the flood using assorted fishing gear such as clap nets, scope nets, basket traps, etc.

Swamps and the lakes are reputed to be more productive than the main river channel with high biological diversity (Scott.1966; Alfred-Ockiya and Otobo, 1990). Some of such swamps and lakes were already impacted by dredging and road construction works and being buried or the channels closed up.

Fish Handling

Fish handling involves processing, preservation and marketing, and in the Nun River and Taylor Creek constitutes a part time activity. The fishermen and members of their family may be engaged in fish handling.

Fishes were processed for preservation by gutting or merely washed in water for drying. Large size fishes were gutted, washed and may be preserved whole or cut into two or more pieces. Small fishes such as the *Pellonula leonensis* and *Parailia pellucida* and most juvenile fishes were washed and preserved without gutting.

Smoke-drying over fire was the most common form of fish preservation. Fishes to be dried were spread out on raised platforms or altars and energy for drying was from wood which was abundant in the area.

Large quantities of fish were sold fresh in the river or at the landing site to fish mongers, who subsequently sold to consumers in and around the fishing settlements and to markets outside the area. Fresh, dried and live fish kept in tins and plastic containers were transported to more distant markets in Yenagoa, Mbiama, Ahoada and Port Harcourt. Dried fish were packaged in bags, baskets or carried in basins for marketing.

4.3.8 Socio economics (SIA)

The map of the project area shows that the project will traverse 6 Local Government Areas - 4 in Bayelsa State and 2 in Rivers State with a total of 68 communities. These comprise 50 communities in Bayelsa and 18 communities in Rivers State. This socio-economic report is based on a review of previous reports. The following are covered in this report: History and power structure and governance, population characteristics, household characteristics, social infrastructure, economic infrastructure, local economy and livelihoods, lifestyle and culture as well as community perception, concerns and expectations.

4.3.8.1 History of the People and Power Structure

Various reports (SPDC, 2013; 2015) indicate that the Koroama, Obunagha, Ogbolama, Okolobiri and Polaku constitute the Gbarain Clan in the Yenagoa Local Government Area of Bayelsa State.The individual founders of each of these communities were all descendants of Gbarainowei (The founder of Gbarain Clan/kingdom). The language group here is Izon as they are indigenous Ijaw (Izon) ethnic group.

Obunagha was founded by Ogoro, one of the sons of Gbaran-owei years ago along with Okolobiri and Ben-Obunagha. A number of social organizations exist in the community and these include: Youbarapa Ogbo 60:60 club of Obunagha and Obunagha Youth Association. Koroama is made up of five main compounds namely Igbainwari, Sumabiri, Okumbiri, Biemwari and Waripele; this Ijaw community belongs to Isoko tribe. Polaku was founded years ago by Ebuyai-owei who migrated from Okotiama. He gave birth to Ijewaribo and Iyewaribo, which has developed to present day Polaku Community. The community is made of five quarters/compounds which include: Ijewaribo, Iyewaribo, Nebiegberegba, Opokuma-owei, and Yoropele. The community accommodates strangers. Dodena and Ogbo are social organizations existing in the community.

Otuasega Community: Otuasega was founded by ASEGA, descendant of Olei, in Ogbia LGA. Olei first settled at Emeyal and later moved to Otuasega. As a result, the people of Otuasega and Emeyal have always identified themselves as people of one stock.The community is made up of ten compounds and these are: Ebarama West, Ebarama East, Adodu, Adema, Otu-Fiebiri, Otu-Efrguruga, Ahololo and Amuso.

Opolo Epie Community: Opolo-Epie is one of the Communities in Epie clan of Yenagoa LGA. This community was said to have migrated from Benin kingdom. Altogether, there are five compounds in the community. The compounds are: Yeni Shiadu, Yeni Odufa, Yeni Kenegbi, Yeni Oziki and Yeni Fanbule.

Agudama-Epie Community: Agudama-Epie community is also one of the descendants of Epie who migrated from ancient Benin Empire. This community was founded by Aguda some years ago. The community has a total of three compounds namely: Ogbobiri, Biogbolo and Agbosi. Agudama-Epie is situated in the heart of the Yenagoa capital city development territory with a high proportion of visitors/strangers compared to natives.

Gbarantoru Community: The community is situated in Gbaran Ekpetiama Clan of Yenagoa LGA. It is made up of two main compounds: Ogbabiri and Ayaibiri with Ayakumama and Kanofa Layouts. Various social organizations exist in the community and these include Ibolou Amatam Ogbo, Gbarantoru Ladies club, Komunomo Ogbo and Gbarantoru Coopprative Farmers Club. The community is of Ijaw extraction. It is a community that accommodates strangers and natives. Natives are more in number compared to strangers living in the community.

Tombia Community: This community is of Gbaran Ekpetiama clan in Yenagoa LGA. The community is made up of three quarters/compounds namely: Friebawari, Ingbelebiri and Adimo. Tombia-owei was the founder. Dorotari Ogbo, Kenumoke biogbo and Tombia Youth movement are some of the social organizations in the community. The community also accommodates strangers.

Ahoada West Communities: These are descendants of Akoh, the second son of Ekpeye. Akoh a brave hunter, a trader, a farmer, and a great medicine man lived at Ula-Ehuda. He named his son after the Ula-Ehuda (Ahoada). He founded the waterside at the bank of Sombriero River which was developed as a fort against invasion. The position of the place attracted trade with the new Calabar. That became the seat of the colonial Government after the Ekpeye/British war of 1900.

Traditional Line of Authority and Governance:

The traditional line of authority of communities in Yenagoa, Kolokuma/Opokuma, and Ogbia axis (Bayelsa State) of project area begins with Clan Council of Chiefs headed by a Clan Head. At the community level, there is a paramount ruler at the apex, who presides over the affairs of a community, called an Amananaowei in Izon and Ebeniken in Epie. The Amananaowei is elected by the community and seats in council with these other chiefs (compound chiefs, and councilors) to take decision on matters concerning the community. Below the Paramount Ruler and his Council of Chiefs are the elders, Community Development Committee (CDC), youth leaders and women leaders. The CDC is open to all adult male in the community; they are very vital in maintaining intra-communal law and order. They can discipline erring community members and enforce order passed by themselves or those from the Chiefs' Council. Elders used to be very prominent in the affairs of the community, but grea ter access to education, political power, wealth and agitation for better living conditions in the Niger Delta has made the youths very vocal. Women also play a role in maintaining family cohesion and social stability. The outline of the traditional governance structure in the Yenagoa, Kolokuma/Opokuma, and Ogbia axis (Bayelsa State) of project area is illustrated in Figure 4.3.8.1while that of the Ahoada West and Abua/Odua arm (Rivers State) is shown as Fig. 4.3.8.2.

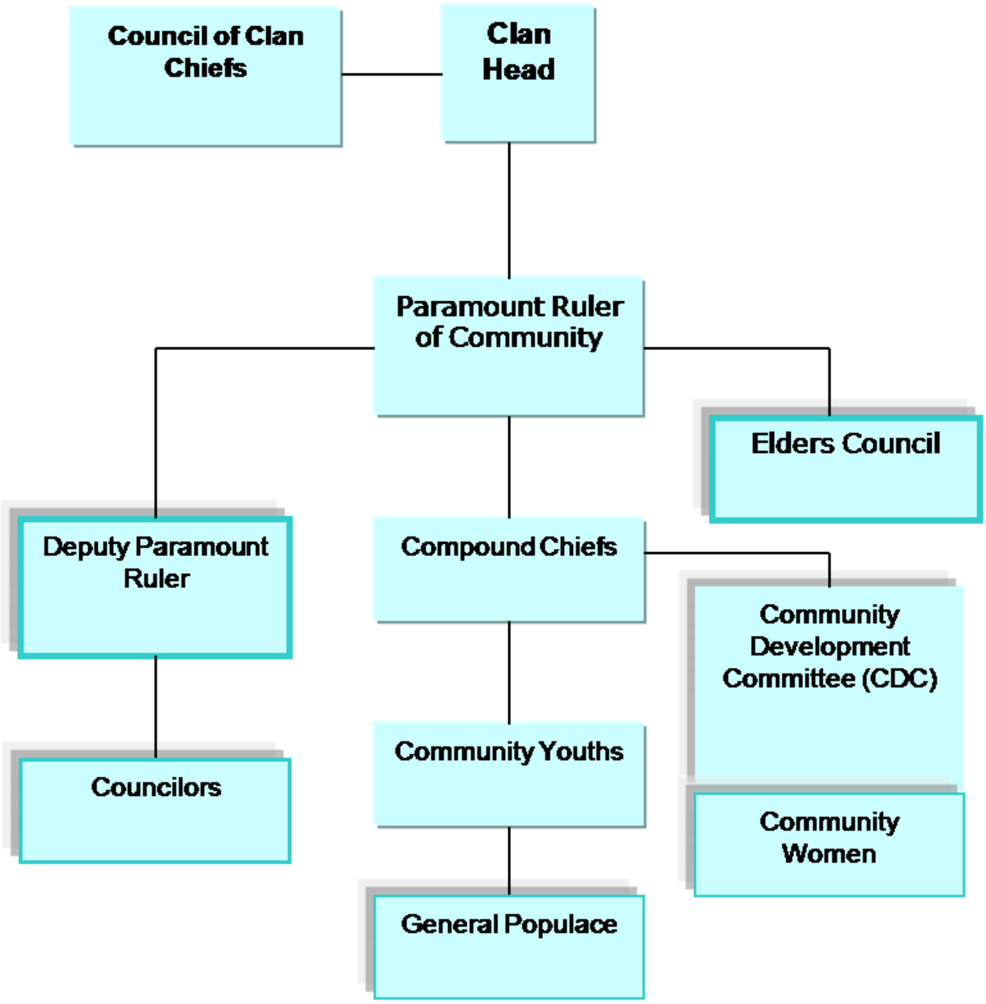


Fig. 4.3.8.1: Hierarchy of Authority in Project Communities of Bayelsa-Based LGAs.
Source: SPDC (2008).

Among the Ahoada and Abua/Odua communities, the paramount ruler known as Eze or Ochioha is at the head of Council of Chiefs in taking community decisions. The Ezes or Ochiohas are assisted in their task of community governance by a Council of Chiefs and Elders. The Council of Chiefs (village council) is in a good position of traditional governance in the communities working in collaboration with the Community Development Council (CDC) in playing key roles. Next on the line of power is the CDC. This body helps to articulate and implement community development needs of the locality. The CDC is headed by a chairman and also has a secretary. The Youths come next in the chain alongside the women and groups in governance. They are responsible for keeping the community clean (General Sanitation), and participate in community development programmes. The youths mobilize members for vigilante activities or peace-keeping, and are the law enforcement agents in most of the communities.

The hierarchy of Authority in Rivers and Bayelsa State-based line of authorities are similar in the sense that they discharge their powers to members of the society through the same set (type) of stakeholders. However, they differ in the sense that the Bayelsa State-Based line of authority has in-built Advisory Elders' Council which is missing in Rivers state-based line of authority. This should be noted and accorded the necessary treatment to avoid them becoming a clog in the wheel of implementation of this project.

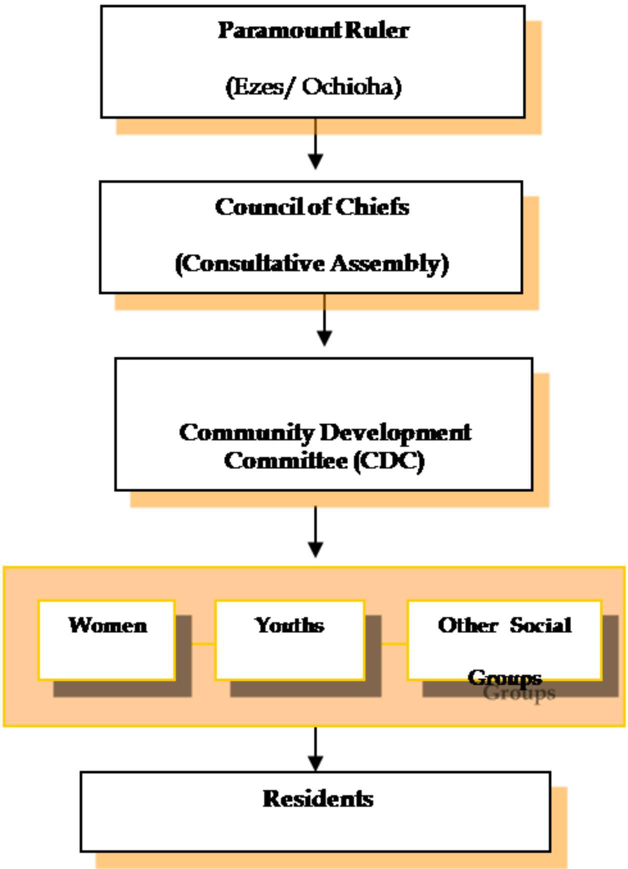


Fig. 4.3.8.2: Hierarchy of Influence/Line of Authority in Ahoada and Abua/Odua Communities of River State
Source: SPDC (2014).

4.3.8.2 Population Characteristics

Project Communities

As earlier stated, this Seismic study will be carried out in an area that spans across communities of Bayelsa and Rivers States. In Bayelsa State, four (4) Local Government Areas (LGAs), namely: Sagbama, Kolokuma/Opokuma, Yenagoa, and Ogbia. In Rivers State, two LGAs, namely: Abua/Odua, and Ahoada West. A total of 50 communities in Bayelsa State and 18 communities in Rivers State will be traversed in the course of this project (Table 4.3.8.1).

Table 4.3.8.1: Project Communities

	Bayelsa State				Rivers State	
S/N	**Sagbama**	**Kolokuma/Opokuma**	**Yenagoa**	**Ogbia**	**Abua/Odua**	**Ahoada West**
1.	Sagbama	Egbedi	Ikarama	Otuasega	Odau	Ususu
2.	Ogoloma	Seibokorogha	Zarama	Ibelebiri	Odua	Chebele
3.		Asaingbere	Agbobiri	Oruma		Akala-Olu
4.		Gbaranma	Anyambele			Oshi
5.		Okoloba	Akumoni			Akinima
6.		Sampou	Igbogene			Oruama
7.		Igbaniwari	Epie			Mbiama
8.		Aya Ama	Nyenegwe			Agbo
9.		Kaiama	Okutukutu			Odiopitis
10.		Ibie	Elemini			Odieke
11.		Orubiri	Edepie			Otegwe
12.		Kalama	Akenfa Epie			Okarki
13.			Ovelemini			Orashi
14.			Agudama Epie			Kunusha
15.			Etegwe			Manuso
16.			Opolo Epie			Igovia
17.			Kpansia			
18.			Yenizia Epie			
19.			Yeneka			
20.			Ovom			
21.			Opuama			
22.			Ikolo			
23.			Akaba			
24.			Fangbe			
25.			Akaibiri			
26.			Bumoundigbene			
27.			Bumodi			
28.			Gbarantoru			
29.			Tombia			
30.			Agudama			
31.			Polaku			
32.			Okotiama			
33.			Okolobiri			
34.			Korama			
35.			Obunagha			

Macro-Population Structure

The macro environment consists of the Local Government Areas hosting the project. These cover a geographic area of about 3,225.01 square kilometers. The 2006 population census gave the population of inhabitants as 1,329,668 persons as shown in **Table 4.3.8.2.**

Table 4.3.8.2.Population of Project Area

State	Local Government Area	2006 Population	2015 Projection
Rivers	Abua/Adual	282,410	284,522
	Ahoada West	249,232	251,344
Bayelsa	Kolokuma/Opukuma	79,266	81,378
	Ogbia	179,606	181,718
	Sagbama	186,869	188,981
	Yenagoa	352,285	354,397
	Total	**1,329,668**	**1,342,340**

$P_n = P_0 (1 + r)^n$ where n=9; r= 3.0%; P_0=base year (2006).

Source: NPC, 2007

Table 4.3.8.2 reveals that the present population of all the LGAs to be impacted by the project is 1,342,340 persons. This reveals that the population density of the area has merely grown from about 412 persons per kilometer in 2006 to about 416 persons per kilometer in 2015.

Micro-Population Structure

The projected population of the communities using exponential growth rate model and an annual growth rate of 3.0% is given for the period 1991 – 2015 in **Table 4.3.8.3a and Table 4.3.8.3b in** Bayelsa and Rivers States respectively.

Table 4.3.8.3a: Population of some of the communities impacted by the project

	1991			1996	2006*	2015*
Community	**Male**	**Female**	**Total**			
Otuasega	3,349	2,977	6,326	7,487	10,061	12,173
Opolo-Epie	1,947	1,784	3,731	4,413	5,930	8,042
Agudama-Epie	1,593	1,409	3,002	3,553	4,774	6,886
Gbarantoru	402	428	830	982	1,319	3,431
Tombia/Ekpetiama	1,883	1,883	3,766	4,457	5,989	8,101
Obunagha	1,381	1,279	2,660	3,169	4,258	6,370
Koroama	2,527	2,227	4,754	5,626	7,560	9,672
Polaku	1,044	913	1,957	2,316	3,112	5,224
Etegwe	300	224	524	620	803	2,915
Okutukutu	968	702	1,670	1,976	2,538	4,650
Yenezue-Epie	--	--	1,075	1,275	1,695	3,807
Edepie	--	--	1,222	1,446	1,924	4,036
Okolobiri	--	--	6,058	7,169	9770	11,882
Ogboloma	--	--	2,288	2,708	3,619	5,731
Okotiama	--	--	590	698	980	1,210
Total	**15,394**	**13,826**	**40,447**	**45,892**	**64,429**	**94,130**

Source: NPC, 1991. * =Projected **with the exponential growth model; base year is 1991.**

Table 4.3.8.3b: Projected Populations for the Study Locations using the Exponential Growth Model at Assumed Average Annual Growth Rates of 2.83% and 3.0%

Settlements	1991 Population	2008 Projected Populations	
		2.83%	**3%**
Ekpeye			
Ebiriba II	739	1196	1231
Ebiriba I	813	1315	1354
Enito II	444	718	739
Akalamini	430	696	716
Ombor	706	1142	1176
Enito I	-		847
Ula-Ubie	861	1393	1434
Idu-Ekpeye	2912	4711	4849
Total	6905	11171	12346
Agbobiri			
Agbobiri	2266	3666	3774
Total	**2266**	**3666**	**3774**
Zarama			
Epie Zarama	2483	4017	4135
Total	**2483**	**4017**	**4135**
Engenni			
Oshie-Egenni	302	489	503
Edagberi	2129	3444	3545
Total	**2431**	**3933**	**4048**

The combined projected population of gender in some of the communities for the period 1996, 2006 and 2015 are 45,892; 64,429 and 94,130 respectively showing increase of 13.5%, 59.3% and 132.7% for the year 1996, 2006 and 2011 respectively. It can be concluded that the population of the project area is a young and growing one.

Household Population Structure

Findings in many SPDC recently conducted studies report household characteristics that will help inform policies. The reports include: (SPDC 2007, 2008, 2009, 2010, 2012, and 2015).

Age

These studies all agreed that in terms of age, the population is a young one characterized with dominance of working population aged 18-60 years.This is followed in size by children aged 0-5 and 6-17 years; and declining aged population above 60 years. For instance, SPDC (2009) estimated the elderly to constitute 11.4%, children 38,0%, and work age 59.0%. SPDC (2010) observed that household population of less than 14 years of age averaged 40.0%, and members aged at least 65 years averaged 2.7%. SPDC (2012) estimated that the population of the work age members of the households constituted 62.0%, that of the children constituted 33.1% and that of the elderly members constituted 4.9% (**Table 4.3.8.4)**.This trend of age of household members had implications on the expectations of the people in terms of job provision and types of goods and services required. Issues of providing jobs for the unemployed to help provide food, clothing and education for the large number of children of school age featured prominently.

Table 4.3.8.4: Distribution of Households by Age Cohorts in Studies

Age (Years)	GBU 1 (2009)	Kolo Creek (2012)
Elderly (> 60).	11.4%	4.9%
Work Age (25-60)	59.0%	62.0%
Children (< 25)	38.0%	33.1%

GBU 1=Gbaran Ubie Phase 2 IOGP (EIA Cluster 1) report (2009).

Age-Sex Structure

The age sex structure from these studies helped to confirm the growing nature of the household population in the area. For instance, the SPDC (2010) shown as Figures 4.3.8.3 and 4.3.8.4 revealed that household population in the lower age-sex cohort were in the dominance with the males slightly being greater than the females in Agbobiri and Zarama communities. The figures further revealed that as the age cohorts increased, there were progressively more females than males in Agbobiri community (Fig. 4.3.8.3), while the story was slightly different in Zarama community (Fig. 4.3.8.4) whereas the age cohort increased there was slightly more males than the females. Male dominance in rural households suggests availability of employment (practice of traditional occupations) in such communities, while female dominance suggests out-migration of the male folk to urban centers in search of jobs.

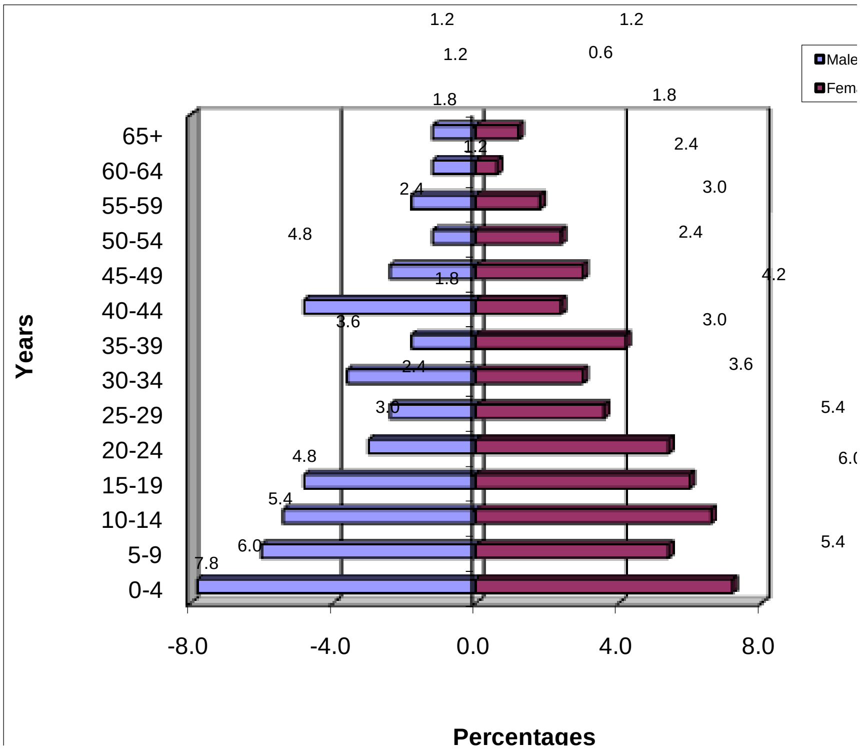


Figure 4.3.8.3: Age-Sex Distribution in Agbobiri Community

Source: SPDC (2010)

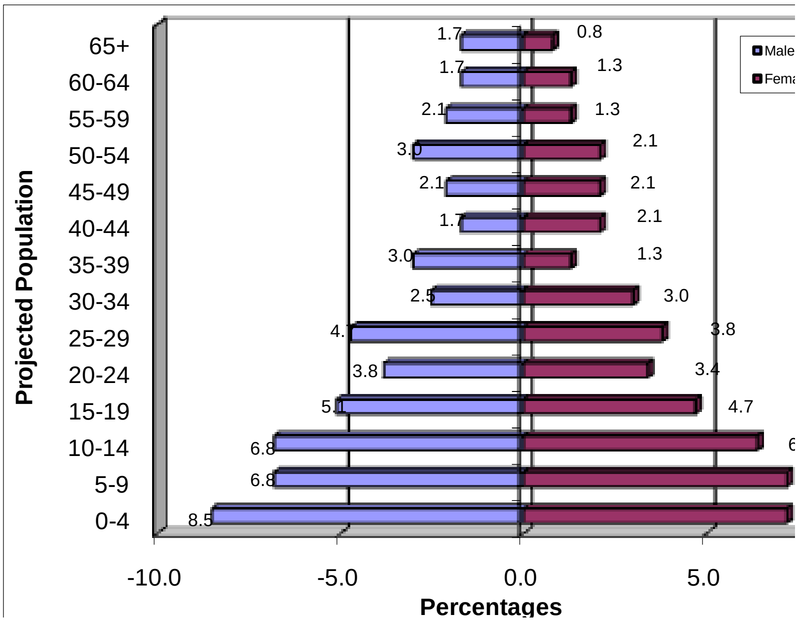


Fig. 4.3.8.4: Age-Sex Distrbution in Zarama Community
Source: SPDC (2010)

Marital Status: The proportion of married household respondents was overwhelmingly higher than singles in all the study communities.This distribution shows that marriage is an important social institution in the area cherished and respected by many, and a relatively stable institution in the communities. Different studies gave different proportions of married persons to the singles. For instance, the PIA report of Etegwe and Tombia (2008) estimated that between 79% and 88% of the members of the households were married, and between 13% and 18% of members of the households were single while what remained of these were widowed or divorced. The Gbaran Ubie Phase 2 IOGP (EIA Cluster 1) report (2009) observed that 59.8% of the household members were married, 16.7% of them were singles, 13.6% of the members were either divorced or separated with 9.8% of them widowed or were widowers. Most recently, the EE based EIA of Gbaran Ubie Node Integrated Oil and Gas Project (2013) estimated that married members of the household were 68.0%, singles were 27.0%, while those divorced/separated constituted 8.0% and 10.0% were widows/widowers **(see Table 4.3.8.5)**.

In the EIA of Gbaran Ubie Phase 2 IOGP (EIA Cluster 2 Epu-Field) (2015) revealed that 68.4% of members of households were married, 29.1% were single, and the rest were either widowed or separated (**Fig. 4.3.8.5**). Although none of the respondents indicated divorce, it is unlikely to be the case in the population. The graph reveals that divorce and separation are not very common issues in the entire Project area (spanning across communities in Rivers and Bayelsa State (See Table 4.3.8.1)).

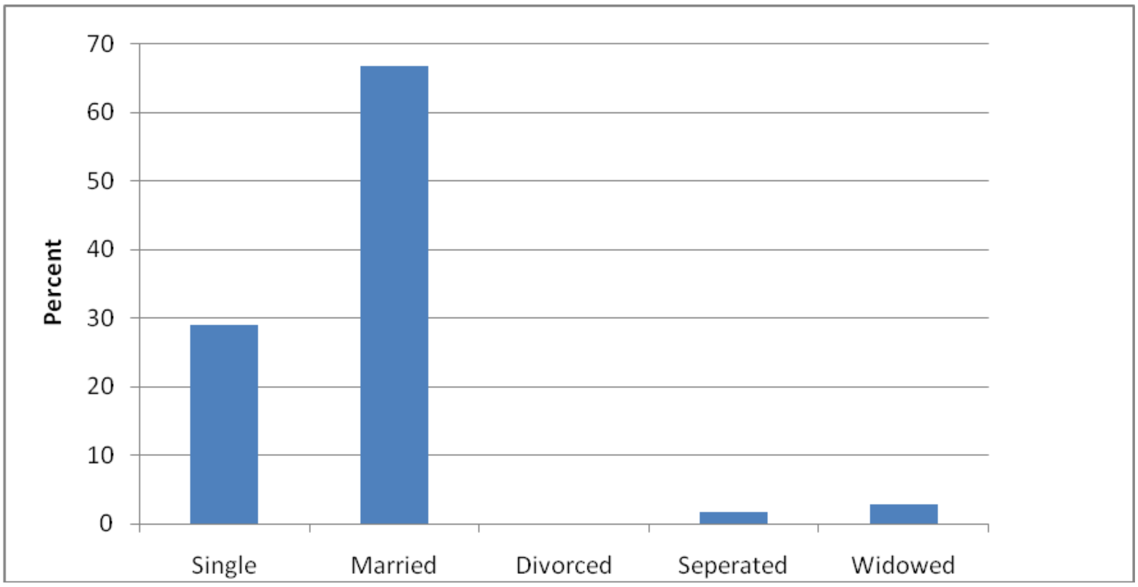


Fig. 4.3.8.5: Marital Status Amongst Members of Households
Source: SPDC (2015)

Table 4.3.8.5: Summary of Distribution of Marital Status in Households

Marital Status	**GB E2, E4 (2007)**	**Etewe/Tombia (2008)**	**GBU 1 (2009)**
Married	68.0%	79 – 88%	59.8%
Single	27.0%	13 – 18%	16.7%
Divorced/Separated	8.0%	--	13.6%
Widows	10.0%	--	9.8%

SPDC (2007, 2009)

Household Size: The size of the household seen as the number of persons in a household who eat and feed from the same pot but who may not necessarily be living under the same roof was extensively examined by these studies. The estimated household size varied from 5 to 11 persons. The PIA report of Etegwe and Tombia (2008) and EIA of Kolo Creek NAG Manifold to Soku Gas Pipeline report (2012) estimated mean household sizes of 5 persons. The Environmental Evaluation based EIA of Gbaran Ubie Node Integrated Oil and Gas Project (2013) and the EIA of Gbaran Ubie Phase 2 IOGP (EIA Cluster 1) report (2009) estimated the mean household size at 8 persons.In the same approach, the EIA of Gbaran Ubie Phase 2 IOGP (EIA Cluster 2 Epu-Field) (2015) (Fig. 4.3.8.6) estimated a mean household size of 7 persons.These estimated sizes of households could be judged to be moderate since the population regulation efforts in Nigeria is striving to achieve a four persons' household size structure and higher than the national average of five persons (5 persons). Moderate household sizes may be good to provide the needed household labour for traditional occupations of farming and fishing in these communities.

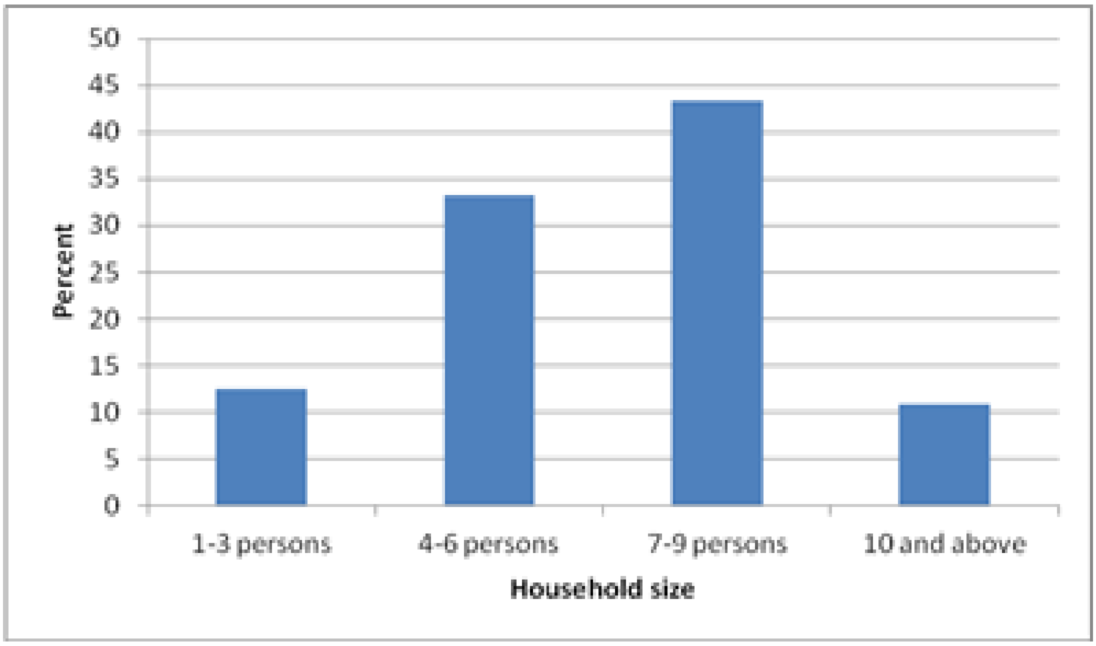


Fig. 4.3.8.6: Household Size Distribution of Project Communities
Source: SPDC (2015)

Dependency Ratio: This is a measure of the ratio of the economically dependent part of the population to the productive part; arbitrarily defined as the ratio of the elderly (ages 65 and older) plus the young (under age 15) to the population of the 'working ages'(ages 15-64) (Haupt and Kane, 2004). In Nigeria, the EIA report of Gbaran Ubie Phase 2 IOGP (EIA Cluster 1) report (2009) adapted it to reflect the real situation of Nigeria and stated the Dependency ratio as follows:

$$\frac{\text{Number of persons under 25 or over 60}}{\text{Numbers of person between 26 60 years old}} \text{ X } \frac{100}{1}$$

The EIA of Kolo Creek NAG Manifold to Soku Gas Pipeline report (2012) estimated the dependency ratio in Kolo Creek /Soku project communities as 83.5%. Similarly, the EIA report of Gbaran Ubie Phase 2 IOGP (EIA Cluster 1) (2008) estimated the dependency ratios of 106.2, 122.6 and 115.1 for Agbobiri, Zarama, and Ahoada communities respectively.This means that in a household of ten persons, at least eight persons depend on a bread winner for their livelihood. The data were obtained from communities in Bayelsa state as highlighted in Table 4.3.8.1.

4.3.8.3 Infrastructure/Facilities:

Education Facilities: All the communities to be impacted by this Seismic activity have at least one primary school. For instance, Opolo-Epie, Okutukutu, and Etegwe communities each havea primary school **(Plate 4.3.8.1 and Plate 4.3.8.2)**. The public primary schools in Opolo-Epie, and Okutukutu have adequate structures for learning, but the Primary School at Etegwe communityhas structures that are in dilapidated state. In each of Otuasega and Oruma communities of Ogbia there are two primary schools. Common problem to public schools in the communities are insufficient number of teachers, chairs, laboratories, libraries, absence of perimeter fences, security personnel and other utilities. Number of schools providing basic education in the area has been growing over the years. At inception of democratic governance in 1999, there were four hundred and thirty-six (436) public primary schools in the entire Bayelsa State with Yenagoa LGA (to which most the communities to be impacted by this project belongs), ranked 3rd inhosting number of public primary schools. Available statistics in 2004 further revealed that there was a 20.4% increase in the number of primary schools in the state (548 publicly owned schools and 19 approved non-public schools or 567 primary schools in Bayelsa State. Yenagoa LGA, alone had 74 primary schools (up from 54). All the communities are equally within walking distance to a secondary school. **Table 4.3.8.6a and Table 4.3.8.6b** shows the number of educational institutions in areas to be impacted this seismic project.

Table 4.3.8.6a: Inventory of Educational Institutions in Study Communities

Community	Nursery	Primary	Secondary	Tertiary
Agudama-Epie	1	1	1	–
Akaubiri	–	1	–	–
Koroama	1	1	1	–
Gbarantoru	2	1	–	–
Okotiama	1	1	–	–
Etegwe	3	1	1	–
Polaku	2	1	2	–
Obunagha	1	1	–	–
Edepie	2	1	–	–
Okutukutu	2	1	–	–
Opolo Epie	4	1	1	–
Yenezue-Epie	1	–	–	–
Tombia	1	1	–	–
Ayama	1	1	–	–
Okolobiri	2	1	2	–

Source: SPDC (2008)

Table 4.3.8.6b: Availability of Educational Institutions in the Study Area

Settlement	**Nursery School Pupils**	**Primary School**	**Secondary School**
	N	**N**	**N**
Ekpeye			
Ombor	-	1	-
Idu-Ekpeye	2	2	2
Ebiriba I	-	1	-
Ebiriba II	-	1	-
Akalamini	-	1	-
Enito I	-	1	-
Enito II	-	-	-
Ula-Ubie	-	1	
Engenni			
Edagberi	5	2	-
Oshie-Engenni	-	1	-
Agbobiri			
Agbobiri	-	1	1
Zarama			
Epie-Zarama	1	2	1

Note: [x] Signifies the predominance of Members of NYSC and Volunteer teachers
Source: Field Survey 2008

Primary school enrolment has been on the increase in the area.For instance, in Bayelsa state, with a total pupil enrolment of 348,801;Yenagoa LGA alone had 14% of the pupil enrolments (Bayelsa State, 2000). There were also 3,034 teachers of which 24% of them are serving in Yenegoa LGA alone and has justified the growing literacy level.Literacy level in the communities has been higher than the national average of 60% (CBN, 2005).

a b

Plate 4.3.8.1: Structures for the Community primary school

(a) Opolo-Epie; and (b) a Library block

Plate 4.3.8.2: Building infrastructure for the Opolo Central School; left is a 6-Classroom block built and donated by SPDC

Public post-primary institutions in the communities are relatively few. With the exception of Opolo-Epie, and Okutukutu that have their own secondary schools, others own theirs jointly with their kindred communities. For instance, Okutukutu and Etegwe own and run one post-primary institution (Okutukutu-Etegwe Community Secondary School). As part of social responsibility, the Shell Petroleum Development Corporation (SPDC), the available secondary schools have received some infrastructure. Yenagoa Local Council also had the second highest number of post-primary schools in Bayelsa state as at the 1998/1999 academic year and the situation has not changed much since then **(Figure 4.3.8.7)**.

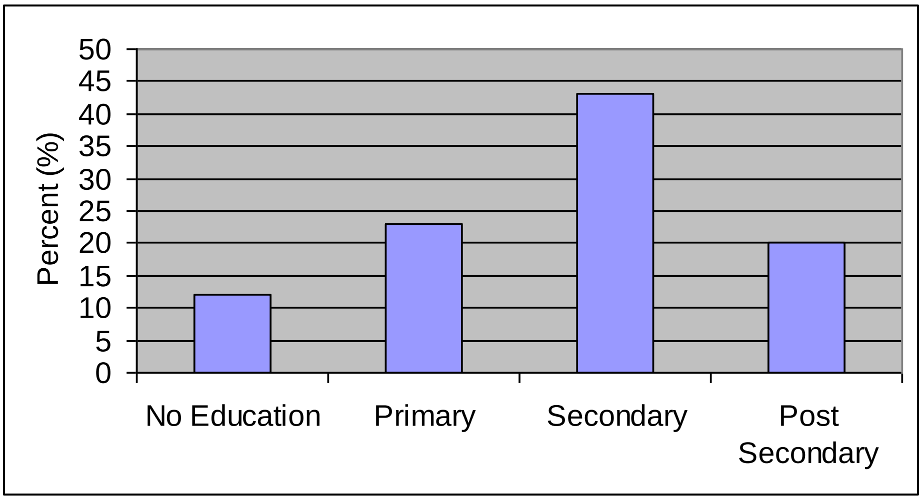


Fig.4.3.8.7: Level of Educational Attainment in project area
Source: SPDC (2008)

4.3.8.4 Other community Social and Economic infrastructures

The level of available or functional infrastructure and amenities in any area or community has direct implications on the quality of life in that area, and therefore thewillingness of people to live and remain there. These amenities may bephysical, social or institutional in nature and service.The infrastructureas they are called also influences socio-cultural and economic identities of people in an area. **Table 4.3.8.7a and 4.3.8.7b** shows the status of infrastructure in the host communities in Bayelsa and Rivers State.

Table 4.3.8.7a: Status of Infrastructure/Social Amenities in Communities to be Impacted by Gbaran Seismic Project

Community	Amenities Available/Status
Opolo-Epie	• One public primary school with buildings built and donated by the SPDC and another 6-classroom block for the Community Secondary School. There is also a structure meant for a library built by the SPDC but is yet to be furnished and stocked with books. • Potable water available courtesy of SPDC, since 5-6 years ago. • A Community Health Centre and SPDC donated structure. • There is access to electricity via the Kolo Creek Gas Turbine, but wiring/electrification sponsored by SPDC, and energy boosted through donation of 2 transformers. • Community central market place, a big town hall built by community but renovated by the SPDC. • An 18-seater bus donated by SPDC is used for transport to generate income for community.

Community	**Amenities Available/Status**
Okutukutu	• Has a public Primary School with housing infrastructure donated by the SPDC in 1997. Another 6-classroom block donated but allocated to the Secondary School. • Joint ownership of Post-primary school with Etegwe founded in 1994. • Have access to electricity; although regular supply of energy was a major complain. • Community lacks potable water supply; water project by the NDDC, commissioned since 2003 has brought no drop. Depends on private boreholes and water vendors for domestic supply. • Has a community town hall, but now doubles as a Magistrate Court house.
Etegwe	• Have a Primary School but lack adequate chairs and tables for both pupils and teachers. • A Secondary School jointly owned with Okutukutu; building donated by the SPDC, but heavy burden on communities because of staff salaries and other running costs. • Same water project with Okutukutu; non-functional, therefore water is sourced from creek, natural rain, and also from vendors. • Community has access to electricity but supply is erratic; old wiring materials and only 200KVA transformer which is inadequate for population. • No health centre/facility; attend to health matters at FMC, Ovom, Yenagoa.
Otuasega, Odau and Oruma	• There is a tarred road running through Otuasega and terminate at Oruma; • The Ogbia and Odaul communities can be conveniently linked by roads; However absence of roads in Odau makes access difficult; • Odua can be accessed by road using motor cycles and by canoe on water; • Functional public electricity is transmitted from Kolo Creek Gas turbine to the Ogbia communities in Bayelsa State to the Odual communities in Rivers State free of charge; • Global System for Mobile (GSM) communication services provided by MTN and GLO were available in the Ogbia communities
Koroama, Polaku, Obunagha, OKolobiri, Polaku	• The communities are contiguous and all lie on one road that runs through the area, covering a distance of about 12 kilometers. Koroama is the community that hosts the three gas wells. • All the five communities are linked socially and economically by the road that runs through all of them; • There is river serving the area (Taylor Creek) and some other shared facilities which include a General Hospital, now the (Niger Delta University Teaching Hospital) at Okolobiri.
Gbaran-Ama	▪ The paramount ruler and his council of chiefs/elders form the highest decision making organ in the community. ▪ Other institutions appointed (CDC Exco, youth and Women group) have tenure of two years.

Source: SPDC (2007, 2015)

Table 4.3.8.7b: Availability of Electricity and Telephone facilities in the Study Areas

Settlement	Electricity				Telephone	
	National Grid	State Utility Board	Gas Turbine	Other	Land Lines	Availability of GSM Signals
Ekpeye						
Ombor	-	-	-	-	-	+(OR)
Idu-Ekpeye	-	-	-	+(SPDC)	-	-
Ebiriba I	-	-	-	-	-	+(OR)
Ebiriba II	-	-	-	-	-	+(OR)
Akalamini	-	-	-	-	-	+
Enito I	-	-	-	+(NAOC)	-	+(OR)
Enito II	-	-	-	Generator (NAOC)	-	+(GLO,MTN)
Ula-Ubie	-	-	-	-	-	+(OR)
Engenni						
Edagberi	-	-	-	+(NAOC)	-	-
Oshie-Engenni	-	-	-	+(NAOC)	-	-
Agbobiri						
Agbobiri	-	-	-	OP (SPDC)	-	+
Zarama						
Zarama Epie	-	-	-	-	-	

	LEGEND	PR	Private	NO	Non-Operational
-	Absent	OR	Operational (Sporadic)	AP	Abandoned Project
+	Present	OA	Operational All Year Round	OP	Ongoing Project

Source: Field Survey, 2008.

A good proportion of the infrastructures (42%) in these communities are provided by the State Governments and by the SPDC (26%), donations (6.0%) and others by local and Federal Governments **(Fig. 4.3.8.8)**.

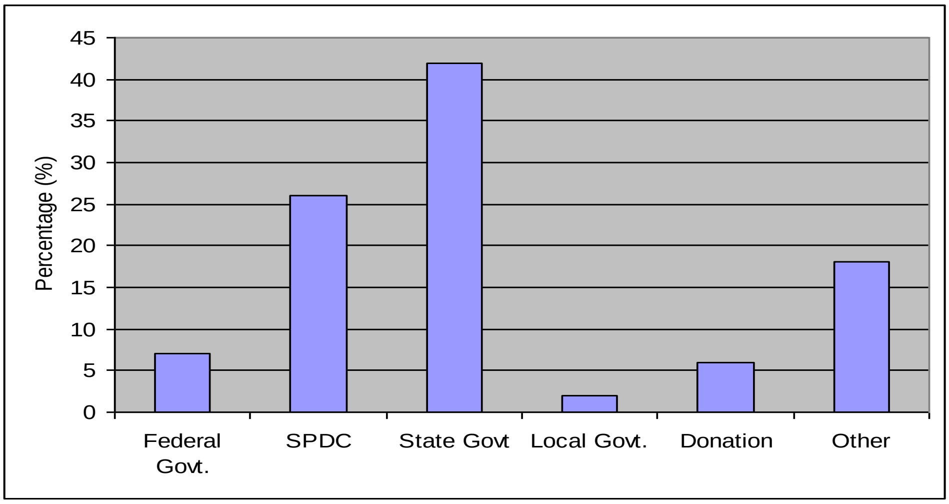


Figure 4.3.8.8 Proportions of Infrastructures by Providers in project communities
Source: SPDC (2008).

4.3.8.5 Local Economy and Livelihood

Employment: The employment situation in the communities has been reported inKolo Creek NAG Manifold to Soku Gas Plant Pipeline EIA study (SPDC, 2010). One common phenomenon was the problem of unemployment. The unemployment problem was felt mostly among secondary school leavers who were unskilled and who had also neglected traditional farming and fishing activities of the people. Unemployment was more among males than females. The females adapted better to economic hardship by engaging in petty trading.The same report (SPDC, 2010) noted that the level of unemployment among household members in Ogbia as 36%, Odual communities as 28.3%. This is a mean of 34.0%, higher than 8.3% unemployment recorded for Odual communities in Kolo Creek NAG Manifold to Soku Gas Plant Pipeline EIA study by SPDC in 2010, and far lower than the estimate of 80.0% in report of EIA of Gbaran Ubie Phase 2 IOGP (EIA Cluster 2 Epu-Field)(2015). The mean rate of unemployment in the project communities is 37.32%. The dependency ratio was estimated as 83.5 as reported in the Kolo Creek NAG Manifold to Soku Gas Plant Pipeline EIA study by SPDC in 2010. High level of unemployment suggests greater dependency ratios since the unemployed will add to the burden of catering for the needs of the very young, very old, and invalids by individuals within the work force that are gainfully working.

Livelihood Activities: Livelihood activities that have been identified in the study area included farming, fishing, petty trading (especially shop keeping and hawking) timber works (logging, sawing), food processing (especially palm oil milling and gari production) and artisan practices (especially carpentry, welding, masonry). Others include residents who are engaged in public/civil services, and persons who provide transportation services and contractors. These livelihood activities as observed in the communities are presented in **Table 4.3.8.8**.

Many residents get engaged in multiple livelihood activities in similar project communities. It is very common in many Nigerian rural communities to see public and civil servants doing some petty trading and in some cases owning and managing family farms with crops like plantain, banana, cassava and vegetables. Many farmers also get involved in off-season fishing when they are not cultivating or harvesting. There are really no limits to combinations of livelihood activities, once an individual is able to engage resources profitably in the activities.

Crop farming especially at subsistence level is a major livelihood activity in the area. Farming implements have remained use of traditional hoes, machetes and cutlasses. Many of these local farmers do not make use of fertilizers but bush fallow, organic mulch and land rotation in maintaining fertility of their soils. Residents grow crops in their farms which they sell in the markets. Although the farms are not mechanized and output is not large, yet, most households in the farming communities depend largely on their farms for livelihood. Cropping is done mostly between November and May and harvesting between September and February. For early crops like maize, harvesting is in June while most vegetables are harvested several times in the year. With application of mechanization and use of modern farming technologies, it is possible to have more than one cropping season for capital to fund farming activities and hindered all-season access to farms and market on account of inaccessible roads and difficult water transportation schedules. most of the food crops in the area. The major food crops grown in the communities include cassava, plantain, banana, cocoyam, sweet potato and vegetables. Economic trees or cash crops grown include Ogbono, oil palm, and various fruit trees. The major challenges of farmers in these communities include lack of modern (mechanized) farming equipment, inadequate

Fishing equipment is also rudimentary with capture fisheries being the common practice. Residents who perform most of the fishing activities live in fishing camps in satellite communities such as Gbara-Ama. The popular fishing sites are the rivers, creeks, ponds and swamps around the communities. Fishing equipment are mostly different sizes of nets, hooks and traps. The fishing practice in these communities is also seasonal. The dry season months of November to March are when active fishing takes place.Active fishing is hindered by capital inadequacy to buy boats, out board engines and equipment and difficulties experienced in accessing some of the communities.

Petty trading has become quite an important livelihood activity in terms of the number of household members that are engaged in it. In all the project communities there were small shops which sold variety of products ranging from food items to stationery and minor electrical appliances. There are also itinerary traders who hawk vegetables, fruits and fresh fish. Many of the artisans do not have workshops to work from. These people are consulted in their homes but in communities of Otuasega, and Oruma there is a good numberwelding and carpentry workshops. EIA report for Gbaran E2, E4 Wells drilling and Manifold Construction of 2007 noted that respondents earned mean monthly income of ₦6, 667.67 in the area. Another report EIA of Kolo Creek NAG Manifold to Soku Gas Plant Pipeline study by SPDC in 2012 notedthat householdsmonthly income in Ogbia group communities (mostly from farming, petty trading and public/civil service employment) was between₦35, 000 and ₦50, 000. The same report noted that households in the Odual group of communities earned relatively lowly, between ₦ 20,000 to ₦ 35,000 monthly.Personal and household monthly income varied on account of type of occupation and ability to effectively combine money yielding activities.

Table 4.3.8.8: Economic Activities in Project Communities

Economic Activities	Gbarantoru	Zarama	Ogbia Communities	Okotiama	Edepie	Abua Communities	Ahoada Communities
Canoe carving	+	+	+	+			
Tombo Camp	+						
Subsistence farming (cassava, yam, cocoyam, plantain, vegetables)	+	+	+	+	+	+	+
Garri and Fufu processing	+	+		+			
Palm oil processing	+	+		+			
Motocycle technicians	+	+		+	+		+

Economic Activities	Gbarantoru	Zarama	Ogbia Communities	Okotiama	Edepie	Abua Communities	Ahoada Communities
Telecommunications	+	+	+	+	+	+	+
Plantain roasting				+			
Menial job	+	+	+	+	+	+	+
Petty trading			+		+	+	+
Shop business	+				+		
Carpentry			+		+		+
Furniture			+		+		
Motor mechanic					+		+
Technicians					+		
Transport business			+		+		+
Food vendors					+		
Restaurant business					+	+	+
Hair dressing					+		+
Barbing					+		
Fishing net and trap making	+	+					
Fishing	+	+	+	+	+	+	+
Palm wine tapping		+	+				

Source: SPDC (2012, 2013).

4.3.8.6 Lifestyle and Culture

Table 4.3.8.9 is a summary of lifestyle and culture of the people in the proposed seismic project communities.The major form of refuse disposal was open dumping. Sweepings from homesteads are often heaped at an open corner, in farms or nearby creeks and streams. This enhances littering of wastes in all the communities, posing serious health threat to the people as rodents and insect vectors of disease breed uncontrollably. Inhabitants of the communities defecate unrestrictedly in nearby bushes and creeks. The use of pit latrines and water closets is not popular among the people.

Table 4.3.8.9: Lifestyle and Culture

Cultural Values	**GBU E2, E4 (2007)**	**GBU 1 (2009)**	**GBU 3 (2010)**	**Kolo Creek (2012)**	**EE Base GBU Node Int, Oil & Gas (2013)**	**Etegwe/Tombia (2008)**
Religion	Christians and traditional religionists; Traditional shrines and forests	Christians and traditional religionists; Traditional shrines and sacred forests	Christians and traditional religionists; Traditional shrines and sacred forests	-Christians and traditional religionists; Traditional shrines and sacred forests eg. Abadiofoni Shrine at Fikoruama	Christians and traditional religionists; Traditional shrines and sacred forest	Christians and traditional religionists; Traditional shrines and sacred forests,
Festivals	-New yam festival; -Christian festivals of Easter, Christmas.	Ekuobhi festival in Otuasega; Obunam festival for Epie communities; Okolode in Tombia and Gbrantoru , and Obunagha communities.	-New yam festival; -Christian festivals of Easter, Christmas etc.	Ekwori, fishing festival; Eyali Oduema- masquerade festival, rights are performed by men only; Eyali Okperenedum- marks a break from farm work; Olua festival.	-New yam festival; -Christian festivals of Easter, Christmas.	Festivals associated with the following shrines:Kukwata, Koroyai, Toruta, Opuada
Taboos	-Strangers are forbidden from entering sacred forests; -forbidden to have sex with another man's wife;	• Having sexual intercourse with a woman in the bush/forest. • A woman under menstruation is not allowed to enter the shrine. • No killing of white eagle (Agbala koko)		-Infidelity of a married woman; -killing/eating of tortoise and python is forbidden. -Suicide is forbidden; -having sex in the bush is forbidden;	-Olala (women forbidden total entry to some areas; -Oleilia, Akpole, Eberiba, Okpolokpor bush, Akpolususu and Otumele are forbidden bushes.	-Desecration of the shrines is forbidden,

Cultural Values	GBU E2, E4 (2007)	GBU 1 (2009)	GBU 3 (2010)	Kolo Creek (2012)	EE Base GBU Node Int, Oil & Gas (2013)	Etegwe/Tombia (2008)
		• No eating of Iguara (monitor lizard). • Chewing of sugarcane in the community.	Nil	-Desecration of shrines is forbidden.		
Housing Material and Housing Quality	- Cement, block and Zinc for durable structures; - Thatch and mud for low quality structures. – Buildings are Personally owned homes.	-Mainly Cement, block and Zinc for high quality buildings; -Thatch, wattle and mud for low quality buildings.	-Mainly Cement, block and Zinc for high quality buildings; -Thatch, wattle and mud for low quality buildings.	- Cement, block and Zinc for durable structures; - Thatch and mud for low quality structures. –Buildings are Personally owned homes.	-Mainly Cement, block and Zinc for high quality buildings; -Thatch, wattle and mud for low quality buildings.	-Mainly Cement, block and Zinc for high quality buildings; -Thatch, wattle and mud for low quality buildings.
Access to Land, land use, and Tenure	• Mainly by Family inheritance; • Growing of food and cash crops; • Owned throughout the life of a male child in family.	-Through Family inheritance ; -Used for family and public buildings; -Used for food and cash crop growing; -Building market and recreational facilities -owned as long as the owner lives -.	-Through Family inheritance ; -Used for family and public buildings; -Used for food and cash crop growing; -owned as long as the owner lives.	-Through Family inheritance ; -Used for family and public buildings and shrines/sacred places; -Used for food and cash crop growing; -owned as long as the owner lives.	-Through Family inheritance ; -Used for family and public buildings; -Used for food and cash crop growing; -owned as long as the owner lives.	-Through Family inheritance ; -Used for family and public buildings; -Used for food and cash crop growing; -owned as long as the owner lives.

Cultural Values	**GBU E2, E4 (2007)**	**GBU 1 (2009)**	**GBU 3 (2010)**	**Kolo Creek (2012)**	**EE Base GBU Node Int, Oil & Gas (2013)**	**Etegwe/Tombia (2008)**
Waste Management	**Sewage Disposal:** Creek/river -Pier latrine in creeks; **Other Waste:** Open dumping; Farmlands	**Sewage Disposal:** Pit Latrine ; Bush; Water Closet; Creek/river (pier Latrine) ; **Solid Waste Disposal:** Dump in river/Creek ; Backyard; Dug pit.	**Sewage Disposal:** Bush; Creek/river (pier Latrine) ; **Solid Waste Disposal:** Dump in river/Creek ; Backyard; Dug pit.	**Sewage Disposal:** Creek/river; **Other Waste:** Open dumping; -dumping on Farmlands	**Sewage Disposal:** Creek/river -Pier latrine in creeks; **Other Waste:** Open dumping; Farmlands	**Sewage Disposal:** -Creek/river -Pier latrine in creeks; **Other Waste:** -Open dumping; -Farmlands -Burning
Conflict and Conflict Resolution	Nil	Power tussle (in Otuasega); Family Clashes (in Opolo Epie that was resolved)	Nil	-Land squabbles in Odua; -conflict of sharing employment slot; Resolved by dialogue out of court. -Court resolution.	Nil	-Power tussle over chieftaincy stool; -conflict of ownership of land and other assets;

SPDC (2007, 2009, 2010b).

4.3.8.7. Community Perceptions, Concerns and Expectations

All the communities had been exposed to oil and gas activities in the past. **Across the** communities, the proposed project shall be welcome but with strong reservations. These reservations are in form of perceptions, concerns, and expectations. The concerns of seismic project communities on activitiesare quite general and similar. SPDC is aware of claims for recognition of communities as land owners. This is important as negotiation and agreements are reached in payment of preliminary and final compensations are made to land owners.The GMoU agreements in sharing of benefits like employment from its operations are issues of concerns as all the parties were engaged in discussions about these. No party would like to be cheated in such deal. These engagements and discussions are continuous. Issues raised by community members include:

- There are concerns on type of seismic operations to be used;
- There are concerns on type and power of energy source (dynamite or Vibroseis truck) mounted on their land might produce deafening sound;
- There are concerns about where the seismic lines and access routes will pass through and cause damage to personal and/or communal buildings/investments;
- There are concerns about the extent of vegetation to be cleared along proposed seismic lines and access routes.
- Concerns that social interaction in the past had turned local girls into seasonal wives, exploited and dumped by itinerant workers.
- Increased promiscuity.
- Occurrence of teenage pregnancies and unwanted babies.
- Damage to cultural resources, especially shrines in the forests;
- Concerns that Farmland, crops and economic trees would be destroyed during vegetation clearing for seismic lines;
- Increased insecurity due to the fact that the project would attract large population;
- There would be price increases, especially of transport and food
- Increased pressure on the already inadequate infrastructures with no local capacity to attend to needs especially medical.

Expectations of the communities may differ based on their different needs and concerns. These expectations amongst others shall be:

- That the project would bring about new interactions and relationships that may result in marriages;
- Expectations that there would be skilled interactions with workers from other places resulting in increase in knowledge and ideas about seismic activities;
- Some communities would expect a repeat of previous experiences on use of their communal resources and inter-personal relationships;
- Expectations of a positive impact in the employment of local hands in construction of seismic lines, and drilling of shot holes;
- Expectations of increased income from increased volume of commerce;

4.3.8.8: Consultations

Stakeholder Consultation framework in SPDC seeks to listens and acts on the views of stakeholders. The process helps in environmental planning, develops solutions to identified concerns. It is also a structured means of integrating the SPDC vision for sustainable development in the course of implementing projects. Sustainable development is about integration and balance. Integrating the economic, environmental and social aspects of the business and balancing short-term priorities with longer-term needs. The company has sought the views and permission of stakeholder groups. This responsibility has been captured early enough with relevant parties consulted at the very early stage of planning of these reviewed projects. Appropriate liaison was established through notification of intent with both DPR and FMENV, as well as the Bayelsa State Ministry of Environment, Rivers State Ministry of Environment and the affected Local Government Councils of Bayelsa and Rivers States. The move was to allow greater public involvement in environmental decision-making, especially at the local or community level, where issues of environmental quality and social well-being are of immediate concern.

The Process: The Nigerian Federal laws and regulations prescribe a process of agency, public and community consultations. In line with SPDC HSE policy, rapport was maintained with the key stakeholders in this project.

i. The key elements of consultation include:
ii. Early notification of the nature, scale and timing of the proposed activity.
iii. Information gathering and exchange between interested parties.
iv. Liaison to promote understanding and reconciliation of competing aims and objectives.

SPDC recognizes that consultation is not a once-off business but continues throughout the assessment with a clear "action plan" developed in full consultation with its HSE and Sustainable Community Development (SCD) Departments. The identified issues and concerns in a consultation process and the methodology for managing them, is presented in a logical framework in **Fig. 4.3.8.9**. Due to the dynamic nature of human relationships the status and value of the relationship with each stakeholder was constantly reviewed and updated in the Stakeholder Engagement plan.

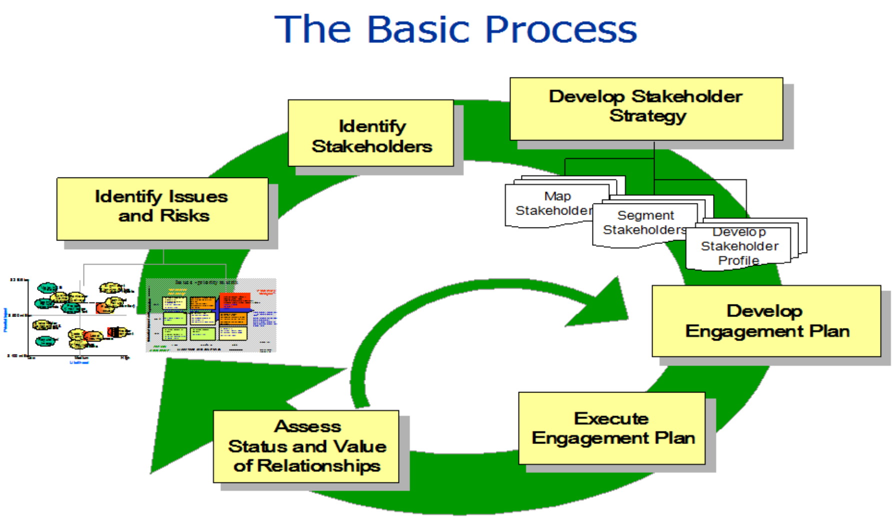


Fig. 4.3.8.9: The SPDC Strategy for the Consultation Process

The consultations done in some of these studies are shown in **Plate 4.3.8.3**

Plate 4.3.8.3 Consultation during the field data gathering exercise in New Jerusalem community (Zarama)

Source: SPDC (2010)

4.3.9 Health Studies (HIA)

The health of a community is the aggregate health of the individuals in the community. This is affected by many factors in the environment as well as within the individuals. The physical environment, income, education, social support system, individual biology and genetics as well as individual health practices and available health services all determine the health of the community.

This report is a review of various health impact studies done at different times spanning several communities cutting across two states in the Niger Delta. There are healing homes, traditional birth attendants, and patent medical stores that provide medical services in all communities. This is a reflection of the poor quality of health care available in the area. A closer look at the health seeking behavior of the study population revealed that self-medication; visits to patent medicine stores, traditional birth attendants and alternative medical practice are key practices that define their health care situation.

Demographic Characteristics of Study Population

These are as reported in the socio- economic section of this report (4.3.8) with accompanying tables displaying data on education, marital status, age, and sex.

4.3.9.1 Morbidity and Mortality Pattern

Several factors contribute to define the morbidity and mortality pattern of a given community. Such factors include poverty, infections, inadequate health facilities, poor housing, unsanitary environmental conditions and nutrition.

Survey results indicate that members of the study communities suffer from several conditions and sicknesses. The most common conditions include: Malaria, diarrhoeal diseases (including dysentery), tuberculosis, respiratory tract infections, typhoid fever, and hypertension. An estimate of the proportions of morbidity from the commonest conditions is presented in Figure 4.3.9.2.

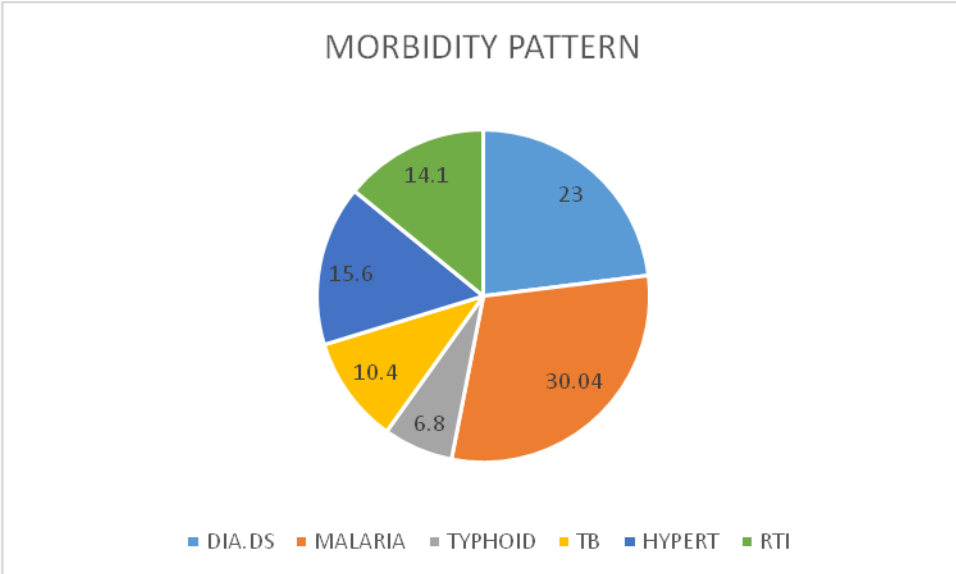


Fig. 4.3.9.1: Morbidity Pattern in study communities
Source: SPDC (2007, 2008, 2009, 2010, 2012, 2013, 2015)

Malaria accounted for more than 30% of the morbidity cases in all the communities put together. The next most reported morbidities were diarhoeal diseases and respiratory tract infections. There was not much difference in the number of males and females that took ill in the communities in the period under review. The pattern of morbidity seen in the communities is more a reflection of the living conditions of the people. With poor drainage facilities and stagnant water in the midst of swampy vegetation, malaria is obviously predominant. The poor waste and sewage disposal methods seen in the communities no doubt contributed to the high prevalence of diarhoeal diseases while air pollution occasioned by use of firewood and kerosene stoves for cooking, vehicular emisions, exploratory and production activities may contribute to the high respiratory disease prevalence. Poor housing including dampness and overcrowding may also have contributed to the prevalence of respiratory diseases seen. Mortality patterns mirror those of morbidity in all communities under review.

Respiratory Function Test

Studies within the communities indicate a mean peak flow rate used to measure the function of the lungs that is within normal range for younger adults between ages 22 – 44 years; while it is abnormal for adults between 45 and 70 as shown in Table 4.3.9.2. This is a significant tell tale sign of possible impact of air pollutants and chronic respiratory diseases on community health.

Table 4.3.9.1: Mean Peak flow rate in the communities

Age group (Yrs)	Standard Value (L/min)	Study Communities (L/min)
20-44	580 – 650	584.3
45 –70	500 – 560	486.4

Source: SPDC (2009).

4.3.9.2 Health Facilities and Services

The healthcare facilities available to a community could be an important index of the health status of that community. Figure 4.3.9.1 shows a summary of the health facilities and services available in the study communities. Health care in the study areas is dominated by patent medicine dealers, traditional medical practitioners including the ubiquitous herbalists, and the healing homes where natives run medical services using knowledge gleaned from orthodox and native sources. The traditional birth attendants fall into this category.

A very important factor that defines the health seeking behaviour of the studied communities is the deep rooted cultural belief passed on from generations past which tend to discourage use of modern facilities and encourage the known age long traditional practices.

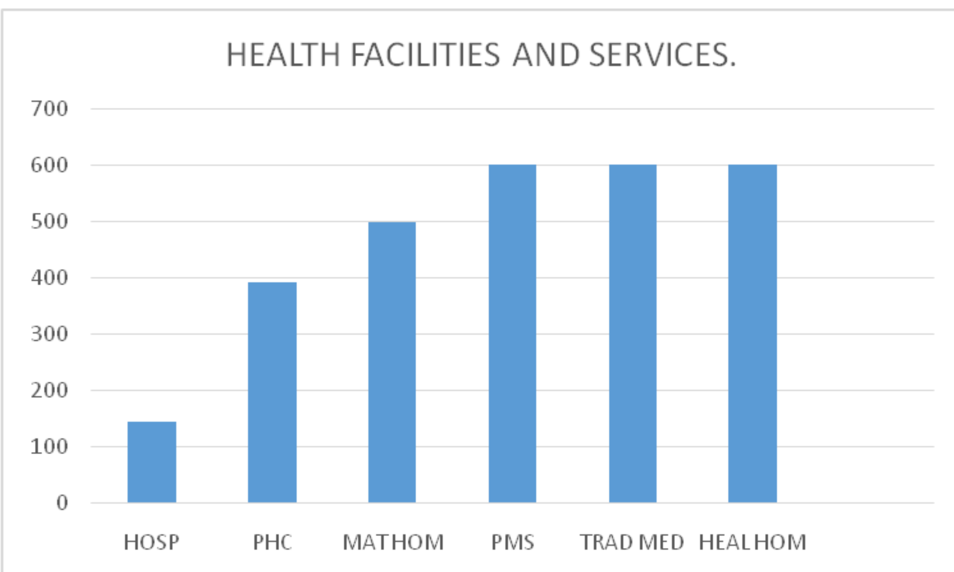


Fig. 4.3.9.2: Summary of Health Facilities and Services

Source: SPDC (2007, 2008, 2009, 2010, 2012, 2013)

KEY: HOSP = Hospitals. PHC =Primary Health Centers. MAT HOM =Maternity Homes. PMS = Patent Medicine Stores. TRAD MED =Traditional Medical practices. HEAL HOM = Healing Homes

As seen in the data in Figure 4.3.9.2 orthodox medical care as represented by hospitals and primary health care centres are relatively few. In many of the study communities, people travel long distances to receive modern health care. This encourages the use of other forms of unorthodox care with attendant consequences of mismanagement.

Traditional and herbal medicine practices

Traditional medical practice was available in almost all the communities. In many of the communities they formed the main stay of the healthcare delivery system. Their practice involved use of herbs derived from medicinal plants, and bodily charms; each of which they claim could cure several diseases, such as malaria, peptic ulcer, diabetes, hypertension, and snake bites. Plate 4.3.9.1 shows a member of the study team interacting with a prominent traditional medicine practitioner at Idu-Ekpeye. Some of the medicinal plants used in the traditional medical practice in this study area are given in Tables 4.3.9.2(a) and (b).

Plate 4.3.9.1: Traditional medical practitioner posing with a health consultant
Source: SPDC (2010).

Table 4.3.9.2(a): Common medicinal plants in the study communities and their uses

Common/local names	Botanical names	Medicinal use
Pawpaw leaves	*Carica papaya*	Treatment of malaria
Alligator pepper plant	*Afromomum melegueta*	Galactogogue, purgative, sore throat, malaria, used by herbalists for consulting their oracles
Lemon orange	*Citrus aurantium*	Abdominal upset, and as a base for other herbs in treatment of malaria
Cashew fruit, leaf and bark	*Anarcadium occidentale*	Treatment of diarrhoea and menstrual problems
Mango leaves and bark	*Mangifera indica*	Treatment of malaria
Banana plant	*Musa spp*	Treatment of fever
Guava tree leaves and bark	*Psidium guajava*	Treatment of malaria, diarrhoea and menstrual disorders

Source: SPDC (2010)

Table 4.3.9.2(a): Common medicinal plants in the study communities and their uses

Name of community	Medicinal plant	Use
Egbebiri-Biseni	Igirya Epe	Diabetes Malaria
Ebrass	Dogon Yaro	Malaria
Ukpeliede	Idata Uchichi Okpubulu	Scabbies) Healing wounds Hynernia
Okaka-Epie	Unuru, agala	Eye problems
Ihuowo	Ogbuchuru Ugbola Ukwoline Udo	Healing wound Malaria Eye Hyernia
Isua	Bitterleaf	Diabetes
Ula Okobo	Uche,ubulu, Enyi	Malaria Hyernia
Okogbe	Ewe madu Ubulu	Malaria Stomach ache
Ogoda	Nsikala uchichi	Stops bleeding Hyernia
Odiereke-ubie	Ikite Enyi	Blood clot Stomach

Source: SPDC (2007, 2008 .2010, 2012 .2013, 2015)

Traditional Birth Attendants (TBA)

The role of TBAs in the study communities cannot be over emphasized. They constitute a significant proportion of the traditional medical practitioners. In all the study communities they were very actively involved in the management of pregnancies and deliveries, and despite the high levels of pregnancy related morbidity and mortality, the people had a lot of confidence in the services of this category of health providers. This is probably because there were no viable alternatives in terms of availability and affordability, or due purely to ignorance in a few instances. For instance at Ebiriba where a health centre is managed by the church, the study found that close to half of the women within child bearing age prefer to utilize the services of TBAs than go to a hospital at nearby Ahoada (SPDC, 2010). The capabilities of these TBAs could not be determined during the study. However at Ebiriba with an estimated population of less than 5000 people, three women were said to have died from pregnancy related causes a short time prior to the study. This may well be used as an indicator of the success or failure of maternal health services in the area.

Hospitals including tertiary and secondary health facilities are few and far in-between. Where available, they are far from most of the study communities hence their patronage of the traditional medical practitioners and patent medicine vendors who live among them, and can be reached within a short period of time. Primary Health centers are available in over fifty percent of the communities. They are usually poorly staffed and more often, do not have drugs to meet the common medical needs of the natives.

4.3.9.3: Sexual and Reproductive Health

The sexual and reproductive health of the study population is a very important part of the total health of the community. In view of the likely influx of job seeking and working people of different age groups, most of whom are sexually active, knowledge of sexually transmitted infections including HIV could empower the citizens to take steps aimed at driving down new infections and protecting themselves on a sustainable basis. Good sexual health enables the population to operate optimally in the pursuit of social and economic goals. Knowledge of the existence and mode of acquisition of common sexually transmitted infections varies among communities. On the whole, over three quarter of respondents in study population were aware of sexually transmitted infections and HIV/AIDS though only few inhabitants had gone for HIV test. **Figure 4.3.9.4** displays a distribution of respondent’s knowledge of sexually transmitted infections.

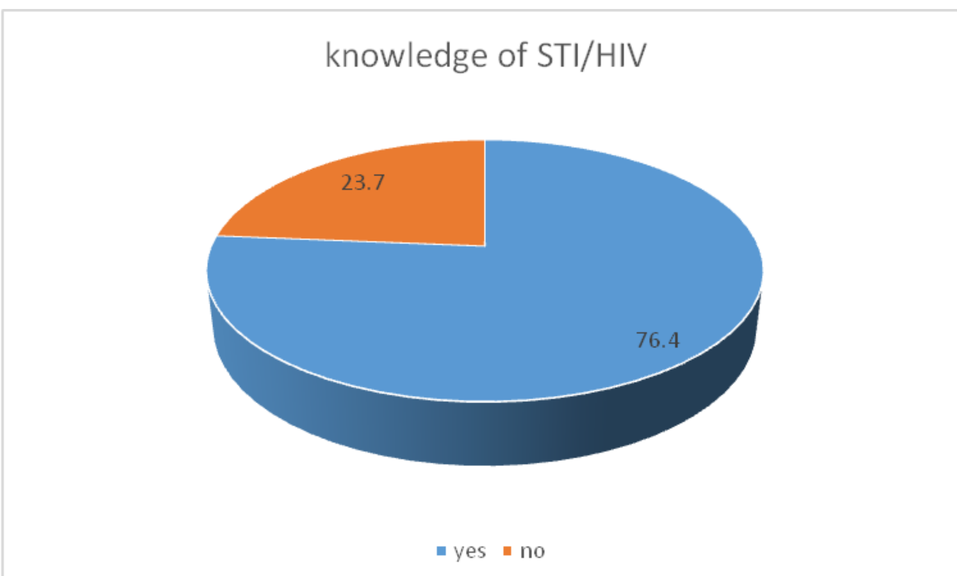


Fig. 4.3.9.3: Knowledge of sexually transmitted infections& HIV
Source: SPDC (2007, 2008, 2010, 2012, 2013)

Blood transfusion, sharp objects, unprotected sex, unsterilized clippers and needles were mentioned by respondents as ways by which people can contract HIV/AIDS. As populations continue to increase, a disconnect between knowledge of STI and practice is possible. There is therefore the need for a sustained community education on the importance of sexual health and people to take personal responsibility for their health. It is important to stress that while the national prevalence of HIV is reported to be going down, the prevalence remains high in the two study states of Bayelsa and Rivers where the prevalence is over 15% as against a national prevalence of less than 4% (National agency for the control of AIDS 2014 report). It is important to note that the prevalent social practice of uncontrolled alcohol use and the common practice of multiple sex partners in the study population could act as drivers of STI acquisition. One particular study (SPDC, 2009) found that nearly 20 % of the respondents had at least 2 sexual partners while some had up to 6 partners.

Maternal Health

Reports from the various study communities indicate a poor maternal health status probably a fall out of the general sub-optimal health status of the study area. The findings indicate that < 50 % of pregnant women in this area received some form of antenatal care and only about a third of pregnant women attending antenatal clinic actually deliver in a health facility. This is typically represented in Figure 4.3.9.4 (SPDC, 2010). A large proportion of women (about 23.0%) either deliver at home (mostly without any form of skilled assistance) , or in the home of a TBA (44.0%). As shown, almost one in every four pregnant women was as likely to deliver at home unassisted than in a clinic or hospital. The few privileged ones, about 8.0% would deliver their children in a private clinic in the closest city. These findings indicate relatively low health status compared to recent estimates of the national average for the region.

Current WHO estimates on health profiles in Nigeria indicate that only 31.0% of all deliveries take place in a health care facility. Moreover, only one-third of all deliveries are attended by skilled attendants. This scenario compares very closely with the findings in the study area (WHO 2006; Eds Joy Lawn and Kate Kerber: Partnership for Maternal Newborn and Child Health (PMNCH), 2006).

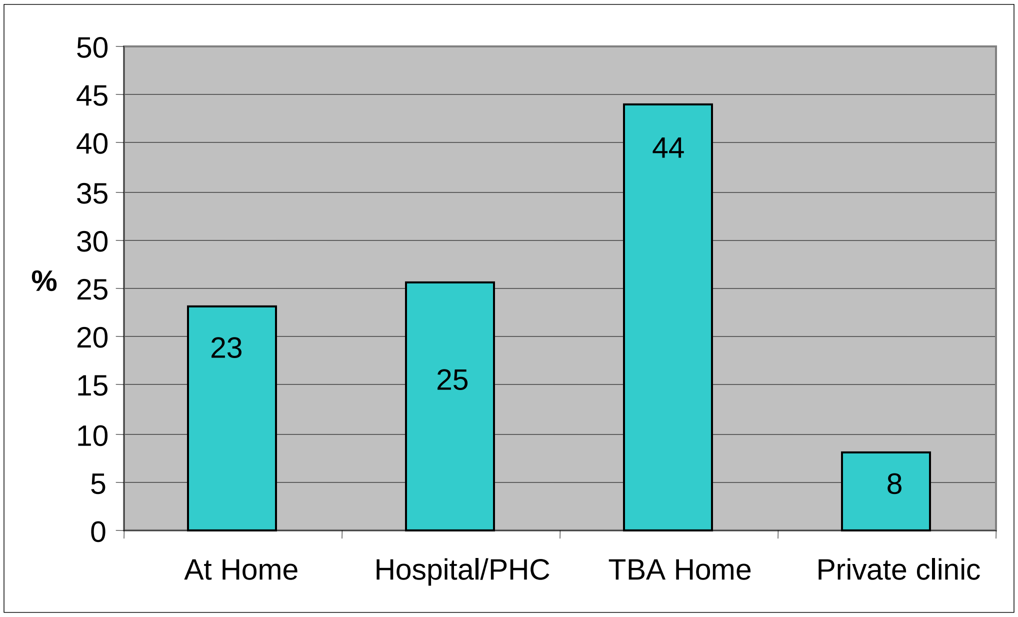


Fig. 4.3.9.4: Maternal delivery system in the project area.
Source: SPDC (2010)

4.3.9.4: Child Health

The various reports indicate that diarrhoeal diseases, malaria and respiratory tract infections are high on the list of common diseases among children in the study communities. The mortality pattern seen among children follows a similar pattern among the study populations as shown in Table 4.3.9.3.

Table 4.3.9.3 Mortality pattern among children in study communities

Rate per 1000	**National Data(2003)**	**Average in study communities**
Infant mortality rate	100	98
Under five mortality rate	201	197
Maternal mortality rate	10	9.62

Source: SPDC (2008)

Nutritional Status

The foods commonly consumed in the study region comprise richly of carbohydrates ie garri, starch and cassava. Foods like milk and egg are not common on the menu of most households. Some of the nutritional indices seen in the communities studied revealed values at variance with the national average as shown in Figure 4.3.9.7.

Malnutrition is a major health problem in Nigeria and provides an overall picture of the health status of the population. Children who are malnourished are several times at a greater risk of morbidity and mortality than children who are not malnourished. Standard indices of child growth have been used to describe the nutritional Status. Figure 4.3.9.5 shows the nutritional status of under five children in the study communities compared with the national average as provided in the Nigerian food consumption and Nutrition survey (2001 -2003). Three standard indices of child growth have been used to describe the nutritional status namely, Height-For-Age (stunting), Weight-For-Height (wasting) and Weight-For-Age (underweight).

A child with a significantly low height-for-age ratio is considered to be stunted or short for his age. This is generally the result of a failure to receive adequate nutrition over an extended period of time and is also affected by recurrent episodes of chronic illness. More than one third of surveyed children are short for their age. Children whose Weight-For-Height (W/H) ratio is significantly low are defined as wasted or thin for their age. One in nine surveyed children was classed as wasted.

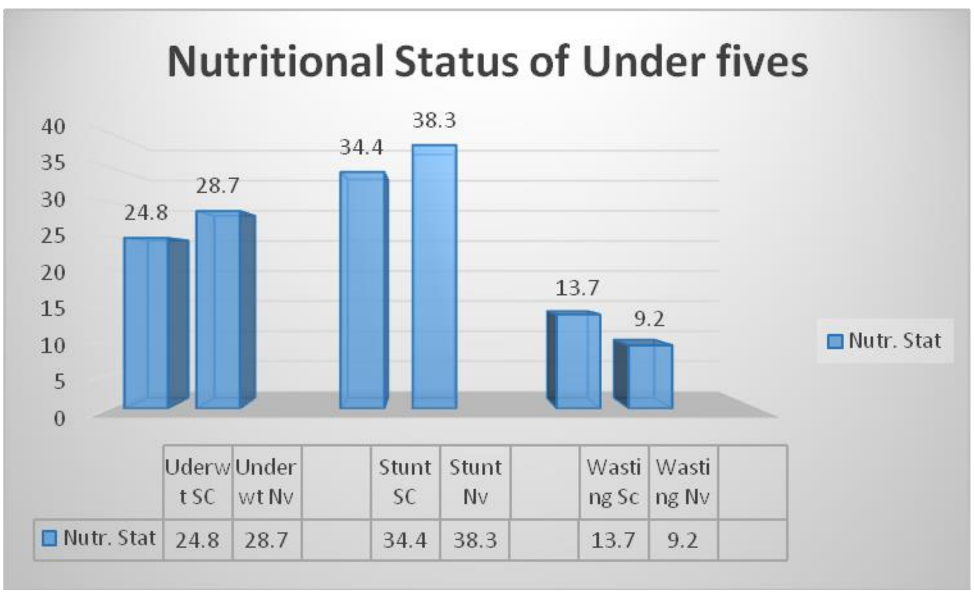


Fig. 4.3.9.5 Nutritional status of under five children
Source: SPDC (2007, 2008, 2010.2012, 2013, 2015)

Immunization Status:
Immunization against childhood killer diseases is an important index of the present and serves as a guide to future health plans geared towards the improvement of the future health condition of a community. While a good number of children within the study communities were immunized against these diseases, the average is still less than the national average as shown in Fig 4.3.9.6.

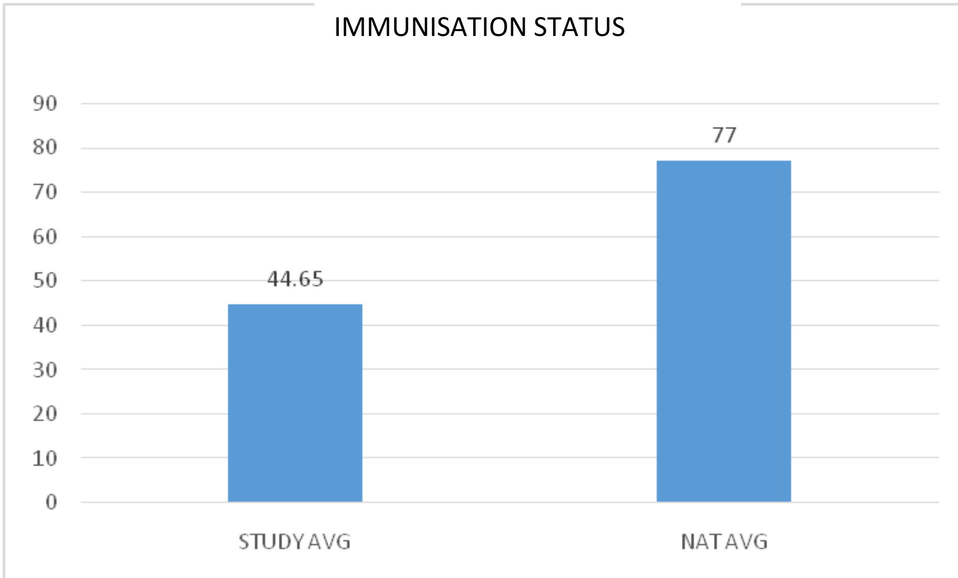


Fig. 4.3.9.6: Immunisation status of children in study communities
Source: SPDC (2007, 2008, 2010, 2012 , 2013)

4.3.9.5: Environmental risk factors in the community

The environment and living conditions have significant impact on the health of individuals and the community.

Water Sources

Sources of domestic water supply to the communities include rain, surface water (streams and rivers), wells and boreholes. Most of these sources are veritable sources of contamination. Water treatment practices are unknown in the communities, so inhabitants are exposed to various water borne diseases including typhoid fever, hookworm and hepatitis which can lead to fatal complications. This probably explains the high rate of diarrhoeal diseases. Most of the houses in the communities had no toilet facilities with a minimum of 3 people per room as opposed to a maximum of 2 as stipulated by WHO. This encourages poor sanitary conditions even as their waste and excreta are dumped in the bush and nearby rivers which doubles as major source(s) of water supply for domestic use - an unhealthy practice that exposes them to various diseases. Figure 4.3.9.7 shows the sources of domestic water used in the study communities. Nearly half of the population source their domestic water from rivers and streams while a significant 20.5% use rain as their main source of water for domestic use.

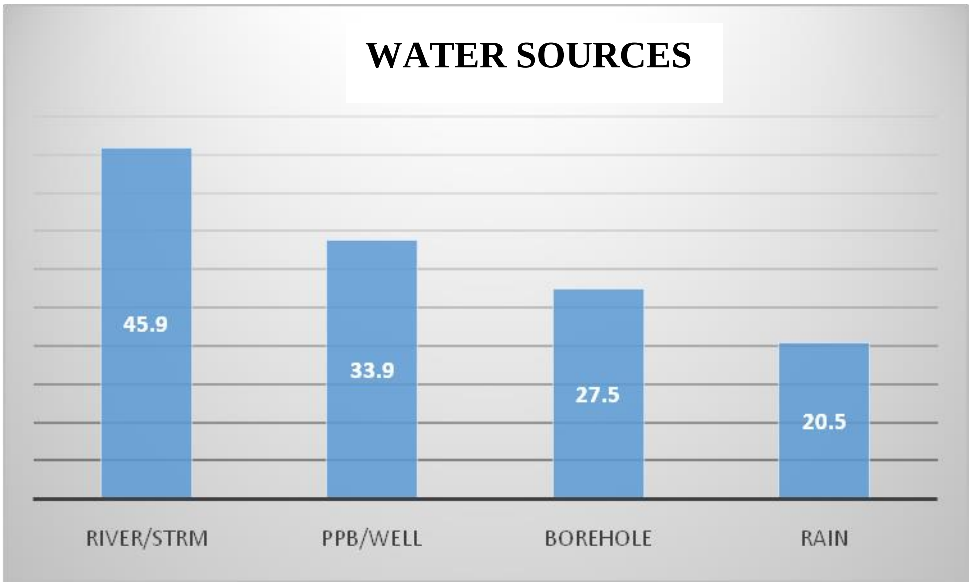


Fig. 4.3.9.7: Sources of water in study communities
PPB =Pipe borne

Source: SPDC (2007,2008, 2010,2012, 2013)

Solid Waste Disposal

Waste disposal methods in the study communities included open dumping, burning and disposal in running bodies of water. Open dumping is the predominant waste disposal practice in the study communities as seen in Figure 4.3.9.8

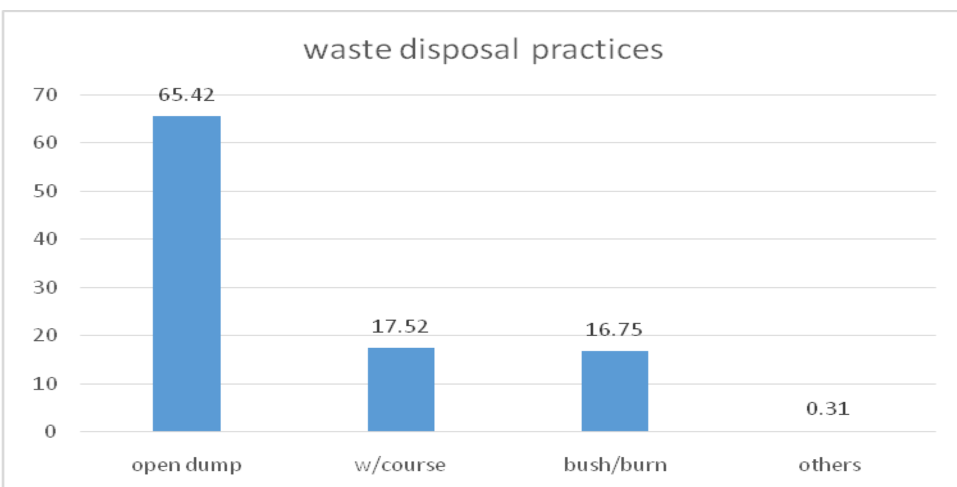


Fig. 4.3.9.8: Waste disposal practices in study communities
Source: SPDC (2007, 2008, 2010, 2012, 2013)

Solid waste from homesteads are often heaped at an open corner, usually towards the road or beside nearby vegetation. This often promotes the breeding of rodents and insect vectors of disease. Accumulating refuse in this manner also has the consequence of being subject to wind effects resulting in litter. Refuse so collected may be abandoned to the effects of wind or dumped into the river (Plate 4.3.9.2), burned or buried. There were no central refuse collecting and disposal system in any of the study communities. A household may use one or a combination of these methods. Plate 4.3.9.3 shows open dumping as commonly practiced in study communities.

a

b

Plate 4.3.9.2a,b: Open refuse disposal in one of the study communities
Source: SPDC (2008)

Sewage Disposal

Bad excreta disposal practices contribute to disease burden. The sewage disposal practices prevalent in the study communities are as shown in Figure 4.3.9.9.

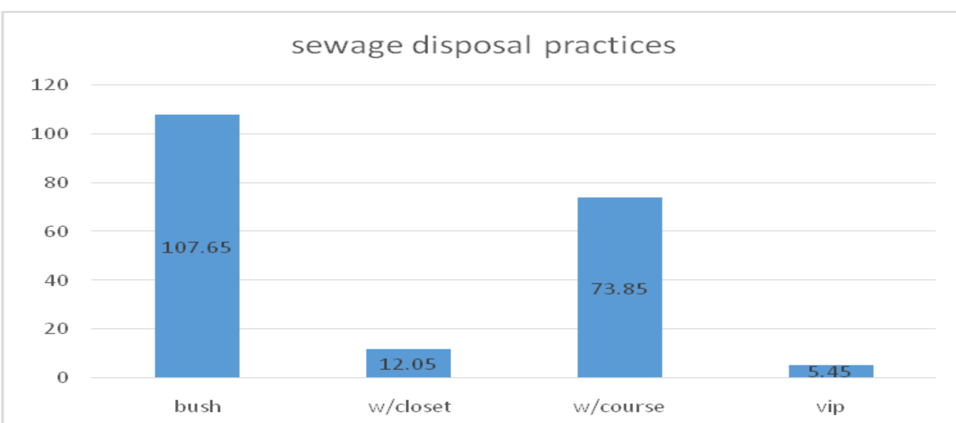


Fig. 4.3.9.9: Sewage disposal practices in study communities
Source: SPDC (2007, 2008, 2009, 2010, 2012, 2013)

Unhygienic handling and disposal of faeces contribute to the spread of communicable diseases especially those transmitted by water and food like cholera, typhoid and intestinal helminthiasis. These unhygienic sewage disposal practices may have significantly contributed to the high prevalence of diarhoeal diseases as seen in the study communities. Bush and flowing water source are the dominant methods for the disposal of feaces in the communities as shown in Figure 4.3.9.9 and Plate 4.3.9.3.

Open defecation encourages the breeding of flies, which help in spreading certain diseases. In moist soil such as that found in the communities, larva of intestinal worms can develop form these faeces, which can be carried and spread by both man and animals. Besides, most of the bushes in the communities are at the banks of flowing rivers which means faeces deposited in these bushes can easily be washed into the river by rain. Because of the lack of good sanitation facilities in the communities, children are allowed to defecate wherever it is convenient for them; and little effort is made to give the stool the proper disposal.

Plate 4.3.9.3: Jetty toilet (into flowing water course) in one of the study communities.
Source: SPDC (2012)

Air Quality

The importance of air quality in the environment cannot be overemphasised. While urbanization brings about its impact on air quality due to fumes from motor vehicles and industrial activities, liberated gas from activities of oil exploration could add significantly to an altered air quality. Impaired air quality could have a direct bearing on the burden of respiratory diseases as it could serve as a trigger and also complicate airway diseases. Studies done in the study communities across the various clusters indicate normal values of all indices of air quality measurement as seen in this report (Table 4.3.1.4a – 4d) and the regulatory standards (Table 4.3.1.5).

However, **Figure 4.3.9.10** shows the response of study participants in one cluster on the perceived status of air quality in their environment. The perception of about half of the respondents towards air quality in their environment were in agreement with good air quality while about 30.0% of the respondent perceived that the air quality was poor. This they alleged is a consequence of activities of oil production activities (although there are currently no production facilities in the area) and bush burning in the area.

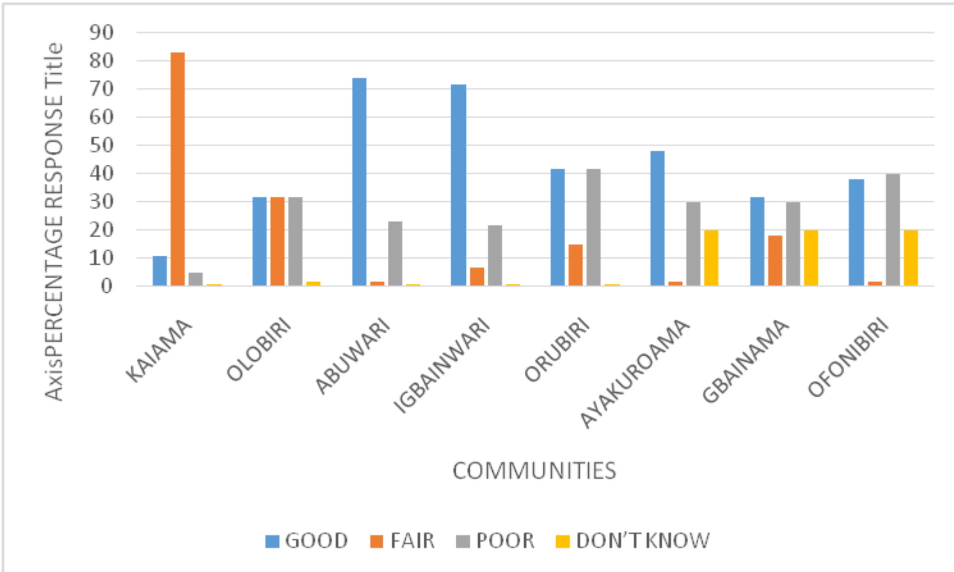


Fig. 4.3.9.10: Inhabitants response to air quality issues
SPDC (2015)

This review indicates that respiratory diseases rank among the first three most prevalent diseases in the study area and as such needs to be given due attention in the planning of further exploratory activities in the area.

Noise

The noise levels recorded in the study area were in the main, within limits, within which hearing impairments are not expected. However, a maximum noise level of 83.10 dBA was recorded in cluster 3 (SPDC, 2013; Fig. 4.3.1.4a -d). However, increased noise levels from vehicles on the road have been mainly blamed by the communities for the noise levels. It is however instructive to note that as urbanization continues to expand, increasing levels of noise are not unexpected. It is expected that this will be considered in planning mitigating factors in the event of industrial activities likely to increase noise levels.

Housing

Typical homesteads in the study area are shown in Plates 4.3.9.3 and 4.3.9.4. In many of the communities the housing pattern was a mosaic of mud houses with thatch roofs; mud houses with corrugated iron sheet roofing; wood houses (or batcher) and brick houses with corrugated iron sheet roofing in order of decreasing number. Inadequate housing has both direct and indirect effects on mental and physical health. The nature of the physical structure determine to a large extent the capacity of the building to protect from heat, cold, dampness, mould indoor air pollution and disease parasites and vectors.

Plate 4.3.9.2: A typical homestead in a study community

Plate 4.3.9.3: A homestead showing poor environmental conditions

CHAPTER FIVE
ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1: Introduction

A number of methods exist for evaluating potential impacts of any project on the environment. These include the Overlays techniques (McHarg, 1968), Leopold matrix (Leopold et al., 1971), Battelle Environmental Evaluation System (Dee *et al*., 1973), and Peterson Matrix (Peterson *et al*., 1974) and ISO 14001. The method employed in this EIA study is the ISO 14001 method. The ISO 14001 method is simple to apply and provides a high level of detail, and also relies on limited data. The following considerations were adopted in this impact assessment:

- Comprehensiveness - ability to handle all possible range of elements and combinations thereof;
- Selectivity - capability to identify early in the procedure those aspects that are important;
- Mutual exclusiveness - should be able to examine every component of an impact from different perspectives;
- Confidence limits - is the method able to ascertain and isolate uncertainties?
- Objectivity - should allow no bias either from the assessor or project initiator;
- Interactions - should be able to examine both sides of a coin and provide feedback.

5.2: Uncertainties

In our efforts to produce a credible EIA report, we are constantly assailed by the problem of uncertainties. Any Impact Assessment contains five kinds of uncertainties. These are uncertainties due to:

- The natural variability of the environment, particularly the occurrence of rare events such as floods, unpredictable climate change and natural disasters;
- Inadequate understanding of the behaviour of the environment;
- Inadequate time-tested data for the area being assessed;
- Socio-economic uncertainties (inadequate data for prediction of human response to economic crises). There is always uncertainty in predicting the way a community will respond to the activities of oil companies in their domain.
- Health uncertainties such as the problem of determining the direct causes and effects of diseases, and that of ascertaining the disease vectors that are brought into the project environment by itinerant applicants.

In this study, we have endeavored to use available cost-effective techniques and review of published data to mitigate these uncertainties where possible.

5.3: Impact screening

Comprehensive checklists of developmental activities and possible environmental/health/social impacts were produced, and based on past experience and reviews of literature and Impact Assessment reports on similar projects; these lists were tailored to specific project components and associated historical effects.

Basis for Screening

The rationale for assessing the likely impacts of the proposed project derives from the following considerations:

- Knowledge of the project activities, equipment types, material inputs/outputs and operational procedures;
- Findings of other EIA studies on similar projects and other literature findings on the primary project activities;
- Comparison with FMEnv Guidelines and Standards for Environmental pollution control in Nigeria, 1999;
- Series of expert group discussions.

The criteria applied to the screening of various activities are:

- Magnitude - probable level of severity.
- Prevalence - likely extent of the impact.
- Duration and frequency - likely duration - long-term, short-term or intermittent.
- Risks - probability of serious impacts.
- Importance - value attached to the undisturbed project environment.

In assessing potential impacts, cognizance was taken of the inherent judgmental subjectivity involved; consequently, the analytical results of field studies, relevant literature reviews and observations of existing facilities and practices were used to assess the level of potential impacts of the proposed project as shown in Table 5.1.

Table 5.1: Screening Matrix of impacts for the proposed Project

Project phase	Project activity	Potential and Associated impacts	Adverse	Beneficial	Direct	Indirect	Localized	Widespread	Short term	Long term
Premobilization	Permitting via consultation and signing of agreement(Acquisition of Social License to operate)	Acceptance of project and co-operation/participation from stakeholders (communities and government) leading to peaceful and timely execution of the project		√	√		√		√	
	Temporary Land use for base camp or use of an existing camp facility.	Third party agitations over compensations, land disputes, wrong stakeholder identification, leadership tussles, etc.	√		√		√		√	
Mobilization	Mobilization to Site (Transportation of equipment and personnel)	Increase in usage of roads and waterways with possibilities of accidents	√		√		√		√	
		Increase in usage and resultant Obstruction of /damage to existing roads	√		√		√		√	
		Nuisance (Noise, Vibration etc.) from machinery.	√		√		√		√	
	Recruitment of workers	Creation of opportunities for employment		√	√		√		√	
		Conflicts/ Third party agitations over employment issues	√		√		√		√	
		Increase of population in communities, thereby exerting	√		√		√		√	

Project phase	Project activity	Potential and Associated impacts	Adverse	Beneficial	Direct	Indirect	Localized	Widespread	Short term	Long term
		pressure on infrastructure								
	Site Preparation/Clearing of base camp	Exposure of workers and community members to poisonous snakes, bees, scorpions, other wildlife and contact with poisonous plants,	√		√		√		√	
		Loss of flora and fauna	√		√		√		√	
		Opportunities for contracting		√	√		√		√	
		Injuries during vegetation clearing.	√		√		√		√	
		Increased level of disease vectors (Mosquitoes, Tsetse fly, black fly etc.)	√		√		√		√	
Construction Phase	Building/Construction works of Base Camp - Workshop, - Generator house, - Sheet Fencing, - Plumbing, - Electrification, - Communication mast,Recreation etc.	Increase in Noise level	√		√		√		√	
		Increase in Financial flow resulting in: social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon	√		√		√		√	

Project phase	**Project activity**	**Potential and Associated impacts**	**Adverse**	**Beneficial**	**Direct**	**Indirect**	**Localized**	**Widespread**	**Short term**	**Long term**
		associated with temporary labor contracts, etc.								
		Increased financial flow due to compensations leading to improved standard of living		√	√		√		√	
	Waste generation-Construction: (Solids/liquid/gaseous) Wood chippings, cement bags, PVC pipes, paint, lubricants, fencing sheets off cuts, exhaust from cranes/heavy equipment, domestic waste, plumbing accessories, medical waste etc.	Nuisance noise, dust, emissions, lighting and contamination of soil	√		√		√		√	
	Accommodation of workers	Increase in financial flow resulting in: social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts, etc.	√		√		√		√	
		Opportunities for contracting, supply of food and other supplies		√	√		√		√	
		Third party agitation over indiscriminate littering of waste	√		√		√		√	
Operation	Survey line cutting	Destruction of vegetation resulting in loss/alteration of	√		√		√		√	

Project phase	**Project activity**	**Potential and Associated impacts**	**Adverse**	**Beneficial**	**Direct**	**Indirect**	**Localized**	**Widespread**	**Short term**	**Long term**
		wildlife habitat, medicinal, economic and food materials and reduction of biodiversity								
		Increased access for hunting and logging	√		√		√		√	
		Possibility of lines cutting across sensitive locations, property, sacred places, public utilities	√		√		√		√	
		Third party agitation over damage to property, encroachment and compensations	√		√		√		√	
	Drilling of shot holes	Contamination of ground and surface water	√		√		√		√	
		Potential for the shot holes causing accidents (trips and falls)	√		√		√		√	
	Shooting and Recording	Increase in nuisance noise from explosives	√		√		√		√	
		Vibrations resulting in cracking of structures	√		√		√		√	
		Scaring away /Loss of wildlife	√		√		√		√	
		Potential for accidents during hole shooting	√		√		√		√	
	Repairs and maintenance: (Welding, motor vehicle repairs, maintenance of facilities and servicing in workshop)	Generation of high intensity welding flash, fumes and noise from grinders	√		√		√		√	
		Burns and injuries	√		√		√		√	

Project phase	Project activity	Potential and Associated impacts	Adverse	Beneficial	Direct	Indirect	Localized	Widespread	Short term	Long term
		from welding sparks/injuries from other maintenance activities								
Decommissioning	- Repair of damaged roads - Removal of structures, Restoration of site	Increased opportunity for employment and contracting resulting in increased income level.		√	√		√		√	

5.4: Impact Identification and Evaluation

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 (Fig. 5.1):

- Impact identification
- Impact qualification
- Impact rating
- Impact description

5.4.1: Impact Identification

The objective of impact identification is to account for the entire potential and associated bio-physical, social and health impacts making sure that both significant and insignificant impacts are accounted for. The anticipated impacts were determined based on the interaction between project activities and environmental sensitivities. These impacts include but not limited to the following:

- Noise and vibrations.
- Effects on Ecosystems.
- Effects on Socio-economics
- Effects on People's Health

The ISO14001 requires identification, evaluation and registration of environmental aspects associated with SPDC's activities. SPDC's HSE MS is the tool for achieving ISO 14001 requirement, and this EIA report is a component of the HSE-MS. We identified impacts associated with activities of the project through many sources of documentation including:

- FMEnv approved Environmental Impact Assessment for similar projects e.g. Agbada 4D Seismic Data Acquisition Project, 2010.
- Procedure for Evaluation and Registration of Environmental Aspects, HSE P-04.
- Accompanying Guidelines for SPDC EIA Process, Report Review, SPDC 2004-0002713 Vol iv, 2004

The identified potential impacts during the different phases of the proposed project are listed in Table 5.1.

Table 5.2: Checklist of associated and potential impacts of the proposed project

Project phase	**Project activity**	**Potential and Associated impacts**
Pre-mobilization Phase	• Permitting via consultation and signing of agreement(Acquisition of Social License to operate)	• Acceptance of project and co-operation/participation from stakeholders (communities and government) leading to peaceful and timely execution of the project
	• Temporary Land use for base camp or use of an existing camp facility.	Third party agitations over compensations, land disputes, wrong stakeholder identification, leadership tussles etc.
Mobilization Phase	• Mobilization to Site (Transportation of equipment and personnel)	• Increase in usage of roads and waterways with possibilities of accidents • Increase in usage of roads and waterways with possibilities of accidents • Increase in usage and resultant Obstruction of /damage to existing roads • Nuisance (Noise, Vibration etc.) from machinery.
	Recruitment of workers	• Creation of opportunities for employment • Conflicts/ Third party agitations over employment issues • Increase of population in communities, thereby exerting pressure on infrastructure
	Site Preparation/ Clearing of base camp	• Exposure of workers and community members to poisonous snakes, bees, scorpions, other wildlife and contact with poisonous plants • Loss of flora and fauna • Opportunities for employment • Injuries during vegetation clearing. • Increased level of disease vectors (Mosquitoes, tse- tse fly, black fly etc.)
Construction Phase	Building/Construction works of Base Camp - Workshop, - Generator house, - Sheet Fencing, - Plumbing, - Electrification, - Communication mast,	• Increase in Noise level • Increase in Financial flow resulting in: social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts etc.

Project phase	Project activity	Potential and Associated impacts
	Recreation etc.	
	Building/Construction works of Base Camp	• Increased financial flow due to compensations leading to improved standard of living • Food insecurity due to migration of farm labour to construction work
	Waste generation: (Solids/liquid/gaseous) Wood chippings, cement bags, PVC pipes, paint, lubricants, fencing sheets off cuts, exhaust from cranes/heavy equipment, domestic waste, plumbing accessories, medical waste etc.	• Nuisance noise, dust, emissions, lighting and contamination of soil
	Accommodation of workers	• Increase in Financial flow resulting in: social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts etc. • Opportunities for contracting, supply of food and other supplies • Third party agitation over indiscriminate littering of waste
Operations Phase (Survey Activities)	Survey line cutting	• Destruction of vegetation resulting in loss/alteration of wildlife habitat, medicinal, economic and food materials and reduction of biodiversity • Increased access for hunting and logging • Possibility of lines cutting across sensitive locations, property, sacred places, public utilities • Third party agitation over damage to property, encroachment and compensations
	Drilling of shot holes	• Contamination of ground and surface water • Potential for the shot holes causing accidents (trips and falls)
	Shooting and Recording	• Increase in nuisance noise from explosives • Vibrations resulting in cracking of structures

Project phase	Project activity	Potential and Associated impacts
		• Scaring away /Loss of wildlife • Potential for accidents during hole shooting
	Repairs and maintenance: (Welding, motor vehicle repairs, maintenance of facilities and servicing in workshop)	• Generation of high intensity welding flash, fumes and noise from grinders • Burns and injuries from welding sparks/injuries from other maintenance activities
Decommissioning Phase	- Repair of damaged roads - Removal of structures - Restoration of site	• Increased opportunity for employment and contracting resulting in increased income level.

5.4.2: Impact Qualification

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

- Positive or negative
- Short-term or long-term
- Reversible or irreversible
- Direct or indirect

Negative impacts are those that adversely affect the biophysical, health and social environments while positive impacts are those, which enhance the quality of the environment. 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. By reversible/irreversible, is meant whether the environment can either revert to previous conditions or remain permanent when the activity causing the impact is terminated.

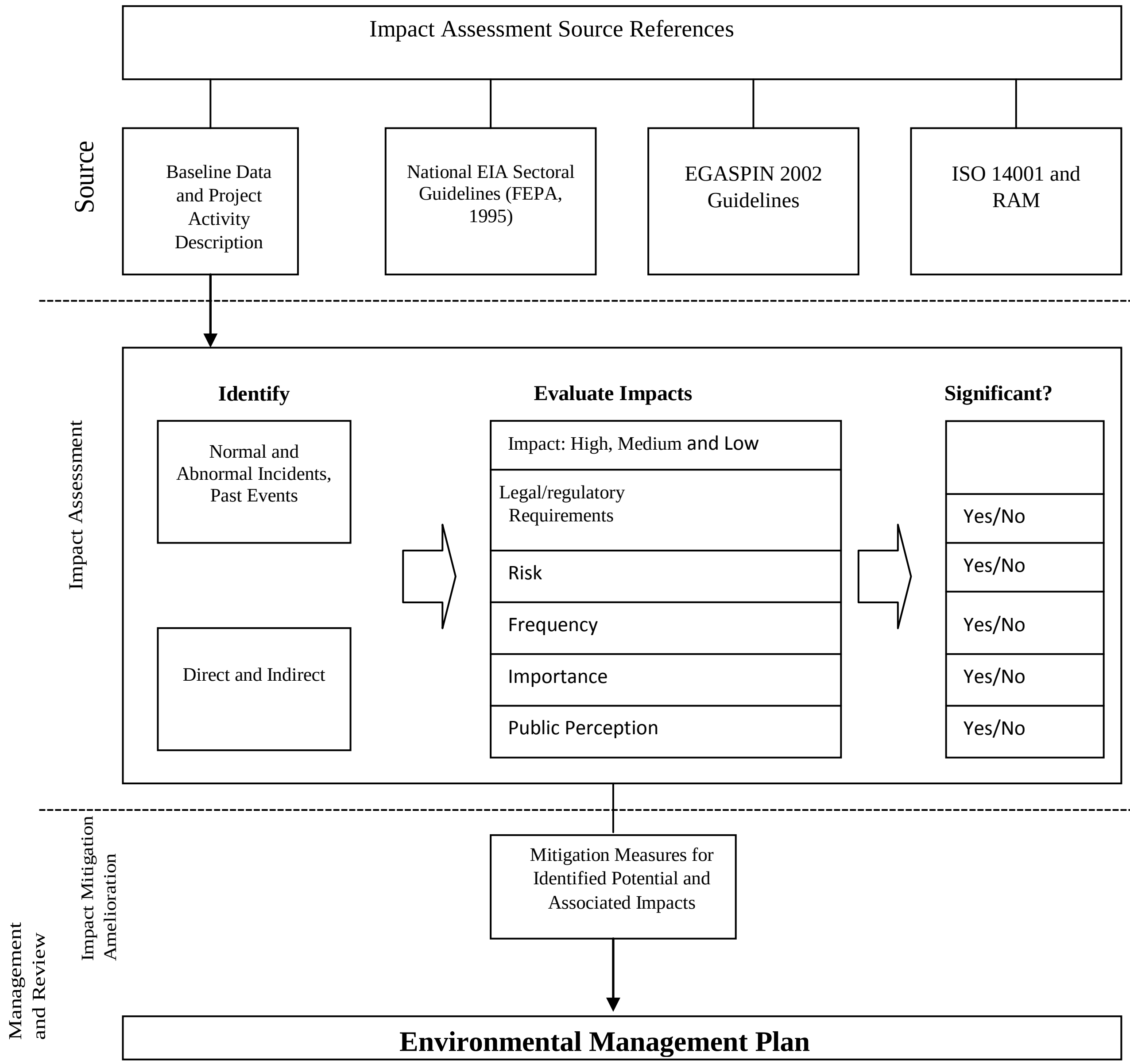


Fig. 5.1: Approach to Impact Assessment

5.5: Risk Assessment for Environmental Consequences

Risk (R) – What is risk/hazard rating based on Risk Assessment Matrix (RAM) (Table 5.3 and Table 5.4). The risks/hazards associated with the project were rated as follows:

1= Low risk
3 = Medium/intermediate risk
5 = High risk

The severity of risks/hazards was further defined as in Table 5.3 and Table 5.4.

Table 5.3: Risk Assessment Matrix

Consequence		**Increasing Probability**				
		A	**B**	**C**	**D**	**E**
Severity	Environment	Never heard of incident in industry	Incident has occurred in oil industry	Incident has occurred in SPDC	Happens several times per year in SPDC	Happens several times per year in District
0	No effect					
1	Slight effect		**Low**			
2	Minor effect		**Risk**			
3	Localized effect			**Medium**		
4	Major effect			**Risk**	**High**	

Table 5.4: Further definition of consequence – severity rating for risk matrix

Severity	**Potential Impact**	**Definition**
0	Zero effect	No environmental damage. No change in the environment. No financial consequences.
1	Slight effect	Local environmental damage within the fence and within systems. Negligible financial consequences.
2	Minor effect	Contamination, damage sufficiently large to affect the environment. Single exceedance of statutory or prescribed criteria, single complaint. No permanent effect on the environment
3	Localized effect	Limited loss of discharges of known toxicity. Repeated exceedance of statutory or prescribed limit. Affecting neighborhood
4	Major effect	Severe environmental damage. The company is required to take extensive measures to restore the contaminated environment to its original state. Extended exceedance of statutory or prescribed limits
5	Massive effect	Persistent severe environmental damage or severe nuisance extending over a large area. In terms of commercial or recreational use or nature conservancy, a major economic loss for the company. Constant high exceedance of statutory or prescribed limits.

Source: SIEP (1996)

5.6: Impact Assessment Methodology

Stage one: Classification

The first stage involved in the assessment of impact is impact classification. Impacts are classified as follows:

- Adverse (-) or Beneficial (+) in nature,
- Short term < 3 months (S) or Long term > 3 months (L), and
- Reversible (R) or Irreversible (I).

Adverse impacts are those, which impact negatively on the environmental components while beneficial impacts are those that enhance the quality of the environment. 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. By reversible/irreversible, is meant whether the environment can either revert to previous conditions or remain permanent once the activity causing the impact is terminated.

Stage two: Significance

The second stage involves evaluation to determine whether or not the impact is significant. The criteria and weighting scale employed in evaluation are as follows:

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

The quantification scale of 0, 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.

- **Legal/Regulatory Requirements (L) – Is there a legal/regulatory requirement or a permit required?**
  - 0 = There is no legal/regulatory requirement
  - 3 = There is legal/regulatory requirement
  - 5 = There is a legal/regulatory requirement and permit required
- **Risk Factor (R) – What is the risk/hazard rating based on the Risk Assessment Matrix?**
  - 1 = Low risk
  - 3 = Intermediate risk
  - 5 = High risk

- **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)

- **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

- **Importance of affected environmental components and impacts (I) – What is the rating of importance based on consensus of opinions?**
  - 1 = Low
  - 3 = Medium
  - 5 = High

This approach 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 activities; and
- Projected duration of the impact of each project activity on various environmental components.

The frequency of occurrence of each impact was determined from historical records while the importance of affected environmental component was determined through consultation and consensus of opinions. The perception of the communities and the general public on each potential impact and its effects as reported in the various reports reviewed were determined through consultation with the communities and consensus of opinions of environmental professionals. The overall impact rating is determined as shown in Table 5.5. The potential and associated impacts of the project are presented in Table 5.6.

Table 5.5: Impact Value and Rating

Impact value	Cut off values	Impact Rating
L+R+F+I+P	<8	Low
L+R+F+I+P	≥8 but <15	Medium
L+R+F+I+P	≥15	**High**
F + I	≥6	
P	= 5	
Positive		**Positive**

Table 5.6: Potential and Associated Impacts of the proposed Adibawa-Gbaran 3D Seismic Reshoot Project

Project phase	Project activities	Description of Impact	Impact Qualification								Impact Quantification							
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
Premobilization	Permitting via consultation and signing of agreement(Acquisition of Social License to operate)	Acceptance of project and co-operation/participation from stakeholders (communities and government) leading to peaceful and timely execution of the project	√		√		√		√		-	-	-	-	-	-	-	P
	Temporary Land use for base camp or use of an existing camp facility.	Third party agitations over compensations, land disputes, wrong stakeholder identification, leadership tussles etc.		√	√		√		√		3	1	3	1	3	11	4	M
Mobilization	Mobilization to Site (Transportation of equipment and personnel)	Increase in usage of roads and waterways with possibilities of accidents		√	√		√		√		3	1	1	3	5	13	4	M

Project phase	Project activities	Description of Impact	Impact Qualification								Impact Quantification							
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
		Increase in usage and resultant Obstruction of /damage to existing roads		√	√		√		√		0	5	5	3	3	16	8	H
		Nuisance (Noise, Vibration etc.) from machinery.		√	√		√		√		3	1	1	3	3	11	4	M
	Recruitment of workers	Creation of opportunities for employment	√		√		√		√		-	-	-	-	-	-	-	P
		Conflicts/ Third party agitations over employment issues		√	√		√		√		0	3	3	3	3	12	6	M
		Increase of population in communities, thereby exerting pressure on infrastructure		√	√		√		√		0	3	3	3	3	12	6	M

Project phase	Project activities	Description of Impact	Impact Qualification								Impact Quantification							
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Site Preparation/Clearing of base camp	Exposure of workers and community members to poisonous snakes, bees, scorpions, other wildlife and contact with poisonous plants,		√	√		√		√		0	1	3	3	1	8	6	M
		Loss of flora and fauna		√	√		√		√		3	1	1	3	1	9	4	M
		Opportunities for contracting	√		√		√		√		-	-	-	-	-	-	-	P
		Injuries during vegetation clearing.		√	√		√		√		3	3	1	3	3	13	4	M
		Increased level of disease vectors (Mosquitoes, Tse tse fly, black fly etc.)		√	√		√		√		0	3	3	3	3	12	6	M

Project phase	**Project activities**	**Description of Impact**	**Impact Qualification**								**Impact Quantification**							
			Positive	**Negative**	**Direct**	**Indirect**	**Short term**	**Long term**	**Reversible**	**Irreversible**	**L**	**R**	**F**	**I**	**P**	**Total**	**F+I**	**Impact Rating**
Construction Phase	Building/Construction works of Base Camp - Workshop, - Generator house, - Sheet Fencing, - Plumbing, - Electrification, - Communication mast,Recreation etc.	Increase in Noise level		√	√		√		√		3	3	1	3	3	13	4	M
		Increase in Financial flow resulting in: social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor		√	√		√		√		0	5	1	5	5	16	6	H

Project phase	Project activities	Description of Impact	Impact Qualification								Impact Quantification							
			Positive	**Negative**	**Direct**	**Indirect**	**Short term**	**Long term**	**Reversible**	**Irreversible**	**L**	**R**	**F**	**I**	**P**	**Total**	**F+I**	**Impact Rating**
		contracts etc.																
		Increased financial flow due to compensations leading to improved standard of living	√		√		√		√		-	-	-	-	-	-	-	P
	Waste generation-Construction: (Solids/liquid/gaseous) Wood chippings, cement bags, PVC pipes, paint, lubricants, fencing sheets off cuts, exhaust from cranes/heavy equipment, domestic waste, plumbing accessories, medical waste etc.	Nuisance noise, dust, emissions, lighting and contamination of soil		√	√		√		√		3	3	1	3	3	13	4	M

Project phase	Project activities	Description of Impact	Impact Qualification								Impact Quantification							
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Accommodation of workers	Increase in Financial flow resulting in: social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts etc.		√	√		√		√		0	5	1	5	5	16	6	H
		Opportunities for contracting, supply of food and other supplies	√		√		√		√		-	-	-	-	-	-	-	P
		Third party agitation over indiscriminate littering of waste		√	√		√		√		0	3	1	3	3	10	4	M
Operation	Survey line cutting	Destruction of vegetation resulting		√	√		√		√		3	1	1	3	3	11	4	H

Project phase	Project activities	Description of Impact	Impact Qualification								Impact Quantification							
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
		in loss/alteration of wildlife habitat, medicinal, economic and food materials and reduction of biodiversity																
		Increased access for hunting and logging		√	√		√		√		0	3	1	3	3	10	4	M
		Possibility of lines cutting across sensitive locations, property, sacred places, public utilities		√	√		√		√		0	5	3	3	5	16	6	H
		Third party agitation over damage to property, encroachment and compensations		√	√		√		√		0	3	3	5	5	16	8	H
	Drilling of shot holes	Contamination of ground and surface		√	√		√		√		3	3	3	3	3	15	6	H

Project phase	**Project activities**	**Description of Impact**	**Impact Qualification**								**Impact Quantification**							
			Positive	**Negative**	**Direct**	**Indirect**	**Short term**	**Long term**	**Reversible**	**Irreversible**	**L**	**R**	**F**	**I**	**P**	**Total**	**F+I**	**Impact Rating**
		water																
		Potential for the shot holes causing accidents (trips and falls)		√	√			√		√	3	1	3	3	3	13	6	M
	Shooting and Recording	Increase in nuisance noise from explosives		√	√		√		√		3	1	3	3	3	13	6	M
		Vibrations resulting in cracking of structures		√	√		√		√		3	1	3	3	3	13	6	M
		Scaring away /Loss of wildlife		√	√		√		√		3	1	3	1	3	11	4	M
		Potential for accidents during hole shooting		√	√		√		√		3	1	3	3	3	13	6	M
	Repairs and maintenance: (Welding, motor	Generation of high intensity welding flash, fumes and		√	√		√		√		3	3	1	3	3	13	4	M

Project phase	**Project activities**	**Description of Impact**	**Impact Qualification**								**Impact Quantification**							
			Positive	**Negative**	**Direct**	**Indirect**	**Short term**	**Long term**	**Reversible**	**Irreversible**	**L**	**R**	**F**	**I**	**P**	**Total**	**F+I**	**Impact Rating**
	vehicle repairs, maintenance of facilities and servicing in workshop)	noise from grinders																
		Burns and injuries from welding sparks/injuries from other maintenance activities		√	√		√		√		0	3	1	3	3	10	4	M
Decommissioning	- Repair of damaged roads - Removal of structures, Restoration of site - Removal of machineries	Increased opportunity for employment and contracting resulting in increased income level.	√		√		√		√		-	-	-	-	-	-	-	P
		Nuisance noise, dust and emissions		√	√		√		√		0	3	1	3	3	10	4	M

5.7: Prediction and Analysis of Significant Impacts

The predictions of potential and associated impacts for this study employed the use of professional judgment with scientific justifications and experience from similar projects. The impact analyses for various environmental components are discussed in this subsection.

Premobilization phase

Acceptance of project and co-operation/participation from stakeholders (communities and government) leading to peaceful and timely execution of the project

The acceptance of the project and cooperation of relevant stakeholders has been rated as Positive and it will foster a great working relationship throughout the entire project. The project area spans six (6) Local Government Areas in Rivers and Bayelsa State (Sagbama, Kolokuma/Opokuma, Yenagoa, Ogbia (Bayelsa) and Ahoada West and Abua/Odua Local Government Areas) each with their own peculiarity. The proposed project is envisaged to provide jobs for different categories of persons both skilled and unskilled; boost local economies and enhance skills transfer etc. Shell Petroleum Development Company (SPDC) will continue to consult with all the relevant stakeholders concerned with or likely to be affected by the project throughout the project life cycle.

Third party agitations over compensations, land disputes, wrong stakeholder identification, leadership tussles

There is usually community agitations over compensations paid for acquired land in the Niger Delta. The execution of this project is unlikely to be different. This was rated as negative and medium impact.

Mobilization phase

Increase in usage of roads and waterways with possibilities of accidents

This increased road and water traffic involving transportation of personnel and equipment along the major waterways and roads can lead to localized disturbances to local commuters. Heavy duty trucks on roads and frequent movement of water crafts can generate waves which may endanger local fishermen or disrupts activities at the river banks. This increased voyage on water and road transportations has the possibilities of causing accidents. The impact was rated as Medium.

Increase in usage and resultant obstruction of /damage to existing roads

The increased road transportation especially movement of heavy trucks and machineries may lead to damage of existing road infrastructures. Some road infrastructures within these communities are narrow and used by artisan farmers, fishermen etc. About 1,500 personnel are expected during the Seismic operations and heavy trucks will be used to convey these personnel from one point to the other. The proposed project is likely to cause obstruction/damage to existing roads. The impact was there rated High.

Plate 5.1: Heavy duty trucks (Personnel carrier) that will ply the existing roads in the project area

Nuisance (Noise, Vibration etc.) from machinery

The ambient noise levels within the field were within FMEnv regulatory limits of 90dB(A). The significant factors considered in predicting the nuisance (noise and vibrations) include but not limited to the following:

- the sound power outputs from the equipment
- the periods of operation of the equipment,
- the distances of the noise sources to the sensitive receptors,
- the presence of screening barriers,
- the reflection of sound by surrounding surfaces, and
- wind speed and direction, as well as atmospheric and ground absorption characteristics.

The major sources of nuisance during the Mobilization phase aremachineries from heavy duty trucks during transportation of equipment and personnel. The sound output from truck engines and periods of operations of these trucks are potential sources of nuisance and rated Medium.

Creation of opportunities for employment

Employment is one area in which expectations are very high in the communities. Employment opportunities shall be extended to the communities by the contractor with due regards to the contract and bearing in mind the 60% community employment ratio that would be prescribed by the contract. The Gbaran 3D Seismic Reshoot Data Acquisition has potential to employ different categories of skilled and unskilled personnel because of the low skill development in relation to the project requirement. The creation of opportunities for employment was rated Positive.

Conflicts/ Third party agitations over employment issues

Due to the number of local governments and communities the Gbaran 3D Seismic Reshoot Data acquisition will be traversing, there is likelihood for conflict/third party agitation in some of these communities over employment quota. This conflict/third party agitation over employment is rated Medium.

Increase of population in communities, thereby exerting pressure on infrastructure

The increases in population in the communities are envisaged to be attributed to people seeking employment or trade. Others may be employees of the project who may take up residence in any of the host communities.Other categories of people who may move into the communities to take advantage of the Gbaran 3D Seismic Reshoot data Acquisition Project are contractors. This will lead to pressure on existing facilities and social infrastructure, housing, sanitation and health services. Considering that the state of infrastructure and facilities is already very poor, the impact will be very negative. More substandard houses may be built in response. There may even be a rise in anti-social activities.The structure of the population will be further skewed in favour of the youth as immigrants are likely to be young adults looking for ways of eking out a living. The impact is therefore rated as Medium.

Exposure of workers and community members to poisonous snakes, bees, scorpions, other wildlife and contact with poisonous plants

As part of the construction activities for site preparation and base camp, workers are exposed to different types of hazards depending on the vegetation ecotype these are activities are done. These vegetation ecotypes (secondary forest, primary forest, swamp forest etc.) are natural habitats for different flora and fauna. Previous studies around the Gbaran area suggest a large presence of poisonous snakes, bees, scorpions etc., which can harm workers. The impact was rated Medium due to SPDC is very familiar with the area as a result of her large footprint.

Loss of flora and fauna

During site preparation, the clearing of the base camp area and de-stumping using heavy duty machineries such as tractors, bulldozers, swamp boogies etc. may lead to the loss of economic plants, reduction of habitats for arboreal and infaunal species. These plants have different economic importance such as food, medicine, construction works etc. However, due to SPDC’s policy on biodiversity and her commitment to ensuring a safe environment, the company shall limit clearing to only areas needed. The impact was rated Low.

Opportunities for contracting

The implementation of the various phases of the proposed project require contracting and also hiring of some members of host communities, as required by the law of the Federal Government of Nigeria. Thus a source of livelihood and meaningful engagement and the attendant diversion from idleness and social vices are of benefit and should be enhanced. The impact was rated as a Positive impact.

Injuries during vegetation clearing

During site preparation, the clearing of the base camp area using heavy duty machineries such as tractors, bulldozers, swamp boogies etc., accidents may occur which will lead to injuries of workers on site. Shell Petroleum Development Company limited has policies and control measures in place to minimize work related accidents and injuries. Based on the aforementioned, the impact was rated **Medium.**

Increased level of disease vectors (Mosquitoes, Tse-tse fly, black fly etc.)

As part of the construction activities for site preparation and base camp, workers are exposed to different types of entomological hazards such as bees, tse-tse flies etc. These insects can bite workers during site clearing activities and lead to illnesses. The impact was therefore rated as Medium.

Construction Phase

Increase in Noise level

The ambient noise levels within the field were within FMEnv regulatory limits of 90dB(A). The significant factors considered in predicting the nuisance (noise and vibrations) include but not limited to the following:

- The sound power outputs from the equipment
- The periods of operation of the equipment,
- The distances of the noise sources to the sensitive receptors,
- The presence of screening barriers,
- The reflection of sound by surrounding surfaces, and
- Wind speed and direction, as well as atmospheric and ground absorption characteristics.

The major sources of Noise during the construction phase are construction equipment such as Excavators, generators etc. Typical noise levels for relevant construction equipment at 10m is presented in **Table 5.7.**The sound output from construction equipment is a potential source of noise levels during construction activities. The impact was rated Medium.

Table 5.7: Typical Noise Levels for relevant Construction Equipment*

S/N	Equipment Description	$L_{Aeq,}$ dB(A) @ 10 m	Remarks
1	Excavator	87	73 KW, 100% on-time
2	Trenching	78	52 KW, 100% on-time
3	Trench filling	80	46 KW, 60% on-time
4	Chain Saws	78 @ 15m	Usage (0.04) - % of the time equip. is operating at noisiest mode
5	Generator	78@ 15 m	Usage (0.4) - % of the time equip.

S/N	Equipment Description	$L_{Aeq,}$ dB(A) @ 10 m	Remarks
			is operating at nosiest mode

*Noise Control on Construction and Open Sites, BS 5228, Part 1, 1984.

** Noise in the Human Environment, Vol. 2, Environment Council of Alberta, Canada, 1979.

Increase in Financial flow resulting in: social vices, (drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts etc.

The increased cash flow in these communities may need to different social vices. These vices include but not limited to the following: Drug abuse, Commercial Sex Workers, exposure to HIV/AIDS etc.Inference from similar projects and expert judgments suggest that a large population of workers will be youth and are susceptible to this impact. The impact was rated High.

Increased financial flow due to compensations leading to improved standard of living

The influx of people and flurry of activities has the potential to increase buying and selling of consumer goods and lead to a boost in the local economy. This impact was described as direct, and rated as positive.

Food Insecurity due to migration of farm labour to construction:

The dominant livelihoods in the project communities are farming and fishing. Higher pay and ready income from the project could lead to migration of farm labour to the project. This could lead to food insecurity in the project communities. This impact described as negative and rated high.

Operation phase

Destruction of vegetation resulting in loss/alteration of wildlife habitat, medicinal, economic and food materials and reduction of biodiversity/Increased access for hunting and logging

The survey line cutting activities for the control, receiver and source lines shall be done manually with a machete which maylead to loss of economic trees and animals as the lines will cleared minimally for easy access. As a result, economic trees maybe lost and scaring wildlife that depends on them away. The impact was rated high. Similarly, the survey cutting activities may provide access to wildlife poachers. The impact was therefore rated Medium.

Contamination of ground and surface water

Overlying communities in the project area either obtain their water supplies from creeks and streams or from ground water based schemes. Boreholes schemes will normally obtain water from deeper horizons than the test holes that were put down for these studies and it may be safe to assume that groundwater obtained from them would be of better quality than that from the shallower test holes. Contamination may arise from the shot holes used for the seismic surveys but this is expected to be quite negligible. Increase in turbidity in surface water may also result from traverse lines that will criss-cross streams and creeks. This impact is rated as High.

Potential for the shot holes causing accidents (trips and falls)/ Potential for accidents during hole shooting

Shot points (shot positions) of the Gbaran 3D Seismic Reshoot Project shall be spaced at 50m intervals on the source lines. The drilling activity will involve clearing of shot points in some cases to a radius of about 1m. These holes are potential hazards in the area. Reptiles such as snakes can hibernate in these holes and bite workers in the field. Also, these shot holes can cause workers to trip and fall during operation activities (Plate 5.2). These impacts were rated as Medium.

Plate 5.2: Thumping shallow pattern holes (Removing debris)

Increase in nuisance noise from explosives/Vibrations resulting in cracking of structures

The noise levels in the study area were generally within the FMEnv limits of 90dB(A) for 8hours exposure. A shot hole of 1m depth at 2m away from the uphole survey hole would be thumped and used for energy source. A maximum of 200g explosives would be used as the source. These explosives are likely to cause noise and vibrations around the communities. These impacts were rated Medium.

Scaring away /Loss of wildlife

The noise from the explosives (200g max) used during the seismic survey has the potential to scare away wildlife. The forest reserves around the area especially the Nun River forest reserve play host to a variety of wildlife some of which are endemic (IUCN classification). Loud bangs from the explosives have the potential to scare these animals away. The impact was therefore rated as Medium.

Generation of high intensity welding flash, fumes and noise from grinders

Repairs and maintenance from servicing workshops especially during welding activities have the potential to cause noise disturbance and accidents. Welding fumes may enter the eyes and lead to discomfort. The impact is rated Medium due to sound HSSE work procedures in place.

Possibility of lines cutting across sensitive locations, property, sacred places, public utilities

There is a potential of coming across sacred areas, forest reserves, shrines etc. during the seismic data acquisition in the proposed project area. These sensitive areas are important components of each community's history. These areas are considered sacred and will be identified and avoided. The impact was there rated as High.

Decommissioning phase

Increased opportunity for employment and contracting resulting in increased income level

Employment is one area in which expectations are very high in the communities. Contracting services such as supplies, waste management, and recruitment etc; has the potential to increase the income levels and micro economies of these communities. The impact is therefore rated as Positive.

CHAPTER SIX
MITIGATION MEASURES

6.1: Introduction

The actions and measures that SPDC intend to take to reduce (or eliminate) significant negative impacts and promote positive Environmental, Social and Health impacts of the proposed project are presented in this chapter. These actions and measures are aimed at reducing the impacts to As Low As Reasonably Possible (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. Significant negative impacts are expected to be mitigated through effective implementation of Health, Safety and Environment (HSE) plans put in place during the different phases of the project.The mitigation measures proposed are in keeping with the following:

- Department of Petroleum Resources guidelines and standards;
- Environmental laws at national, regional and internal levels;
- FMEnv (formerly FEPA, 1991) regulations on oil and gas exploration and waste management;
- Bayelsa State Ministry of Environment policies;
- Rivers State Ministry of Environment policies;
- Best Available Technology for Sustainable Development;
- Social wellbeing and
- Concerns of stakeholders.

The following criteria were used to define mitigation measures for the identified associated and potential 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 possible 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 practical.

Table 6.1 presents a summary of the mitigation measures recommended to ameliorate all the significant associated and potential impacts identified for the Adibawa-Gbaran 3D Seismic Reshoot Project.

Table 6.1: Impact Mitigation Measures for the proposed Adibawa-Gbaran 3D Seismic Reshoot Project

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
Premobilization	Permitting via consultation and signing of agreement(Acquisition of Social License to operate)	Acceptance of project and co-operation/participation from stakeholders (communities and government) leading to peaceful and timely execution of the project	P	• Relevant stakeholders shall be identified • Early stakeholders' engagement sessions shall be held, with all the agreed issues properly documented and signed.	P
	Temporary Land use for base camp or use of an existing camp facility.	Third party agitations over compensations, land disputes, wrong stakeholder identification, leadership tussles etc.	M	• The relevant stakeholders/legacy issues shall be identified. • Consultations with stakeholders (Community, Govt., NGOs, CBOs etc.) shall be carried out	L
Mobilization	Mobilization to Site (Transportation of equipment and personnel)	Increase in usage of roads and waterways with possibilities of accidents	M	• Journey management shall be employed to limit the amount of traffic • Regular maintenance /checks of vehicles and boats shall be carried out • Swimming/Driving training and certification shall be conducted. • Compliance with speed limits shall be enforced • Warning signs shall be established where desirable	L
		Increase in usage and resultant Obstruction of /damage to existing roads	H	All earth roads damaged shall be restored to the original state	M
		Nuisance (Noise, Vibration etc.) from machinery.	M	Machinery with noise levels within acceptable limits (85 dB (A)) shall be used	L

Project phase	**Project activities**	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**
	Recruitment of workers	Creation of opportunities for employment	P	Savings and judicious use of income shall be encouraged	P
		Conflicts/ Third party agitations over employment issues	M	• At least 60% of the unskilled workforce shall be employed from the host communities • Prompt communication of employment policy to communities during various stakeholders engagement	L
		Increase of population in communities, thereby exerting pressure on infrastructure	M	• At least 60% of the unskilled workforce shall be employed from the host communities • Provide potable water and medical facilities to workers	L
	Site Preparation/Clearing of base camp	Exposure of workers and community members to poisonous snakes, bees, scorpions, other wildlife and contact with poisonous plants	M	• Provide and enforce usage of PPE by field workers. • First aid /Anti- venom shall be provided on site • Awareness shall be created among site workers and nearby communities on the likelihood of exposure to wildlife	L
		Loss of flora and fauna	M	Clearing should be limited to areas of operation	L
		Opportunities for contracting	P	At least 60% of the workforce shall be employed from the communities	P
		Injuries during vegetation clearing.	M	• Provide and enforce usage of PPE by field workers • First aid shall be provided on site	L

Project phase	**Project activities**	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**
				• Compliance with HSE procedures shall be enforced • Medevac procedure shall be provided.	
		Increased level of disease vectors (Mosquitoes, tse-tse fly, black fly etc.)	M	• Affected areas shall be drained to eliminate breeding sites of disease vectors • Area shall be fumigated to eliminate disease vectors • Adequate refuse management	L
Construction Phase	Building/Construction works of Base Camp - Workshop, - Generator house, - Sheet Fencing, - Plumbing, - Electrification, - Communication mast,Recreation etc.	Increase in Noise level	M	• SPDC HSE policy of wearing ear muffs/plug shall be applied in all construction sites • Site construction shall done within the shortest possible time • No night construction. • Machinery with noise levels within acceptable limits (85 dB (A)) shall be used	L
		Increase in Financial flow resulting in: social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts etc.	H	• Awareness campaigns on HIV/AIDS, drug and alcohol abuse shall be carried out. • Recreational facilities shall be provided at camp sites • SPDC alcohol and drug policy shall be implemented.	L
		Increased financial flow due to compensations leading to improved standard of living	P	• Adequate and prompt compensation shall be made • Savings and judicious use of income shall be encouraged	P

Project phase	**Project activities**	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**
		Food insecurity due to migration of farm labour to construction work	H	SPDC shall support agricultural activities to encourage farmers to continue in food production (improved seeds/seedlings and other crop & livestock production inputs, training and market information)	L
	Waste generation- Construction: (Solids/liquid/gaseous) Wood chippings, cement bags, PVC pipes, paint, lubricants, fencing sheets off cuts, exhaust from cranes/heavy equipment, domestic waste, plumbing accessories, medical waste etc.	Nuisance noise, dust, emissions, lighting and contamination of soil	M	• Machinery with noise levels within acceptable limits (85 dB (A)) shall be used. • Site construction shall be done within the shortest possible time • Ear mufflers shall be provided for generator engines with noise level above acceptable limits • SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction sites. • Sufficient separation distances shall be provided for sources of high energy sound to reduce noise levels. • Waste segregation, treatment and disposal in compliance with standards and procedures (Govt. approved site, etc).	L
	Accommodation of workers	Increase in Financial flow resulting in: social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts etc.	H	• Awareness campaigns on HIV/AIDS, drug and alcohol abuse shall be carried out. • Recreational facilities shall be provided at camp sites • SPDC alcohol and drug policy shall be implemented.	L

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
		Opportunities for contracting, supply of food and other supplies	P	Indigenous contractors shall be used	P
		Third party agitation over indiscriminate littering of waste	M	Awareness campaigns.	L
Operation	Survey line cutting	Destruction of vegetation resulting in loss/alteration of wildlife habitat, medicinal, economic and food materials and reduction of biodiversity	H	• Clearing shall be minimized and confined to the 1 meter width • Compensations shall be paid for loss of economic plants • Re-vegetation of cleared line in mangrove shall be undertaken after the project work where desirable	L
		Increased access for hunting and logging	M	• Awareness campaign of the adverse effects of hunting and logging shall be undertaken	L
		Possibility of lines cutting across sensitive locations, property, sacred places, public utilities	H	• Compensations shall be paid for certified damaged property • Wildlife reserves and sacred forests shall be identified and avoided. • Strict adherence to guidelines by contact personnel and survey crews	L
		Third party agitation over damage to property, encroachment and compensations	H	• The appropriate beneficiaries of damaged property shall be identified and the loss evaluated • Consultations with the relevant communities and property owners shall be carried out • Adequate and prompt compensation shall be made when liable	L
	Drilling of shot holes	Contamination of ground and surface water	H	• Pattern shot holes shall be used as much as possible	L

Project phase	**Project activities**	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**
				• Uphole location (single deep hole drilling) shall be spaced on 4 x 4 km grid across the prospect area	
		Potential for the shot holes causing accidents (trips and falls)	M	Awareness shall be created on the existence and locations of shot holes through appropriate markings/signs	L
	Shooting and Recording	Increase in nuisance noise from explosives	M	Sufficient separation distances shall be provided for detonation of explosives to reduce noise levels and vibration effects on structures.	L
		Vibrations resulting in cracking of structures	M	• Built up areas shall be avoided • Adherence to minimum shooting distances as in EGASPIN	L
		Scaring away /Loss of wildlife	M	Shooting and recording shall be carried out within the shortest time	L
		Potential for accidents during hole shooting	M	• Personnel handling explosives shall be licensed in line with 1967 Explosive Regulatory Act • Explosive handlers training with regard to seismic operations	L
	Repairs and maintenance: (Welding, motor vehicle repairs, maintenance of facilities and servicing in workshop)	Generation of high intensity welding flash, fumes and noise from grinders	M	• Awareness sessions on health risk and safety precautions of welding operations shall be carried out for workers • Use of Appropriate PPEs shall be enforced	L
		Burns and injuries from welding sparks/injuries from other maintenance activities	M	• Use of Appropriate PPEs • SPDC shall enforce the use of welders mask, ear muffs, jackets, gloves, boots and coveralls by welders during welding.	L

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
				• A site clinic and Medevac shall be provided	
Decommissioning	- Repair of damaged roads - Removal of structures, Restoration of site. - Removal of machineries	Increased opportunity for employment and contracting resulting in increased income level.	P	• Indigenous contractors shall be used • Site restoration shall be carried out at the end of the survey.	P
		Nuisance noise, dust and emissions	M	• Machinery with noise levels within acceptable limits (85 dB (A)) shall be used. • Ear mufflers shall be provided for generator engines with noise level above acceptable limits • SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction sites. • Sufficient separation distances shall be provided for sources of high energy sound to reduce noise levels. • Waste segregation, treatment and disposal in compliance with standards and procedures (Govt. approved site, etc).	L

CHAPTER SEVEN
ENVIRONMENTAL MANAGEMENT PLAN

7.1: Introduction

Environmental management is concerned with a planned and integrated programme aimed at ensuring that unforeseen and unidentified impacts of a proposed project are contained and brought to acceptable minimum levels. Environmental management provides confidence on the part of project planners that a reliable scheme has been put in place to deal with any contingency that may arise during all phases of the project development, from mobilization to abandonment.In keeping with SPDC's policy on the environment, considerations of environmental implications of this project began from feasibility study, conceptual design and will continue throughout the project life cycle.

Environmental management will be carried out in accordance with the provisions of ISO 14001, sections 4.3.2 to 4.3.4, which are reflected in SPDC HSE-MS Manual. The HSE-MS addresses the overall approach adopted for management of HSE risks through the project development phases by the project management team. HSE-MS document provides central guidance and co-ordination for project-wide documents - work procedures, standards, work practices, etc., and demonstrates how the Hazards and Effects Management Process (HEMP) will be applied on the project such that HSE risks are kept As Low As Reasonably Practicable (ALARP). Good environmental management, which is part of SPDC's HSE-MS goals, has the following long term objectives:

- Ensure compliance with Legislations and Company policy;
- Achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- Provide strategy for overall planning, operation, audit and review;
- Enable project planners establish environmental priorities.

To provide assurance that the risk management and control procedures identified are implemented, a comprehensive EMP was developed (Table 7.2).

7.2: SPDC's Corporate HSE Programme

It is the policy of Shell companies to conduct their activities in such a way as to take foremost account of the health and safety of all their employees and other persons, and to give proper regards to the conservation of the environment. In implementing this policy, Shell companies not only comply with the requirements of the relevant legislations but promote, in an appropriate manner, measures for the protection of health, safety, environment and the security of all who may be involved directly or indirectly with their activities.The Environmental Management activities initiated by SPDC are intended to implement the above policy and the policy will be applied to all stages of the decommissioning. The projects' HSE-MS is fully aligned to SPDC's corporate HSE programs.

7.3: Monitoring Objectives

The following monitoring objectives are established:

- to create local data bank on the impacts of project activities on the environment, for future development of predictive models;
- to monitor emissions and discharges at all stages of project development to ensure they meet national standards;
- to determine whether environmental changes are results of development or a result of natural variations;
- to determine the effectiveness of the mitigation measures;
- to determine long term impacts.
- to determine the duration of return to normalcy of the environmental components of the project area .

7.4: Resourcing

Shell Petroleum Development Company (SPDC) considers environmental management as an important aspect of project procedures. Consequently, in any project for which project management team is set up, an environmental specialist always forms an integral part of the team. In this project, an environmental focal point has been appointed to liaise between the engineering project managers and the environmental specialist, consultants as well as advises on all environmental issues in conformity with SPDC's HSE policy. Shell Petroleum Development Company (SPDC) recognizes the need to use external environmental consultants to supplement in-house environmental specialists. To this end, the environmental consultants will continue to provide expert advice to the SPDC environmental managers throughout the Life cycle of this project.

7.5: Environmental Audits

Shell Petroleum Development Company (SPDC) has instituted audit scheme, as part of its programme on environmental management. The scheme is aimed at verifying the effectiveness of environmental control and highlighting areas of weakness in environmental management. The audits are focused on areas of project perceived as having the highest environmental impacts. They are carried out annually and reviewed by SPDC environmental audit committee. It is recognized that to be truly effective, these audits need to be conducted within the overall structured management systems. The structured approach is aimed at disseminating information, providing advice and assistance in its application, and at corporate assurance of performance in meeting the environmental requirement/targets.

7.6: Responsibilities and Training

Within SPDC, environmental protection, like safety, is a line responsibility for which staff, at all levels, have accountabilities. An environmental specialist assists the line management with advice on environmental matters, from an expert point of view. However, responsibility and accountability is clearly defined, from senior management who allocate resources and monitor environmental performance to individual contractors who have responsibility for environmentally sound practices in their workplace. All staff will be made aware of their responsibilities through induction and training courses as outlined in the projects’ HSE-MS document. In addition, procedures, guidelines and notices will advise staff on how to respond in the event of an environmental emergency. The Shell Corporate Environment Department is responsible for monitoring and auditing the environmental activities of this project.

7.7: Waste Management

The Waste Management Plan includes procedures for safe handling, control and disposal of generated waste in accordance with the SPDC procedure. Wastes emanating from operational activities are mainly food wastes, garbage, shrubs/vegetation, waste papers etc. These wastes are handled in compliance with the Petroleum (Drilling & Productions) Regulations, 1969, Sections 25, 36 49 and (b), (c) and (d), which stipulate *inter alia* that:

The licensee or lessee shall adopt all practical precautions, including the provision of up-to-date equipment to prevent the pollution of inland waters, rivers, creeks, water courses, the territorial waters of Nigeria or the high seas by oil, mud or other fluids or substances which might contaminate the water or marine life, and where any such pollution occurs or has occurred, shall take prompt steps to control and, if possible, end it."

The waste management strategy to be adopted in the proposed project has been highlighted in Section 3.8 of chapter three.

7.8: SPDC's Corporate HSE Programme

It is the policy of Shell companies to conduct their activities in such a way as to take foremost account of the health and safety of all their employees and other persons, and to give proper regards to the conservation of the environment. In implementing this policy, Shell companies not only comply with the requirements of the relevant legislations but promote, in an appropriate manner, measures for the protection of health, safety, environment and the security of all who may be involved directly or indirectly with their activities.The Environmental Management activities initiated by SPDC are intended to implement the above policy and the policy will be applied to all stages of this project from feasibility to decommissioning. The HSE-MS is fully aligned to SPDC's corporate HSE programs.

7.9: Monitoring Objectives

The following monitoring objectives are established:

- To create local data bank on the impacts of project activities on the aquatic ecosystem, for future development of predictive models;
- To compare effluent quality and quantity with design specifications, impact predictions and regulatory standards;

- To monitor emissions and discharges at all stages of project development to ensure they meet national standards;
- To determine whether environmental changes are results of development or a result of natural variations;
- To determine the effectiveness of the mitigation measures;
- To determine long term impacts.
- To determine the duration of return to normalcy of the environmental components of the project area.

Table 7.1: Environmental Monitoring Plan for the proposed Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition Project

Environmental component	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	**Requirements/ Limits**	**Parameters to be monitored**	**Sampling Location**	**Frequency**	**Data collection method**
Groundwater	FMEnv Standards for water quality: Drinking water	p H: 6.5 – 8.5 TDS: 500mg/l TSS: >10mg/l Turbidity: 1mg/l Fe: 1mg/l Cu: 1mg/l Zn: 5mg/l Mn: 0.05 - 0.5mg/l Cr: 0.05mg/l Cd: 0.01mg/l Coliform: 0MPN/100ml	Physico-chemical parameters (pH, Temperature, THC, Cl^-, Turbidity, TDS, TSS, Oil in water HCO_3^-, Chloride (Cl^-) SO_4^{2-}, NO_3^-, NH_4^+, Temperature, Dissolved oxygen TPH, PAH, BTEX, Heavy metals and other metals (Ni, Zn, Cu, Fe, Mn, Cd, As, Ba, Pb, Ca, Na, Mg, Co, Ag, Cr, Na, K, Hg, V Total Heterotrophic Bacteria, Total fungi, Hydrocarbon utilizing Bacteria, Hydrocarbon utilizing Fungi, Total Coliforms, Faecal coliforms	All borehole locations within the Base camp area	Weekly/Monthly	Sample collection and analysis in an external approved laboratory.
Air Quality	FMEnv green book, Table 3.4 National Ambient Air Quality Standards	Daily average mean (µg/m^3) CO =11.4 SO_2 = 26 NO_2 = 75 – 113 Total SPM = 250 VOC = 160	Particulates, H_2S, heavy and trace metals in ambient air	Emission point around the Base camp	Weekly	Normal operations flow meter is read daily.

Environmental component	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	**Requirements/ Limits**	**Parameters to be monitored**	**Sampling Location**	**Frequency**	**Data collection method**
Wildlife	Food and Agricultural Organization : Conservation Agriculture (2007)	25% Forest cover	Noise levels, Records of wildlife kill, or sighting of wildlife	Around the vegetation ecotypes in the project area	Biannually during construction and Monthly thereafter.	Standard methods as recommended by FMEnv, WHO, World Bank, UNEP and DPR; Direct Observation
Local population			Actual population density, population distribution and number of emerging squatter settlements	Communities and settlements around the project area	Peak of construction activities and one year thereafter	Field surveys and determination of population spread
Natural resources	Food and Agricultural Organization: Land resources (Agenda 21)		Actual land area taken or vegetation cut	Communities and settlements within the project area	Yearly	Field surveys to ensure no encroachment into new lands

Environmental component	**ASSOCIATED LIMITATIONS**		**MONITORING PROGRAMME**			
	Regulation/ Standard	**Requirements/ Limits**	**Parameters to be monitored**	**Sampling Location**	**Frequency**	**Data collection method**
Community health and safety	National/ WHO standards IFC/World Bank	Available safe water/ pers/day (< 20l/ pers/day) Access to safe water (Rural communities (65%) Urban Access to latrine (63% (National average, 2003) Access to improved sanitation (National average, 30-48%) Malaria prevalence (21.0% national average (MICS4) Prevalence of fever in under 5s (National Av. 10.3% (NDHS,2003) Infant mortality rate (11.3/ 1000 live births National target by 2011 (NEEDS 2)	• % access to safe water (new water provision) • faecal coliforms count in water • % use of insecticide treated nets, • % children under five with high fever, • % children under five treated with proper anti-malaria, diarrhoea prevalence • No of health awareness sessions • Waste management • Sexual health prevalence	Communities/ communities water sources Base camp	Monthly	• Field survey • Secondary clinic data collation

Environmental component	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
Healthcare infrastructure		Population/ doctor (3473 (National target by 2005, Vision 2010) Population/ nurse (467 (National target by 2005, Vision 2010) Population/ hospital bed (747 (National target by 2005, Vision 2010) Births attended by professionals (27% (Nat. Av. NDHS 2008) Access to healthcare (97% (National target in Vision 2010) Immunization (25% DPT 3 (Nat Av.) & 70% (National target for 2007) coverage	Population increase, access to healthcare, health personnel to population ratio, health service coverage index, evidence of support for community healthcare facilities, Waste management	Project site clinic Communities/settlements in the zone of influence	Annually	Demographic and health surveys.

Table 7.2: Environmental Management Plan for the proposed Adibawa-Gbaran 3D Reshoot Seismic Acquisition Project

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Action party	Timing	Parameters for monitoring	Monitoring frequency	Responsible party
Premobilization	Permitting via consultation and signing of agreement (Acquisition of Social License to operate)	Community concerns due to conflicting notions and acceptance of Project	P	• Relevant stakeholders shall be identified. • Early stakeholders' engagement sessions shall be held, with all the agreed issues properly documented and signed. • Signing of MoU agreements with the community/stakeholders	P	SPDC Seismic Acquisition Team	Pre-mobilization	Stakeholders' engagement reports/agreement	Once prior to mobilisation	FMEnv/ SPDC
	Temporary Land use for base camp or use of an existing camp facility.	Third party agitations over compensations, land disputes, wrong stakeholder identification, leadership tussles etc.	M	• The relevant stakeholders/legacy issues shall be identified. • Consultations with stakeholders (Community, Govt., NGOs, CBOs etc.) shall be carried out	L	SPDC Seismic Acquisition Team	Pre-mobilization	Community /Other stakeholder engagement reports	Monthly	FMEnv/ SPDC
Mobilization	Mobilization to Site (Transportation of equipment and personnel)	Increase in usage of roads and waterways with possibilities of accidents	M	• An appropriate traffic management plan shall be employed to limit the amount of traffic • Regular maintenance /checks of vehicles and boats shall be carried out • Swimming/Driving training and certification shall be conducted. • Compliance with speed limits shall be enforced • Warning signs shall be established where desirable	L	SPDC Seismic Acquisition Team	Pre- and During mobilization to site	Inventory of approved journey management forms Basic swimming certification Vehicle Premob reports/permits IVMS checks/Reports	Daily/Weekly/Monthly	FMEnv/ SPDC
		Increase in usage and resultant Obstruction of	H	All earth roads damaged shall be restored to the original state	M	SPDC Seismic Acquisiti	During tenure of the project	Site inspection /community engagement	Monthly	FMEnv/ SPDC

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Action party	Timing	Parameters for monitoring	Monitoring frequency	Responsible party
		/damage to existing roads				on Team		reports		
		Nuisance (Noise, Vibration etc.) from machinery.	M	• Machinery with noise levels within acceptable limits (85 dB (A)) shall be used. • Padding of machineries to limit their contact with the floor to further reduce noise. • Regular servicing/greasing of machineries to decrease noise. • Appropriate use of PPEs shall be enforced.	L	SPDC Seismic Acquisition Team	Monthly during mobilization	Equipment maintenance report Camp site Noise mapping Changes in air quality parameters	Weekly	FMEnv/ SPDC
	Recruitment of workers	Creation of opportunities for employment	P	Savings and judicious use of income shall be encouraged	P	SPDC Seismic Acquisition Team	Prior to mobilization and during operations	Employment records and community Engagement reports	Prior to mobilization and during operations	FMEnv/ SPDC
		Conflicts/ Third party agitations over employment issues	M	• At least 60% of the unskilled workforce shall be employed from the host communities • Prompt communication of employment policy to communities during various stakeholders engagement	L	SPDC Seismic Acquisition Team	Prior to mobilization and during operations Pre-Recruitment and during operations	Employment records and community Engagement reports	Prior to mobilization and during operations	FMEnv/ SPDC
		Increase of population in communities, thereby exerting pressure on infrastructure	M	• At least 60% of the unskilled workforce shall be employed from the host communities • Provide potable water and medical facilities to workers	L	SPDC Seismic Acquisition Team	During recruitment	Community /Other stakeholder engagement reports	Quarterly	FMEnv/ SPDC

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Action party	Timing	Parameters for monitoring	Monitoring frequency	Responsible party
	Site Preparation/Clearing of base camp	Exposure of workers and community members to poisonous snakes, bees, scorpions, other wildlife and contact with poisonous plants	M	• Provide and enforce usage of PPE by field workers. • First aid /Anti-venom shall be provided on site • Awareness shall be created among site workers and nearby communities on the likelihood of exposure to wildlife	L	SPDC Seismic Acquisition Team	During site preparation	Pep Talks/tool box meetings Health Records for all the workforce Induction Report	Weekly	FMEnv/ SPDC
		Loss of flora and fauna	M	Clearing should be limited to areas of operation	L	SPDC Seismic Acquisition Team	During site preparation	Inspection records	Monthly	FMEnv/ SPDC
		Opportunities for contracting	P	At least 60% of the workforce shall be employed from the communities	P	SPDC Seismic Acquisition Team	Pre-Recruitment	Community /Other stakeholder engagement reports	Weekly	FMEnv/ SPDC
		Injuries during vegetation clearing.	M	• Provide and enforce usage of PPE by field workers • First aid shall be provided on site • Compliance with HSE procedures shall be enforced • Medevac procedure shall be provided.	L	SPDC Seismic Acquisition Team	During site preparation	Incidents reports Record of PPEs issued to workforce Health/first aid reports	Weekly	FMEnv/ SPDC
		Increased level of disease vectors (Mosquitoes, tse-tse fly, black fly etc.)	M	• Affected areas shall be drained to eliminate breeding sites of disease vectors • Area shall be fumigated to eliminate disease vectors • Adequate refuse management	L	SPDC Seismic Acquisition Team	During site preparation	Sanitary and site inspection reports	Weekly	FMEnv/ SPDC
		Waste generated from site clearing	M	• Waste segregation, treatment and	L	SPDC Seismic	During site preparation	Site inspection report	Weekly/ Monthly	FMEnv/ SPDC

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Action party	Timing	Parameters for monitoring	Monitoring frequency	Responsible party
				disposal in compliance with standards and procedures (Govt. approved site, etc.)		Acquisition Team		Compliance report Waste generated/disposal management Data		
Construction Phase	Building/Construction works of Base Camp: -Workshop, -Generator house, -Sheet Fencing, -Plumbing, -Electrification, -Communication mast, Recreation etc.	Increase in Noise level	M	• SPDC HSE policy of wearing ear muffs/plug shall be applied in all construction sites • Site construction shall done within the shortest possible time • No night construction. • Machinery with noise levels within acceptable limits (85 dB (A)) shall be used	L	SPDC Seismic Acquisition Team	During construction	Compliance monitoring report Site inspection report	Weekly	FMEnv/ SPDC
		Increase in Financial flow resulting in social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon associated with temporary labor contracts etc.	H	• Awareness campaigns on HIV/AIDS, drug and alcohol abuse shall be carried out. • SPDC alcohol and drug policy shall be implemented. • Skills transfer shall be encouraged.	L	SPDC Seismic Acquisition Team	During construction	Community engagement report Health Report	Weekly/ Monthly	FMEnv/ SPDC
		Increased financial flow due to compensations leading to improved standard of living	P	• Adequate and prompt compensation shall be made • Savings and judicious use of income shall be encouraged	P	SPDC Seismic Acquisition Team	Prior to mobilization	Community /Other stakeholder engagement reports	Prior to mobilization	FMEnv/ SPDC

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Action party	Timing	Parameters for monitoring	Monitoring frequency	Responsible party
	Waste generation-Construction: (Solids/liquid/gaseous) Wood chippings, cement bags, PVC pipes, paint, lubricants, fencing sheets off cuts, exhaust from cranes/heavy equipment, domestic waste, plumbing accessories, medical waste etc.	Nuisance noise, dust, emissions, lighting and contamination of soil	M	• Machinery with noise levels within acceptable limits (85 dB (A)) shall be used. • Site construction shall be done within the shortest possible time • Ear mufflers shall be provided for generator engines with noise level above acceptable limits • SPDC HSE policy of wearing ear muffs/ plugs, noise masks and other appropriate PPEs shall be applied in all construction sites. • Sufficient separation distances shall be provided for sources of high energy sound to reduce noise levels. • Waste segregation, treatment and disposal in compliance with standards and procedures (Govt. approved site, etc.)	L	SPDC Seismic Acquisition Team	Daily/Weekly/ Monthly	Maintenance log of equipment Site inspection report Compliance report Waste generated/disposal management Data	Weekly/ Monthly	FMEnv/ SPDC
	Accommodation of workers	Increase in Financial flow resulting in: social vices,(drug abuse, CSWs, exposure to HIV/AIDS, unwanted pregnancies, truancy, violence), boom and bust phenomenon	H	• Awareness campaigns on HIV/AIDS, drug and alcohol abuse shall be carried out. • Recreational facilities shall be provided at camp sites • SPDC alcohol and drug policy shall be	L	SPDC Seismic Acquisition Team	During construction	Community engagement report Health Report	Weekly/ Monthly	FMEnv/ SPDC

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Action party	Timing	Parameters for monitoring	Monitoring frequency	Responsible party
		associated with temporary labor contracts etc.		implemented.						
		Opportunities for contracting, supply of food and other supplies	P	Indigenous contractors shall be used	P	SPDC Seismic Acquisition Team	During construction	Community engagement report	Weekly	FMEnv/ SPDC
		Third party agitation over indiscriminate littering of waste	M	Awareness campaigns.	L	SPDC Seismic Acquisition Team	During survey	Community engagement reports	Monthly	FMEnv/ SPDC
Operation	Survey line cutting	Destruction of vegetation resulting in loss/alteration of wildlife habitat, medicinal, economic and food materials and reduction of biodiversity	H	• Clearing shall be minimized and confined to the 1 meter width • Compensations shall be paid for loss of economic plants • Re-vegetation of cleared line in mangrove shall be undertaken after the project work where desirable	L	SPDC Seismic Acquisition Team	During survey cutting	Site Inspection report and community engagement and assessment report. Evidence of payment for the loss of economic plants to the community members	Daily/ Weekly/ Monthly	FMEnv/ SPDC
		Increased access for hunting and logging	M	• Awareness campaign of the adverse effects of hunting and logging shall be undertaken	L	SPDC Seismic Acquisition Team	During survey cutting	Site report and community engagement report	Monthly	FMEnv/ SPDC
		Possibility of lines cutting across sensitive locations, property, sacred places, public utilities	H	• Compensations shall be paid for certified damaged property • Wildlife reserves and sacred forests shall be identified and avoided. • Strict adherence to guidelines by contact personnel and survey crews	L	SPDC Seismic Acquisition Team	SPDC Seismic Acquisition Team	After survey cutting	Evidence of compensation for damaged property to community members affected. Community engagement report	FMEnv/ SPDC

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Action party	Timing	Parameters for monitoring	Monitoring frequency	Responsible party
		Third party agitation over damage to property, encroachment and compensations	H	• The appropriate beneficiaries of damaged property shall be identified and the loss evaluated • Consultations with the relevant communities and property owners shall be carried out • Adequate and prompt compensation shall be made when liable	L	SPDC Seismic Acquisition Team	SPDC Seismic Acquisition Team	After survey cutting	Site report and community engagement report	FMEnv/SPDC
	Drilling of shot holes	Contamination of ground and surface water	H	• Pattern shot holes shall be used as much as possible • Uphole location (single deep hole drilling) shall be spaced on 4 x 4 km grid across the prospect area	L	SPDC Seismic Acquisition Team	During drilling of shot holes	Site report and community engagement report	Monthly	FMEnv/SPDC
		Potential for the shot holes causing accidents (trips and falls)	M	Awareness shall be created on the existence and locations of shot holes through appropriate markings/signs	L	SPDC Seismic Acquisition Team	During drilling of shot holes	Site report and community engagement report	Daily	FMEnv/SPDC
	Shooting and Recording	Increase in nuisance noise from explosives	M	• Sufficient separation distances shall be provided for detonation of explosives to reduce noise levels and vibration effects on structures. • Nearby communities shall before informed before shooting the explosives.	L	SPDC Seismic Acquisition Team	During shooting and recording	Site report and community engagement report	Daily	FMEnv/SPDC
		Vibrations resulting in cracking of structures	M	• Built up areas shall be avoided • Adherence to minimum shooting distances as provided	L	SPDC Seismic Acquisition Team	During shooting and recording	Compliance report	Daily	FMEnv/SPDC

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Action party	Timing	Parameters for monitoring	Monitoring frequency	Responsible party
				in Environmental Guidelines and Standards for Petroleum Industries in Nigeria (EGASPIN)						
		Scaring away /Loss of wildlife	M	Shooting and recording shall be carried out within the shortest time	L	SPDC Seismic Acquisition Team	During shooting and recording	Site report and community engagement report	Daily	FMEnv/SPDC
		Potential for accidents during hole shooting	M	• Personnel handling explosives shall be licensed in line with 1967 Explosive Regulatory Act • Explosive handlers training with regard to seismic operations	L	SPDC Seismic Acquisition Team	During shooting and recording	License monitoring renewal	Monthly	FMEnv/SPDC
	Repairs and maintenance: (Welding, motor vehicle repairs, generators, maintenance of facilities and servicing in workshop)	Generation of high intensity welding flash, fumes and noise from grinders	M	• Awareness sessions on health risk and safety precautions of welding operations shall be carried out for workers • Use of Appropriate PPEs shall be enforced	L	SPDC Seismic Acquisition Team	During survey activities	Health records Minutes of Toolbox meetings/safety briefings Site inspection reports	Weekly	FMEnv/SPDC
		Burns and injuries from welding sparks/injuries from other maintenance activities	M	• Use of Appropriate PPEs • SPDC shall enforce the use of welders mask, ear muffs, jackets, gloves, boots and coveralls by welders during welding. • A site clinic and Medevac shall be provided	L	SPDC Seismic Acquisition Team	During survey activities	Health records Minutes of Toolbox meetings/safety briefings Site inspection reports	Weekly	FMEnv/SPDC

Project phase	Project activities	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Action party	Timing	Parameters for monitoring	Monitoring frequency	Responsible party
Decommissioning	-Repair of damaged roads -Removal of structures, Restoration of site - Removal of machineries	Increased opportunity for employment and contracting resulting in increased income level.	P	• Indigenous contractors shall be used • Site restoration shall be carried out at the end of the survey.	P	SPDC Seismic Acquisition Team	During line cutting	Community engagement report Site restoration certificate	End of the project	FMEnv/SPDC
		Nuisance noise, dust and emissions	M	• Machinery with noise levels within acceptable limits (85 dB (A)) shall be used. • Ear mufflers shall be provided for generator engines with noise level above acceptable limits • SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction sites. • Sufficient separation distances shall be provided for sources of high energy sound to reduce noise levels. • Waste segregation, treatment and disposal in compliance with standards and procedures (Govt. approved site, etc).	L	SPDC Seismic Acquisition Team	Daily/Weekly/ Monthly	Maintenance log of equipment Site inspection report Compliance report Waste generated/disposal management Data	Weekly/ Monthly	FMEnv/ SPDC

Note: M: Medium impact; H: High impact; P: Positive impact

7.10: Emergency Response Programme

In compliance with all regulatory standards, as well as Health, Safety, Environment and Security (HSES) procedures shall form the basis for the execution of the project. However, emergency situations could still occur as a result of equipment failure, negligence and/or sabotage. Consequently, a site-specific contingency plan shall be developed as back up to site specific emergency response systems which shall be put in place to handle any incident emergency. As a minimum, the contingency plans that shall apply shall address the following emergency situations:

- Fires and explosions;
- Serious injury or illness;
- Road and water mishaps.

In order to accomplish the above targets, the EMP has considered each environmental, social and health impacts and parameters for their monitoring. It also specifies the responsible party/parties for each action, responsible party as well as parameters for monitoring.

7.11: Contractor Management

The contractor staff shall be well informed and trained on the HSE policies and guidelines and be made aware of SPDC’s HSE performance targets. All activities shall be executed within the confines of relevant legislation and stakeholders’ interests. Contractors shall provide adequate health services as well as site first aid services for its workforce. The first aid services shall be extended to visiting personnel. All project activities shall be properly managed through careful planning and the application of relevant HSE policies including the following:

- Job Hazard Analysis and toolbox meetings;
- Use of Personal Protective Equipment in work areas;
- Prohibition of alcohol during work hours and at work sites;
- Regular emergency drills;
- Prohibition of smoking in fire hazard areas.

CHAPTER EIGHT
DECOMMISSIONING AND ABANDONMENT

8.1: Introduction

The Decommissioning and Abandonment Plan outlines the ways and methods to be adopted for decommissioning and abandonment of the facilities such as the Base camps and temporary structures at the end of the project. This chapter illustrates a logical process of managing abandonment effectively from conception, through execution, to completion stage resulting in an abandoned site that is restored to a clean, safe, usable and environmentally acceptable condition.

8.2: Objectives of Decommissioning and Abandonment

The Objectives of the Decommissioning and Abandonment Plan of the Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition Project includes but not limited to the following:

- To ensure that identified issues arising from the project activities have been addressed;
- To minimize impacts to the environment and land use while implementing a cost-effective abandonment system.

8.3: Decommissioning and Abandonment Alternatives

The advantages and disadvantages of the Decommissioning and Abandonment alternatives for the proposed project are presented in Table 8.1.

Table 8.1: Decommissioning and Abandonment Alternatives

Project activity	Advantages	Disadvantages
Option 1: Leave facilities (e.g. Base camp) *insitu* for future reuse	• Least expensive to execute. • Risk of accidents during transportation is reduced; • Metal scrap is reduced • Low cost of abandonment	• Maybe used as hide out for criminals • Vandalism by communities
Option 2: Removal of structures	• Facilities maybe reused for another project; • Environment can be properly reinstated	• Third party agitation • High cost of abandonment • Risk of road accidents is high

Note: The decision to fully decommission or abandon-in-place shall be made on the basis of a comprehensive site-specific assessment. However, No option has been chosen.

8.4: Decommissioning and Abandonment Considerations

The decommissioning and abandonment of the Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition Project shall be executed with keen considerations to issues arising from the need to address public safety, legal requirements, environmental protection, and future land use. During the pre-abandonment review a risk assessment shall be performed to identify and closeout all applicable risk issues arising from the abandonment scope, and execution methods and issues identified shall be documented for implementation in the execution contractor’s procedures and method statements and tracked for closure by the project team.

8.4.1: Environmental Conditions

The project EIA report and environmental impact monitoring reports of the proposed project shall form input to the pre-abandonment environmental impact assessments. Requirements for environmental reinstatement during abandonment shall be captured in the Environmental Monitoring Plan for abandonment phase (Table 7.2).

8.4.2: Soil and Groundwater Contamination

Any soil or ground water contamination noted prior to the abandonment activities shall be cleaned up to the applicable regulatory standards prior to commencement of the decommissioning and abandonment work program by the execution contractors, unless it can be demonstrated that environmental damage will not be amplified. The execution contractor's work programme shall provide controls to prevent effluent release to the environment or seepage to the ground water table leading to ground water contamination.

8.4.3: Site Reinstatement/Restoration

Site reinstatement activities are anticipated around the base camp area and damaged roads. The following site reinstatement activities are proposed to be executed post abandonment of the pipeline in-situ:

- Exhume contaminated soil around the base camp area, workshops etc. Contaminated soil shall be incinerated in line with SPDC's Waste Management Plan.
- Back-fill with appropriate top soil;
- Repair damaged roads resulting from Seismic activities if any
- Allow two rainy seasons for natural vegetation to sprout and root

8.4.4: Regulatory Interfaces

Implementation of decommissioning and abandonment of the Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition facilities/structures shall be carried out in line with applicable statutory requirements. As a statutory requirement, a letter-of-intent shall be dispatched seeking the consent for abandonment approval from the FMEnv/DPR before the planned abandonment. In addition, The Federal Ministry of Environment shall be invited to witness the decommissioning and abandonment activities and a Joint Monitoring Site Visits with Representatives of the Federal Ministry of Environment shall be performed during the abandonment phase.

8.4.5: Community Interfaces

The decommissioning plan to be adopted shall have minimum negative impact on the community. Community concerns related to SPDC's exit plans would be taken on board to ensure successful decommissioning.

8.4.6: Scrap Handling

All recovered scraps shall be treated in accordance with standard procedures on handling/sales of scrap. SPDC will investigate the possibility of donation to local government for local projects or to Universities for research works.

8.4.7: Abandonment Cost

Decommissioning and Abandonment Cost estimate shall be prepared for the Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition Project to support the decommissioning initiation process.

8.5: Potential and Associated Impacts of Decommissioning and Abandonment activities

Detailed description of the Potential and Associated impacts of the Decommissioning and Abandonment activities have been highlighted in the Environmental Management Plan section (Table 7.2).

CHAPTER NINE
CONCLUSION AND RECOMMENDATION

This Environmental Impact Assessment Report was carried out in accordance to the directives of the Federal Ministry of Environment (i.e. to conduct a desktop study). The EIA study involved detailed literature review, data analyses, impact identification/evaluation, and reporting.The Adibawa-Gbaran 3D Reshoot Data Acquisition Project will be beneficial in identifying deep exploration opportunities (by leveraging on the existing technology, using longer recording cable lengths and recording higher fold) which will maximize economic recovery of hydrocarbons, increase production, maximize economic use of existing facilities by keeping the facilities full and grow Nigeria's / SPDC's reserve base.

Furthermore, the impact assessment of the proposed project showed that it would have significant impacts which includes but not limited to Creation of opportunities for employment and contracting and increased financial flow due to compensations leading to improved standard of living. The identified adverse impacts were generally short-term and can be prevented, reduced, ameliorated, or controlled if the recommended mitigation measures are implemented. An Environmental Management Plan and a Monitoring Plan have been developed to ensure that the identified potential impacts can be reduced to "as low as reasonably practicable" (ALARP). The EMP should therefore form the basis for the actual project implementation and future monitoring of environmental components.The approval of this EIA report for the execution of the proposed project is hereby recommended.

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APPENDICES
Appendix 1.1

FEDERAL MINISTRY OF ENVIRONMENT
Environment House
Independence Way South, Central Business District, Abuja - FCT.
Tel: 09-2911 337 www.environment.gov.ng, ea-environment.org
ENVIRONMENTAL ASSESSMENT DEPARTMENT

The Shell Petroleum Development Company of Nigeria Limited
RECEIVED
15 APR 2015
SIGN.
SPDC ABUJA

Ref: FMEnv/EA/EIA/123:3189/Vol.I/78

Date: 14th April, 2015.

The Managing Director,
The Shell Petroleum Development
Company of Nigeria Limited (SPDC),
Freeman House, 21/22 Marina,
Lagos State.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR THE PROPOSED ADIBAWA-GBARAN 3D RESHOOT SEISMIC DATA ACQUISITION.

Please refer to your letter to the Ministry referenced UIO/G/NG/SPDC-HSSE-03-2015-010L dated 10th March, 2015 on the above project.

2. I am directed to acknowledge receipt of the letter and to inform you that the Ministry has requested that a Desktop Environmental Impact Assessment (EIA) Report be submitted for Adibawa-Gbaran 3D Reshoot Seismic Data Acquisition in OMLs 27 and 28 straddling Bayelsa and Rivers States.

3. In line with the above, you are required to pay a Final Assessed Charge to the Ministry for the project's EIA Approval as per the attached invoice.

4. Kindly note that this is not an approval letter and that the EIA Approval shall be issued on the confirmation of above payment.

5. Thank you for your co-operation.

J.A. Alonge
Director, Environmental Assessment Dept.
For: Honourable Minister.

Appendix 4.2

FIELD SAMPLING TECHNIQUES AND PROCEDURES

AIR QUALITY AND METEOROLOGY

Carbon Monoxide, Oxides of Sulphur, Oxides of Nitrogen, Hydrogen Sulphide, Ammonia, Volatile Organic Compounds/Hydrocarbons and Carbon dioxide.A portable air analyzer was employed for the air quality measurement of the above pollutants i.e. RKI SC-01 (SOx: Model number; 842030021R), RKI Eagle Air sampler (NOx, N_20 and NH_3: Model number; E08X055), RKI GX-2003 Air sampler (VOC, CO, CO_2 and H_2S: Model number; 883030340RN).

Noise Level

A pre-calibrated Precision Gold 4-in-one Env sound level meter (Model number; 08029996) was used to measure the noise level at all the sampling locations. Measurements were done by directing the probe towards the direction of the prevailing sound and the reading recorded from the digital meter in decibels dB (A).

Total Suspended Particulates (TSP*)*

Airborne particulate matter was monitored by Gravimetric sampling approach, using a Mini Vol Portable Air sampler (Model number: 3018). With the aid of a pump and a flow-regulating device, air samples were pumped at a flow rate of 5 LPM at ambient conditions. Particle size separation was achieved by impaction and an impactor of 10-micron cut-point was employed. A quartz filter of 47mm diameter was used for trapping and a sensitive analytical microbalance was used for weighing.

Skywatch Goes Meteorological Station

The Skywatch Geos meteorological station measures all the meteorological indicators to the precision outlined in the Table below:

Table 10.1: Meteorological indicators and their associated sensitivities

Parameter	Equipment	Sensitivity (precision)
Wind Speed	Skywatch GEOS meteorological meter	0.01m/s
Wind Direction		0.1-1%
Relative Humidity		0.2%
Temperature		0.01^oC
Pressure		0.1mb

Soil Studies

Soil samples were collected using a screw-type soil auger for top (0-15 cm) and bottom (15-30 cm) soil samples. Composite samples were obtained from three spots at each site and homogenized before separate subsamples were taken for physico-chemical, heavy metals, and microbiological analysis in plastic container paper bags fitted with sterile plastic (polythylene) liners and stored in coolers containing ice-chips to maintain the sample temperature in accordance with the provisions in the EGASPIN (DPR, 2002) on the field before onward delivery to the laboratory (US EPA, 2000). Also, site observations and description of soil samples were also done in addition to digging a profile pits for better soil characterisation. Metal cores of soil samples were obtained for bulk density determination. See Table 10.2 below:

Table 10.2: Soil Sample Handling, Preservatives and Storage Procedures

Parameters	Minimum sample vol.	Container	Preservative	Container Pre-treatment
Heavy Metals: V, Ni, Pb, Cr, Zn, Cd, Cu, Mn, Ar.	1.0L	Container paper bags fitted with plastic (polyethylene) liners	Cool below 0ºC	Rinsed with 1+1HNO_3
Soil colour and appearance	Determined at site	NA	NA	NA
Physico chemical characteristics	2.0L	Container paper bags fitted with plastic (polyethylene) liners	Cool, 4ºC	Rinsed with distilled water
TPH	1.0L	Container paper bags fitted with plastic (polyethylene) liners	Cool, 4ºC	Rinsed with distilled water
Microbiology, total heterotrophic bacteria and fungi (THB and THF) and hydrocarbon degrading bacteria and fungi (HDB and HDF)	200ml	Container paper bags fitted with plastic (polythylene) liners	Cool, 4ºC	Sterilized

Vegetation Studies

Information on species composition and structure were obtained using 50 meter long transects. Study plots (100m^2 quadrats) were also established at each site for the determination of population density of the key economic plants. The number of strata in the vegetation was noted and the dominant species recorded. Where counting of individuals were not possible as in situations where there are creeping plants, cover was measured using the Braun-Blanquet scale (Sutherland, 2006). Rare, invasive and endangered species were listed. Samples of plants not identified in the field were collected, pressed and carried to the herbarium for correct identification. The health status of the vegetation was visually determined. Where a disease symptom was noticed, samples of the plant organ(s) were taken to the laboratory for correct identification of causative organism(s).

Wildlife

Wildlife observation and counting along existing tracks, roads and along Orashi River was the method employed in the study. An 8 x 40 pair of binocular was used in viewing distant birds to ensure correct identification. The number of times a species was encountered during the study was used as an index for its abundance in the area.

Surface Water/Ground Water Studies

Water quality parameters determined on site (*in-situ*) includes pH, Conductivity, Dissolved oxygen, Total Dissolved Solids, Turbidity and Temperature. Samples were collected and preserved (<4^{o}C) for Anions, Cations, Total hardness, Salinity and Alkalinity analysis. Also, samples for BOD_5, Microbiological analysis (<4^{o}C), Heavy metals (acidified using nitric acid pH<2), Oil and grease/Total Petroleum Hydrocarbon/Total Hydrocarbon Compounds and Chemical Oxygen Demand (acidified using sulphuric acid pH<2) were collected and preserved separately before onward delivery to the laboratory. Details of handling and storage procedures for water samples are presented in the Table 10.3 below:

Table 10.3: Water Sample Handling, Preservatives and Storage Procedures

Parameters	**Minimum sample vol.**	**Container**	**Preservative**	**Container Pre-treatment**	**Remark**
Metals: V, Ni, Pb, Cr, Zn, Cd, Cu, Mn, Ar.	1.0L	Plastic bottles	Add 2ml conc. HNO_3 & cool, 4^{o}C ± 2^{o}C	Rinsed with 1+1HNO_3	Do not fill to the brim
Sulphate, total phosphorus, TSS, Chloride, Nitrate, Nitrite.	2.0L	Plastic bottles	- Cool, 4^{o}C ± 2^{o}C-	Rinsed with distilled water	Do not fill to the brim
Chemical Oxygen Demand	2.0L	Plastic bottles	H_2SO_4 to 2ml & cool, 4^{o}C ± 2^{o}C	Rinsed with distilled water	Do not fill to the brim

Parameters	Minimum sample vol.	Container	Preservative	Container Pre-treatment	Remark
THC	1.0L	Wide-mouth Glass bottles	H_2SO_4 to 2ml & cool, $4^oC \pm 2^oC$	Rinsed with Solvent	Do not fill to the brim
Zooplanktons and Phytoplanktons.	500ml	Wide mouthed plastic bottles	10% Formalin, lugol solution	-	
Microbiology, total heterotrophic bacteria and fungi (THB and THF) and hydrocarbon degrading bacteria and fungi (HDB and HDF)	200ml	Wide mouthed glass bottles	Cool, $4^oC \pm 2^oC$	Sterilized	Do not fill to the brim

Sediment Studies

Sediment samples were collected with the aid of a steel Ekman Grab ($0.0225m^2$) sampler. Prior to the first deployment and between sample stations, the grab sampler was thoroughly rinsed to remove visible sediment. At each station, the grab sampler was deployed and then heaved out with sediments. One successful grab bite was collected per area. On retrieval the grab bite sediment sample was scooped from the grab cup into a plastic container, it was transferred into various containers based on the parameters to be analysed and preserved.

Table 10.4: Sediment Samples Handling, Preservatives and Storage Procedures

Parameters	Minimum Sample Volume	Container	Preservative	Container Pre-treatment
Metals: V, Ni, Pb, Cr, Zn, Cd Fe,Mn.	-	Plastic bags	Freeze	Rinsed with distilled water
Physico-chemical (TOC, pH, particle size)	-	Plastic bags	Freeze	Rinsed with distilled water
Hydrocarbons (THC)	200ml	Plastic bags	Freeze	Rinsed with distilled water
Benthos	500ml	Plastic	10% Formaldehyde	-
Microbiology, total heterotrophic bacteria and fungi (THB and THF) and hydrocarbon degrading bacteria and fungi (HDB and HDF).	200ml	Glass bottle	Cool, $4^oC \pm 2^oC$	Sterilized

AQUATIC BIOLOGY

Benthos and Benthic Fauna

Quantitative samples for benthic fauna were collected at each station using the Ekman Grab ($0.0225m^2$) and sieved in the field using 250 and 500µm Tyler sieves. All samples were preserved in wide mouthed plastic containers by adding some quantities of 40% formaldehyde and stained with Rose Bengal solution.

Laboratory analysis was carried out using the binocular dissecting microscope and Nikon compound microscope for sorting, dissection of relevant taxonomic parts, and preparation of slides. Specimens were identified to the lowest possible taxonomic level using reliable identification keys and texts (Pennak, 1978; Barnes, 1980).

Plankton

Phytoplankton and Zooplankton composite samples were taken quantitatively by filtering 50litres of water through 55µm Hydrobios plankton net. All samples (concentrated to 100ml) collected for phytoplankton analysis were preserved in Lugol's iodine, while samples collected for Zooplankton analysis were preserved in 4% buffered formaldehyde in polyethylene bottles. In the laboratory, the phytoplankton and zooplankton were identified and counted using a Wild-Lietz Stereo Zoom dissecting microscope and a Nikon Compound Research microscope. Density computations were expressed in numbers per m^3 based on number of each species observed per 50 litres of samples collected. Identifications were made to the lowest possible taxonomic level using relevant identification keys (Han Maosen, 1995; Pennak, 1978). Representative species of zooplankton were mounted in polyvinyl lactophenol tinted with lignin pink after dissecting the relevant taxonomic parts. Individuals of each identified taxon in each sample were enumerated using Petri dish and Sedgwick – Rafler counting cell.

Statistical Analysis

Indices of diversity and evenness were used to characterize biotic communities. The following indices were used:

a. Margalef's index (d) of taxa richness

$$d = \frac{S-1}{\ell n\, N}$$

where S = number of taxa

N = total number of individuals

ℓ n = Natural log.

b. Shannon's Index (H^1)

$$H' = --\sum_{i=1}^{s} pi\ \ell n\ pi$$

Where: pi is the proportion of individuals found in

the ith species

(i.e. $pi = ni/N$, N being the total abundance)

c. Evenness Index (E^1)

$$E' = \frac{H'}{\ell n\ S}$$

Fisheries

Fish samples were identified, measured and weighed following methods of Bagenal (1971) in order to establish species diversity, distribution and seasonal abundance. Interviews, consultations and literature review were also used to obtain information on species diversity and relative abundance of fish species in the study area.

Microbiology

The enumeration of total viable heterotrophic bacteria and fungi, Hydrocarbon degrading bacteria and fungi in water, sediment and soil were conducted by APHA 1998 (Plating method) and APHA 907 (Standard plate count). Determination of total heterotrophic bacterial and fungal counts provides information on the level of biodegradable organic matter, Hydrocarbon degrading bacteria and fungi on the self-purification capacity of medium in the event of spilled oil, and coliform on sanitary quality.

The total microbial colonies were calculated as follows:

Plate count (cfu/ml) = Number of colonies on plate x Dilution factor (i.e. VI/V2)

Where V1= volume of broth being diluted.

V2= Total combined volume of broth and diluent.

Furthermore, for heterotrophic and hydrocarbon degrading bacteria enumeration, it was expressed as:

$$\text{Plate count (cfu/ml)} = \frac{\text{Number of colonies on plate x Dilution factor (V1/V2)}}{\text{Actual volume of sample}}$$

For coliform count, Multiple Tube fermentation Method was used as described by Michael and Burton, 2005.

Social Assessment

This study employs the logic of survey research design in defining the study populations, sampling methods and data acquisition techniques. The research design is essentially “non-experimental” or what Cook and Campbell (1979) have described as “passive observational”. This is because subjects have been studied *in-situ* without any conscious manipulation, as opposed to “quasi experimental” (where there is full manipulation of subjects, randomisations and the use of control groups) (Cook and Campbell, 1979). Study samples were therefore drawn from these host communities for both the Community/Socio-economic and the environmental safety assessments. In the host communities, the study elements/groups included the paramount ruler and members of the council of chiefs, youth groups, women groups, community-based organizations, economic subgroups (e.g. hunters, fishermen, farmers, etc), the Community Development Committee (CDC) etc. The questionnaires and interview schedules (Key Informants Interview and Focus Group Discussion) were the main sources of data collection for socio-economic attributes of the target populations in the host communities. For the purpose of data collection, 20 household-based questionnaires were administered per settlement to elicit household-related information in the fifteen (15) study locations giving a total of 300 household-based questionnaires administered in the study area. Other types of questionnaires were also administered in the field in conjunction with the household questionnaire. Thus, in all, a total of 440 questionnaires (of 5 different types) were administered in the field. The questionnaires used for the Social Impact Assessment is highlighted below:

COMMUNITY/SOCIO-ECONOMICS IMPACT ASSESSMENT STUDIES

GENERAL HOUSEHOLD QUESTIONNAIRE

EIA OF GBARAN-UBIE IOGP PHASE II PROJECT	(DO NOT WRITE IN THIS PLACE)

1. Study No.--------------------------------
2. Interview No-----------------------------
3. Interviewer's No.-----------------------
4. Ward-------------------------------------
5. Ward Code-------------------------------

This questionnaire is in connection with EIA of the proposed Gbaran-Ubie IOGP Phase II project in your area. The goal of the study is to establish relevant socio-economic information vital for the sustainable development planning of the area. The study has nothing to do with taxation. Please answer the questions completely and accurately, as any correct answer you provide would facilitate our work. All answers you provide will be treated confidentially.

6. Date of Interview: --
7. Local Gov't Area: ……………………………………………….
8. State:………………………………………………………….
9. Settlement:……………………………………………………….
10. Settlement Status: ……………………………………………….

SECTION A

PERSONAL CHARACTERISTICS

PLEASE PROVIDE US SOME INFORMATION ABOUT YOURSELF AND HOUSEHOLD

A.1 Sex of the Respondent. 1. Male ☐ 2. Female ☐

A.2 Age of the respondent: …………………Years.

A.3 What is your marital status:………………………

A.4 State of Origin: ……………..; Ethnic Group:………………..

A.5 Please tell us the number of persons in your household (including yourself)………………….

A.6 Please state the number of persons in your household (including yourself) who fall into the following age categories.

S/No.	Age Categories.	Gender		Total
		Male	Female	
1.	≤ 4			
2.	5 - 9			
3.	10-14			
4.	15-19			
5.	20-24			
6.	25-29			
7.	30-34			
8.	35-39			
9.	40-44			
10.	45-49			
11.	50-54			
12.	55-59			
13.	60-64			
14.	≥ 65			

A.7 What is the highest level of education that you have attained?…………………..

A.8 How many numbers of your household including yourself fall into the following educational categories?

S/No	Education Attained	Gender		Total
		Male	Female	
1.	No Formal Education			
2.	Pre-Primary			
3.	Primary (Uncompleted)			
4.	Primary (Completed)			
5.	Secondary (Uncompleted)			
6.	Secondary (Completed)			
7	Tertiary (Uncompleted)			
8	Tertiary (Completed)			

A.9 Are you employed (Including self-employed), unemployed, retired or a housewife?…………………………………………………………………………

A 9(a). If employed, please what is the title of your job and name of establishment?……………………………………………………………………

A.9 (b) Please give a brief description of your job responsibility in your place of work: ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………….................................

A.9 (c). Do your engage in any secondary occupation:……………………………

A.9 (d). If "YES", please state the nature of your occupation..

………………….…………………………………………………………………… ……………...……………………………………………………………………… …………...

A.10 How many number of your household (including yourself) fall into the following employment categories?

S/No	Employment Status	Gender		Total
		Male	Female	
1.	Employed			
2.	Unemployed			
3.	Retired			
4.	Housewife			

A.11 Please estimate your annual income from primary and secondary sources:

1. Primary N…………………..
2. Secondary N…………………..

A.11 (a) To which of the following monthly income categories do your household belong?

1. ☐ Less than 3,000
2. ☐ 3,000-5, 000
3. ☐ 6,000- 9,000
4. ☐ 10,000- 19,000
5. ☐ 20,000-39,000
6. ☐ 40,000-49,000
7. ☐ 50,000-59,000
8. ☐ 60,000-69,000
9. ☐ 70,000-79,000
10. ☐ 80,000-89,000
11. ☐ 90,000 and 100, 000
12. ☐ 100, 000 and above.

SECTION B

ENVIRONMENTAL CONDITIONS AND

NEIGHBOURHOOD QUALITY

B.1 How do you dispose of your household refuse? …………………………………

B.2 What type of toilet system do you use?………………………………………..............................

B.3 What is the source(s) of energy used in cooking for your household?……….............................

B.3 (a): How do you source for this energy requirement? ………………………..............................

B.3 (b): What are the problems encountered in meeting the energy demand of the household? ………………………………………………………………..
..........................……………………………………………………………………………….

B.4 Do you have River/Stream/Lake/Pond in your locality?……………………..............................

B.4 (a): If "YES", please state what uses you make of these water resources?

……………………………………………………………………………………...............

B.5 Do you have public water supply in your neighbourhood?………………….

B.5 (a) If 'YES', how regular or otherwise is this?

1. ☐ Very regular
2. ☐ Somewhat irregular
3. ☐ Somewhat regular
4. ☐ Very regular

B.5 (b) Please give reasons for your answer..

....
....

B.5 (c) How do you rate pipe-borne water supply in your area?

☐ Potable

☐ Somewhat potable

☐ Not potable

.5 (d) Is the water directly connected to your house or within the neighbourhood i.e. 200metres from your house)?

☐ Within the neighbourhood

☐ Directly connected

B.6 If 'No', What is the source of water for your household?………………………..

……………………………………………………………………………………….

B.6 (a) Would you say this water is potable (i.e. good for drinking)?

1. ☐ Yes 2. ☐ No

B.6 (b) If 'No', Please explain………………………………...

………………………………………………………………………………………………

B.7 Please tell us the estimated distance to source of water supply meter.

B.8 Do you pay water rates? 1. No ☐ 2. Yes ☐

B.8 (A) IF 'YES', HOW MUCH DO YOU PAY PER ANNUM? N------------------------

B.8 (b) When last did you pay your water rate (State month/Year)-----------

B.8 (c) If 'No', Why not?…………………………………………………...

…………………………………………………………………………………………………

B.9 On the whole, how much of your household income is expended on water supply monthly? N…………………………………………

B.9 (a) What percentage of your household monthly income is spent on water acquisition?…………………………………………………….

B.10 What is the daily average water consumption by your household? (i.e. how many 20 litres jerry cans used daily/drums)…………litres.

B.11 In your opinion, what are the problems of water supply in your neighbourhood?…………………………………………………………………………
……………………………………………………………………………………………
………………………………………………………………………….......................
....

B.12 Please make general suggestions on ways you think the water supply can be improved………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
…………

B.13 I shall now use some statements to describe your residential neighbourhood/Settlement. Please tell us your satisfaction or dissatisfaction with development/social service provisions in the area.

S/No	**Aspects**	**1.Very Dissatisfied**	**2.Rather Dissatisfied**	**3. About Okay**	**4. Rather Satisfied**	**5. Very Satisfied**
1.	Overall level of living					
2.	Health Delivery					
3.	Housing					
4.	Employment opportunities					
5.	Income position					
6.	Availability of potable water					
7.	Electricity provision					
8.	Public transport facilities					
9.	Educational facilities/ Services					
10.	Security of life and					

S/No	Aspects	1.Very Dissatisfied	2.Rather Dissatisfied	3. About Okay	4. Rather Satisfied	5. Very Satisfied
	property					
11.	General sanitation					
12.	Population of the area					
13	Environmental conditions					

B.14 All things considered, would you say that your neighbourhood/settlement is a good place to live in? 1. No. ☐ 2. Yes ☐

B.15 (a) If 'No', please explain…………………………………………..

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………….....................................
....

SECTION C

DIRECT OBSERVATION AND MEASUREMENT

FOR THE INTERVIEWER

C.1 House Type:

1				Rooming house (courtyard)
2				Rooming house (wagon type)
3				Single-family
4				Block of flats (multi-family)
5				Semi-detached
6				Storied building (single family)

C.2 Building Materials:

C.2 (a) Walling:

1				Corrugated iron sheets
2				Wood
3				Mud
4				Blocks
5				Burnt bricks

6				Cardboard/plywood sheets

C.2 (b) Roofing:

1				Corrugated iron sheets
2				Wood
3				Slate
4				Thatch
5				Decking
6				Cardboard/plywood sheets
7				Any other, specify: ____________________

C.3 Foundation:

1				Strip
2				Raft
3				Pile
4				None

C.4 House Condition:

1				Good (needs no repair)
2				Fairly Good (needs minor repair)

3				Bad (needs major repair)
4				Very bad (beyond repair)

C.5 Household Parking:

1				Private garage
2				Street side
3				Cartilage (premises)
4				Communal

C.6 Open Spaces:

1				Available within compound
2				Not available

C.7 Distance to nearest dwelling house from respondent:

1				Less than 5 metres
2				5 – 9
3				10 – 14
4				15 or more

C.8 Distance from Respondent's Dwelling to Basic Facilities:

S/No	Facility	1.more than 2 km	2.between 1 and 2 km	3.less than 1 km
(i)	Elementary School			
(ii)	Police Station			
(iii)	Hospital/Clinic/Maternity			
(iv)	Shopping area/local market			
(v)	Recreational Playground			
(vi)	Church			
(vii)	Mosque			
(viii)	Secondary School			

Thank you for your cooperation

EXACT TIME NOW.

COMMUNITY/SOCIO-ECONOMICS IMPACT ASSESSMENT STUDIES

SETTLEMENT HISTORY, SOCIAL ORGANISATIONS AND CULTURE QUESTIONNAIRE

EIA OF GBARAN-UBIE IOGP PHASE II PROJECT	(Do not write in this place)

1. Study No.--------------------------------
2. Interview No-----------------------------
3. Interviewer's No.-----------------------
4. Ward ----------------------------------
5. Ward Code-------------------------------

This questionnaire is in connection with the proposed Gbaran-Ubie IOGP Phase II Project in your area. The goal of the study is to establish relevant socio-economic information with respect to social organisation, culture and general perception of the planned SPDC operations in your area. The study has nothing to do with taxation. Please answer the questions completely and accurately, as any correct answer you provide would facilitate our work. All answers you provide will be treated confidentially.

6. Date of Interview: --

7. Settlement:…………………………………………………………….

8. Informants' Name, Position/Organisation:

(a) ____

(b) ____

(c) ____

(d) ____

Exact time now: ____

SECTION A

FOR THE PARAMOUNT CHIEF OR HIS APPOINTEES

A.1 Please give a brief account of the history of this settlement?

A.2 What is the name and rank of the paramount chief of this settlement? …………………………………………………………………………………………………… …………………………………………………………………………………………………… ……………………………………

A.3 Please tell us briefly the administrative structure of this settlement, starting with the role of the paramount chief?

…………………………………………………………………………………………………… ……………………………………………………………………………………………………

A.4 What are the criteria for appointing chiefs (traditional rulers) in this settlement (in descending order of importance)?

a) …………………………………………………………………………………………………… ………………

b) …………………………………………………………………………………………………… ……………….

c) …………………………………………………………………………………………………… ……….................

A.5 please list the criteria for appointing other chiefs (non-traditional rulers) in this settlement?

…………………………………………………………………………………………………… ……………………………………………………………………………………………………

A.6 Are there any age groups in this settlement?

Yes ☐ No ☐

A.6(a) If “Yes”, please state the traditional role(s) of these age-groups in the governance of this settlement. ……..

A6(b) please tell us how these groups are organised: …………………………………………………………..

…………………………………………………………………………………………

A.7 After the paramount chief, which persons or groups come next in the authority and power hierarchy of this settlement?

………………………………………………………………………………………………………

A.8 What traditional instruments of control are available in this settlement, with regards to rewards and punishment?

i) Rewards…………………………………………………………………………………………

ii) Punishment: ……………………………………………………………………………………….

………………………………………………………………………………………

A.9 Please tell us how the womenfolk are organised in your settlement.

…………………………………………………………………………………………

…………………………………………………………………………………………

A.10 Do women have any defined role in the traditional governance of your settlement?

Yes ☐ No ☐

A.10(a) If “Yes”, please explain

A.11 Please list t he types of festivals you have in this settlement?

S/No.	Festival	Period of Observation	Reason for Celebration

A.12 Please give us a short description of the three most important festivals observed in this community.

i) Festival

1:

…………………………………………………………………………………………………

.ii) Festival

2:

…………………………………………………………………………………………………
…..

iii) Festival

3:

……………………………………………………………………………………………….
……..

A13 Please describe the marriage practices of your people

…………………………………………………………………………………………………
…………………………………………………………………………………………………

A.13 (a) Do you think that the marriage practices have been affected in any way by the presence of strangers/modernisation?

Yes ☐ No ☐

A.13 (b) If "Yes", please explain

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………

SECTION B

NOW WE SHALL ASK YOU SOME QUESTIONS ABOUT THE LAND AND FARMING PRACTICES OF YOUR PEOPLE

B.1 Please tell us how farmland is owned in this settlement

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………..…………………………………………………………………

B.2 Are individuals or groups permitted to sell farmland or lease it out?

☐ Yes ☐ No

B.3 Can non-indigenes among you acquire farmland whenever the land is ripe for farming?

☐ Yes ☐ No

B.4 Can strangers and non-indigenes acquire land for other development purposes (residential, commercial, industrial etc.) in this settlement?

☐ Yes ☐ No

B.4 (a) If "Yes", please tell us the modalities and security of such landed property.

…………………………………………………………………………………………
…………………………………………………………………………………………
……………………………………

B.5 What is the average cost of a plot of land (100ft x 50ft) in this settlement?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………..…

B.5 (a) Please recall the cost of the same size of residential land five years ago?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………

B.6 What is the usual fallow period in this settlement? ……………………. (Years)

B.6 (a) Would you say that there have been an increase or decrease in the fallow period?

☐ Increase ☐ Decrease

B.6 (b) Please give reasons for your answers

…………………………………………………………………………………………………
………………………………………………………………………………………………
…………………………………………………………………………………………………
....

SECTION C

PERCEPTION, ASSESSMENT AND EXPECTATIONS

1 Are you aware of the presence of Oil Company (ies) in your area?

☐ YES ☐ NO

2 If "YES", please state the name(s) of the company or companies as provided below:

S/No	Name of Oil Company	Date of Commencement of Operation in the Community
1		
2		
3		

4		

3 Please state the nature of SPDC's operations in your area?

C.3 (a) Does the company generate or discharges any waste material into the environment?

☐ YES ☐ NO

C.3 (b) If "YES', please tell us what you considered to be the most adverse aspect of its 0perations?

1.0 ☐ Air Pollution

1.1 ☐ Black Smoke (Gorgeous Succession)

1.2 ☐ Particulate Matters/Dusts

1.3 ☐ Chemical Substances

2.0 ☐ Water Pollution

2.1 ☐ Surface Water

2.2 ☐ Ground Water

3.0 ☐ Odour

4.0 ☐ Solid Wastes (waste Papers, Plastics Scraps, Wood Scraps, Metal Scraps etc.)

5.0 ☐ Others (please Specify)
……………………………………………………………

3. (C) Please give reasons for your answer:
…………………………………………………….........

…………………………………………………………………………………………

4 Please indicate (in order of importance), what you consider the most beneficial aspects of SPDC's operations in your area?

☐ Increased employment opportunities for the local populace

☐ Scholarships for the training of the youth

☐ Opportunities to execute contract works

☐ Increased revenue in the form of taxes to the government

☐ Welfare programmes for the community (e.g. provision of social, economic, institutional, and physical infrastructure)

☐ Improvement of local agriculture

☐ Increased opportunity for small-scale business to spring up

☐ Company-induced influx of people with the attendant injection into the local environment of different value systems

Others, please specify:……………………………………………………………………………

Give reasons for your answer:…………………………………………………………………………

…………………………………………………………………………………………………

6 Please rate the performance of SPDC in the area of welfare improvements in your community with reference to the following aspects.

(TICK APPROPRIATE BOX)

i) Provision of scholarship for the training of the youth

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

ii) Provision of infrastructure facilities

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

iii) Provision of employment opportunities for the indigenes of host community

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

iv) Provision of opportunities for contract works

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

v) Improvement of local agriculture

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

vi) Aiding small-scale industry

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

vii) Youth development programmes

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

vii) Prompt and satisfactory response to company-caused environmental problems.

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

7 Are you aware of the proposed SPDC operation in your area?

☐ YES ☐ NO

7(a) if "Yes" how pleased or displeased are you with the proposed SPDC operations in the area?

(TICK APPROPRIATE BOX)

1. Very displeased ☐
2. Somewhat displeased ☐
3. Neither pleased nor displeased ☐
4. Somewhat pleased ☐
5. Very pleased ☐

8 If you are displeased, please tell us (in order of importance) three major reasons for your displeasure.

…………………………………………………………………………………………
……………………………………………………………………………………………
…………………………………………

9 If you are pleased, state (in order of importance) the three major reasons for your pleasure.

…………………………………………………………………………………………
…………………………………………………………………………………………

10 Do you expect anything from SPDC as a company operating in your area?

(TICK APPROPRIATE BOX)

1 Yes ☐ 2. No ☐

C.10 (a). If "YES", state your three most urgent expectations (in order of urgency):

1. ____

2. ____

3. ____

10 (b). Please specify expectations from other companies operating in your area.

……
………

11 How would you describe the relationship between your settlement and SPDC?

1. Very strained ☐
2. Somewhat strained ☐
3. Don't know/uncertain (DK/UC) ☐
4. Somewhat cordial ☐
5. Very cordial ☐

11 (a) Please give reasons for your answer:

……
………..

12 Has your community ever had any conflict with SPDC?

☐ Yes ☐ No

a). If "Yes", please indicate:

i) Number of Conflicts:
…………………………………………………………………..............................

ii) Bases of the conflicts:

……………………………………………………………………………………......

……

iii) Nature of the conflict:

……………………………………………………………………………….............

iv) Frequency of the conflicts:

……………………………………………………………………………................

v) Intensity (level of violence) of the conflict:

…………………………………………………………….................

vi) Mode of conflict resolution:

…………………………………………………………………………….......

vi) Effects of the conflicts on the socio-economic well being of the community: ……………………..

……………………………………………………………………………………………………

b). If “No”, please explain:

……………………………………………………………………………......

……………………………………………………………………………………………………

13 Please comment freely on SPDC as a company operating in your area.

……………………………………………………………………………………………………

…..

THANK YOU FOR YOUR COOPERATION.

EXACT TIME NOW: ________________________

HEALTH ASSESSMENT

This section presents the baseline health data of communities within the Gbaran project area and is comprised mainly of information generated from sampled groups in the study communities. The data presented comprise of information generated through on the spot observations, informant interviews, self-reporting by respondents and hospital data where available. The questionnaires and checklist used for the Health Impact Assessment for the Environmental Impact Assessment studies is highlighted below:

QUESTIONNAIRE ON HEALTH IMPACT ASSESSMENT FOR EIA STUDIES

We are interested in studying the Health Impact for the proposed EIA project in your community. This questionnaire is designed to enable us to obtain related information. We need your assistance and cooperation in answering the questions asked below. Your answer will be treated as confidential.

Please fill in or tick as appropriate

A. SOCIO-DEMOGRAPHIC VARIABLES:

Name of town /village: ………………………………

(1) Name of head of household………………………...

(2).Age (last birthday)…………………

(3). Sex: Male ☐ Female ☐

(4) What is your marital status: Married ☐ Single ☐ Divorced ☐

Separated ☐ Widow ☐ Cohabit ☐

(5) Educational status:

a) No formal education

b) Primary School

c) Secondary School

d) Tertiary (NCE / OND / AL / HND / Degree)

e) Higher degree

(6) Occupation: (a) Farming ☐ (b) Fishing ☐ (c) Trading ☐

(d) Civil servant ☐ (e) Others (specify) ☐

(7) In your work place, what health problems are you exposed to:

……………………………………………………………………………………………

(8) Income per month (Adult only)………………………………………………….

(9) How much does it cost you to take care of your family in a month?..................

(10) Religion……………

(11) Ethnic group…………………..

(12) How long have you lived in this community?

(13) Have you changed your residency in this community within the last five (5) years?

Yes ☐ No ☐

Reproductive Health Data:

How many children were born in your household between Jan. 1, 2007 and Nov. 1 2008 and what are the ages of their mothers?

Age of mother	Total Number of children ever born by the same mother		Number of children born between Jan. 1, 2007 & Dec 31 2007	
	Male	Female	Male	Female
(i)				
(ii)				
(iii)				
(iv)				
(v)				
(vi)				

(B) Life style / Habits

(1) Do you drink Alcohol? Yes ☐ No ☐

(2) If yes how often

- Every day
- At least once in a week
- Occasional

(3) Do you smoke? Yes / No

If yes, how many sticks/day……………

(4) Exercise: Yes / No

What type of exercise do you do?...

Knowledge, Attitude, Practice and Behavior on Sexually transmitted Infections

1. Do you have sexual partners not married to you Yes ☐ No ☐
2. How many are they? Yes ☐ No ☐
3. Have you heard of sexually Transmissible infections? Yes ☐ o ☐
4. Have you ever had any sexually Transmissible Infection? Yes ☐ No ☐
5. What symptoms (complaints) did you have then………………………………..
6. Were you treated by a doctor, a nurse or by yourself

- Treated by a doctor Yes ☐ No ☐
- By Nurse Yes ☐ No ☐
- By yourself Yes ☐ No ☐

7. How many times have you had STIs before?.......................................
8. Have you heard of HIV/AIDS before? Yes ☐ No ☐
9. Do you know how HIV / AIDS can infect somebody? Yes ☐ No ☐
10. Name the method by which somebody can get HIV / AIDS……………….......................

………………………………………………………………………………............................

11. Have you checked your status? Yes ☐ No ☐

12. Do you know anybody who has HIV/ AIDS Yes ☐ o ☐

13. How many do you? ………………………………………

14. Has member of your family, friends or community had or having tuberculosis?

Yes ☐ No ☐

Morbidity and Mortality

1. Please list persons (if any) who dies in your household between Jan.1 2007 and Dec. 31 2007.

Name (Optional)	Sex	Age	Cause of death (if known)
(i)			
(ii)			
(iii)			
(iv)			
(v)			
(vi)			
(vii)			

2. Please indicate number of members of your household that suffered from each of the different disease listed below between Jan. 1 2007 and Dec. 31, 2007 (if any)

Types of Disease	Male	Female	Total
(i)Diarrhoea			
(ii)Dysentery			
(iii)Measles			
(iv)Pneumonia			
(v)Typhoid fever			
(vi)Malaria			
(vii)Cholera			
(viii)Polio			
(ix)Yellow fever			
(x) Chicken pox			
(xi) Diphtheria			
(xii) Cancer			
(xiii) Tetanus			
(xiv) Tuberculosis			
(xv) AIDS			

(xvi) Guinea worm			
(xvii) Sleeping sickness			
(xviii) River blindness			
(xix) Stroke			
(xx) Others(specify)			

3. Please indicate how many members of your family that are below 5 years who have suffered from the under-listed condition between Jan1, 2007 and Dec 31,2007.

Clinical Condition			
(i) Kwashiorkor			
(ii) Anaemia			
(iii) Rickets			
(iv) Goitre			
(v) Others(specify)			

4. How many members of your family have died from each of the diseases listed below between Jan.1, and 2007 and Dec 31, 2007 (lf any)

Type of Disease	Male	Female	Total
(i) Diarrhoea			
(ii) Dysentery			
(iii) Measles			
(iv) Pneumonia			
(v) Typhoid fever			
(vi) Malaria			
(vii) Cholera			

Type of Disease	Male	Female	Total
(viii) Polio			
(ix) Yellow Fever			
(x) Chicken pox			
(xi) Diphtheria			
(xii) Cancer			
(xiii) Tetanus			
(xiv) Tuberculosis			
(xv) AIDS			
(xvi) Guinea Worm			
(xvii) Sleeping sickness			
(xviii) River Blindness			
(xix) Stroke			
(x) Others (Specify)			

Types	Total Number	Total Number of Midwifes/ Nurses	Total Numbers of Doctors	Total Number of Medical staff
Hospital				
Maternity				
Dispensary				
Health Centre				
Private Clinic				
Patent Medicine Store				

Pharmacy Chemist				
Traditional Healing home				

Health Seeking Behaviour Data

1. Indicate types /number of health care institutions in your community
2. What treatment did/do you employ when sick?
   i. Attended hospital / clinic
   ii. Buys drugs from nearby chemist
   iii. Consult native Doctors
   iv. Self medication
3. Where did you go for child delivery(ies) ?
   i. Attend hospital/health centres…….
   ii. Maternity/private clinic…………..
   iii. At home alone…………………...
   iv. Native Doctors/traditional midwife
   v. Any other (specify)………………..

Environmental Health Data

1. What is the major source of water available for your household? (tick the correct option)
   I. Rivers / Stream
   II. Well
   III. Pond
   IV. Rain Water
   V. Public pipe-borne water
   VI. Mono pump
   VII. Borehole (commercial)
   VIII. Borehole (private)
   IX. Commercial Tankers
2. What type (s) of residential houses do you have in your community?
   (Tick the correct option)

Types of Houses (by Nature of Construction Materials	Total Number
(i) Wood (Batcher)	
(ii) Mud	
(iii) Corrugated iron sheets (zinc batcher)	
(iv) Cellophane (nylon)	
(v) Thatcher	
(vi) Block (Cement or brick)	
(vii) Others (specify)	

3. How many person live in a house?..
4. How many rooms are in your house / residence? ……………………………….
5. What type of toilet facility do you use? please tick from below.
    1) Pit
    2) Bush
    3) Prier head
    4) Bucket
    5) Water Closet
    6) Others (specify)……………………………………………………………….

6. How do you dispose of your household refuse? Please tick from the list below.
    I. Private open dump
    II. Public open dump
    III. Organized collection (by Local Government, Community etc)
    IV. Organized collection by (individual-commercial)
    V. Burning
    VI. Bush
    VII. Burying
    VIII. Rivers/stream

CHECK LIST FOR HEALTH ASSESSMENT

(A) ENVIRONMENTAL HEALTH CHECKLIST

(1) STATUS OF THE PHYSICAL ENVIRONMENT: CLEANLINESS STATUS OF THE PREMISES

S/NO	DESCRIPTION	GRADE	REMARK
1	Unswept + weed /bush uncleared	1	Poor
2	Swept / weed / bush not cleared to ground level or completely cleared to ground level but unswept	2	Fair
3	Cleared to ground level and swept	3	Good
4	3 + packed or burnt	4	V. Good

NOTE:

(2) REFUSE DISPOSAL (TYPE)

- Open dumping on land
- Thrown into the river
- Composting
- Incineration (or burning)
- Others P/S specify ………………………………………………………….

S/NO	DESCRIPTION	GRADE	REMARK
1	Full and over flowing / scattered around	1	Poor
2	Full and not over flowing or Incompletely packed	2	Fair
3	Completed packed, clean, empty or not full	3	Good

NOTE:

____
____
____
____

(3) SEWAGE

1) Defaecate into rivers / stream
2) Defaecate in the bush
3) Bucket
4) Pit toilet
5) Trench
6) VIP
7) Others (P/S specify)

(4) STATUS OF TOILET FACILITY

S/NO	DESCRIPTION	GRADE	REMARK
1	Sewage littering the whole place / unflushed /unwashed	1	Poor
2	Clean surrounding and Unwashed/unflushed	2	Fair
3	Clean / covered flushed and washed	3	Good

NOTE:

____
____
____
____

(5) WATER

- Sources of drinking water
  - Tap
  - Well
  - Stream
  - Rain

Indicator	Unity of Measurement	Community Performance
Quantity of water	No of litres per person per day	
Quantity of water (access)	No of users per point (of Tap or Well)	
% of households without safe drinking		

Indicator	Unity of Measurement	Community Performance
water supply		

(6) HOUSING

(a) Type:

- Mud with thatched roof
- Mud with zinc roof
- Blockhouse with zinc roof.

(b) Number of persons living in a room

(c) Ventilation

- Cross ventilation
- No-cross ventilation

(d) Distance from high-tension cable/wire (Minimum 30m)

(7) TRAFFIC

- Means of transport
- Use of seat belts, helmets
- Status of vehicle (good motoring condition)
- Traffic regulations/sign boards

(8) HEALTH RELATED SOCIAL AMENITIES

- Electricity
- Tarred Roads
- Education facilities
- Recreational

CHECKLIST FOR ASSESSING THE QUALITY OF AVAILABLE HEALTH FACILITY

A. Name of Community____

- Name of Health Institution___________________________________
- Outpatient and Inpatient (Delete not applicable)

B. Health professionals

S/N	Personnel	Number	Qualification	Years of Experience
1	Doctors			
2	Nurses			
3	Midwifes			
4	Lab Scientists			
5	Radiographers			
6	Anaesthetists			

7	Record Clerk			
8	Pharmacist			
9	Others			

C. Equipment

- Consulting table and chairs
- Examination couch
- Disposable needless and syringes
- Disposable suture kits
- Methods for sterilization
- Refrigerators
- Medical waste disposal methods
- X-ray facilities
- ECG
- Ultrasound
- Laboratory facilities
- Pharmacy (WHO Essential Drug List Available, List)
- No of beds
- Laundry facilities
- Catering facilities
- Operating theatre.

D. Hospital Building with the following features

FEATURES	YES	NO
• Clean consultation room		
• Clean waiting room		
• Treatment/minor procedures room		
• Privacy rooms		
• Clean running water/hand washing facilities		
• Toilet		

• Good light		
• Good ventilation (or AC)		
• Insect screens		

Remarks

E. Administration

FEATURES	YES	NO
• Appointment system		
• Health records		
• Security		
• Confidentiality		
• Scale of changes		
• Cleaning and maintenance routine		

Remarks

F. LOGISTICS

- Accessibility of the health Institution (average radial distance of the center from the members of the community) ______________________
- Communications Telephone/radio
- Hospital Ambulance

G.

- Average daily clinic attendance:
- Common diseases treated:

____

____

H MORBIDITY AND MORTALITY STATISTICS

H1 Table of distribution of common disease conditions last 12 months

Name of disease/Health condition	**Frequency**		**TOTAL**
	Males	**Females**	

H2: Table of distribution of common causes of death last 12 months

CAUSE OF DEATH	**Frequency**		**TOTAL**
	Males	**Females**	

Record of births last 12 months:

____

Appendix 4.3: Air Quality and Noise level measurements

AIR QUALITY/NOISE MEASUREMENTS RESULT FOR KAIMA COMMUNITY

Parameter	**Method**	**DPR Limit (Daily Mean)**	**LOCATION POINTS IN DOOR**				**OUT DOOR**
			HOUSE 1 1	**HOUSE 1 2**	**HOUSE 2 1**	**HOUSE 2 2**	**OUT**
(COORDINATES)	**GPS**	-			N05^{0}07.040	N05^{0}07.040	
					E006^{0}18.077	E006^{0}18.077	
O_2 (µg/m^3)	Instrumental		21.01	21.06	21.10	21.07	21.10
SO_X, (µg/m^3)	Instrumental	100 – 150	<19.9	<19.9	<19.9	<19.9	<19.9
NO_X (µg/m^3)	Instrumental	150	<1.0	<1.0	<1.0	<1.0	<1.0
Carbon Monoxide CO (µg/m^3)	Instrumental	10		<1.0	<1.0	<1.0	<1.0
H_2S (µg/m^3)	Instrumental	-		<1.0	<1.0	<1.0	<1.0
C_XH_Y (µg/m^3)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1
Ambient Temperature (°C)	Thermometer	-	28.9	28.6	29.9	29.8	28.5
Total SPM,(µg/m^3)	Instrumental	60-90		5	4	5	6
Atmospheric Pressure (Pa)	Digital Barometer	-	1011	1011	1010	1010	1010
Relative Humidity (%)	Humidity meter		65	65	60	62	68
Wind Direction (Degrees)	Wind Vane	-	SW	SW	SW	SW	SW
Wind Speed (m/s)	Anemometer	-	0.4	0.4	0.5	0.4	1.0
Wind Turbulence	Anemometer	-	CALM	CALM	CALM	CALM	CALM
Noise Level (dBA)	Sound Meter	80 - 100	61.4	60.8	50.8	51.0	68.4

AIR QUALITY/NOISE MEASUREMENTS RESULT FOR OLOIBIRI

Parameter	Method	DPR Limit (Daily Mean)	LOCATION POINTS IN DOOR				OUT DOOR
			HOUSE 1 1	HOUSE 1 2	HOUSE 2 1	HOUSE 2 2	OUT
(COORDINATES)	GPS	-	N05^{0}06474	N05^{0}06.474	N05^{0}06.442	N05^{0}06.442	N05^{0}06.490
			E006^{0}18162	E006^{0}18.162	E006^{0}18.168	E006^{0}18.168	E006^{0}18.166
O_2 (µg/m^3)	Instrumental		12.09	12.05	12.11	21.10	21.11
SO_X, (µg/m^3)	Instrumental	100 – 150	<19.9	<19.9	<19.9	<19.9	19.9
NO_X (µg/m^3)	Instrumental	150	<1.0	<1.0	<1.0	<1.0	<1.0
Carbon Monoxide CO (µg/m^3)	Instrumental	10	<1.0	<1.0	<1.0	<1.0	<1.0
H_2S (µg/m^3)	Instrumental	-	<1.0	<1.0	<1.0	<1.0	<1.0
C_XH_Y (µg/m^3)	Instrumental	-	<1.0	<1.0	<1.0	<1.0	<1.0
Ambient Temperature (°C)	Thermometer	-	30.4	30.7	31.2	31.6	35.1
Total SPM,(µg/m^3)	Instrumental	60-90	4	3	5	4	7
Atmospheric Pressure (Pa)	Digital Barometer	-	1009	1009	1009	1009	1008
Relative Humidity (%)	Humidity meter		56	54	50	50	43
Wind Direction (Degrees)	Wind Vane	-	SW	SW	SW	SW	SW
Wind Speed (m/s)	Anemometer	-	0.4	0..5	0.5	0.4	1..9
Wind Turbulence	Anemometer	-	CALM	CALM	CALM	CALM	UNSTABLE
Noise Level (dBA)	Sound Meter	80 - 100	64.8	62.9	51.9	59.0	61.7

AIR QUALITY/NOISE MEASUREMENTS RESULT GBARAN-AMA

arameter	Method	DPR Limit (Daily Mean)	GBARAN-AMA OUTDOOR
(COORDINATES)	**GPS**	**-**	N $05^0$04.269 E $006^0$17.259
O_2 ($\mu g/m^3$)	Instrumental		21.04
SO_X, ($\mu g/m^3$)	Instrumental	100 – 150	<19.9
NO_X ($\mu g/m^3$)	Instrumental	150	<1.0
Carbon Monoxide CO ($\mu g/m^3$)	Instrumental	10	<1.0
H_2S ($\mu g/m^3$)	Instrumental	-	<1.0
C_XH_Y ($\mu g/m^3$)	Instrumental	-	<1.0
Ambient Temperature (°C)	Thermometer	-	35.1
Total SPM,($\mu g/m^3$)	Instrumental	60-90	8
Atmospheric Pressure (Pa)	Digital Barometer	-	1013
Relative Humidity (%)	Humidity meter		50
Wind Direction (Degrees)	Wind Vane	-	SW
Wind Speed (m/s)	Anemometer	-	3.5
Wind Turbulence	Anemometer	-	UNSTABLE
Noise Level (dBA)	Sound Meter	80 - 100	55.8

AIR QUALITY/NOISE MEASUREMENTS RESULT SHEET

PROJECT/FACILITY/AREA/SITE: /E I A/ KAIAMA **SAMPLE TYPE: AIR/NOISE**

YEAR: 2008 **MONTH: JULY** **SAMPLING DATE: 08/07/2008**

Parameter	Method	DPR Limit (Daily Mean)	LOCATION POINTS IN DOOR									OUT DOOR
			HOUSE 1 1	HOUSE 1 2	Average	HOUSE 2 1	HOUSE 2 2	Average	HOUSE 3 1	HOUSE 3 2	Average	OUT
(COORDINATES)	**GPS**	-				$N05^0 07.040$	$N05^0 07.040$		$N05^0 07.040$	$N05^0 07.040$		
						$E006^0 18.077$	$E006^0 18.077$		$E006^0 18.077$	$E006^0 18.077$		
O_2 ($\mu g/m^3$)	Instrumental		21.18	21.16	21.17	12.11	21.14	16.63	21.08	21.10	21.10	
SO_X, ($\mu g/m^3$)	Instrumental	100 – 150	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	
NO_X ($\mu g/m^3$)	Instrumental	150	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Carbon Monoxide CO ($\mu g/m^3$)	Instrumental	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	60.8	52.1	56.5	
H_2S ($\mu g/m^3$)	Instrumental	-	3.2	1.1	2.2	2.1	<0.1	2.1	1.1	1.1	1.1	
C_XH_Y ($\mu g/m^3$)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Ambient Temperature (°C)	Thermometer	-	27.6	28.4	28.0	29.3	30.7	30.0	30.9	30.9	30.9	
Total SPM,($\mu g/m^3$)	Instrumental	60-90										
Atmospheric Pressure (Pa)	Digital Barometer	-	1011	1011	1011	1011	1011	1011	1010	1010	1010	
Relative Humidity (%)	Humidity meter		77	75	76	76	73	74.5	67	65	66	
Wind Direction (Degrees)	Wind Vane	-	SW	SW		SW	SW		SW	SW		
Wind Speed (m/s)	Anemometer	-	0.4	0.4	0.4	0.4	0.4	0.4	0.7	0.4	0.6	
Wind Turbulence	Anemometer	-	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	
Noise Level (dBA)	Sound Meter	80 - 100	51.8	50.9	51.4	59.6	56.9	58.3	61.9	62.2	62.1	

AIR QUALITY/NOISE MEASUREMENTS RESULT SHEET

PROJECT/FACILITY/AREA/SITE: /E I A/OLOIBIRI **SAMPLE TYPE: AIR/NOISE**

YEAR: 2008 **MONTH: JULY** **SAMPLING DATE: 08/07/2008**

Parameter	Method	DPR Limit (Daily Mean)	LOCATION POINTS IN DOOR									OUT DOOR
			HOUSE 1 1	HOUSE 1 2	Average	HOUSE 2 1	HOUSE 2 2	Average	HOUSE 3 1	HOUSE 3 2	Average	OUT
(COORDINATES)	GPS	-	N05^{0}06474	N05^{0}06.474		N05^{0}06.442	N05^{0}06.442		N05^{0}06.492	N05^{0}06.492		N05^{0}06.490
			E006^{0}18162	E006^{0}18.162		E006^{0}18.168	E006^{0}18.168		E006^{0}18.183	E006^{0}18.183		E006^{0}18.166
O_2 ($\mu g/m^3$)	Instrumental		21.08	21.11	21.1	21.14	21.15	21.15	21.08	21.10	21.09	21.07
SO_X, ($\mu g/m^3$)	Instrumental	100 – 150	39.7	19.9	29.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9
NO_X ($\mu g/m^3$)	Instrumental	150	<0.1	14.2	14.2	14.2	14.2	14.2	<0.1	<0.1	<0.1	<0.1
Carbon Monoxide CO ($\mu g/m^3$)	Instrumental	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
H_2S ($\mu g/m^3$)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C_XH_Y ($\mu g/m^3$)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ambient Temperature (°C)	Thermometer	-	30.5	30.2	30.4	29.8	29.1	29.5	29.4	29.2	29.3	28.9
Total SPM,($\mu g/m^3$)	Instrumental	60-90										
Atmospheric Pressure (Pa)	Digital Barometer	-	1009	1009	1009	1009	1009	1009	1008	1008	1008	1008
Relative Humidity (%)	Humidity meter		70	70	70	73	72	72.5	72	71	71.5	70
Wind Direction (Degrees)	Wind Vane	-	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Wind Speed (m/s)	Anemometer	-	0.5	0.4	0.45	1.0	1.3	1.2	0.5	0.4	0.45	2.3
Wind Turbulence	Anemometer	-	CALM	CALM		CALM	CALM		CALM	CALM		UNSTABLE
Noise Level (dBA)	Sound Meter	80 - 100	58.8	55.2	57.0	55.6	60.8	58.2	63.4	46.9	55.2	66.1

AIR QUALITY/NOISE MEASUREMENTS RESULT SHEET

PROJECT/FACILITY/AREA/SITE: /E I A/ IGBAINWARI **SAMPLE TYPE: AIR/NOISE**

YEAR: 2008 **MONTH: JULY** **SAMPLING DATE: 10/07/2008**

Parameter	Method	DPR Limit (Daily Mean)	LOCATION POINTS IN DOOR									OUT DOOR
			HOUSE 1 1	HOUSE 1 2	Average	HOUSE 2 1	HOUSE 2 2	Average	HOUSE 3 1	HOUSE 3 2	Average	OUT
(COORDINATES)	GPS	-	N05^{0}04.259	N05^{0}04.259		N05^{0}04.286	N05^{0}04.286		N05^{0}04.287	N05^{0}04.287		N05^{0}04.283
			E006^{0}16.408	E006^{0}16.408		E006^{0}16.429	E006^{0}16.429		E006^{0}16.441	E006^{0}16.441		E006^{0}16.443
O_2 (μg/m^3)	Instrumental		21.08	21.14	21.11	21.08	21.10	21.09	21.12	21.10	21.11	21.09
SO_X, (μg/m^3)	Instrumental	100 – 150	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9
NO_X (μg/m^3)	Instrumental	150	14.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Carbon Monoxide CO (μg/m^3)	Instrumental	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
H_2S (μg/m^3)	Instrumental	-	<0.1	<0.1	<0.1	1.1	<0.1	1.1	<0.1	<0.1	<0.1	<0.1
C_XH_Y (μg/m^3)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ambient Temperature (°C)	Thermometer	-	30.5	31.0	30.7	30.8	30.5	30.7	30.4	30.8	30.6	31.4
Total SPM,(μg/m^3)	Instrumental	60-90										
Atmospheric Pressure (Pa)	Digital Barometer	-	1011	1011	1011	1011	1011	1011	1012	1012	1012	1012
Relative Humidity (%)	Humidity meter		70	67	68.5	68	67	67.5	70	71	70.5	77

Parameter	**Method**	**DPR Limit (Daily Mean)**	**LOCATION POINTS IN DOOR**									**OUT DOOR**
			HOUSE 1 1	**HOUSE 1 2**	**Average**	**HOUSE 2 1**	**HOUSE 2 2**	**Average**	**HOUSE 3 1**	**HOUSE 3 2**	**Average**	**OUT**
Wind Direction (Degrees)	Wind Vane	-	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Wind Speed (m/s)	Anemometer	-	0.4	0.4	0.4	0.4	0.4		1.0	1.0		1.4
Wind Turbulence	Anemometer	-	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM
Noise Level (dBA)	Sound Meter	80 - 100	60.0	58.8	59.4	57.2	55.4	56.3	61.9	60.2	61.1	64.6S

AIR QUALITY/NOISE MEASUREMENTS RESULT SHEET

PROJECT/FACILITY/AREA/SITE: /E I A/ OFONBIRI **SAMPLE TYPE: AIR/NOISE**

YEAR: 2008 **MONTH: JULY** **SAMPLING DATE: 11/07/2008**

Parameter	Method	DPR Limit (Daily Mean)	LOCATION POINTS IN DOOR									OUT DOOR
			HOUSE 1 1	HOUSE 1 2	Average	HOUSE 2 1	HOUSE 2 2	Average	HOUSE 3 1	HOUSE 3 2	Average	OUT
(COORDINATES)	GPS	-	N05^{0}07.241	N05^{0}07.241		N05^{0}04232	N05^{0}04232		N05^{0}04257	N05^{0}04257		N05^{0}04.257
			E006^{0}18.060	E006^{0}18.060		E006^{0}16505	E006^{0}16505		E006^{0}16495	E006^{0}16495		E006^{0}16.494
O_2 (µg/m^3)	Instrumental		21.11	21.13	21.12	21.10	21.13	21.11	21.10	21.08	21.09	21.08
SO_X, (µg/m^3)	Instrumental	100 – 150	19.9	19.9	19.9	19.9	<0.1	19.9	<0.1	19.9	19.9	<0.1
NO_X (µg/m^3)	Instrumental	150	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Carbon Monoxide CO (µg/m^3)	Instrumental	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
H_2S (µg/m^3)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	<0.1	1.1	1.1
C_XH_Y (µg/m^3)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ambient Temperature (°C)	Thermometer	-	33.0	33.0	33.0	32.8	32.6	32.7	32.3	32.2	32.3	32.2
Total SPM,(µg/m^3)	Instrumental	60-90										
Atmospheric Pressure (Pa)	Digital Barometer	-	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
Relative Humidity (%)	Humidity meter		65	65		67	68		65	66		68

Parameter	Method	DPR Limit (Daily Mean)	LOCATION POINTS IN DOOR									OUT DOOR
			HOUSE 1 1	HOUSE 1 2	Average	HOUSE 2 1	HOUSE 2 2	Average	HOUSE 3 1	HOUSE 3 2	Average	OUT
Wind Direction (Degrees)	Wind Vane	-	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Wind Speed (m/s)	Anemometer	-	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Wind Turbulence	Anemometer	-	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM
Noise Level (dBA)	Sound Meter	80 - 100	48.9	46.2	47.6	46.0	44.8	45.4	59.6	57.2	58.2	62.4

AIR QUALITY/NOISE MEASUREMENTS RESULT SHEET

PROJECT/FACILITY/AREA/SITE: /E I A/ ORUBIRI **SAMPLE TYPE: AIR/NOISE**

YEAR: 2008 **MONTH: JULY** **SAMPLING DATE: 08/07/2008**

Parameter	Method	DPR Limit (Daily Mean)	LOCATION POINTS IN DOOR									OUT DOOR
			HOUSE 1 1	HOUSE 1 2	Average	HOUSE 2 1	HOUSE 2 2	Average	HOUSE 3 1	HOUSE 3 2	Average	OUT
(COORDINATES)	**GPS**	-	N05^{0}04.192	N05^{0}04.192		N05^{0}04.221	N05^{0}04.221		N05^{0}04.227	N05^{0}04.227		N05^{0}04.236
			E006^{0}16.516	E006^{0}16.516		E006^{0}16.531	E006^{0}16.531		E006^{0}16.536	E006^{0}16.536		E006^{0}16.541
O_2 ($\mu g/m^3$)	Instrumental		21.08	21.07		21.08	21.09		21.07	21.08		21.10
SO_X, ($\mu g/m^3$)	Instrumental	100 – 150	<0.1	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9
NO_X ($\mu g/m^3$)	Instrumental	150	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	Method	DPR Limit (Daily Mean)	LOCATION POINTS IN DOOR									OUT DOOR
			HOUSE 1 1	HOUSE 1 2	Average	HOUSE 2 1	HOUSE 2 2	Average	HOUSE 3 1	HOUSE 3 2	Average	OUT
Carbon Monoxide CO ($\mu g/m^3$)	Instrumental	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
H_2S ($\mu g/m^3$)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C_XH_Y ($\mu g/m^3$)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ambient Temperature (°C)	Thermometer	-	32.4	32.4	32.4	32.3	32.0	32.0	32.5	32.4	32.45	32.5
Total SPM,($\mu g/m^3$)	Instrumental	60-90										
Atmospheric Pressure (Pa)	Digital Barometer	-	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
Relative Humidity (%)	Humidity meter		69	69	69	68	69		68	68	68	67
Wind Direction (Degrees)	Wind Vane	-	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Wind Speed (m/s)	Anemometer	-	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Wind Turbulence	Anemometer	-	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM
Noise Level (dBA)	Sound Meter	80 - 100	48.2	46.0		58.1	48.7		50.5	46.2		60.3

PROJECT/FACILITY/AREA/SITE: /E I A/ AYOKOROMA **SAMPLE TYPE: AIR/NOISE**

YEAR: 2008 **MONTH: JULY** **SAMPL ING DATE: 11/07/2008**

arameter	Method	DPR Limit (Daily Mean)	LOCATION POINTS IN DOOR									OUT DOOR
			HOUSE 1 1	HOUSE 1 2	Average	HOUSE 2 1	HOUSE 2 2	Average	HOUSE 3 1	HOUSE 3 2	Average	OUT
(COORDINATES)	GPS	-	N05^{0}04.233	N05^{0}04.233		N05^{0}04.228	N05^{0}04.228		N05^{0}04.226	N05^{0}04.226		N05^{0}04.226
			E006^{0}17.028	E006^{0}17.028		E006^{0}17.028	E006^{0}17.028		E006^{0}17.037	E006^{0}17.037		E006^{0}17.037
O_2 (µg/m^3)	Instrumental		21.08	21.09		12.10	12.10		21.12	12.10		21.14
SO_X, (µg/m^3)	Instrumental	100 – 150	<0.1	<0.1		19.9	19.9		19.9	19.9		19.9
NO_X (µg/m^3)	Instrumental	150	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Carbon Monoxide CO (µg/m^3)	Instrumental	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
H_2S (µg/m^3)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C_XH_Y (µg/m^3)	Instrumental	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ambient Temperature (°C)	Thermometer	-	31.6	31.6	31.6	31.9	31.9	31.9	32.0	32.4	32.2	31.3
Total SPM,(µg/m^3)	Instrumental	60-90										
Atmospheric Pressure (Pa)	Digital Barometer	-	1009	1009	1009	1009	1009	1009	1009	1009	1009	1009
Relative Humidity (%)	Humidity meter		70	70	70	70	70	70	71	71	71	67
Wind Direction (Degrees)	Wind Vane	-	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Wind Speed (m/s)	Anemometer	-	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	2.8
Wind Turbulence	Anemometer	-	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	CALM	
Noise Level (dBA)	Sound Meter	80 - 100	71.4	75.9		74.1	73.0		63.7	62.9		67.7

Appendix 4.4.2.1: Soil

APPENDIX 4.4.2.1B - 1: Physico-chemistry of Soils in the Study Area during the dry season

SAMPLE POINT ID.	PARAMETERS/RESULTS														
	pH ASTM D293 B	Cond ASTM D 1125 (µS/cm)	Cl ASTM D 512 mg/kg	THC ASTM D3921 (mg/kg)	TOM Cmbst @555 ^{0}C (%)	TOC APHA 5310 (%)	TN ASTM D 3590 (mg/kg)	NH4 APHA 4500-NH_4 (mg/kg)	NO2 APHA 4500-NO_2 (mg/kg)	NO3 APHA 4500 NO_3 mg/kg	Avail.P APHA 4500-P mg/kg	SO4 ASTM D 516 mg/kg	THB APHA 9215B (cfu/g)	THF APHA 9215B (cfu/g)	Moist. Contnt. Wt/wt
SOIL															
SS 1 Top	6.1	134	63.9	<1.0	0.80	0.58	24.3	0.03	<0.01	4.2	24.6	353.0	$5.1x10^6$	$3.2x10^4$	8.11
SS 1 Bottom	6.2	128	63.9	<1.0	0.91	0.65	22.1	0.03	<0.01	3.8	22.1	241.0	$3.8x10^6$	$3.0x10^4$	8.33
SS 2 Top	6.4	119	64.5	<1.0	0.52	0.33	17.4	0.04	<0.01	5.6	27.5	335.0	$4.1x10^6$	$3.8x10^4$	7.24
SS 2 Bot	6.3	101	64.6	<.0	1.35	0.89	36.2	0.03	<0.01	5.9	25.3	220.0	$3.8x10^6$	$3.1x10^4$	6.45
SS 3 Top	6.2	120	66.0	<1.0	1.74	1.37	25.3	0.02	<0.01	6.2	28.1	343.0	$4.5x10^6$	$3.6x10^4$	7.32
SS 3 Bo	6.0	112	65.8	<1.0	1.81	1.35	18.4	0.03	<0.01	4.4	20.2	323.0	$3.4x10^6$	$3.2x10^4$	3.21
SS 4 Top	6.0	154	67.8	<1.0	1.46	1.02	462	0.04	<0.01	3.6	30.3	454.0	$4.3x10^6$	$3.3x10^4$	5.20
SS 4 Bot	5.9	136	67.5	<1.0	1.32	0.90	287	0.02	<0.01	4.7	29.1	440.0	$4.1x10^6$	$2.9x10^4$	6.10
SS 5 Top	5.9	125	60.3	<1.0	1.65	1.13	658	0.01	<0.01	6.4	28.1	532.0	$4.6x10^6$	$3.6x10^4$	5.40
SS 5 Bot	5.7	119	60.1	<1.0	1.58	1.12	156	0.02	<0.01	3.8	27.3	514.0	$3.5x10^6$	$3.6x10^4$	7.28
SS 6 Top	6.1	168	57.2	<1.0	0.48	0.31	15.3	0.02	<0.01	4.2	25.4	603.0	$5.2x10^6$	$3.6x10^4$	8.31
SS 6 B	6.0	147	53.4	<1.0	2.96	1.90	56.4	0.03	<0.01	4.8	24.3	587.0	$4.7x10^6$	$3.4x10^4$	8.26
SS 7 Top	6.3	144	49.7	<1.0	2.60	1.71	235	0.03	<0.01	4.4	23.3	613.0	$3.5x10^6$	$3.0x10^4$	7.59
SS 7 Bot	6.0	121	48.9	<1.0	2.28	1.73	687	0.01	<0.01	3.6	26.0	485.0	$5.7x10^6$	$3.1x10^4$	6.61
SS 8 Top	5.9	134	63.9	<1.0	2.41	1.58	541	0.02	<0.01	4.6	22.1	491.0	$4.2x10^6$	$3.7x10^4$	5.98
SS 8 Bot	6.0	120	62.4	<1.0	0.56	0.31	628	0.02	<0.01	4.2	29.8	353.0	$3.4x10^6$	$3.6x10^4$	6.94
SS 9 Top	5.9	155	63.4	<1.0	1.95	1.41	412	0.02	<0.01	5.1	25.9	412.0	$4.6x10^6$	$3.2x10^4$	6.21

SAMPLE POINT ID.	PARAMETERS/RESULTS													
	pH ASTM D293 B	Cond ASTM D 1125 (µS/cm)	Cl ASTM D 512 mg/kg	THC ASTM D3921 (mg/kg)	TOM Cmbst @555 ^{0}C (%)	TOC APHA 5310 (%)	TN ASTM D 3590 (mg/kg)	NH4 APHA 4500-NH_4 (mg/kg)	NO2 APHA 4500-NO_2 (mg/kg)	NO3 APHA 4500 NO_3 mg/kg	Avail.P APHA 4500-P mg/kg	SO4 ASTM D 516 mg/kg	THB APHA 9215B (cfu/g)	THF APHA 9215B (cfu/g)	Moist. Contnt. Wt/wt
SS 9 Bot	5.9	137	63.0	<1.0	2.0	1.12	381	0.01	<0.01	6.4	27.3	395.0	$4.1x10^6$	$2.8x10^4$	4.48
SS 10 Top	5.9	102	64.2	<1.0	1.51	1.14	402	0.02	<0.01	6.2	23.2	450.0	$3.7x10^6$	$2.6x10^4$	5.56
SS 10 Bot	6.1	96.0	63.9	<1.0	1.49	1.20	17.2	0.03	<0.01	7.3	26.0	323.0	$4.4x10^6$	$3.4x10^4$	6.21
SS 11 Top	6.1	122	61.5	<1.0	0.80	1.24	34.3	0.03	<0.01	6.1	25.9	526.0	$3.6x10^6$	$3.2x10^4$	3.15
SS 11 Bot	6.0	92.0	61.2	<1.0	0.71	0.52	22.5	0.02	<0.01	8.9	27.1	430.0	$3.2x10^6$	$3.2x10^4$	5.98
SS 12 Top	6.4	137	60.4	<1.0	0.93	0.72	25.6	0.02	<0.01	6.2	20.2	682.0	$4.3x10^6$	$3.2x10^4$	6.25
SS 12 Bot	6.2	128	59.8	<1.0	0.96	0.62	36.2	0.02	<0.01	4.4	31.2	606.0	$3.3x10^6$	$3.5x10^4$	6.31
SS 13 Top	6.3	149	62.0	<1.0	0.89	0.58	35.3	0.02	<0.01	3.6	26.4	489.0	$4.8x10^6$	$3.2x10^4$	6.14
SS 13 BOt	6.0	124	63.8	<1.0	0.82	0.61	28.4	0.03	<0.01	3.8	25.0	455.0	$4.5x10^6$	$3.0x10^4$	3.86
SS 14 Top	5.9	98.0	62.8	<1.0	0.97	0.69	46.4	0.01	<0.01	6.0	29.8	493.0	$5.1 x10^6$	$3.0x10^4$	5.26
SS 14 Bot	5.7	78.0	64.5	<1.0	1.03	0.71	38.7	0.02	<0.01	5.3	25.9	413.0	$5.6x10^6$	$3.3x10^4$	5.69
SS 15 Top	6.5	116	60.8	<1.0	1.25	0.89	68.8	0.03	<0.01	6.4	31.7	591.0	$4.2x10^6$	$3.4x10^4$	6.21
SS 15 Bot	5.6	104	60.4	<1.0	1.36	0.91	35.2	0.03	<0.01	4.4	25.0	462.0	$4.8x10^6$	$3.1x10^4$	4.85
SS 16 Top	6.1	93.0	67.2	<1.0	1.36	0.95	46.3	0.01	<0.01	5.5	31.1	612.0	$4.4x10^6$	$3.5x10^4$	4.92
SS 16 Bot	6.0	84.0	58.5	<1.0	1.43	1.04	48.1	0.02	<0.01	4.9	26.1	554.0	$4.9x10^6$	$3.0x10^4$	4.50

APPENDIX 4.4.2.1B - 1: Heavy Metals and Exchangeable Cations in Soils during Dry Season

SAMPLE POINT ID.	PARAMETERS/RESULTS															
	Na ASTM D 4191 meq/ 100g	K ASTM D 3561 meq/ 100g	Ca ASTM D1068 meq/ 100g	Mg ASTM D1068 meq/ 100g	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cr ASTM D1687 mg/kg	Mn ASTM D1068 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	V ASTM D3373 mg/kg	Ni ASTM D1886mg/kg	Cu ASTM D 1688 mg/kg	CEC APHA 3111B meq/100g (CAEM)	Excch. Acidity	Colour	Parti /Graisize >50%
Soil																
SS 1 Top	76.1	5.20	2.54	1.14	1123	<0.001	6.84	2.i4	11.01	0.18	<0.001	4.18	<0.001	66.2	2.80	Grayish brown	Silty
SS 1 Bott	110	5.01	0.154	1.35	1115	<0.001	19.85	2.45	8.11	0.21	<0.001	5.10	<0.001	95.7	3.10	Grayish brown	Silty
SS 2 Top	56.1	4.21	3.56	1.05	930	<0.001	8.16	1.88	10.45	0.12	<0.001	8.18	<0.001	48.8	3.30	brown	Silty
SS 2 Bott	65.2	4.53	4.85	1.25	945	<0.001	9.33	2.34	11.62	1.01	<0.001	7.13	<0.001	56.7	3.30	Reddish brown	Sandy
SS 3 Top	90.2	4.78	5.52	0.80	910	<0.001	7.18	2.81	8.64	0.16	<0.001	4.73	<0.001	78.4	4.46	brown	Sandy
SS 3 Bott	54.2	4.56	4.84	0.70	1024	<0.001	8.57	2.66	9.04	0.28	<0.001	5.33	<0.001	47.1	3.04	Grayish brown	Sandy
SS 4 Top	83.2	4.31	4.71	2.1	1188	<0.001	8.18	3.15	8.77	0.10	<0.001	6.12	<0.001	72.3	3.04	brown	Silty
SS 4 Bott	95.1	4.72	5.60	1.5	1304	<0.001	9.32	3.68	10.12	0.45	<0.001	8.22	<0.001	82.7	3.92	Grayish brown	Sandy
SS 5 Top	85.2	4.21	6.58	1.7	865	<0.001	11.42	2.31	6.78	0.14	<0.001	6.28	<0.001	74.1	3.04	brown	Silty
SS 5 Bott	63.1	4.52	6.49	1.01	846	<0.001	15.72	2.84	6.68	1.10	<0.001	6.66	<0.001	54.9	3.04	Reddish brown	Sandy
SS 6 Top	64.1	4.02	3.00	0.71	871	<0.001	8.12	2.46	11.29	0.180	<0.001	7.18	<0.001	55.7	4.11	Dark brown	Silty
SS 6 Bott	82.4	4.05	3.11	1.10	882	<0.001	11.38	2.33	11.88	0.110	<0.001	8.04	<0.001	71.6	3.5	Dark brown	Silty
SS 7 Top	85.4	4.11	5.24	1.00	1321	<0.001	12.08	3.16	8.14	0.060	<0.001	6.10	<0.001	74.3	3.1	Dark brown	Silty

SAMPLE POINT ID.	PARAMETERS/RESULTS															
	Na ASTM D 4191 meq/ 100g	K ASTM D 3561 meq/ 100g	Ca ASTM D1068 meq/ 100g	Mg ASTM D1068 meq/ 100g	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cr ASTM D1687 mg/kg	Mn ASTM D1068 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	V ASTM D3373 mg/kg	Ni ASTM D1886mg/kg	Cu ASTM D 1688 mg/kg	CEC APHA 3111B meq/100g (CAEM)	Excch. Acidity	Colour	Parti /Graisize >50%
SS 7 Bott	86.2	4.25	5.48	1.30	1248	<0.001	12.65	3.41	12.11	0.120	<0.001	5.68	<0.001	75.0	2.81	Brown	Silty
SS 8 Top	72.3	4.22	5.90	1.31	1121	<0.001	12.88	2.14	13.08	0.080	<0.001	5.92	<0.001	62.9	3.77	brown	Sandy
SS 8 Bott	84.1	4.12	6.30	0.81	1461	<0.001	11.88	3.12	13.09	0.110	<0.001	8.14	<0.001	73.1	2.58	Grayish brown	Sandy
SS 9 Top	73.3	4.59	3.54	1.54	1225	<0.001	15.38	3.14	8.12	0.090	<0.001	7.42	<0.001	63.7	2.33	Dark brown	Silty
SS 9 Bott	74.2	4.75	4.57	1.84	1120	<0.001	8.44	2.25	11.08	0.080	<0.001	8.12	<0.001	64.5	3.64	Dark brown	Silty
SS 10 Top	85.4	4.03	3.01	0.68	1110	<0.001	9.11	3.43	8.22	0.060	<0.001	10.42	<0.001	74.3	3.42	brown	Silty
SS 10 Bott	64.2	3.86	2.98	0.78	1441	<0.001	9.47	3.64	10.22	0.080	<0.001	11.02	<0.001	55.9	3.33	brown	Silty
SS 11 Top	120	3.54	4.57	0.44	942	<0.001	8.22	2.47	8.11	0.120	<0.001	13.46	<0.001	104.3	3.81	Grayish brown	Sandy
SS 11 Bott	65.1	3.89	1.50	0.4	909	<0.001	9.17	2.12	7.94	0.090	<0.001	13.11	<0.001	56.6	2.44	Grayish brown	Silty
SS 12 Top	98.1	4.01	1.50	1.34	1143	<0.001	8.24	2.66	12.08	0.010	<0.001	8.44	<0.001	85.3	4.06	Grayish brown	Sandy
SS 12 Bottom	64.1	4.05	1.80	1.49	1484	<0.001	11.04	3.10	11.84	0.260	<0.001	6.81	<0.001	55.7	3.18	Grayish brown	Sandy
SS 13 Top	82.1	4.52	1.70	1.86	1171	<0.001	12.64	3.14	8.47	0.080	<0.001	13.19	<0.001	71.4	3.23	Grayish brown	Silty
SS 13 Bott	101	4.60	8.60	1.92	1385	<0.001	9.47	3.08	12.18	0.140	<0.001	6.82	<0.001	87.8	3.33	Grayish brown	Sandy
SS14 Top	122	3.98	8.20	1.56	1437	<0.001	12.32	3.18	11.88	0.070	<0.001	6.24	<0.001	106.1	4.14	brown	Silty

SAMPLE POINT ID.	PARAMETERS/RESULTS																
	Na ASTM D 4191 meq/ 100g	K ASTM D 3561 meq/ 100g	Ca ASTM D1068 meq/ 100g	Mg ASTM D1068 meq/ 100g	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cr ASTM D1687 mg/kg	Mn ASTM D1068 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	V ASTM D3373 mg/kg	Ni ASTM D1886mg/kg	Cu ASTM D 1688 mg/kg	CEC APHA 3111B meq/100g (CAEM)	Excch. Acidity	Colour	Parti /Graisize >50%
SS 14 Bott	99.4	4.52	8.10	1.42	1152	<0.001	12.47	2.48	8.82	0.090	<0.001	8.04	<0.001	86.4	2.88	Grayish brown	sandy
SS 15 Top	110	4.11	4.61	1.48	744	<0.001	6.18	2.11	5.34	0.100	<0.001	6.22	<0.001	95.7	3.11	Brown	Silty
SS 15 Bott	131	4.25	4.40	1.42	884	<0.001	12.84	2.18	5.21	0.080	<0.001	6.12	<0.001	113.9	3.30	Grayish brown	Silty
SS 16 Top	125	4.32	4.30	0.46	1144	<0.001	6.11	2.42	8.14	0.050	<0.001	6.22	<0.001	108.7	2.80	Brown	Silty
SS 16 Bott	122	4.65	5.11	0.48	1112	<0.001	12.04	2.38	8.99	0.009	<0.001	8.33	<0.001	106.1	3.38	brown	Silty

APPENDIX 4.4.2.1B - 2: Physico-chemistry of Soils in the Study Area during the dry season

SAMPLE POINT ID.	PARAMETERS/RESULTS														
	pH ASTM D293 B	Cond ASTM D 1125 (µS/cm)	Cl ASTM D 512 mg/kg	THC ASTM D3921 (mg/kg)	TOM Cmbst @555 ^{0}C (%)	TOC APHA 5310 (%)	TN ASTM D 3590 (%)	NH4 APHA 4500-NH_4 (mg/kg)	NO2 APHA 4500-NO_2 (mg/kg)	NO3 APHA 4500 NO_3 mg/kg	Avail.P APHA 4500-P mg/kg	SO4 ASTM D 516 mg/kg	THB APHA 9215B (cfu/g)	THF APHA 9215B (cfu/g)	Moist. Contnt. Wt/wt
SOIL															
SS 1 Top	6.4	108.4	35.5	<1.0	0.75	0.53	0.53	0.02	<0.001	1.1	20.6	220.0	4.3×10^6	4.0×10^4	9.24
SS 1 Bottom	5.9	124.5	17.8	<1.0	0.86	0.62	0.42	0.02	<0.001	1.2	18.9	220.0	4.2×10^6	4.5×10^4	9.38
SS 2 Top	6.0	83.2	35.5	<1.0	0.45	0.30	1.01	0.01	<0.001	2.4	19.5	440.0	4.8×10^6	4.6×10^4	8.82
SS 2 Bottom	5.9	73.6	53.3	<.0	1.24	0.82	0.66	0.02	<0.001	1.2	17.3	343.0	5.1×10^6	4.9×10^4	9.20
SS 3 Top	5.9	93.5	17.8	<1.0	1.68	1.28	0.72	0.03	<0.001	1.8	21.3	686.0	5.2×10^6	4.1×10^4	5.73
SS 3 Bottom	5.7	67.3	17.8	<1.0	1.76	1.32	0.38	0.03	<0.001	2.4	21.	440.0	4.7×10^6	4.4×10^4	9.10
SS 4 Top	6.2	98.8	53.3	<1.0	1.39	0.96	526	0.02	<0.001	3.2	20.5	323.0	5.1×10^6	4.8×10^4	9.09
SS 4 Bottom	5.5	63.9	106.5	<1.0	1.27	0.84	318	0.01	<0.001	1.4	22.1	220.0	4.6×10^6	4.0×10^4	10.13
SS 5 Top	6.1	94.6	17.8	<1.0	1.58	1.08	1010	0.04	<0.001	0.8	21.6	332.0	5.0×10^6	4.3×10^4	9.56
SS 5 Bottom	6.0	84.6	692.3	<1.0	1.45	1.02	670	0.06	<0.001	4.6	20.1	525.0	4.9×10^6	4.9×10^4	10.01
SS 6 Top	6.4	102.9	53.3	<1.0	0.42	0.26	484	0.04	<0.001	6.2	18.5	618.0	4.8×10^6	3.4×10^4	10.00
SS 6 Bottom	6.3	81.0	17.8	<1.0	0.48	0.32	232	0.30	<0.001	4.4	17.3	330.0	5.3×10^6	4.8×10^4	10.34
SS 7 Top	6.2	8100	53.3	<1.0	2.89	1.86	1.06	0.18	<0.001	30.8	20.1	710.0	5.4×10^6	4.0×10^4	9.53
SS 7 Bottom	6.0	83.5	17.8	<1.0	2.44	1.62	1280	0.01	<0.001	18.2	18.1	626.0	4.8×10^6	4.8×10^4	9.97
SS 8 Top	5.9	73.6	53.3	<1.0	2.24	1.56	660	0.06	<0.001	10.2	23.1	688.0	4.9×10^6	4.5×10^4	11.10
SS 8 Bottom	5.8	70.1	35.5	<1.0	2.16	1.23	526	0.03	<0.001	6.4	21.1	495.0	4.8×10^6	4.8×10^4	10.58
SS 9 Top	6.5	100.5	17.8	<1.0	2.18	1.24	316	0.03	<0.001	2.8	23.5	335.0	5.2×10^6	4.8×10^4	10.37
SS 9 Bottom	5.6	78.8	35.5	<1.0	0.39	0.23	0.33	0.04	<0.001	3.2	20.2	214.0	5.3×10^6	3.9×10^4	10.21

SAMPLE POINT ID.	PARAMETERS/RESULTS														
	pH ASTM D293 B	Cond ASTM D 1125 (μS/cm)	Cl ASTM D 512 mg/kg	THC ASTM D3921 (mg/kg)	TOM Cmbst @555 ^{0}C (%)	TOC APHA 5310 (%)	TN ASTM D 3590 (%)	NH4 APHA 4500-NH_4 (mg/kg)	NO2 APHA 4500-NO_2 (mg/kg)	NO3 APHA 4500 NO_3 mg/kg	Avail.P APHA 4500-P mg/kg	SO4 ASTM D 516 mg/kg	THB APHA 9215B (cfu/g)	THF APHA 9215B (cfu/g)	Moist. Contnt. Wt/wt
SS 10 Top	6.5	109.8	53.3	<1.0	1.86	1.34	1187	0.03	<0.001	4.8	20.6	220.0	$5.1x10^6$	$4.4x10^4$	9.65
SS 10 Bott	6.1	94.6	35.5	<1.0	1.92	0.98	493	0.02	<0.001	3.4	18.9	395.0	$5.3x10^6$	$4.8x10^4$	9.97
SS 11 Top	6.8	121.8	100.5	<1.0	1.30	0.94	284	0.03	<0.001	1.8	19.5	110.0	$5.1x10^6$	$4.8x10^4$	8.97
SS 11 Bott	6.0	84.1	35.5	<1.0	1.39	0.96	220	0.04	<0.001	2.6	17.3	330.0	$4.8x10^6$	$4.8x10^4$	9.49
SS 12 Top	6.0	83.9	53.3	<1.0	1.68	1.15	990	0.02	<0.001	4.2	22.3	110.0	$4.7x10^6$	$4.9x10^4$	10.50
SS 12 Bott	5.8	71.8	53.3	<1.0	0.62	0.48	485	0.15	<0.001	2.1	20.5	440.0	$5.0x10^6$	$3.9x10^4$	9.30
SS 13 Top	6.2	81.6	17.8	<1.0	0.81	0.59	519	0.15	<0.001	14.5	19.6	708.0	$4.6x10^6$	$4.9x10^4$	12.08
SS 13 BOtt	6.0	84.2	17.8	<1.0	0.75	0.53	536	0.06	<0.001	6.2	17.2	465.0	$5.5x10^6$	$4.5x10^4$	11.93
SS 14 Top	6.1	94.8	53.3	<1.0	0.92	0.63	333	0.11	<0.001	11.2	22.0	516.0	$4.9\ x10^6$	$4.6x10^4$	11.45
SS 14 Bott	5.9	73.8	17.8	<1.0	0.97	0.64	264	0.06	<0.001	6.10	21.1	485.0	$4.2x10^6$	$4.9x10^4$	10.12
SS 15 Top	6.1	90.7	17.8	<1.0	1.14	0.72	640	0.45	<0.001	45.2	19.5	310.0	$4.9x10^6$	$4.9x10^4$	10.61
SS 15 Bott	5.7	67.3	53.3	<1.0	1.18	0.78	400	0.56	<0.001	57.6	18.0	613.0	$4.6x10^6$	$4.8x10^4$	10.95
SS 16 Top	6.1	91.8	35.5	<1.0	1.26	0.86	458	0..004	<0.001	4.10	19.6	394.0	$5.1x10^6$	$4.8x10^4$	8.53
SS 16 Bott	5.9	73.8	32.5	<1.0	1.32	0.93	323	0.006	<0.001	6.20	17.2	314.0	$4.8x10^6$	$4.84x10^4$	9.53

APPENDIX 4.4.2.1B -2: Heavy Metals and Exchangeable Cations in Soils during the Wet Season

SAMPLE POINT ID.	PARAMETERS/RESULTS															
	Na ASTM D 4191 meq/ 100g	K ASTM D 3561 meq/ 100g	Ca ASTM D1068 meq/ 100g	Mg ASTM D1068 meq/ 100g	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cr ASTM D1687 mg/kg	Mn ASTM D1068 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	V ASTM D3373 mg/kg	Ni ASTM D1886mg/kg	Cu ASTM D 1688 mg/kg	CEC APHA 3111B meq/100g (CAEM)	Excch. Acidity	Colour	Parti /Graisize >50%
Soil																	
SS 1 Top	1.98	4.76	0.132	0.104	1018.7	<0.001	6.39	2.04	10.39	0.10	<0.001	3.19	<0.001	64.12	2.68	Grayish brown	Silty
SS 1 Bott	1.96	4.85	0.126	0.124	953.40	<0.001	19.12	1.98	6.83	0.14	<0.001	4.20	<0.001	44.59	2.04	Grayish brown	Silty
SS 2 Top	2.14	3.92	0.345	0.114	691.90	<0.001	7.68	1.38	10.22	0.09	<0.001	7.51	<0.001	71.20	2.30	brown	Silty
SS 2 Bott	2.24	3.98	0.462	0.118	885.50	<0.001	8.08	1.77	10.55	0.14	<0.001	6.66	<0.001	71.84	2.30	Reddish brown	Sandy
SS 3 Top	2.37	4.26	0.565	0.098	865.50	<0.001	6.39	1.73	5.21	0.09	<0.001	3.69	<0.001	69.66	1.46	brown	Sandy
SS 3 Bott	3.46	4.32	0.435	0.094	961.50	<0.001	8.14	1.92	6.12	0.13	<0.001	4.13	<0.001	66.77	2.04	Grayish brown	Sandy
SS 4 Top	2,56	4.52	0.432	0.189	1123.7	<0.001	7.68	2.25	8.12	0.06	<0.001	5.93	<0.001	66.14	2.04	brown	Silty
SS 4 Bott	2.75	4.62	0.557	0.192	1234.7	<0.001	8.08	2.47	9.81	0.13	<0.001	6.91	<0.001	233.33	2.92	Grayish brown	Sandy
SS 5 Top	6.87	4.65	0.642	0.179	691.90	<0.001	10.16	1.38	4.70	0.09	<0.001	5.67	<0.001	233.33	2.04	brown	Silty
SS 5 Bott	5.24	4.61	0.654	0.176	645.10	<0.001	12.09	1.29	4.60	0.16	<0.001	5.70	<0.001	66.15	2.04	Reddish brown	Sandy
SS 6 Top	4.67	3.87	0.282	0.032	698.70	<0.001	6.06	1.40	10.12	<0.001	<0.001	6.82	<0.001	69.90	1.98	Dark brown	Silty
SS 6 Bott	5.54	3.56	0.308	0.042	654.70	<0.001	9.68	1.31	10.12	0.08	<0.001	6.11	<0.001	233.33	3.28	Dark brown	Silty
SS 7 Top	3.89	3.94	0.504	0.134	1122.6	<0.001	10.16	2.25	6.93	<0.001	<0.001	4.90	<0.001	233.33	1.89	Dark brown	Silty

SAMPLE POINT ID.	PARAMETERS/RESULTS															
	Na ASTM D 4191 meq/ 100g	K ASTM D 3561 meq/ 100g	Ca ASTM D1068 meq/ 100g	Mg ASTM D1068 meq/ 100g	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cr ASTM D1687 mg/kg	Mn ASTM D1068 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	V ASTM D3373 mg/kg	Ni ASTM D1886mg/kg	Cu ASTM D 1688 mg/kg	CEC APHA 3111B meq/100g (CAEM)	Excch. Acidity	Colour	Parti /Graisize >50%
SS 7 Bott	2.74	4.04	0.624	0.139	1194.7	<0.001	12.09	2.39	11.39	<0.001	<0.001	4.32	<0.001	66.14	2.73	Brown	Silty
SS 8 Top	4-76	4.06	0.645	0.084	906.8	<0.001	12.14	1.81	11.39	<0.001	<0.001	3.67	<0.001	69.91	2.82	brown	Sandy
SS 8 Bott	4.04	3.96	0.628	0.086	1193.6	<0.001	10.12	2.39	12.21	0.04	<0.001	6.80	<0.001	55.68	1.86	Grayish brown	Sandy
SS 9 Top	2.69	4.76	0.342	0.154	1147.9	<0.001	37.57	2.30	7.21	0.01	<0.001	5.68	<0.001	234.35	3.12	Dark brown	Silty
SS 9 Bott	3.73	4.82	0.476	0.184	906.80	<0.001	6.05	1.81	9.37	0.03	<0.001	6.52	<0.001	64.12	2.92	Dark brown	Silty
SS 10 Top	5.12	3.67	0.281	0.068	1041.3	<0.001	7.68	2.08	6.61	<0.001	<0.001	8.94	<0.001	44.58	3.41	brown	Silty
SS 10 Bott	5.44	3.78	0.305	0.078	1262.9	<0.001	8.08	2.53	8.13	<0.001	<0.001	8.11	<0.001	71.20	1.96	brown	Silty
SS 11 Top	4.62	3.60	0.427	0.044	512.10	<0.001	6.39	1.02	6.11	0.010	<0.001	11.63	<0.001	71.84	2.56	Grayish brown	Sandy
SS 11 Bott	5.11	3.62	0.145	0.038	613.10	<0.001	8.12	1.23	7.18	0.040	<0.001	12.75	<0.001	69.66	2.16	Grayish brown	Silty
SS 12 Top	4.84	3.94	0.154	0.134	1041.8	<0.001	6.15	2.08	10.22	0.012	<0.001	6.55	<0.001	66.14	1.98	Grayish brown	Sandy
SS 12 Bottom	5.18	3.96	0.182	0.149	1262.9	<0.001	9.87	2.53	11.22	0.096	<0.001	5.68	<0.001	225.32	2.13	Grayish brown	Sandy
SS 13 Top	4.83	4.68	0.772	0.186	1041.4	<0.001	12.14	2.08	13.22	<0.001	<0.001	12.76	<0.001	215.98	3.21	Grayish brown	Silty
SS 13 Bott	3.98	4.78	0.864	0.192	1262.9	<0.001	15.12	2.53	16.42	<0.001	<0.001	4.90	<0.001	202.98	2.18	Grayish brown	Sandy
SS14 Top	3.96	4.32	0.824	0.156	1261.9	<0.001	10.16	2.52	12.46	<0.001	<0.001	3.68	<0.001	202.98	4.12	brown	Silty
SS 14 Bott	4.81	4.42	0.812	0.142	1041.5	<0.001	12.09	2.08	14.82	<0.001	<0.001	5.68	<0.001	201.32	2.88	Grayish	sandy

SAMPLE POINT ID.	PARAMETERS/RESULTS															
	Na ASTM D 4191 meq/ 100g	K ASTM D 3561 meq/ 100g	Ca ASTM D1068 meq/ 100g	Mg ASTM D1068 meq/ 100g	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cr ASTM D1687 mg/kg	Mn ASTM D1068 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	V ASTM D3373 mg/kg	Ni ASTM D1886mg/kg	Cu ASTM D 1688 mg/kg	CEC APHA 3111B meq/100g (CAEM)	Excch. Acidity	Colour	Parti /Graisize >50%
																brown	
SS 15 Top	4.36	3.58	0.455	0.148	512.10	<0.001	3.64	1.02	1.15	<0.001	<0.001	3.69	<0.001	59.23	2.96	Brown	Silty
SS 15 Bott	4.56	3.64	0.437	0.142	632.10	<0.001	12.09	1.26	1.16	<0.001	<0.001	4.13	<0.001	59.23	1.49	Grayish brown	Silty
SS 16 Top	5.24	3.95	0.432	0.046	1018.8	<0.001	3.66	2.04	11.26	<0.001	<0.001	4.13	<0.001	66.15	3.42	Brown	Silty
SS 16 Bott	6.37	4.34	0.507	0.048	953.50	<0.001	10.55	1.91	12.68	<0.001	<0.001	6.14	<0.001	69.91	2.68	brown	Silty

Appendix 4.4 C: Microbiological characteristics of the soil in the study area during dry season (January 2012)

Sample identity	cfu/g				Species composition			
	THB	**THF**	**HUB**	**HUF**	**THB**	**THF**	**HUB**	**HUF**
SS1 (Top)	$3.3 x 10^6$	$1.10 x 10^5$	NIL	NIL	*Arthrobacter spp., Pseudomonas spp., Klebsiella spp., Bacillus spp., Enterobacter spp., Proteus spp.*	*Aspergillus spp., Mucor spp., Penicillium spp., Fusarium, spp.*	NIL	NIL
Bottom	$2.27 x 10^5$	$8.2 x 10^4$	NIL	NIL	*Norcadia spp., Arthrobacter spp., Pseudomonas spp., Bacillus spp., Rhizobium spp.,*	*Aspergillus spp., Mucor spp., Fusarium spp*	NIL	NIL
SS2 (Top)	$5.8 x 10^6$	$2.30 x 10^5$	NIL	NIL	*Serratia spp., Micrococcus spp., Proteus spp., Norcadia spp., Bacillus spp., Achromobacter spp.*	*Mucor spp., Candida spp., Aspergillus spp., Sporobolomyces spp.,*	NIL	NIL
Bottom	$1.32 x 10^5$	$7.7 x 10^4$	NIL	NIL	*Proteus spp., Norcadia spp., Bacillus spp., Achromobacter spp., Pseudomonas spp., Rhizobium spp.,*	*Sporobolomyces spp., Saccharomyces spp., Aspergillus spp.,*	NIL	NIL
SS3 (Top)	$2.16 x 10^6$	$4.9 x 10^5$	NIL	NIL	*Enterobacter spp., Arthrobacter spp., Micrococcus spp., Serratia spp., Klebsiella spp.*	*Fusarium spp., Candida spp., Mucor spp.*	NIL	NIL
Bottom	$7.2 x 10^5$	$3.1 x 10^4$	NIL	NIL	*Pseudomonas spp., Bacillus spp., Staphylococcus spp., Arthrobacter spp., Proteus spp., Rhizobium spp.,*	*Saccharomyces spp., Candida spp., Aspergillus spp.*	NIL	NIL
SS4 (Top)	$1.09 x 10^6$	$2.16 x 10^5$	NIL	NIL	*Enterobacter spp., Norcadia spp., Proteus spp., Micrococcus spp., Pseudomonas spp.,*	*Fusarium spp., Mucor spp., Penicillium spp., Torulopsis spp.*	NIL	NIL

Sample identity	cfu/g				Species composition			
	THB	THF	HUB	HUF	THB	THF	HUB	HUF
Bottom	$3.2x10^5$	$8.6x10^4$	NIL	NIL	*Rhizobium spp., Proteus spp., Norcadia spp., Arthrobacter spp*	*Saccharomyces spp., Aspergillus spp., Mucor spp.,*	NIL	NIL
SS5 (Top)	$7.1x10^6$	$1.15x10^5$	NIL	NIL	*Acinetobacter spp., Staphylococcus spp., Klebsiella spp, Serratia spp., Pseudomonas spp.*	*Mucor spp., Penicillium spp., Saccharomyces spp., Candida spp.*	NIL	NIL
Bottom	$2.12x10^5$	$4.3x10^4$	NIL	NIL	*Pseudomonas spp., Acinetobacter spp., Bacillus spp., Rhizobium spp., Achromobacter spp.,*	*Mucor spp., Penicillium spp., Saccharomyces spp., Candida spp.*	NIL	NIL
SS6 (Top)	$9.1x10^6$	$6.0x10^5$	NIL	NIL	*Klebsiella spp., Proteus spp., Micrococcus spp., Pseudomonas sp*	*Mucor spp., Aspergillus spp., Saccharomyces spp., Candida spp., Sporobolomyces spp.,*	NIL	NIL
Bottom	$1.36x10^5$	$7.2x10^4$	NIL	NIL	*Pseudomonas spp., Acinetobacter spp., Klebsiella spp., Nocardia spp., Rhizobium spp.,*	*Fusarium spp., Candida spp., Sporobolomyces spp., Aspergillus spp.*	NIL	NIL
SS7 (Top)	$5.7x10^6$	$3.3x10^5$	NIL	NIL	*Bacillus spp., Micrococcus spp., Klebsiella spp., Arthrobacter spp., Pseudomonas spp.*	*Saccharomyces spp., Mucor spp., Candida spp.*	NIL	NIL
Bottom	$1.12x10^5$	$9.1x10^4$	NIL	NIL	*Rhizobium spp., Pseudomonas spp., Staphylococcus spp., Serratia spp.*	*Fusarium spp., Candida spp., Mucor spp.*	NIL	NIL
SS8 (Top)	$2.75x10^6$	$6.4x10^5$	NIL	NIL	*Arthrobacter spp., Serratia spp., Nocardia spp., Proteus spp., Pseudomonas spp.*	*Torulopsis spp., Penicillium spp., Aspergillus spp., Sporobolomyces spp.*	NIL	NIL

Sample identity	cfu/g				Species composition			
	THB	THF	HUB	HUF	THB	THF	HUB	HUF
Bottom	$3.0x10^5$	$8.2x10^4$	NIL	NIL	*Rhizobium spp., Pseudomonas spp., Nocardia spp., Proteus spp., Achromobacter spp.*	*Fusarium spp., Candida spp., Mucor spp., Saccharomyces spp.*	NIL	NIL
SS9 (Top)	$1.97x10^6$	$5.6x10^5$	NIL	NIL	*Staphylocuccus spp., Enterobacter spp., Klebsiella spp., Nocardia spp., Arthrobacter spp.,*	*Penicillium spp., Saccharomyces spp., Aspergillus spp., Fusarium spp.*	NIL	NIL
Bottom	$2.12x10^5$	$1.8x10^4$	NIL	NIL	*Nocardia spp., Pseudomonas spp., Arthrobacter spp., Rhizobium spp.*	*Penicillium spp., Saccharomyces spp., Aspergillus spp., Fusarium spp.*	NIL	NIL
SS10 (Top)	$3.3x10^6$	$9.4x10^5$	NIL	NIL	*Pseudomonas spp., Bacillus spp., Micrococcus spp., Staphylococcus spp.*	*Mucor spp., Saccharomyces spp., Aspergillus spp.,*	NIL	NIL
Bottom	$7.1x10^5$	$2.42x10^4$	NIL	NIL	*Pseudomonas spp., Micrococcus spp., Arthrobacter spp., Rhizobium spp., Bacillus spp.,*	*Aspergillus spp., Mucor spp., Fusarium spp., Candida spp.*	NIL	NIL
SS11 (Top)	$1.59x10^6$	$3.0x10^5$	NIL	NIL	*Pseudomonas spp., Micrococcus spp., Serratia spp., Achromobacter spp.*	*Aspergillus spp., Fusarium spp., Sporobolomyces spp., Candida spp.,*	NIL	NIL
Bottom	$6.2x10^5$	$1.14x10^4$	NIL	NIL	*Nocardia spp., Pseudomonas spp., Rhizobium spp., Serratia spp.*	*Aspergillus spp., Fusarium spp., Sporobolomyces spp., Candida spp.,*	NIL	NIL
SS13 (Top)	$2.59x10^6$	$9.6x10^5$	NIL	NIL	*Pseudomonas spp., Acinetobacter spp., Bacillus spp., Arthrobacter spp., Achromobacter spp*	*Torulopsis spp., Penicillium spp., Aspergillus spp., Mucor spp.,*	NIL	NIL

Sample identity	cfu/g				Species composition			
	THB	**THF**	**HUB**	**HUF**	**THB**	**THF**	**HUB**	**HUF**
Bottom	$3.4x10^5$	$5.1x10^4$	NIL	NIL	*Rhizobium spp., Proteus spp., Achromobacter spp., Arthrobacter spp., Pseudomonas spp.,*	*Torulopsis spp., Penicillium spp., Aspergillus spp.*	NIL	NIL
SS14 (Top)	$1.77x10^6$	$2.9x10^5$	NIL	NIL	*Pseudomonas spp., Klebsiella spp., Norcadia spp., Proteus spp., Micrococcus spp.,*	*Aspergillus spp., Mucor spp., Saccharomyces spp., Fusarium spp.,*	NIL	NIL
Bottom	$4.1x10^5$	$1.75x10^4$	NIL	NIL	*Pseudomonas spp., Proteus spp., Arthrobacter spp.,Micrococcus spp.,*	*Mucor spp., Saccharomyces spp., Fusarium spp., Sporobolomyces spp*	NIL	NIL
SS15 (Top)	$9.9x10^6$	$6.3x10^5$	NIL	NIL	*Acinetobacter spp., Proteus spp., Pseudomonas spp., Bacillus spp., Arthrobacter spp.*	*Saccharomyces spp., Aspergillus spp., Fusarium spp., Candida spp.*	NIL	NIL
Bottom	$3.2x10^5$	$1.17x10^4$	NIL	NIL	*Pseudomonas spp., Rhizobium spp., Arthrobacter spp.,Proteus spp.,*	*Saccharomyces spp., Aspergillus spp., Fusarium spp., Candida spp.*	NIL	NIL
SS16 (Top)	$8.9x10^6$	$5.1x10^5$	NIL	NIL	*Micrococcus spp., Proteus spp., Achromobacter spp., Pseudomonas spp.,*	*Sporobolomyces spp., Torulopsis spp., Mucor spp., Aspergillus spp., Candida spp*	NIL	NIL
Bottom	$2.6x10^5$	$7.3x10^4$	NIL	NIL	*Rhizobium spp., Proteus spp., Achromobacter spp., Pseudomonas spp.,*	*Sporobolomyces spp., Torulopsis spp., Mucor spp., Aspergillus spp.,*	NIL	NIL
SSC1T	$4.9x10^6$	$8.1x10^5$	NIL	NIL	*Norcadia spp., Proteus spp., Micrococcus spp., Pseudomonas spp.,*	*Saccharomyces spp., Mucor spp., Torulopsis spp.*	NIL	NIL

Sample identity	cfu/g				Species composition			
	THB	**THF**	**HUB**	**HUF**	**THB**	**THF**	**HUB**	**HUF**
SSC1B	$1.03x10^5$	$6.2x10^4$	NIL	NIL	*Pseudomonas spp., Arthrobacter spp., Norcadia spp., Rhizobium spp.,*	*Candida spp., Sporobolomyces spp., Torulopsis spp., Saccharomyces spp.,*	NIL	NIL
SSC2T	$7.0x10^6$	$3.1x10^5$	NIL	NIL	*Enterobacter spp., Micrococcus spp., Norcadia spp., Klebsiella spp., Pseudomonas spp.,*	*Aspergillus spp., Candida spp., Saccharomyces spp., Torulopsis spp.*	NIL	NIL
SSC2B	$3.2x10^5$	$6.6x10^4$	NIL	NIL	*Rhizobium spp., Pseudomonas spp., Norcadia spp., Arthrobacter spp.,*	*Aspergillus spp., Candida spp., Saccharomyces spp., Torulopsis spp.*	NIL	NIL

APPENDIX 4.6:
CHECKLIST OF PLANT SPECIES AT DIFFERENT TRANSECTS

S/N	Botanical Name	Common Name	Life form	Family	Uses	VG1	VG2	VG3	VG4	VG 5	VG 6	VG 7	VG 8	VG 9	VG 10	VG 11
1	*Irvingia gabonensis*	Wild (bush) mango	Tree	Irvingiaceae	Food	x	x	x		x						
2	*Abelmoschus esculentus*	Okro	Herb	Malvaceae	Food	x			x							
3	*Musanga cecropioides*	Umbrella tree	Tree	Moraceae	Medicinal	x	x					x	x			
4	*Musa sapientum*	Plantain	Shrub	Musaceae	Food	x	x	x	x	x		x	x			
5	*M. paradisiaca*	Banana	Shrub	Musaceae	Food	x	x	x	x	x		x	x			
6	*Elaies guineensis*	Palm tree	Tree	Arecaceae	Palm oil	x	x	x	x	x	x	x	x		x	x
7	*Raffia hookeri*	Raffia palm	Tree	Arecaceae	Beverage	x	x			x	x	x	x			
8	*Manihot esculenta*	Cassava	Shrub	Euphorbiaceae	Food	x			x							
9	*Cleistopholis patens*	Salt and oil tree	Tree	Annonaceae	Food	x										
10	*Mangifera indica*	Mango	Tree	Anacardiaceae	Food	x				x						
11	*Pennisetum purpureum*	Elephant grass	Shrub	Poaceae	Weed	x				x						
12	*Vossia cuspidata*	Hippo grass	Herb	Poaceae	Weed	x				x	x					
13	*Eichhornia crassipes*	Water hyacinth	Herb	Pontederiaceae	Weed	x				x	x		x		x	x
14	*Anthocleista vogelli*	Cabbage tree	Tree	Loganaceae			x	x			x					
15	*Alchornea cordifolia*	Christmass bush	Shrub	Euphorbiaceae	Medicinal		x	x	x	x	x	x	x		x	x
16	*Liana*	Wild vines	Climbers				x	x								
17	*Antiaris africana*	Bark cloth tree	Tree	Moraceae			x									
18	*Nauclea diderrichii*	Opepe	Tree	Rubiaceae	Timber		x	x								
19	*Pterygota macrocarpa*		Tree	Sterculiaceae			x									
20	*Terminalia*	Afara	Tree	Combretaceae	Timber		x					x				

S/N	Botanical Name	Common Name	Life form	Family	Uses	VG1	VG2	VG3	VG4	VG 5	VG 6	VG 7	VG 8	VG 9	VG 10	VG 11
	superba															
21	Grasses			Poaceae			x									
22	Sedges		Herb	Cyperaceae	Medicinal		x	x							x	x
23	*Calamus rotang*	Climbing cane	Shrub	Arecaceae	Craft			x								
24	Paspalum conjugatum	Hilo grass	Herb	Poaceae	Weed			x								
25	*Piptadeniastrum africanum*	African Piptadenia-like tree	Tree	Mimosaceae	Timber			x								
26	*Peperomia pellucida*	Shiny bush	Herb	Piperaceae	Weed			x								
27	*Bambusa vulgaris*	Bamboo	Tree	Poaceae	Construction				x							
28	*Calapogonium mucunoides*	Calapo	Climber	Fabaceae	Cover crop				x							
29	Ferns			Polypodiaceae	Medicinal				x							
30	*Caladium bicolor*	Heart of Jesus	Herb	Araceae	Weed				x							x
31	*Aspilia africanum*			Asteraceae	Weed				x							
32	*Citrus sinensis*	Sweet orange	Tree	Rubiaceae	Drink				x							
33	*Ficus*	Fig	Tree	Moraceae					x							
34	*Panicum maximum*	Guinea grass	Shrub	Poaceae	Weed				x							
35	*Brachiaria deflexa*		Herb	Poaceae	Weed				x							
36	*Pennisetum polystachion*	Feathery pennisetum	Herb	Poaceae	Weed				x							
37	*Salvinia molesta*	Water (Floating) fern	Herb	Salviniaceae	Weed					x	x					
38	*Pistia stratioites*	Water lettuce	Herb	Araceae	Weed					x	x					
	Lophira alata	Iron wood	Tree	Ochnaceae	Timber					x	x	x	x			
39	*Pentaclethra macrophylla*	Oil bean tree	Tree	Fabaceae	Food /wood					x	x					
40	*Sterculia tragacanth*	African Tragacanth	Tree	Sterculiaceae	Gums					x						

S/N	Botanical Name	Common Name	Life form	Family	Uses	VG1	VG2	VG3	VG4	VG 5	VG 6	VG 7	VG 8	VG 9	VG 10	VG 11
41	*Cyrtosperma senegalense*	Swamp arum	Herb	Araceae	Weed					x						
42	*Cocos nucifera*	Coconut	Tree	Arecaceae	Food/ fibre					x						x
43	*Neptunia oleracea*		Aquatic herb	Mimosaceae							x					
44	*Erythrophleum ivorense*	Sasswood	Tree	Mimosaceae							x					
45	*Alstonia boonei*	Boone's Alstonia	Tree	Apocynaceae							x					
46	*Pentadesma butyracea*	Tallow tree	Tree	Guttifera e							x					
47	*Uapaca heudelotii*	Heudelot's Uapaca	Tree	Euphorbiaceae							x					
48	*Chromoleana odorata*	Siam weed	Shrub	Asteraceae	Weed							x	x			
49	*Persia americana*	Avocado pear	Tree	Lauraceae	Food							x	x			
50	*Ludwigia decurrens*	Water primrose	Herb	Onagraceae								x	x			
51	*Platycerium*	Bracket fern	Herb	Polypodiaceae								x				
52	*Carica papaya*	Pawpaw	Herb	Caricaceae	Food/medicine							x	x			
53	*Terminalia ivorensis*	Black afara	Tree	Combtretaceae	Timber								x			
54	*Pteridium aquilinum*	Bracken fern	Herb	Dennstaedtiaceae									x			
55	*Macharium lanatus*			Fabaceae									x		x	
56	*Platycerium*	Staghorn fern	Herb	Polypodiaceae									x	x		
57	*Pandanus candellabrum*		Tree	Pandanaceae	Craft making/matting									x	x	
58	*Rhizophora racemosa*	Red mangrove	Tree	Rhizophoraceae	Wood /construction									x	x	x
59	*Rhizophora*		Tree	Rhizophoraceae	Construction/wood									x	x	

S/N	Botanical Name	Common Name	Life form	Family	Uses	VG1	VG2	VG3	VG4	VG 5	VG 6	VG 7	VG 8	VG 9	VG 10	VG 11
	harrisoni															
60	*Rhizophora mangle*		Tree	Rhizophoraceae										x	x	
61	*Avicennia africana*	Black mangrove	Tree	Avicenniaceae										x	x	
62	*Laguncularia racemosa*		Tree	Combretaceae										x	x	
63	*Urena lobata*	Caesar weed	Herb	Malvaceae	Medicinal										x	x
64	*Mimosa pudiica*	Sensitive plant	Herb	Mimosaceae											x	x

Appendix 4.6.1: Wildlife

Ref Code	Class	Family	Species	Local Ijaw Name	Date last killed or sighted	Market Price Range (N)	Local	IUCN	WCMC	Act 11
M/01	Mammalia	Muridae	Lemniscomys striatus(Spotted grass mouse)	?	June, 2008	-	S	-	-	-
M/02	"	"	Crocidura nigeriae (Nigerian Musk shrew)	?	May, 2008	-	S	-	-	-
M/03	"	Soricidae	Xeru erythropus(West African ground squirrel)	Okpoi	July., 2008	-	S	-	-	-
M/04	"	"	Epixerus ebii(Palm Squirrel)	Okpoi	July.,2008	-	S	-	-	-
M/05	"	"	Helioscuirus rufobrachium(Red-legged Sun Squirrel)	?	July., 2008	-	S	-	-	-
M/06	"	Cricetidae	Cricetomys emini(Emin's Giant rat)	Buowu-eke	July., 2008	1200-1500	S	-	-	-
M/07	"	Thryonomidae Thryonomys swinderianus	(Cane Rat or Grasscutter)	Ikiri	July., 2008	2800-3500	S	-	-	-
M/08	"	"	Atherurus africanus(Brush-tailed Porcupine)	Lebele	July. 2008	2500-3000	V	-	I	Sch.1
M/09	"	Bovidae	Cephalophus maxwelli Maxwell's Duiker	Bouo	May,2008	15,000-20000	V	-	K	-
M/10	"	"	Tragelaphus scriptus(Bushbuck)	Asalah	Nov,2007	22000-25000 V	V	-	K	-
M/11	"	"	Tragelaphus spekei(Sitatunga)	Bouobori	Aug.2007	22000-25000 V		-	E	Sch 1
M/12	"	"	Hymenoschus aquaticus(Water Chevrotain)	?	Jul. 2006	20000-25000 V		-	-	Sch 1
M/13	"	"	Neotragus batesi(Bate's Pygmy Antelope)	Waah	June,2008	8,000-10000	V	-	-	Sch 1
M/14	"	Suidae	Potamochoerus porcus(Bushpig)	Orbe	Mar,2008	25000-30000 V		-	-	-
M/15	"	Viverridae	Viverra civetta(African Civet Cat)	Elorlei	Jan.2008	12000-15000 V		-	-	Sch 2
M/16	"	"	Genetta poensis(Forest Genet)	Tomi	May, 2008 3000- 4500 V			-	-	Sch 2

Ref Code	Class	Family	Species	Local Ijaw Name	Date last killed or sighted	Market Price Range (N)	Local	IUCN	WCMC	Act 11
M/17	"	"	Nandinia binotata(Two-spotted Palm Civet)	?	Aug.2007	1800-2200	V	-	-	Sch 2
M/18	"	Herpestidae Atilax palidunosus	(Marsh Mongoose)	Edah	Feb., 2008	1500-1800	V	-	-	Sch 2
M/19	"	"	Herpestes ichneumon(Egyptian mongoose)	Edah	Oct. 2007	1600-2000	V	-	-	Sch 2
M/20	"	Mannidae	Manis tetradactyla(Long-tailed Pangolin)	Epu	Jan. 2008 3500-5800 V			-	-	Sch 1
M/21	"	"	Manis tricuspis(Tree Pangolin)	Epu	Apr.2008	2500-4000	V	-	-	Sch 1
M/22	"	Cercopithecidae Cercopithecus mona	(Mona Monkey)	Kemebugor	Apr. 2008	15000-20000	V	-	-	Sch 2
M/23	"	"	Cercopithecus nictitans(Putty-nose monkey)	Kemebugor	June, 2008 15000-20000 V			-	-	Sch 2
M/24	"	"	Colobus sp. Red Colobus ?	Opou-bugor	Sept, 2007 15000-20000		?	-	-	Sch 2
M/25	"	Loridae	Perodicticus potto(Bosman Potto)	Mgbisirisi	April,2007	12,000-1800	?	-	-	Sch 2
M/26	"	Galagonidae	Galagos sp Bush Baby	"	Nov,2007	?	?	-	-	Sch 2
AV/27	Aves	Accipitridae Milvus migrans	Milvus migrans(Black Kite)	Ekulei	July, 2008		S	Afm/B, PM	-	Sch 1
AV/28	"	"	Kaupifalco monogramicus(Lizard Buzzard)	Okporkpor	July,2008		S	RB, ?Afm	-	Sch 1
AV/30	"	"	Accipiter erythropus Chicken Hawk)	Okporkpor	July,2008		S	R(B)	-	Sch 1
AV/31	"	"	Necrosyrtes monachus(Hooded Vulture)	Udele	July, 2008		S	RB	-	Sch 1

Ref Code	**Class**	**Family**	**Species**	**Local Ijaw Name**	**Date last killed or sighted**	**Market Price Range (N)**	**Local**	**IUCN**	**WCMC**	**Act 11**
AV/32	"	"	Gypohierax angolensis(Palmnut Vulture)	Uge	July, 2008		V	RB	-	Sch. 2
AV/33	"		Bucerotidae Tokus fasciatus(African Pied Hornbill)	Gulegule	July,2008		S	RB	-	-
AV/34	"	"	Ceratogymna fistulator(Piping Hornbill)	Agbamgbamtere	July.,2008		V	RB		-
AV/35	"	"	Ceratogymna elata(Yellow-casqued Wattled Hornbill)	"	July,2008		S	R(B), NT		-
AV/36	"		Ardeidae Egretta alba(Great White Egret)	Boi	July,2008		V	RB		Sch.2
AV/37	"	"	Egretta garzetta(Little Egret)	Boi	July, 2008		S	RB		Sch 2
AV/38	"	"	Corvus albus(Pied Crow)		July,2008		V	RB		-
AV/39	"	Anatidae	Dendrocygna viduata White-faced Whistling Duck)	Bou-ordoguma	July,2008		S	RB		-
AV/40	"	Numididae	Guttera pucherani(Crested Guinea fowl))		Feb.,2008		S	RB		-
AV/41	"	"	Francolinus bicalcaratus(Double-spurred Francolin)		Feb.,2008		S	RB		-
AV/42	"		Alcedinidae Halcyon malimbica(Blue-crested Kingfisher)	Okiya	July,.2008		S	RB		-
AV/43	"	"	Halcyon senegalense(Woodland Kingfisher)	Okiya	July, 2008		S	RB		-
AV/44	"	"	Megaceryle maxima(Giant Kingfisher)		July,2008		V	R(B)		-
AV/45	"	Meropidae	Merops pusillis(Little Bee-eater)		July, 2008		S	RB		-
AV/46	"	Apopidae	Apus affinis(Little Swift)		July.,2008		S	RB, PM		-

Ref Code	Class	Family	Species	Local Ijaw Name	Date last killed or sighted	Market Price Range (N)	Local	IUCN	WCMC	Act 11
AV/47	"	"	Cypsiurus parvus(African Palm Swift)		July,2008		S	RB		-
AV/48	"	Picidae	Dendropicos pyrrhogaster(Fire-bellied Woodpecker)	?	July,2008		S	RB		-
AV/49	"	Hirundinidae	Hirundo semirufa (Red-breasted Swallow)		July, 2008		S	Afm/B		-
AV/50	"	Ploceidae	Ploceus cucullatus (Village Weaver)		July,2008		S	RB		-
AV/51	"	"	Ploceus ocularis(Spectacled Weaver)		July, 2008		S	RB		-
AV/52	"	"	Ploceus melanocephalus(Black-headed Weaver)		July,2008		S	RB		-
AV/53	"		Pycnonotidae Pycnonotus barbatus(Common Bulbul)	Okpoloki	July,2008		S	RB		-
AV/54	"	Pscittacidae	Pscittacus erithacus (Grey Parrot)	Okorlobebe	July, 2008		V	RB		Sch.1
AV/55	"	Cuculidae	Centropus senegalensis(Senegal Coucal)		July, 2008		V	RB		-
AV/56	"		Columbidae Streptopelia semitorquata(Red-eyed Dove)		July, 2008		S	RB		-
RE/57	Reptilia	Agamidae	Agama agama (Rainbow Lizard)	Angere	July,2008		S			-
RE/58	"	Scincidae	Mabuya affinis Blanding's skink	Imbelei	July.,2008		S			-
RE/59	"	"	Mochlus fernandi (Red-and-black Forest skink)	Gbele	July, 2008		V			-
RE/60	"	Varanidae	Varanus niloticus(Nile Monitor)	Abedi	May,2008	5,000-6000	V			-

Ref Code	Class	Family	Species	Local Ijaw Name	Date last killed or sighted	Market Price Range (N)	Local	IUCN	WCMC	Act 11
RE/61	"	Crocodylidae	Crocodylus niloticus (Nile Crocodile)	Igere	Oct.,2007	25000-30000	V	LR/lc		Sch.1
RE/62	"	"	Osteolaemus tetrapsis(Short-nosed Crocodile)	Isibiri	May. 2008	10000-15000	V	VU		Sch.1
RE/63	"	Chamaeleonidae	Chameleo sp (Chameleon)	Odumagale	Jul., 2007		V			Sch.1
RE/64	"	Boidae	Python sebae(African Rock Python)	Oturowei	Jan.,2008		V			Sch. 1
RE/65	"	"	Python regius (Royal Python)	Odumo	June., 2007		V			Sch.1
RE/66	"	"	Calabaria reinhardtii (Calabar Python)	Dotebedotobe	June,2008		V			
RE/67	"	Viperidae	Causus maculates (Night Adder)	?	Feb.,2007		V			-
RE/68	"	"	Bitis gabonica (Gabon Viper)	Ofotebeawere	May, 2006		V			-
RE/69	"	"	Bitis nasicornis (Rhinoceros Viper)	Kiriofure	Jan, 2007		V			
RE/70	"		Elapidae Naja nigricollis(Spitting Cobra)	Dirimaowei	Aug., 2007		S			-
RE/71	"	"	Naja melanoleuca (Forest Cobra)	Dirimaowei	June, 2008		S			
RE/72	"	"	Dendroaspis jamesonii (Green Mamba)	?	May, 2008		S			
RE/73	"		Colubridae Gastropyxis smaragdina (Emerald Green Snake)	Osaih	June, 2008		S			
RE/74	"	"	Grayia smythii (Smyth's Water Snake)	Benikor	Jan., 2008					-

Ref Code	**Class**	**Family**	**Species**	**Local Ijaw Name**	**Date last killed or sighted**	**Market Price Range (N)**	**Local**	**IUCN**	**WCMC**	**Act 11**
							S			
RE/75	"	"	Boiga blandingi (Blanding's snake)	Akpara	Nov,2007		S			
RE/76	"	"	Bothrophthalmus lineatus Red & Black stripped snake)	Ou-mgbiowei	Jan, 2008		S			
RE/77	"	Testudinidae	Kinixys erosa (Hinge-back Tortoise)	Iwiri	Jul.,2007		S	DD		-
RE/78	"	Pelomedusidae	Pelusios niger (Mud/ Hinged terrapin)	Umbor	Apr.2007		S			-
AM/79	Amphibia	Bufonidae	Bufo maculates (African toad)	Ogumu	Mar., 2008		S	LC		-
AM/80	"	"	Bufo regularis (Common Toad)	Ogumu	Mar.,2008		S	LC		-
AM/81	"	Rannidae	Ptychadena mascariensis(Mascariene Frog)	Akpalu	Mar.,2008		S	LC		-
AM/82	"	Pipidae	Xenopus tropicalis (Claw-toed Frog)	Ebedibedi	Mar.,2008		S	LC		-
AM/83	"	Hyperolidae	Hyperolius sp(Tree frog)	Tin-ogonoakpalu	Apr.2007		S	LC		-
AM/84	"	"	Afrixalus sp	Tin-ogonoakpalu	Aug.,2007		?	NT		-

Appendix 4.7.1.1 A: RESULTS FOR SURFACE WATER SAMPLES (WET SEASON – JULY 2008)

PARAMETER	METHOD	SURFACE WATER (NUN RIVER)															
		WS1		WS2		WS3		WS4		WS5		WS6		WS7		WS8	
		TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm
Temp. (^{0}C)	Thermometer	25.9	25.6	27.8	28.9	27.9	28.2	28.9	27.4	25.4	26.9	28.7	28.6	29.8	29.2	28.4	26.9
pH	pH meter	7.4	7.4	7.3	7.3	7.4	7.2	6.9	7.4	7.5	7.1	7.1	7.1	7.2	7.2	7.2	7.1
Dissolved Oxygen, mg/L	DO meter	5.4	5.3	5.8	5.6	5.6	5.3	5.3	5.0	5.6	5.6	5.5	5.1	5.4	5.1	5.2	5.0
Conductivity (µS/cm)	Conductivity meter	40.9	41.8	41.2	41.2	41.2	41.3	42.7	40.9	39.4	40.1	52.3	42.3	54.7	51.7	38.4	38.0
Total Dissolved Solid, mg/L	TDS meter	28.7	28.9	28.7	28.8	28.8	29.2	29.1	28.6	27.5	28.0	36.6	29.4	38.4	35.9	26.5	26.6
Turbidity, NTU	Turbidity meter	184	134	179	171	150	163	147	163	145	139	139	139	138	141	224	225
(Apparent, Colour units	APHA 2120B	261	237	243	313	299	270	250	264	274	289	281	268	294	239	260	268
NO_3, mg/L	APHA 4500-NO_3	0.5	<0.1	1.5	0.7	0.6	1.0	0.4	0.3	0.3	0.9	0.50	0.50	0.9	0.4	1.3	0.4
NO_2, mg/L	APHA 4500-NO_2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

PARAMETER	METHOD	SURFACE WATER (NUN RIVER)															
		WS1		WS2		WS3		WS4		WS5		WS6		WS7		WS8	
		TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm
NH_4, mg/L	APHA 4500-NH_4	0.51	0.59	0.60	0.86	0.42	0.45	0.67	1.01	0.79	1.13	0.65	0.88	0.78	0.89	0.91	0.97
Phosphorous (Total), mg/L	APHA 4500-P	0.27	0.33	0.60	0.49	0.68	0.37	0.27	0.26	0.23	0.29	0.50	0.33	0.46	0.45	0.68	0.38
SO_4, mg/L	ASTM D 516	4.0	27.0	8.00	16.0	6.0	20.0	14.0	24.0	10.0	35.0	7.0	11.0	8.0	26.0	3.0	18.0
Chloride, mg/L	APHA 5220	3.55	10.65	3.55	7.10	5.33	7.10	7.10	7.10	7.10	8.88	7.10	7.10	7.10	7.10	7.10	5.33
Alkalinity, mg/L	ASTM D1126	1.08	1.08	2.16	1.08	1.62	1.62	2.16	1.08	1.62	1.62	1.62	1.08	1.62	1.08	2.16	1.62
Hardness (Total), mg/L	APHA 2340 C	28.0	16.0	16.0	16.0	20.0	18.0	16.0	20.0	14.0	15.0	18.0	20.0	16.0	18.0	18.0	17.0
TSS, mg/L	APHA 2540 D	1.82	1.30	1.44	1.72	1.94	1.40	0.24	1.34	0.70	0.45	0.80	1.24	0.80	1.18	1.65	1.26
HCO_3	APHA 2320B	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Carbonate CO_3	APHA 2320B	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

PARAMETER	**METHOD**	**SURFACE WATER (NUN RIVER)**															
		WS1		**WS2**		**WS3**		**WS4**		**WS5**		**WS6**		**WS7**		**WS8**	
		TOP	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**
THC, mg/L	ASTM D 3921	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
TOC	APHA 5310	43	56	52	**45**	**55**	44	40	45	53	50	52	**50**	**54**	**45**	**45**	**52**
COD, mg/L	APHA 4500B	24	53	59	200	**53**	122	46	116	768	14	60	**24**	**68**	**106**	**146**	**197**
BOD5, mg/L	APHA 507	3.0	3.2	3.0	2.8	3.0	2.6	2.6	2.8	2.8	3.5	3.0	**2.9**	**3.0**	**3.0**	**3.2**	**3.0**
THB, cfu/mL	APHA 9215B	$2.8x10^{4}$	$2.8x10^{4}$	$3.0x10^{3}$	$3.0x10^{4}$	$3.2\ x10^{4}$	$2.4x10^{4}$	$2.6\ x10^{4}$	$3.3x10^{4}$	$3.5x10^{4}$	$3.8x10^{4}$	$3.5x10^{4}$	$3.5x10^{4}$	$3.5x10^{4}$	$4x10^{4}$	$3.6x10^{4}$	$3.4x10^{4}$
THF, cfu/mL	APHA 9215B	$3.4x10^{2}$	$3.1x10^{2}$	$3.3x10^{2}$	$3.2x10^{2}$	$2.9\ x10^{2}$	$3.4x10^{2}$	$3.0x10^{2}$	$2.8x10^{2}$	$3.4x10^{2}$	$3.0x10^{2}$	$2.9x10^{2}$	$3.2x10^{2}$	$2.9x10^{2}$	$3.1x10^{2}$	$3.2x10^{2}$	$3.8x10^{2}$
Coliform, mpn/100mL	APHA 9221A	$2.8x10^{3}$	$2.8x10^{3}$	$2.6\ x10^{3}$	$2.4x10^{3}$	$2.5x10^{3}$	$2.4x10^{3}$	$2.8x10^{3}$	$2.15x10^{3}$	$1.95x10^{3}$	$2.0x10^{3}$	$1.9x10^{3}$	$2.6x10^{3}$	$2.6x10^{3}$	$3.4x10^{3}$	$3.2x10^{3}$	$1.8x10^{3}$
Fe, mg/L	ASTM D1068	1.307	1.182	1.132	1.193	0.303	14.638	0.531	0.971	1.231	1.432	1.277	1.478	1.631	1.236	1.251	1.319
Pb, mg/L	ASTM D3559	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

PARAMETER	**METHOD**	**SURFACE WATER (NUN RIVER)**															
		WS1		**WS2**		**WS3**		**WS4**		**WS5**		**WS6**		**WS7**		**WS8**	
		TOP	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**	**TOP**	**BOTm**
Cu, mg/L	ASTM D1688	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cr, mg/L	ASTM D1687	0.108	0.060	0.081	0.032	0.115	0.047	0.113	0.071	0.031	0.038	0.039	0.036	0.031	0.046	0.0621	0.045
Mn, mg/L	APHA 3120 B	0.100	0.032	0.078	**0.011**	**0.112**	0.022	0.045	0.123	0.004	0.045	0.116	**0.062**	**0.045**	**0.11**	**0.058**	**0.147**
Zn, mg/L	ASTM D 1691	0.013	0.018	0.013	0.016	0.006	0.034	0.011	0.013	0.013	0.022	0.003	0.026	0.024	0.031	0.069	0.023
Cd, mg/L	ASTM D3557	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hg, mg/L	ASTM D3223	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
V,mg/L	**ASTM D3373**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
As, mg/L	ASTM D2972	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni,mg/L	**ASTM D1836**	0.151	0.252	0.023	0.135	0.027	0.042	0.003	0.007	<0.001	<0.001	<0.001	0.041	<0.001	<0.001	<0.001	0.026

Appendix 4.7.1.1 B: RESULTS FOR SURFACE WATER SAMPLES (DRY SEASON – JANUARY 2012)

B1: Surface Water

PARAMETER	WS1	WS2	WS3	WS4a	WS5	WS6	WS7	WS8 (Control 1)	Control 2
pH	6.7	6.5	6.6	6.7	6.9	6.8	6.7	7.4	7.1
Temperature (^{0}C)	29.9	29.8	28.9	29.9	29.4	29.3	29.1	30	30.6
Electrical conductivity (□S/cm)	40	50	60	50	290	240	90	80	60
Total Dissolved solids (mg/l)	21	26	34	27	150	128	48	45	34
Turbidity (NTU)	32.3	19.1	23.5	32.3	15.6	18.6	25.2	19.6	18.2
Dissolved Oxygen (mg/l)	1.7	4	1.8	1.7	2.5	1.8	1.7	1.6	1.4
Total Suspended solids (mg/l)	1.32	0.86	1.34	1.29	1.21	0.92	1.01	0.86	0.93
Biological Oxygen Demand (mg/l)	2.04	2.31	2.22	2.41	2.34	2.1	1.9	1.46	2.11
Chemical Oxygen Demand (mg/l)	36.8	32.1	28.7	26.9	23.4	31.2	29.8	32	35.6
Total Hardness (mg/l)	26.8	27.6	32.1	29.7	25.9	27.4	28.1	30	28.4
Alkalinity (mg/l)	15.2	14.5	15.4	18.4	12.4	14	15.6	16	24
Carbonates	3.5	4.12	3.84	3.67	2.84	2.76	2.92	2.98	3.24
Salinity as in Cl- (mg/l)	9.12	8.49	10.2	8.6	7.84	6.94	8.24	9.9	8.5
Nitrogen (mg/l)	0.99	0.87	1.03	1.11	1.12	1.31	1.04	1.24	0.67
Phosphorus (mg/l)	1.34	1.37	1.29	1.45	1.71	1.84	1.49	1.68	1.27
Potassium (K) (mg/l)	8.94	9.12	8.47	9.27	7.24	7.45	6.94	7.82	9.315
TPH	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Oil and Grease	<0.001	0.12	<0.001	<0.001	<0.001	<0.001	0.045	<0.001	0.28
PAH	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
BTEX	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Magnesium (Mg) (mg/l)	5.98	6.47	7.41	6.71	1.24	2.04	1.98	1.52	9.17
Calcium (Ca) (mg/l)	15.4	15.34	14.98	15.7	13.4	11.8	12.6	14.6	16.4
Vanadium (Vn) (mg/l)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium (Ba) (mg/l)	4.124	4.167	3.014	4.231	3.211	2.598	3.006	1.946	4.147
Cobalt (Co) (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001

PARAMETER	WS1	WS2	WS3	WS4a	WS5	WS6	WS7	WS8 (Control 1)	Control 2
Mercury (Hg) (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu) (mg/l)	0.41	0.48	0.45	0.5	0.24	0.31	0.29	<0.001	<0.001
Lead (Pb) (mg/l)	<0.001	0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	<0.001
Zinc (Zn) (mg/l)	0.356	0.417	0.348	0.319	0.312	0.301	0.298	0.291	0.317
Iron (Fe) (mg/l)	2.47	2.59	3.01	2.41	1.27	1.57	1.49	0.51	2.58
Cadium (Cd) (mg/l)	0.0014	0.0019	<0.001	0.0017	0.011	0.009	0.024	<0.001	0.0018
Arsenic (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel Ni (mg/l)	0.002	0.004	<0.001	0.007	0.02	0.08	<0.001	0.21	<0.001
Chromium Cr (mg/l)	0.002	0.004	0.001	0.017	0.38	0.47	0.34	0.42	<0.001
THB (cfu/ ml)	$3.1x10^{6}$	$2.54x10^{6}$	$2.7x10^{7}$	ND	$5.9x10^{6}$	$1.72x10^{6}$	$4.3x10^{6}$	$9.7x10^{5}$	$3.9x10^{5}$
THF (cfu/ ml)	$1.22x10^{5}$	$4.8x10^{5}$	$2.51x10^{5}$	ND	$1.02x10^{5}$	$8.5x10^{5}$	$1.11x10^{5}$	$6.1x10^{4}$	$4.5x10^{4}$
HUB (cfu/ ml)	$9.8x10^{4}$	$1.32x10^{4}$	$7.9x10^{4}$	ND	$8.1x10^{4}$	$3.1x10^{4}$	$7.2x10^{4}$	5.0x103	NIL
HUF (cfu/ ml)	$6.3x10^{3}$	$7.9x10^{3}$	$3.5 x10^{3}$	ND	$9.9x10^{3}$	$2.2x10^{3}$	$5.8x10^{3}$	$9.8x10^{2}$	NIL

ND = No data

Appendix 4.7.1.1C: Physico-chemical characteristics of Surface Water in the study area (Wet Season 2014)

SAMPLE CODE	PARAMETERS	pH	EC, µS/cm	TDS, mg/L	Turbidity, NTU	TSS, mg/L	Dissolved Oxygen, mg/L	Chemical Oxygen Demand, mg/L	Biochemical Oxygen Demand, mg/L	Salinity, mg/L
	ANALYSIS METHOD	**APHA 4500-H**	**APHA 2510-B**	**APHA 2540-C**	**ASTM D1889**	**APHA 2540-C**	**APHA 5210-B**	**APHA 5220-D**	**APHA 5210-B**	**APHA 4500-CL^-**
	METHOD DET. Limits	-	-	-	-	-	-	-	-	-
	DPR LIMIT									
SW 1		7.70	136	67.5	93.8	55.2	4.98	13.4	6.52	70.0
SW 2		7.81	125	62.2	105	71.1	4.03	16.7	5.49	70.0
SW 3		7.61	116	58.6	90.2	57.0	4.92	10.2	6.04	62.3
SW 4		7.67	112	56.2	81.0	49.8	4.41	9.10	6.84	62.3
SW 5		6.98	98.5	49.2	96.0	59.7	4.62	10.9	6.18	50.0
SW 6		7.03	109	53.8	103	68.8	4.92	16.0	5.97	60.0
SW 7		7.13	112	55.9	98.0	59.2	5.01	14.7	5.83	60.0
SW 8		7.85	113	57.1	94.5	55.7	4.01	11.2	5.66	62.3
SW 9		7.26	98.6	47.2	29.1	15.1	3.48	7.89	5.08	50.0

Appendix 4.7.1.1: Contd

Alkalinity, mg/L	Total Hardness, mg/L	Carbonate, mg/L	Chloride, mg/L	Sulphide, mg/L	Sulphate, mg/L	Nitrate, mg/L	Nitrite, mg/L	Phosphate, mg/L	Cadmium, mg/L
APHA 2320-B	**ASTM D1126**	**APHA 2320-B**	**APHA 4500-CL^-**	**Spectrometry**	**Spectrometry**	**Spectrometry**	**Spectrometry**	**Spectrometry**	**ASTM D3557**
-	**-**	**-**	**-**	**1**	**1**	**0.1**	**0.001**	**0.1**	**0.05**
76.0	17.4	76.0	60.0	<0.10	<1.00	<0.10	0.008	1.22	<0.05
80.0	18.9	80.0	55.6	<0.10	1.00	<0.10	0.010	0.95	<0.05
80.0	17.1	80.0	55.3	<0.10	1.00	<0.10	0.013	1.28	<0.05
76.0	18.0	76.0	50.0	<0.10	1.00	<0.10	<0.001	1.56	<0.05
70.0	16.5	70.0	35.5	<0.10	1.00	0.10	0.005	1.24	<0.05
72.0	18.0	72.0	40.0	<0.10	<1.00	0.60	<0.001	1.90	<0.05
66.0	18.0	66.0	40.0	<0.10	<1.00	0.20	0.006	1.95	<0.05
70.0	17.4	70.0	50.0	<0.10	<1.00	0.10	<0.001	1.47	<0.05
50.0	48.0	50.0	35.5	<0.10	<1.00	0.60	<0.001	1.86	<0.05

Appendix 4.7.1.1C Contd.

Zinc, mg/L	Copper, mg/L	Lead, mg/kg	Chromium, mg/L	Nickel, mg/L	Mercury, mg/L	Arsenic, mg/L	Vanadium, mg/L	Iron, mg/L	Manganese, mg/L	Silver, mg/L	Selenium, mg/L	Total Oil and Grease, mg/L	Total Hydrocarbon Content (THC), mg/L	Total Petroleum Hydrocarbon (TPH), mg/L	Polycyclic Aromatic Hydrocarbon (PAH), mg/L	Phenol, mg/L	Total Organic Carbons (TOC), %
ASTM D1691	**ASTM D1688**	**ASTM D3559**	**ASTM D1687**	**ASTM D1886**	**ASTM D3223**	**ASTM D2972**	**ASTM D3373**	**ASTM D1068**	**ASTM D858**	**ASTM D3866**	**ASTM D3859**	**ASTM D3921**	**ASTM D3921**	**USEPA 8270 & EPA 8015**	**USEPA 8270**	**Spectrometry**	**Spectrometry**
0.05	**0.05**	**0.05**	**0.05**	**0.05**	**0.001**	**0.10**	**0.05**	**0.05**	**0.05**	**0.05**	**0.01**	**1**	**1**	**1E-04**	**0.0001**	**0.001**	**-**
<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05	3.65	<0.05	<0.05	<0.01	3.20	2.39	0.15	<0.01	<0.001	2.87
<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05	7.73	<0.05	<0.05	<0.01	3.86	2.75	0.18	<0.01	0.010	4.11
<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05	2.42	<0.05	<0.05	<0.01	3.47	2.05	0.17	<0.01	<0.001	3.07
<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05	6.21	<0.05	<0.05	<0.01	3.50	2.16	0.18	<0.01	<0.001	2.99
<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05	1.57	<0.05	<0.05	<0.01	4.84	3.35	0.20	<0.01	0.010	5.01
<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05	1.48	<0.05	<0.05	<0.01	5.35	3.95	0.22	<0.01	0.010	4.19
<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05	1.59	<0.05	<0.05	<0.01	0.07	0.02	<0.001	<0.01	0.010	3.77
<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05	1.18	<0.05	<0.05	<0.01	3.92	2.61	0.18	<0.01	0.010	6.00

Zinc, mg/L	Copper, mg/L	Lead, mg/kg	Chromium, mg/L	Nickel, mg/L	Mercury, mg/L	Arsenic, mg/L	Vanadium, mg/L	Iron, mg/L	Manganese, mg/L	Silver, mg/L	Selenium, mg/L	Total Oil and Grease, mg/L	Total Hydrocarbon Content (THC), mg/L	Total Petroleum Hydrocarbon (TPH), mg/L	Polycyclic Aromatic Hydrocarbon (PAH), mg/L	Phenol, mg/L	Total Organic Carbons (TOC), %
<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	<0.01	<0.05	1.57	<0.05	<0.05	<0.01	3.29	2.15	0.17	<0.01	0.010	4.18

Appendix 4.7.1.3A: Microbial Counts of Surface Water (Wet Season, 2008)

PARAMETER	METHOD	SURFACE WATER (NUN RIVER)															
		WS1		WS2		WS3		WS4		WS5		WS6		WS7		WS8	
		TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm	TOP	BOTm
THB, cfu/mL	APHA 9215 B	2.8x10^4	2.8x10^4	3.0x10^3	3.0x10^4	3.2x10^4	2.4x10^4	2.6x10^4	3.3x10^4	3.5x10^4	3.8x10^4	3.5x10^4	3.5x10^4	3.5x10^4	4x10^4	3.6x10^4	3.4x10^4
THF, cfu/mL	APHA 9215 B	3.4x10^2	3.1x10^2	3.3x10^2	3.2x10^2	2.9x10^2	3.4x10^2	3.0x10^2	2.8x10^2	3.4x10^2	3.0x10^2	2.9x10^2	3.2x10^2	2.9x10^2	3.1x10^2	3.2x10^2	3.8x10^2
Coliform, mpn/100mL	APHA 9221 A	2.8x10^3	2.8x10^3	2.6x10^3	2.4x10^3	2.5x10^3	2.4x10^3	2.8x10^3	2.15x10^3	1.95x10^3	2.0x10^3	1.9x10^3	2.6x10^3	2.6x10^3	3.4x10^3	3.2x10^3	1.8x10^3

N/A: Not Available

Method Source

"American Public Health Association" (APHA) 20th Edition 1998

"American Society for Testing and Material" (ASTM) 1999

Appendix 4.7.1.3B Surface Water Microbial Counts (DRY SEASON – JANUARY 2012)

PARAMETER	WS1	WS2	WS3	WS4a	WS5	WS6	WS7	WS8 (Control 1)	Control 2
THB (cfu/ ml)	3.1x10^6	2.54x10^6	2.7x10^7	ND	5.9x10^6	1.72x10^6	4.3x10^6	9.7x10^5	3.9x10^5
THF (cfu/ ml)	1.22x10^5	4.8x10^5	2.51x10^5	ND	1.02x10^5	8.5x10^5	1.11x10^5	6.1x10^4	4.5x10^4
HUB (cfu/ ml)	9.8x10^4	1.32x10^4	7.9x10^4	ND	8.1x10^4	3.1x10^4	7.2x10^4	5.0x103	NIL
HUF (cfu/ ml)	6.3x10^3	7.9x10^3	3.5 x10^3	ND	9.9x10^3	2.2x10^3	5.8x10^3	9.8x10^2	NIL

Appendix 4.7.1.3C Surface Water Microbial Counts (Wet SEASON –2014)

SAMPLE	PARAMETERS	Total Coliform Count cfu/ml	Faecal Coliform, MPN/100ml	THB, cfu/ml	HUB, cfu/ml	THF, cfu/ml	HUF, cfu/ml
	ANALYSIS METHOD	APHA 9251B	APHA 9251B	APHA 9215C	APHA 9215C	APHA 9215C	APHA 9215C
SW 1		248	32	1.05×10^4	3.7×10^2	4.2×10^3	6.0×10^1
SW 2		236	26	5.8×10^4	1.00×10^2	3.8×10^3	5.6×10^1
SW 3		307	48	2.35×10^4	4.1×10^2	9.7×10^3	0
SW 4		313	40	7.4×10^4	7.2×10^2	5.1×10^3	4.4×10^1
SW 5		183	53	1.46×10^4	5.2×10^2	3.6×10^3	3.9×10^1
SW 6		298	11	3.9×10^4	5.0×10^2	3.9×10^3	7.2×10^1
SW 7		225	21	1.20×10^4	4.5×10^2	8.8×10^3	0
SW 8		326	19	1.49×10^4	3.4×10^2	4.7×10^3	6.3×10^1
SW 9		172	15	4.0×10^4	3.1×10^2	9.1×10^3	0

KEY: THB = TOTAL HETEROTROPHIC BACTERIA, HUB = HYDROCARBON UTILIZING BACTERIA, THF = TOTAL HETEROTROPHIC FUNGI, HUF = HYDROCARBON UTILIZING FUNGI

APPENDIX 4.13
HOUSING ATTRIBUTES IN THE STUDY AREA

Attributes	Communities/ Frequency													
	Ogbia Group		Oluasiri Group		Odual Group		Akani		Soku Group		Sangama Group		Total	
	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)
Construction Material (Walling)														
Mud(wattle and daub)	4	23.5	21	56.8	26	65.0	5	83.3	3	15.8	3	13.6	62	44.0
wood	-	-	3	8.1	-	-	-	-	2	10.5	4	18.2	9	6.4
Corrugated iron sheets	2	11.8	4	10.8	-	-	-	-	3	15. 8	7	31.8	16	11.3
Burnt Bricks	1	5.9	-	-	2	5.0	-	-	-	-	-	-	3	2.1
Cement blocks	10	58.8	9	24.3	12	30.0	1	16.7	11	57.9	8	36.4	51	36.2
	17	100.0	37	100.0	40	100.0	6	100.0	19	100.0	22	100.0	141	100.0
B. Construction Material (Roofing)														
Thatch														
Corugated Iron Sheets	-	-	7	18.9	2	5.0	1	16.7	-	-	-	-	10	7.1
Absbestoes	12	70.6	25	67.6	33	82.5	5	83.3	15	78.9	21	95.6	111	78.7
Aluminium	2	11.8	3	8.1	5	12.5	-	-	-	-	-.	-	10	7.1
	3	17.6	2	5.4	-	-	-	-	4	21.1	1	4.4	10	7.1
	17	100.0	37	100.0	40	100.0	6	100.0	19	100.0	22	100.0	141	100.0
C. Sewage Disposal Method														
Pit Toilet	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bush	-	-	-	-	14	35.0	5	83.3	-	-	-	-	19	13.5
Pier Toilet (water side)	12	70.6	34	91.9	18	45.0	-	-	16	84.2	20	90.9	100	70.9
Water Closet														15.6
	5	29.4	3	8.1	8	20.0	1	16.7	3	15.8	2	9.1	22	
	17	100.0	37	100.0	40	100.0	6	100.0	19	100.0	22	100.0	141	100.0
D. Refuse Disposal Method														
Private / Public Open Dump (Bush)	12	70.6	3	8.1	30	75.0	6	100.0	-	-	1	4.5	52	36.9
Organized collection (LGC, community, etc)														

Attributes	Communities/ Frequency													
	Ogbia Group		Oluasiri Group		Odual Group		Akani		Soku Group		Sangama Group		Total	
	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)
Private commercial	-	-	-	-	-	-	-		-	-	-	-	-	-
collection														
Burning	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Burying														
Dumping in rivers/creeks	1	5.9	1	2.7	1	2.5	-	-	2	10.5	1	4.5	6	4.3
	-	-	1	2.7	4	10.0	-	-	-	-	-	-	5	3.5
	4	23.5	32	86.5	5	12.5	-	-	17	89.5	20	91.0	78	55.3
	17	100.0	37	100.0	40	100.0	6	100.0	19	100.0	22	100	141	100.0
E. <u>Energy Source for Cooking</u>														
Firewood	15	51.7	34	66.7	40	71.4	6	75.0	16	59.3	20	55.5	131	63.3
Kerosene	10	34.5	17	33.3	15	26.8	2	25.0	10	37.0	15	41.7	69	33.3
Cooking Gas	4	13.8	-	-	1	1.8	-	-	1	3.7	1	2.8	7	3.4
Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29	100.0	51	100.0	56	100.0	8	100.0	27	36	36	100.0	207	100.0
F. <u>Energy Source for Lighting</u>														
Kerosene lamp														
Gas lamp	5	17.9	20	35.7	33	40.2	6	75.0	8	24.2	10	27.0	82	33.6
Electricity	-	-	-	-	1	1.2	-	-	-	-	-	-	1	0.4
Torch light	17	60.7	12	21.4	28	34.2	-	-	18	54.6	22	59.5	97	39.7
Candle	2	7.1	8	14.3	5	6.1	-	-	3	9.1	-	-	18	7.4
	4	14.3	16	28.6	15	18.3	2	25.0	4	12.1	5	13.5	46	18.9
	28	100.0	56	100.0	8	100.0	33	100.0	33	100.0	244	100.0	244	100.0
G. <u>Source of Water for Domestic Use</u>														
River/Stream/Pond	12	52.2	36	80.0	19	43.2	-	-	-	-	-	-	67	40.1
Well	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rain	2	8.7	2	4.4	3	6.8	1	14.3	2	9.1	4	15.4	14	8.4
Borehole (public)	8	34.8	7	15.6	22	50.0	6	85.7	19	86.4	22	84.6	84	50.3
Borehole (private	1	4.3	-	-	-	-	-	-	1	4.5	-	-	2	1.2
	23	100.0	45	100.0	44	100.0	7	100.0	22	100.0	26	100.0	167	100.0

Attributes	Communities/ Frequency													
	Ogbia Group		Oluasiri Group		Odual Group		Akani		Soku Group		Sangama Group		Total	
	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)
	23	100.0	45	10.00	44	100.0	7	100.0	22	100.0	26	100.0	167	100.0

Appendix 4.12.1: Fieldwork Consultations for 2014 Data Gathering

Olobiri

Kaiama

Abuwari

Igbainwari

Ofonibiri

Consultation in Gbaran-Ama and Orubiri

APPENDIX 4.14

INFRASTRUCTURAL FACILITIES IN PROJECT COMMUNITIES

Community	Facilities / Functional State
Imiringi	• Tarred access road from Yenegua • 2 Paved internal link roads and earth roads • Borehole provided by SPDC (1991) is not functional • Two public primary schools and three private primary • Four private secondary schools and one Federal Government Girls College. • Public electricity by Bayelsa state Govt. • Public toilet (pier toilet) • One health center, not functional • 3 football fields • 2 hotels • GSM services • 2 community town halls (community & SPDC)
Otuasega	Tarred access road from Yenegua • 6 paved internal link roads and 10 other earth roads • Bore hole provided by SPDC • Cottage hospital (SPDC) • Public toilets (pier toilets) • 12 room coppers lodge (SPDC) • 12 rooms guest house (SPDC) • 3 public primary schools, about 10 private schools • 1 public secondary school and one private junior secondary school • 1 Police Post • 1 foot ball field • 1 community/ town hall • GSM services (MTN, GLO, ZAIN) • Public electricity (Bayelsa State Govt) • 4 Hotels
Oruma (Yiba-ama)	• Tarred access road from Yenegua, but road is in disrepair • 5 paved internal link roads • Bore hole provided (Bayelsa 2005 • 2 public primary schools • 1 public secondary school • Public electricity (Bayelsa State Govt 1981) • Public toilet (pier toilet) • One health, center not functional (Bayelsa mid 1980's) • 1 weekly market (holds on Tuesdays) • 1 Hotel • GSM services (MTN, GLO)
Otuma-ama	• Failed borehole project (1996) • paved internal link roads • 1 public primary school • 1 public secondary school • Community electricity generator (SPDC 2002), not functional • 1 Police Post
Fickoru-ama	• 1 concrete jetty (SPDC 2003) • Internal paved lanes (SPDC) • 1 primary school • Community electricity generator (SPDC 2001) currently not functional it was vandalized

Community	**Facilities / Functional State**
Isereama	• No facility
Isaiah-ama	• paved internal link roads • 1 concrete jetty • Bore hole provided (SPDC 2008) but not in use because the community believes that it had taste and was not good for consumption • 1 health centre not functional • Community electricity generator is not functional it was vandalized • 1 primary school • 1 community town hall
Dumoebikumagha-ama	• paved internal lanes • borehole (NICSO/ SPDC, 2007)not functional, the community rejected it because it was believed to have taste • Community electricity generator (NICSO/ SPDC, 2007), maintenance by community • 1 community town hall
Allagoama	• No facility
Tengele-ama	• paved internal lanes • 1 steel jetty • No public schools • Has 1 private primary, nursery school • 1 town hall (Wilbros /SPDC , 2000) • Community electricity generator (SPDC 1998,), currently not functional • Cottage hospital (abandoned during construction 1999) • GSM services (GLO)
Benema	• 1 public primary school • Community electricity generator (SPDC) currently not working • Shore protection (community) • GSM services GLO
Ijawkiri	• Borehole (SPDC , 2003) but abandoned • Community electricity generator currently not functional- provided by SPDC • GSM services GLO , MTN • 1 public primary school
Obedum	• Access road from Yenegua , a seasonal earth road • Public electricity (Bayelsa) • community town hall (Bayelsa) • borehole (SPDC , 2009) • 1 primary school • 1 guest house (SPDC)
Emirikpoko	• Access road from Yenegua, a seasonal earth road • 1 primary school • Public electricity (Bayelsa) • Weekly Saturday market • community town hall is under construction • 1 public secondary school • 2 boreholes ,(2009) • 4 room guest house
Anyu	• Access road from Yenegua • 1 primary school • Internal link roads (earth roads) • Borehole by community • 1 health center • 1 community town hall
Emelego	• Access road (earth road), • 1 hospital • 1 public water supply (NDDC) • 1 public primary school

Community	**Facilities / Functional State**
	• 1 daily market • Community electricity generator • 1 concrete jetty (LGC, 1997) • GSM services MTN • Police post • 1 public secondary school
Ogboloma	• 1 health care center (community 1995) poorly sited and maintained • 1 public primary school • Public electricity (Bayelsa 1981) • 2 public boreholes (NAOC 1994 , Daewoo 2008) none is functional • community town hall • 1 football field
Adada	• 1 public primary school • 1 public borehole (Rivers state Govt) • 1 internal earth lane • 1 community town hall • Public electricity (Bayelsa)
Akani	• 1 health care center in temporary accommodation (Mud building) • 1 public primary school • 1 public borehole (SPDC , 2008) • 1 community town hall (SPDC , 2008) • 3 room teachers quarters for primary school (SPDC ongoing construction) • 1 public secondary school (SPDC, ongoing construction)
Soku	• 1 public secondary school (community) • 1 public primary school (community renovated by SPDC) • 1 public borehole (SPDC in the 1990's) with a water treatment plant), currently not functional • 1 private borehole • Community electricity generator runs from (6pm-6am, SPDC fuels it) • Paved internal walkway • 1 community/ town hall • 1 market (built with open and lock up stalls) currently not in use
Ekeneama I	• 1 concrete (SPDC 2002) jetty • 1 public borehole (SPDC 2003), not functional • 1 community electricity generator (2002) • GSM services MTN, GLO
Ekeneama II	• 1 concrete jetty (2005 SPDC) • 1 public school built by migrant fisherman but stopped functioning because of fear of militants • 1 public borehole (SPDC in the 1990's) with a water treatment plant) (SPDC 2002)) not functional • 1 community electricity generator (2003 SPDC) • GSM services MTN, GLO
Elem sungama	• 1 concrete jetty • Paved internal lane • 1 public primary school • 1 public junior secondary school 1 public borehole (SPDC 2003) with a water treatment plant) • community electricity generator (Rivers State Govt renovated by SPDC , 2005 1 market (built with open and lock up stalls) not functional because of problem from militants 1 community / town hall (2003) GSM services MTN, GLO • 1 public library (community . SPDC wants to mordenize and equip it)

Community	**Facilities / Functional State**
	1 Guest house with 10 rooms (SPDC 2009)
Oru sangama	1 public primary school • 1 community electricity generator currently not functional due to vandalisation when community evacuated following inter community clash Dilapidated public toilet (pier toilet) GSM services MTN

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APPENDIX 4.12

TRADITIONAL GOVERNANCE STRUCTURE IN THE COMMUNITIES

Community	Office	Ascension/Duration	Roles	Over Influential Community/Social Organizations (Stakeholders)
Imiringi	(1) Ogbenema	In office for life, except deposed by community. accession is by election	Traditional head and focal point for decision making and policy formulation	(1) Kolo Creek Committee of Friends – Membership is mixed, male and female (leader. Joseph Okpo) 2) Dollar Club –Membership is mixed, male Female (leader: Chief Lucky Chukwuigwe) (3) Committee of Good Friends – membership is mixed, male and female (Leader: Lonami Inadi)
	(2) Ikein (Elders/Chiefs Council)	At least 40 years and contributed significantly to community development. in office life	Ikein elects chiefs who are also part of the council. Also elect CDC and youth leaders. Responsible for administration of the community and settlement of disputes.	
	(3) CDC	Elected by Ikein to reflect all compounds in the community. Members serve 2 years each.	Internal security, Development planning. report to Ikein and Ogbenema	
	(4) Women (Leader and Executive Committee)	Election, serve 2 years	Welfare of women, development planning	
	(5) Youth (Leader and Executive Committee)	Members are elected from the community and leader by the Ikein. Leadership is rotational. all serve 2 years	Members of internal security council, community mobilization.	
Otuasega	(1) Obenema; has A cabinent Executive (Okoboto Obenema)	Obenema is in office for life except deposed by community.	Highest decision making organ of the community	(1) Otuasega Advocacy Committee - Mixed membership (Leader: Chief Friday Aleke) (2) Otuasega peoples' forum - Mixed (Leader: Chief Okachukwu Michael) (3) Ogbodionin -Mixed (Leader: Mrs. Mercy Emmanuel Benson) (4) Ogboawani –women only (Leader: Mrs. Gloria Igbeta) (5) Ogboawiyen –youth only (Leader: Mr. Nateyen Walson)
		The Cabinet is appointed by the Obenema and members are in office at his instance	Okoboto Obenema assists the Obenema	
	(2) Council of Chief/Elders (Okobo Ibeneoma)	Appointed by the compounds (groups of families they represent), in office for life.	Lenders of their families, settlement of disputes, advice the Obenema, custodians of traditions and culture	

Community	Office	Ascension/Duration	Roles	Over Influential Community/Social Organizations (Stakeholders)
Community	Office	Ascension/Duration	Roles	Over Influential Community/Social Organizations (Stakeholders)
	(3) CDC	Election, represent the Compounds/major families in the community	General administration of the community, development planning	
	(4) Women	Election, serve 2 years	Welfare of women, development planning	
	(5) Youth	Members are elected from the community. Leadership is rotational. all serve 2 years	security, community mobilization.	
Oruma (Yiba-ama)	(1) Amayinaowei Has a council (Amayina-Akasi) council is Made up of 8 Chiefs .Each of the four compounds in the community is represented by 2 Chiefs.	Elected, holds office for life except deposed. Members of cabinet serve for 4years.	Executive arm of the traditional government, responsible for policy formulation and decision making	(1) Ebidou –Agbala - mixed (2) Keni- Osuo Age group- mixed (3) Hope Rising Association – mixed.
	(2) Council of Elders (Kiribuo). Made up of the leaders (Chiefs) of the four compounds in the Community. Leader of Okumali (first son of founder of the community) leads the kiribuo	Ascension is by age and for life except deposed	Advisory role, dispute resolution, custodians of traditions and culture of the community	

Community	Office	Ascension/Duration	Roles	Over Influential Community/Social Organizations (Stakeholders)
	(3) CDC	Election represent the Compounds/major families in the community, serve 2 years	General administration of the community, development planning	
	(4) Women	Election, serve 2 years	Welfare of women, development planning	
	(5) Youth	Members are elected from the community, all serve 2 years	Internal security, community mobilization.	
Oluasiri Clan	Ibeyenowei Oluasiri Development Union (clan wide CDC) Oluasiri, women community (Executive council) Oluasiri Youth Federation (Executive Council)	Election, all the Oluasiri settlements (52 in number) can vie. In office for life except deposed by the clan Election, in office for 2 years Election, in office for 2 years Election, in office for 2 years	Traditional head and focal point for decision making and policy formulation in the entire clan Development planning,assist Ibeyenowei Mobilization &welfare of women Security,Mobilization	(1) Amaebidoge Ogbo-mixed cultural group (2) Okiogbo –mixed cultural group

Community	Office	Ascension/ Duration	Roles	Over Influential Community/Social Organizations (Stakeholders)
Otuma-ama FikoruamaI-V Isereama Isaiah-ama Dumoebikumagha-ama Allagoa-ama Tengele-ama Benema Ijawkiri	Each community has (1) Amayanowei (2) Chiefs Council	Elected from the community in office for life except deposed by the community Representing each of the main sections/ Compounds (‘polo’) in the community. In office for life except deposed.	Traditional and administrative head of the community, reports to the Ibeyemowei Advisory, assist the Amayanowei. Settle disputes in their ‘polo’	
	(3) Elders Council	Must be at least 40 years and contributed significantly to community development	Advisory, assist the Amayanowei	

Community	**Office**	**Ascension/ Duration**	**Roles**	**Over Influential Community/Social Organizations (Stakeholders)**
	(4) CDC	Elected ,in office for 2 years	Development planning. Daily administration of the community	
	(5) Women group (Executive)	Elected, in office for 2 years	Welfare of women, development planning	
	(6) Youth (Executive)	Elected, in office for 2 years	Internal security, community mobilization.	
Obedum Emirikpoko Anyu Emelego Ogboloma Adada	1.O' leema, each community has its own, every one is independent	In office for life except deposed by the community. Elected from one of the main families in the community.	Traditional and administrative head, focal point for decision making and policy formulation.	In Anyu (1) Ogbo-Otulonu (women only) (Leader: Mrs. Ruth Azeri) (2) Anyu League of friends (youth) (Leader: Maxi Ilami Love) (3) Aruhugheel – a group made up of those who are next in line to the family Chiefs and who replace them on their demise (4) Board of Advisers – a group the O'leema wants to put in place.

Community	**Office**	**Ascension/Duration**	**Roles**	**Over Influential Community/Social Organizations (Stakeholders)**
	(2) Chiefs Council	Appointed by their families (compounds) serve for life except deposed.	Advisory, assist the O'leema. Resolve disputes	In Emirikpoko (1) New Life Club (mixed –leader: (Chief: Profit Irele) (2) Enaanasebh (mixed-leader: Lucky Zoybe) (3) Beauty Club (women – Mrs. Rachael F. E. N) (4) Obiedighiomar (mixed-Samuel Eloghom)
	(3) CDC	Elected from the community, serve for 2 years	Development planning daily administration of the community, assist the O'leema	
	(4) Women group (Executive)	Elected serve for 2 years	Welfare of women, development planning	
	(5) Youth	Elected serve for 2 years	security, community mobilization.	
Akani	(1) Olilema	In office for life, except deposed by the community.	Traditional and administrative head, focal point for decision making and policy formulation	
	(2) Chiefs Council	Appointed by their families and	Advisory, assist the Olilema.	

Community	Office	Ascension/Duration	Roles	Over Influential Community/Social Organizations (Stakeholders)
	made up of chiefs of the main families and chiefs of the satellite communities	communities	Resolve disputes.	
	(3) CDC	Elected, serve for 2 years	Development planning, daily administration of the community, assist the Olilema	
	(4) Women group (Executive)	Elected, serve for 2 years	Welfare of women, development planning	
	(5) Youth (Executive)	Elected, serve for 2 years	security, community mobilization.	

Community	Office	Ascension/ Duration	Roles	Over Influential Community/Social Organizations (Stakeholders)
Soku (including Ekineama I and II	(1) Amayanabo	Chosen from the royal family (Nangwo family) serves for life except deposed by the community	Tradition administrative head, custodian of traditions and culture of the community. Focal point for decision making and policy formulation.	(1) Ikine Sekiapu (men) (2) Soku Awo Belema Ogbo (mixed) (3) Manimani Women Club (women) (4) Queen Elizabeth Women Club (women) (5) Akiniama Social Club (mixed)
	(2) Chiefs Council	Represent their 'war canoe houses,' in office for life except deposed	Advisory. Dispute resolution. Assist the Amayanabo	
	(3) CDC	Elected, serve 2 years	Daily administration, assist the Amayanabo, supervise the CDC of Ekinneama I and II	
	(4) Elders Forum and Men's Forum	Elders from the various 'houses' usually up to 50 years old	Advisory, assist the Chiefs Council	
	(5) Women group (Executive)	Elected serve for 2 years	Welfare of women, development planning	
	(6) Youth	Elected serve for 2 years	Internal security council, community mobilization.	

Community	Office	Ascension/ Duration	Roles	Over Influential Community/Social Organizations (Stakeholders)
Elem Sangama (including Oru Sangama)	(1) Amayanabo	In office for life except deposed, chosen from one of the 5 main compounds ('polo)	Traditional and administrative head, custodian of traditions and culture of the community. Focal point for decision making and policy formulation.	(1) Brave heart (youth) (Leader; Gospel Moses) (2) Dynamic (youth) (Leader; Igbigiminasiari Tom-Mercy) (3) Christian Belema Ogbo (mixed) (Leader; Ibiene Thomas)
	(2) Chiefs Council	Represent their 'war canoe houses' in office for life except deposed	Advisory. Dispute resolution. Assist the Amayanabo	
	(3) Oil and Gas Committee (CDC)	Elected, serve 2 years	Daily administration assist the Amayanabo, Development planning	
	(4) Elders Forum	Elders from the various 'houses' usually up to 50 years old	Advisory, assist the Chiefs Council	
	(5) Mens Forum	All males above the age of youth (ie 35 years)	Advisory, welfare of the men, assist other organs in community administration	
	(6) Women group (Executive)	Elected serve for 2 years	Welfare of women, development planning	
	(7) Youth	Elected serve for 2 years	Members of internal security council, community mobilization.	