Final Report

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) ON PROPOSED ESTABLISHMENT OF POLYCHLORINATED BIPHENYLS (PCB) & PCBs CONTAMINATED ELECTRICAL EQUIPMENT'S COLLECTION, STORAGE AND TREATMENT CENTRES AT SHEDA (ABUJA), EPE (LAGOS) AND NEKE-UNO (ENUGU)

December 2020

Project Management Unit for ESM of PCBs in Nigeria Office

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ENVIRONMENTAL IMPACT ASSESSMENT (EIA) ON PROPOSED ESTABLISHMENT OF POLYCHLORINATED BIPHENYLS (PCB) & PCBs CONTAMINATED ELECTRICAL EQUIPMENT'S COLLECTION, STORAGE AND TREATMENT CENTRES AT SHEDA (ABUJA), EPE (LAGOS) AND NEKE-UNO (ENUGU)


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LIST OF ACRONYMS

AEPB	Abuja Environmental Protection Board
AAS	Atomic Absorption Spectrophotometer
AIDS	Acquired Immune Deffiency Symptoms
BCD	Base Catalysed Decomposition
BOD	Biological oxygen demand
CCDI	Central Commission for Discipline Inspection
CEDAW	Convention on the Elimination of all forms of Discrimination Against Women
CEMAC	Center for Environmental Modelling and Computation
CEMC	Central African Economic and Monetary Community
COD	Chemical Oxygen Demand
COPE	Care for the People
CHD	Catalytic Hydride Chlorination
CSR	Community Social Responsibility
DS	Down Stream
DRG	Diagnosis Related Group
EA	Environmental assessment
ECEC	Effective Cation Exchange Capacity
EIA	Environmental Impact Assessment
ELV	Elevation
ESM	Environmentally Sound Management
ESMP	Environmental and Social Management Plan
FAO	Food and Agriculture Organization
FEPA	Federal Environmental Protection Agency (defunct)
FMEnv	Federal Ministry of Environment
GEF	Global Environment facility
GC-ECD	Gas Chromatography-Electron Capture Detector
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GEMIS	Global Emission Model of Integrated Systems
GPS	Global Positioning System
HCE	Heidelberg Center for the Environment

	History and Culture of Environment
HIV	Human Immuno-Deffiency Virus
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ILO	International Labour Organization
ITCZ	Inter-Tropical Convergence Zone
ITD	Inter-Tropical Discontinuity
IUCN	International Union for Conservation of Nature and National Resources
ICCL	International Committee on Contaminated Land
IFC	International French Corporation
IC	Integrated Circuit
LAT	Latitude
LONG	Longitude
LASAA	Lagos State Signage and Advertisement Agency
LASEPA	Lagos State Environment Protection Agency
LASPAR	Lagos State Parks and Gardens Agency
LAWMA	Lagos Waste Management Agency
LCD	Liquid Crystal Detector
LCDA	Local Council Development Area
LGA	Local Government Area
MSW	Municipal Solid Waste
OAAT	Optimal Available and Achievable Technology
OEEP	Optimal Environmentally Friendly Practices
PBB	Polybrominated biphenyls
PCB	Polychlorinated biphenyls
PCD	Polychlorinated dibenzofurans
PCDD	Polychlorinated dibenzodioxins
PCTs	Polychlorinated terphenyls
PEN	PCB Elimination Network
PMU	Project Management Unit
POPs	Persistent Organic Pollutants
QHSE	Quality, Health, Safety, Environment

SIEP	Shell International Exploration and Production
SPL	Sound Pressure Level
SHESTCO	Sheda Science and Technology Complex
TER	Toxicity Equivalency Factors
TOMPs	Toxic Organic Micro Pollutants
ToR	Terms of Reference
UNDP	United Nation Development Programme
UNEP	United Nation Environment Programme
UNFCCC	United Framework Convention on Climate Changes
UNIDO	United Nation Industrial Development Organization
WHO	World Health Organization
LSMWO	Lagos State Waste water Management Office
LWC	Lagos State Water Corporation
M&E	Monitoring and Evaluation
NABDA	National Biotechnology Development Agency
NAFDAC	National Agency for Food and Drug Administration and Control
NESREA	Nigerian Environmental Standards and Regulations Enforcement Agency
NIMET	Nigerian Meteorological Agency
NIP	National Implementation Plan
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Statistics
NCMM	National Commission for Museums and Monument
NCR	National Capital Region
NEWF	National Environment and Wildlife Conservation Trust
NGO	Non-Government Organization
NGSA	Nigeria Geological Survey Agency
NSDW	National Standard for Driving Water

PBTs	Persistence, Bioaccumulative and Toxics
PCB-ISF	PolyChorinated Diphenyl Interior Storage Facilities
PCB-PMU	PolyChorinated Diphenyl-Project Monitoring Unit
PCD	PhotoChemical Dechlorination
PDE	Population, Development and the Environment
PHCN	Power Holding Company of Nigeria
PPP	Public Private Partnership
QHA	Quantitative Habitat Analysis
R&D	Research and Development
SCWO	Supercritical Waste Oxidation
SON	Standard Organization of Nigeria
SPL	Sound Pressure Level
SPM	Suspended Particulate Matter
SRTM	Shuttle Radar Topography Mission
SW	Surface Water
TDS	Total Dissolved Solids
TSP	Total Suspended Particles
TSS	Total Suspended Slides
TVA	Tenessee valley Authority
UNDAF	United Nations Development Assistance Framework
USEPA	United State Environmental Protection Agency
VES	Vertical Electrical Sounding
VOC	Volatile Organic Compound

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EXECUTIVE SUMMARY

PROJECT BACKGROUND

Polychlorinated Biphenyls (PCBs) have been used in almost all sectors of the Nigerian economy as coolants and insulating fluids in transformers and capacitors in electricity generation, transmission and distribution, in flexible coatings of electrical wiring and components. PCBs are among the most toxic Persistent Organic Pollutants (POPs) listed in the Stockholm Convention, which calls for the elimination and/or phasing out of 12 POPs, called the *"dirty dozen"*.

Nigeria, in line with Stockholm Convention on POPs which obliges parties to eliminate the use of PCBs in equipment by 2015, and to make concerted efforts for disposing liquid PCBs and equipment through environmentally sound waste management practices as early as possible, submitted its National Implementation Plan (NIP) in 2009 listing twenty-three areas of action as priorities for meeting its treaty obligations. One of the areas of action is to establish PCBs Interim Storage Facilities (PCB-ISF) at Sheda (FCT), Epe (Lagos) and Neke Uno (Enugu).

Therefore, this Environmental Impact Assessment (EIA) report has been prepared for the proposed facilities as required by the EIA Act.

Policy, Legal and Institutional Framework

Section 20 makes it an objective of the Nigerian State to improve and protect the air, land, water, forest and wildlife of Nigeria. Section 12 establishes, though impliedly, that international treaties (including environmental treaties) ratified by the National Assembly should be implemented as law in Nigeria. Sections 33 and 34 which guarantee fundamental human rights to life and human dignity, respectively, have also been argued to be linked to the need for a healthy and safe environment to give these rights effect.

National Environmental Policy

This policy was launched by Federal Government of Nigeria in November 1989, which prescribed guidelines for achieving sustainable development in fourteen vital sectors of the nation's economy, namely: Human Population; Land Use and Soil Conservation; Water Resources Management; Forestry, Wildlife and Protected Natural Areas; Marine and Coastal Area Resources; Sanitation and Waste Management; Toxic and Hazardous Substances; Mining and Mineral Resources; Agricultural Chemicals; Energy Production; Air Pollution; Noise in the Working Environment; Settlements; Recreational Spaces, Green Belts, Monuments, and Cultural Property. Accordingly, this Policy seeks to promote good environmental practices through environmental awareness and education. The project will have effects on biophysical and human environment, as a result it shall comply with the relevant provisions of this policy.

National Energy Policy

The National Energy Policy approved by the Executive Council of the Federation in 2003 and launched in 2005 has the following objectives:

- To ensure the development of the nation's energy resources, with diversified energy resources options, for the achievement of national energy security and an efficient energy delivery system with an optimal energy resource mix.
- To guarantee increased contribution of energy productive activities to national income.
- To guarantee adequate, reliable, and sustainable supply of energy at appropriate costs and in an environmentally friendly manner, to the various sectors of the economy, for national development.

Activities in the power supply chain from generation to transmission, distribution and consumption may result in wastes containing PCBs to which this policy apply.

National Land Policy

The legal basis for land acquisition and resettlement in Nigeria is the Land Use Act of 1978, modified in 1990. According to the act, all land in Nigeria is vested in the Governor of each State, to be held in trust for the use and common benefit of all people.

The administration of urban land is directly under the control and management of the Governor; whereas non – urban land is under the control and management of the Local Government Area.

The Governor had the right to grant statutory rights of occupancy to land. Local Government has the right to grant customary rights of occupancy.

The Land Act gives government the right to revoke statutory and customary rights to land for the overriding public interest. The act gives the government the right to acquire land by revoking both statutory and customary rights of occupancy for the overriding public interest.

In doing so, the act specifies that the state or local government should pay compensation to the current holder or occupier with equal value. The act also requires the state or local government to provide alternative land for affected people who will lose farmlands and alternative residential plots for people who will lose their house.

The need for an integrated approach towards land use planning is highlighted. The coordination of activities of all stakeholders in land use planning is emphasized. In particular, the involvement of land owners, community groups, women, youth and the less privileged in making land use related decisions that affect them is regarded as being critical in the successful implementation of the policy.

The project will involve land take. Hence, the process for the land acquisition shall comply with the national land policy.

Social Protection Policies

Social protection policy has been on the agenda since 2004, when the National Planning Commission, supported by the international community, drafted a social protection strategy. More recently, the National Social Insurance Trust Fund drafted a social security strategy. The social protection policy approached social protection using a life-cycle and gender lens, recognizing both economic and social risks, including, for example, job discrimination and harmful traditional practices. The policy was organized around four main themes: social assistance, social insurance, child protection and the labour market.

The Environmental Impact Assessment (EIA) Act Cap E12 LFN, 2004

The EIA Act 86 makes it mandatory for any person, authority, corporate body private or public, to conduct EIA prior to the commencement of any new major development or expansion that may likely have significant effect on the environment. The Act sets the EIA objectives and the procedures for consideration of EIA of certain public or private projects.

The project is a major development, which is expected to have some impacts on the environment. Hence, full compliance with the EIA Act is required. The EIA guidelines (procedural and sectoral) issued by the Federal Ministry of Environment (FMEnv) derived from this Act and the project proponent Project Management Unit (PMU) shall conduct its activities for the development of this project in conformance with these guidelines.

National Environmental Standards & Regulations Enforcement Agency (NESREA) Act, 2007

Administered by the Ministry of Environment, the National Environment Standards and Regulations Enforcement Agency (NESREA) Act of 2007, repealed the Federal Environmental Protection Agency (FEPA) Act. It is the embodiment of laws and regulations focused on the protection and sustainable development of the environment and its natural resources. The following sections are worth noting:

- Section 7 provides authority to ensure compliance with environmental laws, local and international, on environmental sanitation and pollution prevention and control through monitory and regulatory measures.

- Section 8 (1)(K) empowers the Agency to make and review regulations on air and water quality, effluent limitations, control of harmful substances and other forms of environmental pollution and sanitation.

- Section 27 prohibits, without lawful authority, the discharge of hazardous substances into the environment. This offence is punishable under this section, with a fine not exceeding, One Million Naira (₦1, 000,000) and an imprisonment term of 5 years. In the case of a company, there is an additional fine of Fifty thousand naira (₦ 50,000), for every day the offence persists.

This project will comply with NESREA regulations, including conducting Environmental and Social Impact Assessment (ESIA), environmental audit every three years after commissioning, obtain permit before disposing hazardous wastes, etc.

The Nigerian Urban and Regional Planning Act CAP N138, LFN 2004

The Urban and Regional Planning Act is aimed at overseeing a realistic, purposeful planning of the country to avoid overcrowding and poor environmental conditions. In this regard, the following sections become instructive:

- Section 30 (3) requires a building plan to be drawn by a registered architect or town planner.
- Section 39 (7) establishes that an application for land development would be rejected if such development would harm the environment or constitute a nuisance to the community.
- Section 59 makes it an offence to disobey a stop-work order. The punishment under this section, is a fine not exceeding Ten thousand naira (₦10, 000) and in the case of a company, a fine not exceeding Fifty thousand naira (₦50, 000).
- Section 72 provides for the preservation and planting of trees for environmental conservation.

The project shall be implemented in line with requirements of this Act, including obtaining development permit from FCT, Abuja, Enugu and Lagos State Governments.

Harmful Waste (Special Criminal Provisions) ACT CAP H1, LFN 2004

The Harmful Waste Act prohibits, without lawful authority, the carrying, dumping or depositing of harmful waste in the air, land or waters of Nigeria. The following sections are notable:

- Section 6 provides for a punishment of life imprisonment for offenders as well as the forfeiture of land or anything used to commit the offence.
- Section 7 makes provision for the punishment accordingly, of any conniving, consenting or negligent officer where the offence is committed by a company.
- Section 12 defines the civil liability of any offender. He would be liable to persons who have suffered injury as a result of his offending act.

The project will generate wastes including construction wastes and transformer oils at the project sites and other harmful wastes. These wastes shall be handled, treated, and disposed of in accordance with the relevant requirements of this Act.

The Endangered Species Act, CAP E9, LFN 2004

This Act focuses on the protection and management of Nigeria's wildlife and some of their species in danger of extinction as a result of over exploitation. These sections are noteworthy:

- Section 1 prohibits, except under a valid license, the hunting, capture or trade in animal species, either presently or likely, in danger of extinction.
- Section 5 defines the liability of any offender under this Act.
- Section 7 provides for regulations to be made necessary for environmental prevention and control as regards the purposes of this Act.

Hence, the project activities shall be carried out to comply with relevant provisions of this Act.

The Factories Act, 1987 (Factory Act cap 126, LFN, 1990)

The factories Act, as contained in the Laws of the Federation of Nigeria 1990, seeks to legislate, and regulate the conduct of health and safety in the Nigerian workplaces. It was enacted in June 1987 with the desire to protect the workers and other professionals against exposure to occupational hazards. The director of factories at the Federal Ministry of Employment, labour and productivity is responsible for the administration of the provisions or requirements of this Act. Section 13 allows an inspector to take emergency measures or request that emergency measures be taken by a person qualified to do so, in cases of pollution or nuisances.

This Act deals with working conditions at work sites, including construction sites, such as the type to be undertaken under the Project. Hence, the occupational health and safety requirements applicable to construction sites, as well as other work sites to be used by the project shall be subjected to the provisions of this Act.

Labour Act - CAP. L1 L.F.N. 2004

This Act deals with labour issues, including payment of wages, recruitment, discipline, employee welfare, employment of women and child labour. Sections 54 to 58 which deal with employment of women, prescribed period of absence from work for nursing mothers and allows her half an hour twice a day during her working hours to attend to the baby for a period of up to six months after she resumes work. Section 55 also exempted women from night work, except when they are employed as nurses. Sections 59-64 deal with employment of young people.

Wages Board and Industrial Council Act, 1974

The Act provides for the establishment of a National Wages Board and Area Minimum Wages Committee for States and for Joint Industrial Councils for particular industries. It empowers the Minister to order or direct that an industrial wages board be established to perform, in relation to the workers described in the order and their employers, the functions specified in the provisions of this Act, including minimum wage. The minimum wage is currently NGN 18,000.00 per month, and all workers employed for this project shall not earn less than the minimum wage. Hence, all workers engaged by the project shall be paid a minimum of N18,000 per month.

Workers' Compensation Act, 1987

The Act to make provisions for the payment of compensation to workmen for injuries suffered in the course of their employment. The compulsory insurance covers employees for injury or death resulting in the course of work or in work places. All types of workers are covered including working under a contract of service or apprenticeship with an employer, whether by way of manual labour, clerical work or otherwise, and whether the contract is expressed or implied, is oral or in writing. The project will employ both skilled and non-skilled labour and shall be subject to this law as applicable.

Lagos State Environmental Management Protection Law, 2017 ("EMPL 2017"): This Law consolidates all the Laws and Regulations applicable to the management, protection and sustainable development of the environment in Lagos State. It deals with modern cosmopolitan environmental issues like waste management, litter, dumping of untreated toxic and or radioactive material into public drains; sanitation, street trading and hawking; obstruction to drainage systems, water generation, effluents, noise, signage, advertisement, gardens and parks, etc.

Enugu State Waste Management Agency Law, 2010: The objectives of this law are

- Efficient and effective waste collection
- Appropriate treatment and disposal of waste from private and public premises in all urban areas of the state
- Establishment, management and maintenance of landfill, dumpsites, waste collection and treatment sites
- Establishment of locations for the purpose of facilitating the sustainable and environmentally friendly management and disposal of waste
- Removal and disposal of silt and obstructions from gutters and drains

- Surcharge of persons or institutions whose misconducts creates any obstruction to drainage channels

Abuja Environment Protection Board Act No. 10 of 1997: This established the Abuja Environmental Protection Board (AEPB), and charged it with the responsibility for waste management, prevention of bush burning, poaching and indiscriminate felling of trees, and control walking or driving on prohibited areas among other functions. The collection and disposal of wastes generated by this project within the FCT will conducted in compliance with requirements of AEPB.

ENVIRONMENTAL IMPACT ASSESSMENT GUIDELINES

This procedural guidelines as well as sectoral guidelines prescribe the steps to be followed in the EIA process from project conception to commissioning and post commissioning impact mitigation, to ensure that the project is implemented with maximum consideration for environment. Hence, the study was conducted in line with provisions of these guidelines.

International Conventions

International conventions, to which Nigeria is a signatory, relevant to this project are as follows:

- African Convention on the Conservation of Nature and Natural Resources
- Convention on Biological Diversity
- Endangered Species (Control of International Trade and Traffic)
- Conservation of Migratory Species of Wild Animals (1973)
- Convention to Combat Desertification (1994)
- United Nation Framework Convention on Climate Change (UNFCCC) 1992.
- International Union for Conservation of Nature and National Resources (IUCN) Guideline, 1996.
- The Rio Declaration on Environment and Development
- The Kyoto protocol, Montreal Protocol on Substances that Deplete the Ozone Layer, 1987.
- The African Convention on the Conservation of Nature and Natural Resources, 1968.
- Convention on the Elimination of All Forms of Discrimination against Women (CEDAW)
- Human and Peoples’ Rights on the Rights of Women in Africa in 2005

- Civil and Political Rights Covenant
- Economic, Social and Cultural Rights Covenant
- Convention on the Elimination of All Forms of Violence Against Women
- Convention on the Rights of the Child
- ILO Occupational Safety and Health Convention, 1981

PROJECT LOCATION

The PCBs sites for storage and treatment are in:

i. Lagos State is located on Latitude 06.62809^{O}N and Longitude 3.92080^{O}E in Shala Village in Epe Local Government Area (LGA);

ii. Enugu State is located on Latitude 6.65768 and Longitude 7.54436 in Neke Uno, Enugu East LGA of the State.

iii. Abuja is located on Latitude 8.84844 and Longitude 7.04119 in Sheda Science and Technology Complex (SHESTCO), Sheda, Abuja, Nigeria.

Project Justification

The following reasons serve as need for this project to address:

- instituting an enabling policy and regulatory environment for managing PCB contaminated substances;
- Strengthening the monitoring capacity for POPs;
- Providing an effective mechanism for orienting R&D towards Convention implementation;
- An effective mechanism for technology transfer (especially for underdeveloped or developed or developing countries
- Enhancing availability and access to information
- Strengthening institutional capacity for planning, guiding and enforcement for the Convention compliance
- Increasing public awareness on POPs;
- Lack of qualified human resources.

Sustainability of the Project

The sustainability of the project was evaluated based on the three pillars of sustainable development -technical/economic, environmental and social factors.

- The proposed project is technically viable because, enjoys technical support from UNDP, who is providing similar support to other countries in the world. As a result, Nigeria will benefit from experiences of others in the design, construction and operation of the facilities.
- The proposed project shall be economically sustainable because the project will be funded by UNDP with additional financing from Global Environmental Facility (GEF).
- The PCB management sites have been carefully selected by considering sensitive ecosystems. In addition, practical mitigation measures for the identified environmental impacts shall be be implemented to address the impacts.
- The project has secured its first social license – the host communities' acceptance of the proposed project shows their eagerness to see it succeed. The proposed project will improve health and social wellbeing by eliminating PCBs from our homes and transformers in our street corners. The PMU shall also implement the social safeguards provided in this EIA.

Analysis of Project Alternatives

Three options were considered- the do-nothing option, which pre-supposes that the status quo remains, the proposed PCB collection, storage and treatment facilities will not be established. This alternative was rejected because transformer oils containing PCBs will continue to litter around transformers, some of which are located in street corners around our neighbourhoods. PCBs are known to be persistent in the environment and very toxic and carcinogenic. The second option- delayed option, implies postponing or delaying initialization of the planned project to a later date. This option is usually considered when prevailing conditions will adversely affect project implementation, for instance during a conflict, or when host communities have reservation for the project, or if the economics of the project are objectionable and unappealing.

Furthermore, a delayed project option will lead to a delay in sound disposal of PCBs in Nigeria. There is also a risk of Nigeria not being able to meet its obligations timely on the Stockholm Convention.

Alternative Technologies

The treatment technologies considered are as follows:

1. Alkali metal reduction
2. Base-catalysed decomposition (BCD)
3. Catalytic hydrodechlorination (CHD)
4. Cement kiln co-incineration
5. Hazardous-waste incineration
6. Photochemical dechlorination (PCD) and catalytic dechlorination (CD) reaction
7. Plasma arc
8. Potassium tert-Butoxide (t-BuOK) method
9. Supercritical water oxidation (SCWO) and subcritical water oxidation

PROJECT DESCRIPTION

The proposed collection, storage and treatment facilities in Sheda, Epe and Neke Uno is to protect Nigeria's environment and the health of all Nigerians by minimizing the risks posed by the use, release and storage of PCBs.

The Project consists of 5 major components;

Component 1: *Institutional capacity and training on PCBs;*

Component 2: *Inventory of PCBs in 22 states not previously covered by other inventories;*

Component 3: *Establishment of PCB collection and treatment centres;*

Component 4: *Environmentally sound disposal of identified PCBs;*

Component 5: *Monitoring, Learning, Adaptive Feedback and Evaluation.*

WASTE MANAGEMENT

Wastes envisaged to be generated are the residual wastes after decontaminating all PCB materials brought to the center. These include sludge, rags and absorbent soaked with oil, metallic containers and decontaminated equipment. The disposal options depend on the nature of waste, PCB content and quantities as well as period of PCB usage.

ENVIRONMENTAL AND SOCIAL BASELINE

The acquisition of baseline data basically involved field data gathering, measurements and the collection of representative samples used to establish the environmental conditions of the study area. This exercise involved a multi-disciplinary approach and was executed within the framework of a QHSE management system approach. This approach assured that the required data and samples were collected in accordance with agreed requirements (scientific and regulatory) using the best available equipment, materials and personnel. Elements of this approach include:

- review of existing reports that contain environmental information on the study area;
- designing and development of field sampling strategies to meet work scope and regulatory requirements;
- pre-mobilization activities (assembling of field team, sampling equipment/materials calibrations/checks, review of work plan and schedule with team, and job hazard analysis);
- mobilization to field; fieldwork implementation - sample collection (including positioning and field observations), handling, documentation and storage protocols and procedures; and
- demobilization from field; transfer of sample custody to the laboratory for analyses.

A 5km wide spatial boundary from the proposed PCB sites in Sheda, Neke Uno and Epe was adopted for this project, as required by the EIA Procedural Guideline.

For effective characterization of the ecology and meteorology of study area and adequate determination of seasonal variations of specific environmentally related parameters, rainy season field data gathering exercise was performed between 22nd October through 29th October, 2018 and the dry season from 6th through 12th January, 2019

PHYSICAL ENVIRONMENT

- **Climate and Meteorology**

About five sampling stations and control point with their respective GPS co-ordinates were adopted for the data collection exercise on meteorology.

Epe, Lagos State

Rainfall, Temperature and Sunlight

The rainfall within the Epe area for the period measure, ranged from 24mm to 386mm while the annual mean was 185.8mm. Rainfall distribution was observed to be highest in the month of June and September (386 and 287mm, respectively) and lowest in December to February (24 to 48mm).

The average temperatures recorded for Epe by the Nigerian Meteorological Agency (NIMET) is 26.5^{0}C. The data obtained recorded a maximum temperature of 28.4^{0}C in the month of March and April, while lowest was recorded in August. Epe seems to have the highest temperature in all the months, hence more delicate measures should be taken in Epe after the commission of the PCB storage facility.

Data obtained from NIMET indicates that Epe recorded most sunshine in November and December (Average sunshine: 6.2h). The month with least sunshine is July (Average sunshine: 3.2h).

Wind speed, wind direction, Relative humidity and cloud cover

Epe recorded average wind speed of 12.6kmph with the highest in April (15.8kmph) and lowest in January (10.4kmph). Apparently, Epe recorded the highest wind speed throughout the year in comparison with other sites. Consequently, PCB pollution will spread faster in Epe region in case of any incident as the speed of the wind will serve as transport agent for the pollutant. Rapid respond is advised in areas where the wind speed is high in case of any volatile pollutant in the environment.

Data obtained from NIMET revealed that south westerly wind direction is prevalent in the Epe area throughout the year (NIMET, 1990-2018). However, during dry season, winds are distributed in all directions, but predominantly South-Southwest direction during the raining season in all the sites under consideration.

Relative humidity is usually higher in the wet season than the dry season because of rainfall caused by precipitation of vapour in the atmosphere. Relative humidity in Epe was relatively constant through the year at an average of 65%. This might be responsible for high rainfall observed in this region. The highest was recorded in the month of July and least in December

Epe recorded about 73% cloud cover for the month of July and lowest in December and January (15%). This seems to corroborate the data obtained for relative humidity, since cloud formation is preceded by upward movement of humid air.

Neke Uno, Enugu:

Rainfall, Temperature and Sunlight

The rainfall within the Neke Uno area for the period measure, ranged from 9mm to 298mm while the annual mean was 125mm. Rainfall distribution was observed to be highest in the month of September (298mm) and lowest in December (9mm).

The average temperatures recorded for Neke Uno by the Nigerian Meteorological Agency (NIMET) is 25.8^{0}C. The data obtained recorded a maximum temperature of 28.3^{0}C in the month of April, while lowest was recorded in August (24.2^{0}C).

Data obtained from NIMET indicates that Neke Uno recorded most sunshine in November and December (Average sunshine: 7.4h). The month with least sunshine is July and August (Average sunshine: 4.2h).

Wind speed, wind direction, Relative humidity and cloud cover

Neke Uno recorded average wind speed of 9.6kmph with the highest in April (11.3kmph and lowest in November (6.1kmph). The wind speed in Neke Uno was found to be moderate hence no fear of high rate of diffusion of PCB in case of any incident of pollution.

Data obtained from NIMET revealed that south westerly wind direction is prevalent in the Neke Uno area throughout the year (NIMET, 1990-2018). However, during dry season, winds are distributed in all directions, but predominantly South-Southwest direction during the raining season in all the sites under consideration.

Relative humidity in Neke Uno was observed to increase steadily from January (25%) to August (92%) and dropped to 31% in December. This confirms that relative humidity usually higher in the wet season than the dry season because of rainfall caused by precipitation of vapour in the atmosphere. Relative humidity in Neke Uno was relatively constant through the year at an average of 58%. This might be responsible for high rainfall observed in this region.

Neke Uno recorded the highest percentage cloud when compared with the other sites. About 78% cloud cover was obtained for the month of August and lowest in January (5%). This seems to corroborate the data obtained for relative humidity, since cloud formation is preceded by upward movement of humid air.

Sheda, Abuja:

Rainfall, Temperature and Sunlight

The rainfall within the Sheda area for the period measure, ranged from 20mm to 283mm while the annual mean was 162mm. Rainfall distribution was observed to be highest in the month of August (273mm) and September (283mm) while the lowest were in December (20mm) and January (25mm).

The average temperatures recorded for Sheda by the Nigerian Meteorological Agency (NIMET) is $26.1^{0}C$. The data obtained recorded a maximum temperature of $28.4^{0}C$ in the month of March, while the lowest was recorded in August. Sheda seems to have an undulating temperature profile increasing from January to March, decline to August and start rising from September.

Data obtained from NIMET indicates that Sheda recorded most sunshine in November and December (Average sunshine: 8.7h) while the month with least sunshine is July (Average sunshine: 5.2h). Sheda recorded the highest among all the other sites considered in the Project. Serious mitigative measure is recommended for Sheda when operating with PCBs, since more sunlight means higher rate of progressive and continuous evaporation. This might converts the PCBs to vapour state at a relatively faster rate.

Wind speed, wind direction, Relative humidity and cloud cover

Sheda recorded average wind speed of 8.6kmph with the highest in January (9.1kmph) and lowest in September and October (5.4kmph). Apparently, Sheda recorded the lowest wind speed throughout the year in comparison with other sites. Consequently, PCB pollution spread resulting from wind carriage will be slow in case of any incident.

Data obtained from NIMET revealed that south westerly wind direction is prevalent in the Sheda area throughout the year (NIMET, 1990-2018). However, during dry season, winds are distributed in all directions, but predominantly South-Southwest direction during the raining season in all the sites under consideration.

Relative humidity is usually higher in the wet season than the dry season because of rainfall caused by precipitation of vapour in the atmosphere. Relative humidity in Epe was relatively constant through the year at an average of 65%. This might be responsible for high rainfall observed in this region. The highest was recorded in the month of July and least in December

Epe recorded about 73% cloud cover for the month of July and lowest in December and January (15%). This seems to corroborate the data obtained for relative humidity, sine cloud formation is preceded by upward movement of humid air.

- **Air Quality**

Atmospheric gases were measured for both dry and wet seasons, using GrayWolf Advanced Sense IAQ Plus Indoor/Outdoor Air Quality Survey with IQ-610 Probe. The value of the atmospheric concentrations of each gaseous pollutant was read off directly on the equipment screen and data documented. Measurements were conducted between 07:00 and 19:00hrs Nigerian time, for air measurements. Multiple locations and control point for measurements were selected with consideration for concentrations of human receptors such as residential areas, commercial areas, hospitals, churches, mosques, recreation centres, schools and farmlands.

Epe, Lagos State:

TPS and CO were observed to be higher in the dry season for all the sample locations in Epe area. This implies that transfer rate of PCBS might be higher during the dry season. NH3, CO_2 and VOC were higher in the wet season, while no trace of SO_2, NO_2 and HCl were noticed in all the considered sites in Epe area. Epe recorded the highest concentration of VOC, which was alluded to current increased in human activities as a result of industrialization. Generally, the air quality for this site does not pose any significant threat to human existence.

Neke Uno, Enugu:

TPS was observed to be higher in the dry season for all the sample locations in Neke Uno. This implies that transfer rate of PCBS might be higher during the dry season. NH3, CO_2 and VOC were higher in the wet season, while no trace of SO_2, CO, NO_2 and HCl were noticed in all the considered sites in Neke Uno area.

Sheda, Abuja:

TPS was observed to be higher in the dry season for all the sample locations in Sheda. This implies that transfer rate of PCBS might be higher during the dry season. NH3 and VOC were higher in the wet season, while no trace of SO_2, CO, NO_2 and HCl were noticed in all the considered sites in Sheda area. The trend of change for the concentration of CO_2 cannot explained directly.

It suffice to mention at this juncture that, all the air influencing parameters were found to be below the standard limit from various known agencies. Sheda and Neke Uno had zero level of CO_2 concentrations for both seasons, which likely implies low industrial activities and little or no fossil fuel combustion machine or industries.

- **Background Noise**

Noise measurements were conducted in accordance with IFC 2012 standard, with the aid of a hand held Pulsar Sound Level Meter about 1.9 m high during the day and night. The measurement of noise was done in the day with respect to the various micro-habitats present in a given area as well as night measurements were imperative since trucks are also expected to move at night time.

Epe, Lagos State:

The average noise level for Epe during wet and dry seasons are 57.55dBA and 59.93 dBA, respectively.

Neke Uno, Enugu:

The average noise level for Neke Uno during wet and dry seasons are 48.25dBA and 50.25 dBA, respectively.

Sheda, Abuja:

The average noise level for Sheda during wet and dry seasons are 56dBA and 57.8 dBA, respectively.

The results obtained for all the sites, indicated an elevated noise level above the day time threshold stipulated for the various environments (school, hospital, residential and farmlands) for all the sections. This might have resulted from the current activities in the study area. Gladly, these results were below the general noise level of short exposure of 105dB (A) or that of prolonged exposure of 90dB (A). Independently of the seasonally changes, the noise level remained very close in values for all the sites considered.

- **Geology**

Epe, Lagos State:

The study area falls within one of the sedimentary basins in Nigeria with geological coordinates of 6.628458° N, 3.920790°E, 6.628260° N, 3.921228° E, 6.627878° N, 3.921060° E, 6.628060° N, 3.920561° E on an average altitude of 8m above sea level.

The study area falls within one of the sedimentary basins of Nigeria, Dahomey Basin, which covers the southern areas of Lagos, Ogun and Ondo States in Nigeria and stretches into Benin Republic. Dahomey basin constitutes part of a system of West African margin developed during a brief period of rifting in the late Jurassic to Early Cretaceous, associated with the Benin Trough Complex. It was accompanied by an extended period of thermally induced basin subsidence through the Middle to Upper Cretaceous to Tertiary times as the South American and African plate entered a drift phase. Dahomey basin is made up of structural elements such as Onshore, the Okitipupa structure and Offshore (Billman 1992). These structural elements have gone three main stages of basin evolution; predrift phase, prolonged transitional phase and open marine (drift phase).

The lithology of the Dahomey basin are mainly sands, clays and limestones. The PCB site lies within the sedimentary environment of Dahomey basin. The surface geology is made up of lithoral and lagoonal sediments of the coastal belt (unconsolidated sandstone) which are deposited during the Quanternary Era as shown using the geologic time scale.

Neke Uno, Enugu:

Neke Uno study area falls within one of the sedimentary Basins in Nigeria with geological coordinates of 06.65768^0 N, 007.54436^0 E, 06.65820 N, 007.54537^0 E, 06. 65634^0 N, 007.54508^0 E, 06.65693^0 N, 007.54607^0 E on an average altitude of 202m above sea level. Neke Uno area falls within the Lower Benue trough (precisely in Anambra Basin) of Nigeria. Nigeria is underlain by seven major sedimentary basins, viz: (from the oldest), the Calabar Flank, the Benue Trough, the Chad Basin, Sokoto Basin, the Dahomey Basin, and the Niger Delta Basin. Sedimentary successions in these basins are of middle Mesozoic to recent in age.

The older sedimentary deposits were not preserved, probably because during the Paleozoic - early Mesozoic regional basement uplift, there was no major basin subsidence for sediment accumulation. The surface geology is made up of undulating topography with a maximum height of 220m and different lithology which are deposited during Early Campanian to Oligocene period. The region has an undulating topography and the elevation varies between 201 and 313 m above sea level. The major land forms typical of this area are the residual hills and dry valleys. These two major geomorphic structures are the resultant effect of weathering and differential erosion of clastic materials which are remnant of Nsukka Formation.

Sheda, Abuja:

Sheda study area falls within the north-central Nigerian Basement Complex with geological coordinates of 08.8467^0 N, 007.04111^0 E, 08.84649^0 N, 007.04269^0 E, 08.84841^0 N, 007.04277^0 E, 08.84827^0 N, 007.04115^0 E, 08.84826^0 N, 007.04115^0 E, 08.84844^0 N, 007.04119^0 E on an average altitude of 198m above sea level.

The lithological cross section observed in the study area are possibly lateritic topsoil underlain by dry regolith of layers 3 and 4, which lie over wet weathered basement. The geoelectric substratum could possibly be of undifferentiated basement units. The porosity of the study area varies from the highly porous and permeable overburden to the less porous and permeable weathered basement rock. The weathered migmatites are rich in clay minerals hence less permeable.

- **Soil Quality and Land Use**

Soils samples were collected at 2 depths (0 – 15 cm and 15 – 30 cm) using auger at three (3) different points (A, B and C) at each of the three proposed sites. A fourth soil sample was collected outside the PCBs site adjacent to the center of the area serving as control point (D).

Epe, Lagos State:

Soil Physiographic and Morphological Properties

The landscape physiographic and soil morphological characteristics of Epe are located within middle slope to lower slope position, whereas the control falls within floodplain (swamps). The soils were well drained within the sampling depth of 0 to 30 cm, except for the control point that was very poorly drained with water table virtually close to surface and some portions were inundated. The area within the project site was generally on gently / undulating slope (2 - 4%), while the control point was nearly level (0 – 2 %). The thick forested vegetation covered the soil surface from erosion soil degradation. Large portion of the upland soil surface was not characterized by any form of erosion.

Physical Properties

Sand dominated particle size of soils within the PCBs project site at Epe with values varied between 700 to 800 g kg^{-1}, and did not vary with depth, with control area having the highest value. Silt content was constant across the landscape, and was recorded as 100 g kg^{-1}. Clay content ranged between 100 and 200 g kg^{-1} in the soils and higher for Control Point.

Chemical Properties

The pH values ranging between 5.60 and 6.45, making the soil nutrient availability for crops. Exchangeable calcium (Ca) and magnesium (Mg) were generally low and varied between 0.16 and 0.33 cmol/kg and 0.13 and 0.19 cmol/kg respectively. This may be attributed to leaching process contributed by high sand content and high amount of rainfall in the area. Sodium (Na) and potassium (K) were varied between low and medium. Calcium and Sodium decreased with depth across the soils, while Mg and K variation was irregular with increase in soil depth. The values of exchangeable bases were far below critical limit of toxicity set by NESREA (2007).

High vegetative cover of the area significantly contributed to organic matter content of these soils and varied between medium to high with values of 14.00 to 45.00 g/kg. The content of total nitrogen and nitrate were very low, and varied from 0.40 to 0.80 gkg^{-1} and 0.02 to 0.30 $mgkg^{-1}$ respectively. Phosphorus and sulphate were high, but did not exceed the critical limit of NESREA (2007). The PCBs site was reported not to have oil and grease (0.00 mg/kg), and may be due to non-spillage or any discharge of this pollutant.

The site is characterised by thick forested area, however presence of dump car parts and scraps were found around some sampling point, indicating the previous use of the area for dumping of car scraps and parts by the adjacent company.

Neke Uno, Enugu:

Soil Physiographic and Morphological Properties

The soils within the PCB project area were on a gentle / undulating topography with slope between 2 % and 4 %, and occupy upper to middle slope positions within the landscape. The soils were well drained with no erosion of any form characterizing the surface of the study area as was covered by the vegetation of the present land use.

Physical Properties

The soils of Neke-Uno-Neke were enriched by deposited material eroded from the surrounding hill, and sand dominated the particle size distribution with values ranging between 750 and 800 g kg^{-1} in the soils which slightly increased from surface to subsurface horizon or remained constant. Silt was constant across the landscape and with soil depth with value recorded as 100 g kg^{-1}. Clay content varied between 100 and 150 g kg^{-1} in the soils and decreased from surface to subsurface horizon, while the other points were constant. Soil texture was similar across the entire project area, and was recorded as sandy loam.

Chemical Properties

Soil reaction was rated as moderate to slightly acid, and the pH ranged between 5.80 and 6.25, making most nutrient availability for crops. Exchangeable Ca and Mg were generally low across the soils of the PCB project area. Sodium and K ranged between 0.10 and 0.15 cmol/kg and 0.14 and 0.30 cmol/kg respectively, and were rated medium and low to medium. The values decreased with increase in soil depth. The values of exchangeable bases were far below critical limit of toxicity set by NESREA (2007). Exchangeable acidity was constant across the soils with value recorded as 0.02 cmol/kg.

The contents of organic carbon (OC) varied between medium to high with values of 13.00 to 41.00 g/kg, is expected to contribute to CEC of the soils for adsorption of soil chemical pollutants as the sand content was reportedly high in the soils. Total nitrogen (TN) and nitrate were very low, and ranged between 0.80 and 1.20 $mgkg^{-1}$ and 0.02 and 0.10 $mgkg^{-1}$ respectively. Phosphorus was high, while sulphate was low to high. The values of OC, TN, nitrate, phosphorus and sulphate decreased with depth, and were generally below the critical limit of NESREA (2007). The PCB site did not experience any deposition or spillage of oil and grease pollutant, and values were determined as 0.00 mg/kg across the area.

The content of Cu, Fe, Mn and Zn varied between 0.72 and 1.40 mg kg^{-1}, 40.08 and 180.00 mg kg^{-1}, 25.93 and 120.00 mg kg^{-1}, and <0.001 and 23.50 mg kg^{-1} respectively. The values of the micronutrients were rated as medium to high for Cu, high for Fe and Mn, and low to high for Zn. The soils are considered not toxic or polluted with regards to Cu, Zn, Mn and Fe as the values have not attained the critical desirable NESREA limits within soils. The values of nickel (Ni) and chromium (Cr) were mostly in trace quantity (<0.001 mg kg^{-1}. The trace content may be associated with the nature of parent material from which the soil was formed and could be attributed to the high sand and low clay content that may affect retention of Ni and Cr. The content of lead (Pb) and cadmium (Cd) ranged between 1.02 and 10.78 mg kg^{-1}, and between <0.001 (trace) and 1.33 mg kg^{-1}. The values of these heavy metals were far below the desirable critical limits in soil reported by NESREA. Anthropogenic activities have been reported to cause contamination in soils. Therefore, in the future there is need for monitoring or environmental audit to ascertain their status in the soils.

Land Use

The land use included intercropping of Oil palm, Maize and cultivation of Cassava. The control sampling point was previously cultivated to cassava, but currently left fallow.

Sheda, Abuja:

Soils of the PCB project site at Sheda FCT Abuja are located between upper slope (three points) and middle slope (one point) positions. The soils were generally well drained and situated along level to nearly level slope (0 – 2 %) for three sampling points; while soils within control sampling point was on a gently/undulating slope (2 – 3 %). The cultivation practice exposed the soils to slight sheet erosion. The area around Point A was characterised by scattered petroplinthites, older granite boulders and rock outcrops, while the surface of some point is characterised by petroplinthic gravels.

Physical Properties

The content of sand within Sheda project site ranged between 440 and 560 gkg^{-1} in the soils. The content mostly increased from surface to subsurface horizon. Silt values ranged between 150 and 260 gkg^{-1} and there was no clear trend of silt distribution between surface and subsurface horizons. Clay content ranged between 210 and 340 gkg^{-1}in the soils and tend to increase from surface to subsurface horizon, except in last point where it decreased with increase in soil depth. The soils were dominated by sandy clay loam texture except in the surface horizon of control point recorded as clay loam.

Chemical Properties

Soil pH ranged between 5.68 and 6.19 and rated as moderately to slightly acid and were found to be within optimum range of most nutrient availability for crop production. Exchangeable bases Ca, Mg, K and Na were generally high and ranged between 11.02 and 12.99 cmol/kg, 7.35 and 9.00 cmol/kg, 1.35 and 3.67 cmol/kg and 2.97 and 5.86 cmol/kg, respectively. The exchangeable bases varied irregularly with increase in soil depth. The high content of exchangeable bases in these soils compared to Epe and Neke Uno may be attributed to less leaching process attributed to lower sand content and amount of rainfall in the area compared to the other areas in southern Nigeria. Total nitrogen was very low, and varied from 0.24 to 0.56 gkg^{-1}. Chloride ranged between 65.37 and 89.66 mg/kg. There was no oil and grease recorded as the values was 0.00 mg/kg across the soils in the PCB site and control point. The content of Fe, Mn and Zn varied from 4.65 to 6.97 mg kg^{-1}, 2.30 to 4.89 mg kg^{-1} and 2.36 to 5.21 mg kg^{-1} respectively. Iron and Zn were rated high and Mn was medium in the soils. The micronutrient values were adequate for purpose of crop production.

Land Use

The land use within the Sheda PCBs project site was characterised by Millet, Sorghum intercropped with millet at a point and Cassava and Cowpea at other point. Some of these land uses did not provide early soil cover to protect the land from degradation by erosion.

- **Surface Water Quality**

Epe, Lagos State:

Temperature in Epe was recorded to 25^0C which is below the WHO and FMEnv limits for drinking and aquatic life. Turbidity level for this area was obtained to be zero, an indication that the water cannot harm animals and no deposit of heavy sediment on leaves, nor reduction in photosynthesis. The conductivity result was 37.9µS/cm for this site and it implies low concentration of ions in it. The value, however fall within the acceptable WHO limits for drinking water. The pH values of water sample was recorded to be 7.78, which is within the WHO limits for sustenance of Aquatic Lives and also within the ICCL secondary data reviewed for pH.

The surface water in Epe is considered to be soft, because the total hardness value is 35.78 mg/L and it fall within the NSDW/WHO limits. The total solids include the suspended and dissolved solids in the water samples was determined to be 25mg/L. High concentrations of suspended solids can cause many problems for aquatic life and humans as well. The low TDS and TSS values for all samples obtained are within the secondary data reviewed for this parameter and the WHO/ISI/NSDW limits.

The concentration of nitrate, phosphate and sulphate in the Epe water samples analyzed were 0.01mg/L, 0.03mg/L and 8.3mg/L and tends to fall within the prescribed permissible limits of WHO/FAO/ISI/SON. The chloride concentration value recorded was 15.79. The concentrations of chloride for all samples were below WHO and ISI critical permissible value (250mg/L), which is acceptable because high concentration of chloride can make water unpalatable and therefore unfit for drinking, livestock watering and irrigation of sensitive crops. A sodium chloride value of 26.06mg/L was obtained in the water sample, falling within the limits for domestic use. Results shows a BOD and COD values of 3mg/L and 8mg/L, respectively, which gladly fell within the WHO standard and EPA guidelines for all sample, as well as secondary data of ICCL. This implies that there is no risk for sustenance of aquatic lives.

The concentrations of iron, lead, copper, cadmium, zinc, chromium and manganese (in mg/L) were determined to be 0.02, <0.001, <0.001, 0.001, <0.01, <0.01 and 0.07, respectively. The concentration of these metals in this study area fall within the limit of SON, USEPA, ICCL secondary data and WHO's limits for sustenance of aquatic lives and humans.

Neke Uno, Enugu:

Temperature in Neke Uno was recorded to 25^{0}C which is below the WHO and FMEnv limits for drinking and aquatic life. Turbidity level for this area was 6FTU, an indication that the water cannot harm animals and no deposit of heavy sediment on leaves, nor reduction in photosynthesis. The conductivity result was 5.85µS/cm for this site and it implies very low concentration of ions in it. The value, however fall within the acceptable WHO limits for drinking water. The pH values of water sample was recorded to be 6.86, which is within the WHO limits for sustenance of Aquatic Lives and also within the ICCL secondary data reviewed for pH.

The surface water in Neke Uno is considered to be soft, because the total hardness value is 18.73 mg/L and it fall within the NSDW/WHO limits. The total solids include the suspended and dissolved solids in the water samples was determined to be 8mg/L. High concentrations of suspended solids can cause many problems for aquatic life and humans as well. The low

TDS and TSS values for all samples obtained are within the secondary data reviewed for this parameter and the WHO/ISI/NSDW limits.

The concentration of nitrate, phosphate and sulphate in the Neke Uno's water sample analyzed were 0.01mg/L, 0.02mg/L and 8.4mg/L and tends to fall within the prescribed permissible limits of WHO/FAO/ISI/SON. The chloride concentration value was 39.49mg/L. The concentrations of chloride for all samples were below WHO and ISI critical permissible value (250mg/L), which is acceptable because high concentration of chloride can make water unpalatable and therefore unfit for drinking, livestock watering and irrigation of sensitive crops. A sodium chloride value of 65.16mg/L was obtained in the water sample, falling within the limits for domestic use. Results shows a BOD and COD values of 3.4mg/L and 7.3mg/L, respectively, which gladly fell within the WHO standard and EPA guidelines for all sample, as well as secondary data of ICCL. This implies that there is no risk for sustenance of aquatic lives.

The concentrations of iron, lead, copper, cadmium, zinc, chromium and manganese (in mg/L) were determined to be 0.02, <0.001, <0.001, 0.001, <0.01, <0.01 and 0.01, respectively. The concentration of these metals in this study area fall within the limit of SON, USEPA, ICCL secondary data and WHO's limits for sustenance of aquatic lives and humans.

Sheda, Abuja:

Temperature in Sheda was recorded to 27.5^{0}C which is below the WHO and FMEnv limits for drinking and aquatic life. Turbidity level for this area was 3.22FTU, an indication that the water cannot harm animals and no deposit of heavy sediment on leaves, nor reduction in photosynthesis. The conductivity result was 456µS/cm for this site which is higher compared with other sites. The wide differences of the conductivity values might be due to various factors such as agricultural and industrial activities and land use, which affect the mineral contents and thus the electric conductivity of the water. The value, however fall within the acceptable WHO limits for drinking water. The pH values of water sample was recorded to be 6.81, which is within the WHO limits for sustenance of Aquatic Lives and also within the ICCL secondary data reviewed for pH.

The surface water in Sheda is considered to be soft, because the total hardness value is 5.99 mg/L and it fall within the NSDW/WHO limits. The total solids include the suspended and dissolved solids in the water samples was determined to be 3.55mg/L. High concentrations of suspended solids can cause many problems for aquatic life and humans as well. The low TDS and TSS values for all samples obtained are within the secondary data reviewed for this parameter and the WHO/ISI/NSDW limits.

The concentration of nitrate, phosphate and sulphate in the Sheda water sample analyzed were 1.3mg/L, while the remaining were below detection limit. These values fall within the prescribed permissible limits of WHO/FAO/ISI/SON. The chloride concentration value was not detected by the method used for chloride determination. Consequently, a very low concentration value of sodium chloride (0.2105mg/L) was obtained in the water sample, falling within the limits for domestic use. Results shows a BOD and COD values of 4.51mg/L and 2.35mg/L, respectively, which gladly fell within the WHO standard and EPA guidelines for all sample, as well as secondary data of ICCL. This implies that there is no risk for sustenance of aquatic lives.

The concentrations of iron, lead, copper, cadmium, zinc, chromium and manganese (in mg/L) were determined to be 0.5231, 0.0512, 0.123, 0.001, 0.0447, 0.001 and 0.4152, respectively. The concentration of some metals in this study area fall within the limit of SON, USEPA, ICCL secondary data and WHO's limits for sustenance of aquatic lives and humans. However, iron, lead, copper and manganese exceeds or equals the WHO/FMEnv desirable limits. Subsequently, Sheda surface water is not suitable for drinking or a treatment is proffered, indicating risk of sustenance to Aquatic Lives and humans.

Ground Water Quality

Epe, Lagos State:

The appearance of ground water sample collected from Epe satisfied the WHO recommendation that any water suitable for drinking must be clear and colourless. Temperature above ambient level is an index of groundwater pollution but gladly the water in this study area have temperature of 25^{0}C falling within the standard acceptable limits for drinking and domestic activities. The groundwater turbidity results obtained here was 0 FTU, which is within the permissible limits for Nigerian Standard of FMEnv and WHO.

Pure water suitable for drinking should contain less or no organic salt making it an excellent insulator and should have a conductivity below the WHO/FMEnv/ Nigerian Standard for Drinking Water Quality limits (1000µS/cm and 1200 µS/cm respectively). The results here show that the measured conductivity of water sample was 10.14µS/cm which is within the WHO/FMEnv/SON permissible limits and suitable for drinking. The pH values for Sheda ground water was 6.5 and is within the permissible level recommended by WHO and suitable for drinking and other domestic use. EPA guidelines recommend a minimum alkalinity level of 20 mg/L, meaning, an alkalinity greater than 20 mg/L is beneficial to water quality. Results for Epe, showed an acidity and alkalinity values of 10.24 and 50 mg/L, respectively.

The results obtained here for total hardness conforms to the soft group WHO standard, since its value was 17.89 mg/L. More so, Sheda sample is safe and suitable for use for its compliance to the FMEnv permissible limits of 150mg/L. The WHO gave the palatability of drinking water according to its TDS level as less than 500 mg/l excellent level and greater than 1700 mg/l as unacceptable. Results shows a relatively low TDS levels (10mg/L) and no TSS in sample from Epe. The values for Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) were within the WHO/FMEnv permissible limit set for drinking water. The concentration of nutrients (nitrate, sulphate and phosphate) recorded were 0.01mg/L, 7.4mg/L and 0.02mg/L, respectively. The WHO has set a 0.03 mg/dm^3 permissible limits for Nitrite due to its huge public health implications, 200 mg/dm^3 set by WHO for sulphate and 0.05mg/L for phosphate. The concentrations of the chloride in the water sample here, was 9.87mg/L and is found to be below the WHO permissible limit. Sodium Chloride concentration in Sheda ground water was 16.26mg/L which falls within the limits for domestic use. The WHO has set a 10mg/L limits for both BOD and COD. Results of the sample are within the constraint of WHO/FMEnv for drinking. The concentrations of iron, lead, copper, cadmium, zinc, chromium and manganese (in mg/L) were determined to be 0.02, <0.001, <0.001, <0.001, <0.001, <0.001 and <0.001 respectively. All these results were found to fall below the standard set by WHO, FMEnv for desirable level and maximum permissible level of drinking water.

Neke Uno, Enugu:

The appearance of ground water sample collected from Neke Uno satisfied the WHO recommendation that any water suitable for drinking must be clear and colourless. Temperature above ambient level is an index of groundwater pollution and gladly the water in this study area have temperature of 25^{0}C falling within the standard acceptable limits for drinking and domestic activities. The groundwater turbidity results obtained here was 0 FTU, which is within the permissible limits for Nigerian Standard of FMEnv and WHO.

Pure water suitable for drinking should contain less or no organic salt making it an excellent insulator and should have a conductivity below the WHO/FMEnv/ Nigerian Standard for Drinking Water Quality limits (1000µS/cm and 1200 µS/cm respectively). The results here show that the measured conductivity of water sample was 8.07µS/cm which is within the WHO/FMEnv/SON permissible limits and suitable for drinking. The pH values for Neke Uno ground water was 5.89 and is within the permissible level recommended by WHO and suitable for drinking and other domestic use. The low pH of Neke Uno water sample may be attributed to the discharge of acidic products into this source by the agricultural, industrial and domestic activities.

EPA guidelines recommend a minimum alkalinity level of 20 mg/L, meaning, an alkalinity greater than 20 mg/L is beneficial to water quality. Result for Neke Uno showed an acidity and alkalinity values of 61.47 and 60 mg/L, respectively. The results obtained here for total hardness conforms to the soft group WHO standard, since its value was 10.73mg/L. More so, Neke Uno sample is safe and suitable for use for its compliance to the FMEnv permissible limits of 150mg/L. The WHO gave the palatability of drinking water according to its TDS level as less than 500 mg/l excellent level and greater than 1700 mg/l as unacceptable. Result shows a relatively low TDS levels (7mg/L) and no TSS in sample from Neke Uno. The values for Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) were within the WHO/FMEnv permissible limit set for drinking water. The concentration of nutrients (nitrate, sulphate and phosphate) recorded were 0.01mg/L, 6.4mg/L and 0.02mg/L, respectively. The WHO has set a 0.03 mg/dm^3 permissible limits for Nitrite due to its huge public health implications, 200 mg/dm^3 set by WHO for sulphate and 0.05mg/L for phosphate. This result revealed that Neke

Uno's ground water with a higher nitrite concentration (1.55 mg/L) and hence not suitable for drinking. The concentrations of the chloride in the water sample was 39.49mg/L and is found to be below the WHO permissible limit. Sodium Chloride concentration in Neke Uno' ground water was 65.16mg/L which falls within the limits for domestic use. The WHO has set a 10mg/L limits for both BOD and COD. Results of the sample are within the constraint of WHO/FMEnv for drinking. The concentrations of iron, lead, copper, cadmium, zinc, chromium and manganese (in mg/L) were determined to be 0.03, <0.001, <0.001, <0.001, <0.001, <0.001 and 0.03 respectively. All these results were found to fall below the standard set by WHO, FMEnv for desirable level and maximum permissible level of drinking water.

Sheda, Abuja:

The appearance of ground water sample collected from Sheda satisfied the WHO recommendation that any water suitable for drinking must be clear and colourless. Temperature above ambient level is an index of groundwater pollution but gladly the water in this study area have temperature of 25^0C falling within the standard acceptable limits for drinking and domestic activities. The groundwater turbidity results obtained here was 2.65 FTU, which is within the permissible limits for Nigerian Standard of FMEnv and WHO.

Pure water suitable for drinking should contain less or no organic salt making it an excellent insulator and should have a conductivity below the WHO/FMEnv/ Nigerian Standard for Drinking Water Quality limits (1000µS/cm and 1200 µS/cm respectively). The results here show that the measured conductivity of water sample was 399µS/cm which is within the WHO/FMEnv/SON permissible limits and suitable for drinking. The wide differences of the conductivity values might be due to various factors such as agricultural and industrial activities and land use, which affect the mineral contents and thus the electric conductivity of the water. The pH values for Sheda ground water was 6.84 and is within the permissible level recommended by WHO and suitable for drinking and other domestic use. EPA guidelines recommend a minimum alkalinity level of 20 mg/L, meaning, an alkalinity greater than 20 mg/L is beneficial to water quality. Results showed an acidity and alkalinity values of 0.57 and 1.22 mg/L. The results obtained here for total hardness conforms to the soft group WHO standard, since its value was 17.89 mg/L. More so, Sheda sample is safe and suitable for use for its compliance to the FMEnv permissible limits of 150mg/L.

The WHO gave the palatability of drinking water according to its TDS level as less than 500 mg/l excellent level and greater than 1700 mg/l as unacceptable. Results shows a relatively low TDS levels (1.12mg/L) and 0.22mg/L TSS in sample from Sheda. The values for Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) were within the WHO/FMEnv permissible limit set for drinking water. The concentration of nutrients (nitrate, sulphate and phosphate) recorded were 1.55mg/L, 0mg/L and 4.21mg/L, respectively. The WHO has set a 0.03 mg/dm^3 permissible limits for Nitrite due to its huge public health implications, 200 mg/dm^3 set by WHO for sulphate and 0.05mg/L for phosphate. The concentrations of the chloride in all the water sample here, was 97.9mg/L and is found to be below the WHO permissible limit. Sodium Chloride concentration in Sheda ground water was 97.9mg/L which falls within the limits for domestic use. The WHO has set a 10mg/L limits for both BOD and COD. Results of the sample are within the constraint of WHO/FMEnv for drinking. The concentrations of iron, lead, copper, cadmium, zinc, chromium and manganese (in mg/L) were determined to be 0.02, <0.001, <0.001, <0.001, <0.001, <0.001 and <0.001 respectively. All these results were found to fall below the standard set by WHO, FMEnv for desirable level and maximum permissible level of drinking water.

Biological Environment

Epe Site, Lagos State

The study site is located around Latitude 06.627.27°E, Longitude 003.921.10°N Coordinates and on an average altitude of 9m above sea level. Epe is within a forest vegetation, the proposed site was the only site that remain undisturbed around the area, probably because it was fenced with barb wire by the Federal Ministry of Environment. The site was also observed to constitute some patches swamps containing surface water at the upstream, while presence of lagoon at the downstream. There are no anthropogenic activities, compared to control sites (nearby compared site). The floral diversity was moderate, though, 16 species were encountered during the survey. Highest distribution of 13.38% of Elephant grass (*Pennisetum purpureum*) recorded.

Animal diversity at the site reveals Soja ants (*Macrotermes subhyalinus*) to be the dominant species with 69.64% distribution. There were two separate colonies encountered the demarcated site. The distribution was followed by *Nylanderia bourbonica* and *Colias eurytheme* which recorded 7.24 % both. The least fauna recorded in demarcated site was *Naja melanoleuca.* While the biodiversity in Epe site could provide ecological services as; source of food, fibre, fuel and fodder.

Neke Uno Site, Enugu State

Neke Uno study site is located within Latitude 06.657.87℃E, Longitude 007.545.35°N Coordinates, it's on an average altitude of 202m above sea level. This proposed site was observed to be under active utilization (farming activities), crops under cultivation among which are; *Zea mays* and *Manihot esculenta* as dominant crops. Floral diversity of the site shows that *Echinchloa colonum* recorded 38.33% distribution among other plant species. Neke Uno site was also observed to the only site among the three proposed without any cultivation undertaken at the Control area.

There is wide variety of animal species, which include; colony of *Carduelis cannabina* birds, with highest distribution among the animal species, *Guttera pucherani* (Guineafowl) has the least distribution in the proposed area. Biodiversity in Neke Uno site could provide ecological services for timber (for building and furniture materials) source of food, which has been adequately been utilized for, as well as fuel.

Sheda Site, FCT

The study site is located within Latitude 08.846.83°E, Longitude 007.041.27°N Coordinates and on an average altitude of 197m above sea level. Sheda was the most diverse sites among the three proposed sites of the project (EPE, NEKE ONU and SHEDA). The site is within Guinea Savanna region with diverse and abundant floral species. Total of 292 floral species were observed. Though, there was lot and active framing activities going on in the site. Species under cultivation were found to include; *Panicum sumatrnse* (Little millet), *Zea mays* (Maize), *Sesamum indicum* (Sesame), Okra, Sorghum, Pepper, Groundnut, Moringa, Cassava, Sweet Potatoes and *Vigna unguiculate* (Beans). The active utilization of the site framing could affect biodiversity and its conservation. Though Sheda is the only Southern Guinea Savanna among the sites it's known with diverse floral species. *Corchorus olitorius* has the highest distribution (7.88%) apart from the cultivated crops found within the demarcated Site. The Control Site in Sheda has much similarity with demarcated Site. There were diverse animal species as other sites, though *Turdus merula* (Black bird) were observed in a colony and as dominant species encountered. Though they were found on a tree, but most likely under migration.

Diversity of life in Sheda site could provide ecological services for source of food mainly from crops, fisheries etc. because it has the most adequately utilized area (for farming) compared to other sites

SOCIO-ECONOMIC

Epe Community

Age groups <45-65, <25-45 and <10-25 were 57%,29% and 14%, respectively, made up of 71% male and 29% Female. All of them were married with one man to one wife.

Household sizes ranged between <1-10 and <11-20 86% and 14% respectively. The number of children ranged from <2-3, <1-3, <4-6 and <7-9 being 43%, 29%, 14% and 14% respectively constituted of 1.2:1 male: female ratio.

Occupation: 29% of the residents are farmers, businessmen and plumbers constitutes 14% each, while 29% are engaged in miscellaneous types of commercial activities.

Education: All the residents are educated to secondary, primary and university level with a distribution of 72%, 14% and 14% respectively.

Average annual income bracket of individuals ranges from, N500,000-4,499,999, N1,500,000-4,499,999, N250,000-499,999 and N1-249,999 at 20%, 40%,20% and 20%, respectively.

Health: 27% of the residents use the general hospital while the remaining 73% patronize the Federal Medical Centre and the University Teaching Hospital.

Neke Uno Community

Age groups <45-65 and <25-45 were 64% and 36%, respectively, made up of males only. All of them were married with one man to one wife.

Household sizes ranged between <1-10 and <11-20 73% and 27% respectively. The number of children ranged from <2-3, <1-3, <4-6 and <7-9 being 33%, 17%, 11% and 11% respectively constituted of 1.2:1 male:female ratio.

Occupation: 27% of the residents are farmers, businessmen constitutes 9%, 14% are plumbers while 35% are engaged in miscellaneous types of commercial activities.

Education: All the residents are educated to secondary, primary and university level with a distribution of 13%, 75% and 134% respectively.

Average annual income bracket of individuals ranges from N500,000-1,499,999 to above N10,000,000, N500,000-4,499,999, N1,500,000-4,499,999, N250,000-499,999 and N1-249,999 at 36%, 27%, 9%, 9% and 20%, respectively.

Sheda Community, FCT

Age groups <45-65 and <25-45 were 33% and 67%, respectively, made up of males only. All of them were married with one man to one wife.

Household sizes ranged between <1-10 and <11-20 are 39% and 45% respectively. The number of children ranged from <2-3, <1-3, <4-6 and <7-9 being 86%, 48%, 10% and 12% respectively constituted of 1.2:1 male:female ratio.

Occupation: 40% of the residents are farmers, businessmen constitutes 34%,.

Education: All sampled residents are educated to secondary, primary and university level with a distribution of 27%, 17% and 28% respectively.

Average annual income bracket of individuals ranges from N500,000-1,499,999 to above N10,000,000, N500,000-4,499,999, N1,500,000-4,499,999, N250,000-499,999 and N1-249,999 at 7%, 32%, 13%, 0% and 26%, respectively.

Health facilities: 39% of the residents use the General Hospital, 16% patronize the Federal Medical Centre and the University Teaching Hospital, 10% patronize Dispensary, 3% patronize Pharmaceutical Chemist, 13% patronize Patent Medicine Store and 3% patronize Traditional Doctors/Herbs.

STAKEHOLDER CONSULTATIONS

The communities and other stakeholders are required to be informed and sort their concerns and views about the project for consideration for inclusion in the scope of the study. Stakeholder groups targeted by the information and consultation of stakeholders' program include the:

- People directly affected by the project
- traditional authorities and leaders of communities affected
- NGOs and community organisations
- Local and state government environmental agencies.

In total, three meetings were held on between October 22nd to 25th 2018, meetings format consisted of a presentation of the project, followed by a question and answer (Q&A) period. The issues of concerns and recommendations made were considered in defining the scope of the study. Meeting with an NGO was also part of the scoping consultations.

The team met with 10 members representing Epe community and other stakeholders at Baale of Sala's House, Sala Village, Epe, Lagos, on October 22nd, 2018. About 17 persons met with the environmental team at Office of the Chairman's of Neke-Uno LGA, Enugu, on October 23rd, 2018. In Sheda site, the total participant were 12 and they deliberated on issues pertaining to storage and treatment of PCBs in their community. The meeting held at Sheda Youth Leader's Residence, Sheda, Kwali LGA, FCT. Savannah Conservation (NGO).

This first round of stakeholder information and consultation as part of the development of the ESIA has served to present the project to stakeholders and obtain issues of concern to them, their expectations and recommendations to be considered for inclusion in the scope of the studies.

Main concerns and observations raised

The main concerns and observations raised during the first round of stakeholder consultation are summarized as follows.

Sheda Site in the FCT: The community members requested employment for the youths during the construction stage of the project and after the project has commenced.

Epe Site in Lagos State: The community expressed concern about the effect of the PCB on their health, and requested that adequate measures should be put in place to protect them.

Neke Uno in Enugu State

- The community expressed concern about the effect of the PCB on their health, and requested that adequate measures should be put in place to protect them.
- Requested for jobs for the youths in the community
- Requested for a school in their community and roads.
- The agreement for the custody of the land was made with the last Chief of the community who is now late and there are some traditional rites to be done on the land before construction can take place.

The second round of stakeholder information and consultation is to present to the Stakeholders the preliminary findings of the EIA for them to validate and improve the preliminary results of the EIA and ensure compliance of proposed measures with the requirements and expectations of the authorities as well as assess the project's social acceptability and the proposed measures.

In total three meetings were held on between March 5th and 19th 2019, meetings format consisted of a presentation of the report, followed by comments and recommendations from stakeholders. On the March 5th, 2019, 12 participant met at Kwali Area Council Secretariat, 14 people met at M-Square Hotel, No 34A Remi Fani Kayode Street, Ikeja, Lagos, on March 7, 2019 and finally in Neke Uno at Blue Island Hotel, Independence Layout Enugu, where 11 participant deliberated on March 19, 2019

ENVIRONMENTAL AND SOCIAL POTENTIAL IMPACT

The assessment of impacts considered project activities in the following phases of the project development.

- Pre-Construction Phase
- Construction Phase
- Operation and Maintenance Phase
- Decommissioning and Closure

The assessment of impacts will pass through an iterative process involving the following four key elements:

- Prediction of potential impacts and their magnitude (i.e., the consequences of the proposals on the natural and social environment);
- Evaluation of the importance (or significance) of impacts taking the sensitivity of the environmental resources or human receptors into account;

- Development of mitigation measures to avoid, reduce or manage the impacts or enhancement measures to increase positive impacts; and
- Assessment of residual significant impacts after the application of mitigation and enhancement measures.

Main Potential Negative impacts

Environmental issues identified involving negative impact includes but no limited to:

- Exposure to emissions from vehicles (PM, NO_2/NOx)
- Quality water resources will be affected due to accidental spill of PCB
- Degradation of aquatic species due to maintenance of the plant
- Potential contamination of soil from inadvertent release of hazardous or contaminating material
- Potential interactions between maintenance works and cultural festivals due to traffic, noise and/or vibration impacts
- Loss of vegetation due to routine clearance of vegetation
- Exploitation of workers
- The activities of PCBs collections, storage and transportation could expose workers to the dangers associated with PCBs as described earlier.

Main Potential Positive impacts

- In all the three phases, there will be job opportunities for construction workers, skilled and unskilled workers, as well.
- Provision of social amenities like portable water supply, electricity, primary health centers, asphalt road and putting the communities on the national map
- Increase income for local labourers for site preparation and decommissioning exercise
- Increased revenue to state, local government and communities through land sales and site maintenance
- Provision of awareness program for proper waste management not only for PCBs but other forms of wastes.
- Generally, speaking protecting the entire nation from indecent disposal of PCBs

ENVIRONMENTAL AND SOCIAL MITIGATION MEASURES

Mitigation measures are developed to avoid, reduce, remedy or compensate for any negative impacts identified, and to create or enhance positive impacts such as environmental and social benefits. In this context, the term "mitigation measures" includes operational controls as well as management actions. These measures are often established through industry standards and may include:

- changes to the design of the project during the design process (eg changing the development approach);
- engineering controls and other physical measures applied (eg waste water treatment facilities);
- operational plans and procedures (eg waste management plans); and
- the provision of like-for-like replacement, restoration or compensation.

The mitigation measures adopted were based on the stages of operation, namely pre-construction, construction and operation while considering the factors that may affecting the environment.

Mitigation measures for all the phases considered and for all forms of pollution.

Air pollutant emission

Regarding impacts of emissions from vehicles and equipment engines the following mitigation measures are recommended:

- Maintain and operate all vehicles and equipment engines in accordance with manufacturers recommendations;
- Stationary generators to be located to facilitate dispersion;
- Cover properly loose materials and keep top layers moist;
- Use binder material for erosion and dust control for long term exposed surfaces;
- Regular cleaning of equipment, drains and roads to avoid excessive build-up of dirt;
- Spray surfaces prior to excavation;
- Use covered trucks for the transportation of materials that release dust emissions; and
- Speed limits on-site of 25km/hr on unhardened roads and surfaces.

Noise and vibration

The following recommendations for mitigation measures on noise and vibration are outlined as follows:

- Develop a detailed plan that relates to noise control for relevant work practices and discuss this with construction staff during health & safety briefings;
- Select ‘low noise’ equipment or methods of work;
- Use temporary noise barriers for equipment (e.g. sound proofing walls around stationary power generating sources);
- Avoid dropping materials from height, where practicable;
- Avoid metal-to-metal contact on equipment;
- Maintain and operate all vehicles and equipment in accordance with manufacturers recommendations;
- Avoid mobile plant clustering near residences and other sensitive land uses;
- Ensure periods of respite are provided in the case of unavoidable maximum noise level events;
- Inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as providing the contact details of the PMU Community Relation Officer;
- Noisy activities (activities that can be heard in nearby communities) restricted to day-time working hours.

Geology and Soil Structure

The following mitigation measures to reduce impacts on soil structure from compaction and erosion are recommended:

- Construction of foundations to be undertaken in the dry season;
- Backfill foundation pits by the excavated soils which will resemble the order of the original soil layers;
- Protect excavated soil materials from erosion;
- Ensure that the land is physically restored (include revegetation where possible) before leaving the site

Potential Soil Contamination

With regards to soil contamination impacts, the following measures will be implemented:

- Implement effective site drainage on the construction camp to allow for the directed flow of surface water off site. This shall include cut-off drains to divert surface runoff from exposed soils or construction areas;
- Install oil/water separators and silt traps before effluent, leaves the site;
- Minimise bare ground and stockpiles to avoid silt runoff;
- Bounding of areas where hazardous substances are stored (eg fuel, waste areas);
- Remove all water accumulation within bunds using manually controlled positive lift pumps not gravity drains;
- Regular checking and maintenance of all plant and equipment to minimize the risk of fuel or lubricant leakages;
- Training of relevant staff in safe storage and handling practices, and rapid spill response and clean-up techniques;
- Set-up and apply procedure regarding dealing with contaminated soils;
- Development and implementation of a Waste Management Plan (as part of the ESMP) to ensure that waste is disposed of correctly; and
- Spread sheet underneath the structures prior to start any painting activity.

Impact on Hydrogeology

The potential contamination of groundwater and surface water from release of hazardous or contaminating material (liquid fuel, solvents, lubricants, paint, etc), can be mitigated by the following actions:

- The construction of drainage around the sites fitted with an API gravity separator for oil removal.
- Development of access road within swamp area around Epe area
- Avoiding storage of materials that are likely to leach into soil in the open
- Construction of bund wall around fuel and oil storage areas

Specific Management Plans

As a result of the final design not being available at this stage. The following specific plans shall be prepared and submitted to the EIA Division of the Federal Ministry of Environment, before commencement of implementation and after the national inventory and the final design have been completed.

- Emergency Response Plan
- Waste Management Plan
- Security Management Plan
- Local Content Plan
- Traffic Management Plan;
- Occupational Health and Safety Management Plan.

Training and Awareness

PMU shall identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact upon the environment or social conditions. This will be achieved through a formal training process. Employee training will include awareness and competency with respect to:

- environmental and social impacts that could potentially arise from their activities (including dust, biodiversity and soil/water contamination);
- necessity of conforming to the requirements of the ESIA and ESMP, in order to avoid or reduce those impacts; and
- roles and responsibilities to achieve that conformity, including those in respect of change management and emergency response.

The HSE Coordinator is responsible for coordinating training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The HSE Coordinator will also periodically verify that staff are performing competently through discussion and observation.

Employees responsible for performing site inspections will receive training by drawing on external resources as necessary. Training will be coordinated by the HSE coordinator prior to commissioning of the facilities. Upon completion of training and once deemed competent by management, staff will be ready to train other people.

Similarly, the Project will require that each of the sub-contractors institute training programmes for its personnel. Each subcontractor is responsible for site HSE awareness training for personnel working on the job sites. The subcontractors are also responsible for identification of any additional training requirements to maintain required competency levels.

The subcontractor training program will be subject to approval by PMU and it will be audited to ensure that:

- training programs are adequate;
- all personnel requiring training have been trained; and
- competency is being verified.

OPERATIONAL CONTROL PROCEDURES

Each potentially significant impact identified in the ESIA will have an operational control associated with it that specifies appropriate procedures, work instructions, best management practices, roles, responsibilities, authorities, monitoring, measurement and record keeping for avoiding or reducing impacts. Operational controls are monitored for compliance and effectiveness on a regular basis through a monitoring and auditing procedure described in the ESMP. This control shall focus on the following:

Managing Changes to Project Activities

Changes in the Project may occur due to unanticipated situations. Adaptive changes may also occur during the course of final design, commissioning or even operations. The Project will implement a formal procedure to manage changes in the Project that will apply to all project activities. The objective of the procedure is to ensure that the impact of changes on the health and safety of personnel, the environment, plant and equipment are identified and assessed prior to changes being implemented.

Emergency Preparedness and Response

PMU will prepare plans and procedures to identify the potential for, and response to, environmental accidents and health and safety emergency situations and for preventing and mitigating potentially adverse environmental and social impacts that may be associated with them. The Emergency preparedness and response will be reviewed by PMU on at least an annual basis which will be undertaken on a regular basis to confirm adequacy of response strategies. Investigations of accidents or incidents will follow formal documented procedures.

Checking and Corrective Actions

Checking includes inspections and monitoring as well as audit activities to confirm proper implementation of checking systems as well as effectiveness of mitigations. Corrective actions include response to out-of-control situations, non-compliances, and non-conformances. Actions also include those intended to improve performance.

Monitoring

Monitoring will be conducted to ensure compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. Monitoring methodologies or processes must be put in place in order to ensure the efficacy of the mitigation measures identified in the ESIA. Identification of Project specific cumulative environmental and social effects, if applicable as well as to monitor the effectiveness of the mitigation and enhancement measures applied.

Auditing

Beyond the routine inspection and monitoring activities conducted, audits will be carried out by PMU to ensure compliance with regulatory requirements as well as their own HSE standards and policies. Audits to be conducted will also cover the subcontractor self-reported monitoring and inspection activities. The audit shall be performed by qualified staff and the results shall be reported to PMU to be addressed.

Corrective action

Investigating a ‘near-miss’ or actual incident after it occurs can be used to obtain valuable lessons and information that can be used to prevent similar or more serious occurrences in the future.

PMU shall implement a formal non-compliance and corrective action tracking procedure for investigating the causes of, and identifying corrective actions to, accidents or environmental or social non-compliances. The HSE coordinator will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programs to avoid repetition of non- conformances and non-compliances.

Reporting

Throughout the Project, PMU will keep the regulatory authorities informed of the Project performance with respect to HSE matters by way of written status reports and face-to-face meetings. PMU will prepare a report on environmental and social performance and submit it to FMEnv. The frequency of this reporting will be determined by FMEnv, in a letter of approval of the project. These reports are prepared as part of requirements for impact mitigation monitoring to be carried by FMENV, Lagos Ministry of Environment, Enugus State Ministry of Environment and Abuja Environmental Protection Board and other relevant agencies.

DECOMMISSIONING ACTIVITIES

At the end of the facilities utility, all equipment will be decommissioned. In general, the activities to be carried out during the decommissioning phase shall include the following:

- Dismantling of facilities including excavation
- Dismantling of all surface equipment
- Removal and disposal of concrete works
- Removal and disposal of conductors, etc

Impacts

The potential impacts that might result from the decommissioning phase of the proposed project include:

- physical disturbance of the environment arising from the removal of the plant and ancillary equipment,
- potential hazards/accidents associated with decommissioning activities, and
- waste management problems

The strategy to be adopted for site remediation shall depend on the prevailing biophysical and social environmental attributes and the attendant impacts that may result from such an action as discussed in Chapter 6. The following measures need to be planned for implementation after decommissioning:

- Facilities and ancillary equipment shall be dismantled completely
- All equipment and debris shall be removed from the environment
- Good waste management plan shall be implemented.

Mitigation Measures

The strategy to be adopted for site remediation shall depend on the prevailing biophysical and social environmental attributes and the attendant impacts that may result from such an action. The following measures need to be planned for implementation after decommissioning:

- Facilities and ancillary equipment shall be dismantled completely
- All equipment and debris shall be removed from the environment
- Good waste management plan shall be implemented.

CONCLUSIONS

The Environmental and Social Impact Assessment (ESIA) of the proposed project has been carried out in line with statutory requirements for environmental management in Nigeria and as such ensures that potential environmental, social and health impacts of the project are fully appraised.

The environmental baseline condition of the project area showed that the physical, chemical and biological characteristics as well as meteorological, climatic and hydrological characteristics were generally consistent with previous studies carried out within the environment with some few exceptions.

The identified adverse impacts of the proposed project include; air pollution, soil, sediment, groundwater and surface water contamination from accidental/ routine discharges of effluent, workplace accidents, improper waste management has been identified. Consequently, cost-effective mitigation/ amelioration measures have been designed to ensure that these impacts are prevented, reduced or controlled to as low as reasonably practicable, in order to ensure conservation of biodiversity in the area and enhance continual compliance with environmental standards and requirements in Nigeria. It is understood that the project will result in substantial social and economic benefit for Nigeria. The EMP developed would ensure that the plans/ procedures for managing the significant impacts of the project are maintained throughout the project implementation.

Socio economic consultations with the project host communities and other relevant stake holders were also carried out and shall continue throughout the life cycle of the project

It is therefore hoped that all data/evidence contained in this report is sufficient in the development of an environmental impact statement (EIS), and afterward in the acquiring of necessary permits for commencement of project.

Therefore, we recommend that the *EIA of the PCB Collection, Storage and Treatment Centers Project* be approved and issued EIA permit. The mitigation measures that have been proffered shall be adequately implemented in accordance with the ESMP and in compliance with the ESIA Act and the World Bank environmental and social standards.

CHAPTER ONE

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

Polychlorinated Biphenyls (PCBs) are among the most toxic Persistent Organic Pollutants (POPs) listed in the Stockholm Convention. PCBs have been used in almost all sectors of the Nigerian economy as coolants and insulating fluids in transformers and capacitors in electricity generation, transmission and distribution, in flexible coatings of electrical wiring and components. With this in mind, PCBs are seen as a threat to public health and the environment. The Stockholm Convention is a global treaty ratified by the international community and led by the United Nations Environment Programme (UNEP) that calls for the elimination and/or phasing out of 12 POPs, called the *"dirty dozen"*. However, to neutralize this threat, Nigeria joined the global community in negotiating and ratifying the Stockholm Convention on POPs which obliges parties to eliminate the use of PCBs in equipment by 2015, and to make concerted efforts for disposing liquid PCBs and equipment through environmentally sound waste management practices as early as possible, but no later than 2028. Nigeria submitted its National Implementation Plan (NIP) in 2009 listing twenty-three areas of action as priorities for meeting its treaty obligations. The priorities included PCB inventory and treatment (priority number one) and PCB disposal options

The Environmentally Sound Management (ESM) of PCB-Project Management Unit, in collaboration with the United Nations Development Programme (UNDP) plans to establish three PCBs Collection, Storage and Treatment Centres, otherwise known as PCBs Interim Storage Facilities (PCB-ISF) in Neke Uno in Enugu State, Epe in Lagos State, and Sheda Science and Technology Complex (SHESTCO) along Abuja-Lokoja Expressway. The facilities are to be used for the safe collection, storage and treatment of PCB oil and PCBs-contaminated equipment identified in the course of the national PCBs inventory in Nigeria.

1.2 PCB IN NIGERIA

Almost all PCB related activities in Nigeria are centred around electricity transmission and distribution. The other uses of PCBs are not very popular in the country; hence it is assumed that majority of PCBs sources are from electrical energy sector. Unfortunately, accurate data on open applications of PCBs in Nigeria are not readily available or not reliable.

In 2001, the government of Nigeria received funding from the GEF to finance enabling activities that would lead to the preparation of its NIP on the Stockholm Convention. FMEnv was the Implementing Agency and UNIDO the executing agency for the project. Given the size of the country, its level of economic development and its complex government structure, and taking into account the amount of GEF resources available, the level of detail that could have been expected from these inventories was limited.

In spite of the inadequacy of the existing PCB survey conducted in Nigeria, PCB management still remained top priorities regarding POPs, which is due to following reasons:

i. The Nigerian electricity sector has facilities located in all 36 states and the Federal Capital Territory, with about 250 transmission transformers, 34,800 distribution transformers, and over 2,000 power transformers. Environmental concern is on the likelihood that many of these transformers and facilities contain PCBs. Accordingly, there are concerns about the potential harm these equipment might be posing to the health of people living and working nearby facilities, as well as to the ecological system.
ii. Due to her desire to become an economical viable country, Nigerian Ministry of Power, Works and Housing is undergoing a massive upgrade of its electricity generation and distribution capacities. The target is to increase both the generation and distribution capacities. This procedure will involve replacement of old equipment and decommissioning of this equipment. This calls for proper data collection on PCB contamination and decommissioning in an environmentally sound manner. Additionally, these outdated equipment containing PCBs might be left unprotected in the open.
iii. The risks to human health and to the environment posed by the unsound management of privately-owned PCB-containing equipment or PCB stocks are also a priority of the government.
iv. Illegal trade of spent oils, poorly managed and inadequately disposed equipment is a source of grave concern, although no actual data currently exists to assess the situation.
v. Today, Nigeria depends mainly on importation of materials and end-products, like adhesives, sealants, flame retardant etc., which might contain unaccounted sources of PCBs.

1.2.1 Project Context

The main objective of the study is to conduct an Environmental Impact Assessment (EIA) of the PCB-ISF in the three locations namely, Sheda, Epe and Neke Uno as required by the EIA Act, while addressing the following;

- identify, predict and evaluate the environmental, social and economic impact and associated risks of the project;
- provide information on the environmental consequences to assist environmentally sound design of the project;
- promote environmentally sound and sustainable development of the project through the identification of appropriate alternatives and mitigation measures;

- ensure critical resources and ecological functions or wellbeing, lifestyle and livelihood of communities and people of the affected locations are not undermined.

1.2.2 Project Aim and Objectives

The purpose of the PCB Regulations is to protect Nigeria's environment and the health of all Nigerians by minimizing the risks posed by the use, release and storage of PCBs, and by accelerating the phasing out and eventual elimination of these substances, in the nearest future.

Accordingly, the project is aimed at developing national capacity to collect PCBs, develop an enhance in-country storage *viz-a-viz* treatment facilities in Sheda, Epe and Neke Uno. The aim will be achieved via the following objectives:

i. Identification of various sources of PCB generating units in the country
ii. Strengthen the institutional and legal framework for PCBs management in Nigeria.
iii. Ensure that inventoried PCBs and PCB-containing equipment are labelled, safely transported and stored.
iv. Reducing risks of exposure to PCBs on human health and the environment by adopting the most environmentally suitable way of PCB handling.
v. Identification, adoption and implementation of Optimal Available and Achievable Technology (OAAT) and Optimal Environmentally Friendly Practices (OEFP) in addressing PCBs management in the country, especially in Power Holding Company of Nigeria (PHCN) facilities.
vi. Preparing Nigerian to meet her reporting obligation under the Stockholm Convention in 2001

1.2.3 Persistent organic pollutants (POPs)

POPs are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes (Ritter *et al.,* 2007). POPs typically are halogenated organic compounds and as such exhibit high lipid solubility. For this reason, they bioaccumulate in fatty tissues. Halogenated compounds also exhibit great stability reflecting the nonreactivity of C-Cl bonds toward hydrolysis and photolytic degradation. The stability and lipophilicity of organic compounds often correlates with their halogen content, thus polyhalogenated organic compounds are of particular concern. Many POPs are currently or were in the past used as pesticides, solvents, pharmaceuticals, and industrial chemicals (El-Shahawi *et al.,* 2010). Although some POPs arise naturally, for example volcanoes and various biosynthetic pathways, most are man-made via total synthesis.

They exert their negative effects on the environment through two processes, long range transport, which allows them to travel far from their source, and bioaccumulation, which reconcentrates these chemical compounds to potentially dangerous levels. Compounds that make up POPs are also classed as Persistent, Bioaccumulative and Toxic (PBTs) or Toxic Organic Micro Pollutants (TOMPs). Because of their persistence, POPs bioaccumulate with potential adverse impacts on human health and the environment. The effect of POPs on human and environmental health was discussed, with intention to eliminate or severely restrict their production, by the international community at the Stockholm Convention on POPs in 2001 (Porta and Zumeta, 2002).

CB is an abbreviation of Poly Chlorinated Biphenyl, a group of compounds. There are theoretically 209 different isomeric forms which differ by number and position of chlorine. Among the forms is a group called coplanar PCB, a kind of dioxin which is highly toxic.

PCB is difficult to dissolve, has a high boiling point, heat-resistant, has high electric insulation properties, and is chemically stable. Thus PCB was used in many electrical products. Polychlorinated biphenyls (PCB) are aromatic hydrocarbon compounds, consisting of two benzene rings linked by a carbon-carbon bond. The hydrogen atoms can be substituted by up to ten chlorine atoms. PCB exist as viscous liquids or resins and may be colourless or yellowish with a strong, characteristic smell. One of the most important characteristics of PCB is that they have excellent dielectric properties, are resistant to chemical and thermal degradation (they decompose at high temperatures above 1000 °C), are not affected by light and are not flammable.

Due to their physico-chemical properties, application of PCBs is commonly divided into closed and open applications. Examples of closed applications include coolants and insulating fluids (transformer oil) for transformers and capacitors, such as those used in old fluorescent light ballasts (Erickson and Kaley, 2010), hydraulic fluids, lubricating and cutting oils, and the like. In contrast, the major open application of PCBs was in carbonless copy ("NCR") paper, which even presently results in paper contamination (Pivnenko *et al.,* 2016).

Other open applications were as plasticizers in paints and cements, stabilizing additives in flexible PVC coatings of electrical cables and electronic components, pesticide extenders, reactive flame retardants and sealants for caulking, adhesives, wood floor finishes, such as *Fabulon* and other products of Halowax in the U.S., de-dusting agents, waterproofing compounds, casting agents (UNEP Chemicals, 1999). It was also used as a plasticizer in paints and especially "coal tars" that were used widely to coat water tanks, bridges and other infrastructure pieces.

One estimate suggested that 1 million tonnes of PCBs had been produced. 40% of this material was thought to remain in use (USEPA, 2009). Another estimate put the total global production of PCBs on the order of 1.5 million tonnes. The United States was the single largest producer with over 600,000 tonnes produced between 1930 and 1977. The European region follows with nearly 450,000 tonnes through 1984. It is unlikely that a full inventory of global PCB production will ever be accurately tallied, as there were factories in Poland, East Germany, and Austria that produced unknown amounts of PCBs (Breivik *et al.,* 2002).

1.3 LOCATION OF PROJECT

The project is located in three centers -Epe in Lagos State, Neke-Uno in Enugu State and Sheda in the FCT. Details are in Chapter 3

1.4 ADMINISTRATIVE AND LEGAL FRAMEWORK

The constitution of Nigeria (1999), as the national legal order, recognizes the importance of improving and protecting the environment and makes provision for it in the following relevant sections:

- Section 20 makes it an objective of the Nigerian State to improve and protect the air, land, water, forest and wildlife of Nigeria.
- Section 12 establishes, though impliedly, that international treaties (including environmental treaties) ratified by the National Assembly should be implemented as law in Nigeria.
- Sections 33 and 34 which guarantee fundamental human rights to life and human dignity, respectively, have also been argued to be linked to the need for a healthy and safe environment to give these rights effect.

1.4.1 Policy Framework

A. National Policy on Environment

Revised by Government in 1999, this document prescribed guidelines for achieving sustainable development in fourteen vital sectors of the nation's economy, namely: Human Population; Land Use and Soil Conservation; Water Resources Management; Forestry, Wildlife and Protected Natural Areas; Marine and Coastal Area Resources; Sanitation and Waste Management; Toxic and Hazardous Substances; Mining and Mineral Resources; Agricultural Chemicals; Energy Production; Air Pollution; Noise in the Working Environment; Settlements; Recreational Spaces, Green Belts, Monuments, and Cultural Property.

It also contains Nigeria's commitment to ensure that the country's natural and built environment is safeguarded for the use of present and future generations. This commitment demands that efficient resource management and minimization of environmental impacts be the core requirements of all development activities. Accordingly, this Policy seeks to promote good environmental practices through environmental awareness and education. The project will have effects on biophysical and human environment, as a result it shall comply with the relevant provisions of this policy.

B. National Energy Policy

The National Energy Policy approved by the Executive Council of the Federation in 2003 and launched in 2005 has the following objectives:

- To ensure the development of the nation's energy resources, with diversified energy resources options, for the achievement of national energy security and an efficient energy delivery system with an optimal energy resource mix.
- To guarantee increased contribution of energy productive activities to national income.
- To guarantee adequate, reliable, and sustainable supply of energy at appropriate costs and in an environmentally friendly manner, to the various sectors of the economy, for national development.

The policy dealt with five focal areas.

- Energy Sources: Oil and Gas and Other Conventional (Coal & Tar Sands) Energy Sources such as Nuclear Renewable Energy.
- Energy Utilization: electricity, industry, agriculture, and transport.
- Energy Issues: Environment, Energy Efficiency and Conservation, Research, Development and Training, Energy Manpower Development; Bilateral, Regional and International Cooperation, Energy Databank.
- Energy Financing: Indigenous participation. Financing.
- Planning and Policy Implementation: energy planning, policy implementation, prioritization of strategies into short, medium, and long term, monitoring and evaluation.

The project is about improving energy supply; as a result, it shall comply with the relevant provisions of this policy.

C. National Land Policy

The legal basis for land acquisition and resettlement in Nigeria is the Land Use Act of 1978, modified in 1990. According to the act, all land in Nigeria is vested in the Governor of each State, to be held in trust for the use and common benefit of all people.

The administration of urban land is directly under the control and management of the Governor; whereas non – urban land is under the control and management of the Local Government Area.

The Governor had the right to grant statutory rights of occupancy to land. Local Government has the right to grant customary rights of occupancy.

The Land Act gives government the right to revoke statutory and customary rights to land for the overriding public interest. The act gives the government the right to acquire land by revoking both statutory and customary rights of occupancy for the overriding public interest.

In doing so, the act specifies that the state or local government should pay compensation to the current holder or occupier with equal value. The act also requires the state or local government to provide alternative land for affected people who will lose farmlands and alternative residential plots for people who will lose their house.

The need for an integrated approach towards land use planning is highlighted. The coordination of activities of all stakeholders in land use planning is emphasized. In particular, the involvement of land owners, community groups, women, youth and the less privileged in making land use related decisions that affect them is regarded as being critical in the successful implementation of the policy.

The project will involve land take. Hence, the process for the land acquisition shall comply with the national land policy.

D. Social Protection Policies

Social protection policy has been on the agenda since 2004, when the National Planning Commission, supported by the international community, drafted a social protection strategy. More recently, the National Social Insurance Trust Fund drafted a social security strategy. The social protection policy approached social protection using a life-cycle and gender lens, recognizing both economic and social risks, including, for example, job discrimination and harmful traditional practices. The policy was organized around four main themes: social assistance, social insurance, child protection and the labour market.

However, only a few of the instruments of this approach were adopted in the national implementation plan, most notably the provision of specific and limited social assistance, social insurance (such as expanding national health insurance to the informal sector) and labour market programmes (such as developing labor-intensive programmes). Moreover, in practice, programmes to date have been focused largely on conditional cash transfers and two health financing mechanisms driven by the federal government with little inter-sectoral or state-federal coordination. A significant number of actors are involved in funding and implementing social protection, including those from government, donors, international non-governmental organizations and civil society. Federal government-led social protection includes three main programmes:

- the community-based health insurance scheme, which was redesigned in 2011 because the previous scheme had design challenges Other social assistance programmes are implemented in an ad hoc manner by various government ministries, departments, and agencies at state level, and some are funded by international donors.
- Labour market programmes include federal-and state-level youth skills and employment programmes, and Nigeria also has agricultural subsidies/inputs.
- Other policies include, school feeding and nutrition, HIV and AIDS programming, youth empowerment scheme, N-power.

The project will have effects on the social aspects of the people around the area, as a result it shall comply with the relevant provisions of this policy.

1.4.2 Legal Framework

NATIONAL LEGISLATIONS

i. The Environmental Impact Assessment (EIA) Act Cap E12 LFN, 2004

The EIA Act 86 makes it mandatory for any person, authority, corporate body private or public, to conduct EIA prior to the commencement of any new major development or expansion that may likely have significant effect on the environment. The Act sets the EIA objectives and the procedures for consideration of EIA of certain public or private projects.

The project is a major development, which is expected to have some impacts on the environment. Hence, full compliance with the EIA Act is required. The EIA guidelines (procedural and sectoral) issued by the Federal Ministry of Environment (FMEnv) derived from this Act and the project proponent Project Management Unit (PMU) shall conduct its activities for the development of this project in conformance with these guidelines.

ii. National Environmental Standards & Regulations Enforcement Agency (NESREA) Act, 2007

Administered by the Ministry of Environment, the National Environment Standards and Regulations Enforcement Agency (NESREA) Act of 2007, repealed the Federal Environmental Protection Agency (FEPA) Act. It is the embodiment of laws and regulations focused on the protection and sustainable development of the environment and its natural resources. The following sections are worth noting:

- Section 7 provides authority to ensure compliance with environmental laws, local and international, on environmental sanitation and pollution prevention and control through monitory and regulatory measures.
- Section 8 (1)(K) empowers the Agency to make and review regulations on air and water quality, effluent limitations, control of harmful substances and other forms of environmental pollution and sanitation.
- Section 27 prohibits, without lawful authority, the discharge of hazardous substances into the environment. This offence is punishable under this section, with a fine not exceeding, One Million Naira (₦1, 000,000) and an imprisonment term of 5 years. In the case of a company, there is an additional fine of Fifty thousand naira (₦ 50,000), for every day the offence persists.

This project will comply with NESREA regulations, including conducting Environmental and Social Impact Assessment (ESIA), environmental audit every three years after commissioning, obtain permit before disposing hazardous wastes, etc.

iii. The Nigerian Urban and Regional Planning Act CAP N138, LFN 2004

The Urban and Regional Planning Act is aimed at overseeing a realistic, purposeful planning of the country to avoid overcrowding and poor environmental conditions. In this regard, the following sections become instructive:

- Section 30 (3) requires a building plan to be drawn by a registered architect or town planner.
- Section 39 (7) establishes that an application for land development would be rejected if such development would harm the environment or constitute a nuisance to the community.

- Section 59 makes it an offence to disobey a stop-work order. The punishment under this section, is a fine not exceeding Ten thousand naira (₦10, 000) and in the case of a company, a fine not exceeding Fifty thousand naira (₦50, 000).
- Section 72 provides for the preservation and planting of trees for environmental conservation.

The project shall be implemented in line with requirements of this Act, including obtaining development permit from FCT, Abuja, Enugu and Lagos State Governments.

iv. Harmful Waste (Special Criminal Provisions) ACT CAP H1, LFN 2004

The Harmful Waste Act prohibits, without lawful authority, the carrying, dumping or depositing of harmful waste in the air, land or waters of Nigeria. The following sections are notable:

- Section 6 provides for a punishment of life imprisonment for offenders as well as the forfeiture of land or anything used to commit the offence.
- Section 7 makes provision for the punishment accordingly, of any conniving, consenting or negligent officer where the offence is committed by a company.
- Section 12 defines the civil liability of any offender. He would be liable to persons who have suffered injury as a result of his offending act.

The project will generate wastes including construction wastes and transformer oils at the project sites and other harmful wastes. These wastes shall be handled, treated, and disposed of in accordance with the relevant requirements of this Act.

v. The Endangered Species Act, CAP E9, LFN 2004

This Act focuses on the protection and management of Nigeria's wildlife and some of their species in danger of extinction as a result of over exploitation. These sections are noteworthy:

- Section 1 prohibits, except under a valid license, the hunting, capture or trade in animal species, either presently or likely, in danger of extinction.
- Section 5 defines the liability of any offender under this Act.
- Section 7 provides for regulations to be made necessary for environmental prevention and control as regards the purposes of this Act.

Hence, the project activities shall be carried out to comply with relevant provisions of this Act.

vi. The Factories Act, 1987 (Factory Act cap 126, LFN, 1990)

The factories Act, as contained in the Laws of the Federation of Nigeria 1990, seeks to legislate, and regulate the conduct of health and safety in the Nigerian workplaces. It was enacted in June 1987 with the desire to protect the workers and other professionals against exposure to occupational hazards. The director of factories at the Federal Ministry of Employment, labour and productivity is responsible for the administration of the provisions or requirements of this Act. Section 13 allows an inspector to take emergency measures or request that emergency measures be taken by a person qualified to do so, in cases of pollution or nuisances.

This Act deals with working conditions at work sites, including construction sites, such as the type to be undertaken under the Project. Hence, the occupational health and safety requirements applicable to construction sites, as well as other work sites to be used by the project shall be subjected to the provisions of this Act.

vii. Labour Act - CAP. L1 L.F.N. 2004

This Act deals with labour issues, including payment of wages, recruitment, discipline, employee welfare, employment of women and child labour. Sections **54 to 58** which deal with employment of women, prescribed period of absence from work for nursing mothers and allows her half an hour twice a day during her working hours to attend to the baby for a period of up to six months after she resumes work. Section 55 also exempted women from night work, except when they are employed as nurses. Sections 59-64 deal with employment of young people.

viii. Wages Board and Industrial Council Act, 1974

The Act provides for the establishment of a National Wages Board and Area Minimum Wages Committee for States and for Joint Industrial Councils for particular industries. It empowers the Minister to order or direct that an industrial wages board be established to perform, in relation to the workers described in the order and their employers, the functions specified in the provisions of this Act, including minimum wage. The minimum wage is currently NGN 18,000.00 per month, and all workers employed for this project shall not earn less than the minimum wage. Hence, all workers engaged by the project shall be paid a minimum of N18,000 per month.

ix. Workers' Compensation Act, 1987

The Act to make provisions for the payment of compensation to workmen for injuries suffered in the course of their employment. The compulsory insurance covers employees for injury or death resulting in the course of work or in work places. All types of workers are covered including working under a contract of service or apprenticeship with an employer, whether by way of manual labour, clerical work or otherwise, and whether the contract is expressed or implied, is oral or in writing. The project will employ both skilled and non-skilled labour and shall be subject to this law as applicable.

National Regulations

1.4.3 National Environmental Standards and Regulations

In exercise of this power, the Minister issued the national environmental regulations covering all sectors of development. The regulations relevant to the project are as follows:

- The National Standards on Hazardous & Pesticides Regulations 2014
- National Environmental (Sanitation and Wastes Control) Regulations, S.I.28 of 2009,
- National Environmental (Noise Standards and Control) Regulations, S.I.35 of 2009;
- National Environmental (Surface and Groundwater Quality) Regulations, S.I.22 of 2011;
- National Environmental (Electrical/Electronic Sector) Regulations, S.I.23 of 2011;
- National Environmental (Control of Bush/Forest Fire and Open Burning) Regulations, S.I.15 of 2011; and
- National Environmental (Soil Erosion and Flood Control) Regulations, S.I.12 of 2011

- National Environmental (Air Quality Control) Regulations, S.I.64 of 2014

1.4.4 State Laws

Lagos State Environmental Management Protection Law, 2017 ("EMPL 2017"): This Law consolidates all the Laws and Regulations applicable to the management, protection and sustainable development of the environment in Lagos State. It deals with modern cosmopolitan environmental issues like waste management, litter, dumping of untreated toxic and or radioactive material into public drains; sanitation, street trading and hawking; obstruction to drainage systems, water generation, effluents, noise, signage, advertisement, gardens and parks, etc. Key requirements related to this project are as follows;

- It is mandatory for all waste collection, transportation, recycling, sorting, treatment and disposal businesses to only operate in Lagos State under a Licence issued, by the Lagos Waste Management Authority ("LAWMA"). Therefore, the Engineering, Procurement and Construction (EPC) contractor during construction shall engage a LAWMA licensed agent to manage its waste. The same applies to relevant PMU department during operation phase.
- All Residents are required to keep their premises and surrounding environment, forty-five (45) metres from all public sidewalks of a street, clean and devoid of litter and waste. As part of this requirement, all wastes generated during construction and operation of the project shall be kept in securely tied and fastened plastic bags or leak proof dustbins, or covered litter bins.
- Prohibition of objectionable loud noises, except where a Licence is obtained prior to the commencement of a noise generating activity.
- Prohibition of street trading, for which both buyer and seller becomes liable. Hence, workers employed by the project (both temporary and permanent) shall not engage in street buyer or patronizing hawkers.
- Any person engaged in any form of commercial activity is required to pay, not later than the 1st day of January of every calendar year, an Environmental Development Levy to the Lagos State Environmental Protection Agency ("LASEPA").
- The dumping and burying of any untreated, injurious gases, toxic or radioactive waste or substances, without a government issued Permit is expressly prohibited.
- Waste Management Facilities, Abattoirs and Livestock establishments, Housing Estates, Hotels, Hospitals and other commercial facilities shall not discharge any trade or industrial waste or effluents into the public drains without first treating such waste and effluent and retaining possession of a prior issued Permit from LASEPA.
- Residents in residential premises are allowed, without a licence from the Lagos State Water Corporation ("LWC"), to construct, dig or extend in their premises, any well, borehole or other works for the supply of water for domestic use only. Such water supply systems must however be sited in hygienically conducive environment, protected from any kind or form of pollution. The quality of the water must also meet the World Health Organisation ("WHO") recommended standards for water consumed.

- Where a borehole or well is for commercial purposes, a Licence for groundwater abstraction must be obtained from LWC.
- No person shall erect any building or structure over, across or adjacent to any drainage, channel, sewer or sewerage system without first obtaining a Clearance Certificate from the Lagos State Wastewater Management Office ("LSWMO"); for drains and channels, the permit is from the Lagos State Office of Drainage Services. Therefore, public drains or water channels shall not be blocked by the project, even if it is temporary without permit.
- It is an offence for any person to discharge, cause or permit to be discharge any kind of untreated trade effluent into any public sewer or drain-line without a Permit. Penalties include fines.
- Construction of any structure that will accommodate or serve 50 or more people must obtain a Wastewater Clearance License from the LSWMO.
- Erection of any structure or signage for advertisement purposes require Permit by the Lagos State Signage and Advertisement Agency ("LASAA").
- It is not permitted to fall or trim trees in Lagos State without a prior Permit obtained for such a purpose from the Lagos State Parks and Gardens Agency ("LASPAR).

Other Lagos laws relevant to the project include Lagos State Properties Protection Law, 2016 and Physical Planning and Urban Development Law, 2010.

Enugu State Waste Management Agency Law, 2010: The objectives of this law are

- Efficient and effective waste collection
- Appropriate treatment and disposal of waste from private and public premises in all urban areas of the state
- Establishment, management and maintenance of landfill, dumpsites, waste collection and treatment sites
- Establishment of locations for the purpose of facilitating the sustainable and environmentally friendly management and disposal of waste
- Removal and disposal of silt and obstructions from gutters and drains
- Surcharge of persons or institutions whose misconducts creates any obstruction to drainage channels

Abuja Environment Protection Board Act No. 10 of 1997: This established the Abuja Environmental Protection Board (AEPB), and charged it with the responsibility for waste management, prevention of bush burning, poaching and indiscriminate felling of trees, and control walking or driving on prohibited areas among other functions. The collection and disposal of wastes generated by this project within the FCT will conducted in compliance with requirements of AEPB.

1.4.5 EIA Procedural Guidelines

This procedure prescribes the steps to be followed in the EIA process from project conception to commissioning and post commissioning impact mitigation, to ensure that the project is implemented with maximum consideration for environment. This EIA study was conducted in compliance with this guideline.

The EIA Process in Nigeria: The Federal Ministry of Environment (FMEnv) developed guidelines to be used by project proponents in conducting EIA, in compliance with the EIA Act. Accordingly, the EIA process, illustrated in Figure 1.1, shall follow the following steps sequentially as outlined in the procedural guideline.

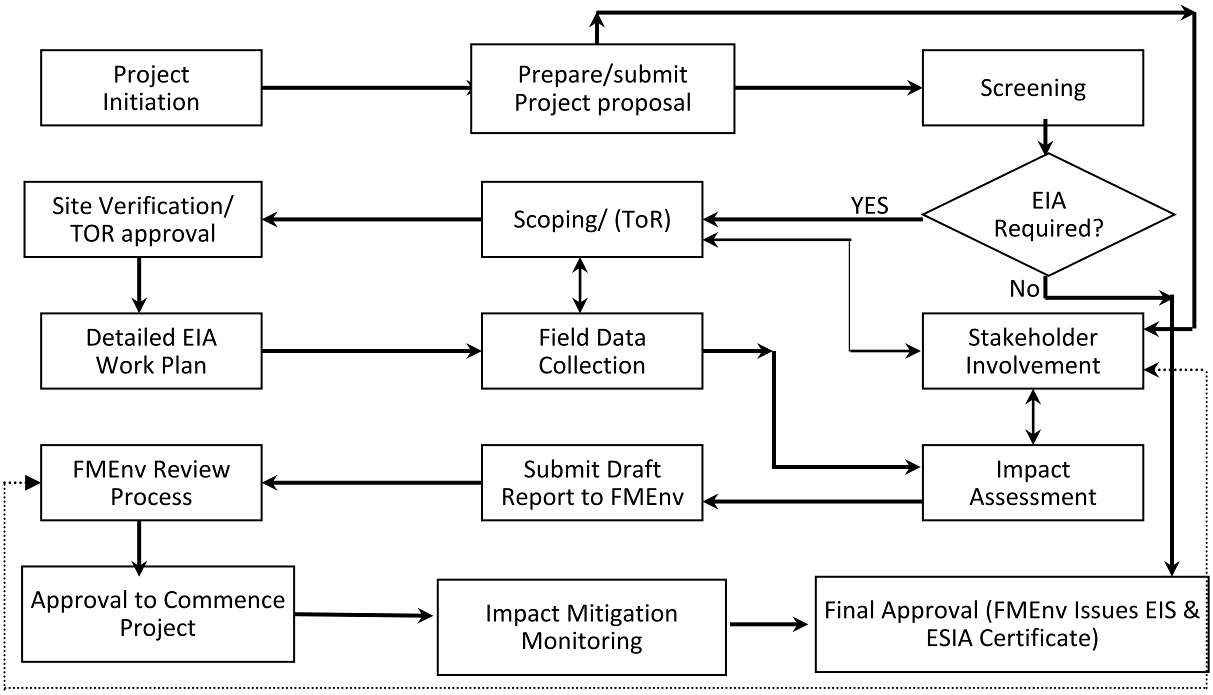


Figure 1.1 The EIA Process of FMEnv

1.4.6 International Laws and Conventions

The Stockholm Convention on POPs which came into force on May 17, 2004 requires the international community to protect human health and the environment from harmful effects of POPs by its reduction and eventual elimination. One of such chemicals targeted is PCBs, which Parties are required to take action to phase out its use, including contaminated equipment, by 2025 and to make determined efforts to have liquid PCBs and equipment contaminated with PCBs subject to environmentally sound waste management as soon as possible, but no later than 2028

Other international conventions, to which Nigeria is a signatory, relevant to this project are as follows:

- African Convention on the Conservation of Nature and Natural Resources
- Convention on Biological Diversity
- Endangered Species (Control of International Trade and Traffic)
- Conservation of Migratory Species of Wild Animals (1973)
- Convention to Combat Desertification (1994)
- United Nation Framework Convention on Climate Change (UNFCCC) 1992.

- International Union for Conservation of Nature and National Resources (IUCN) Guideline, 1996.
- The "Equator Principle"
- World Bank Operational Policies.
- Public Health Legislations and Regulations.
- The Rio Declaration on Environment and Development
- The Kyoto protocol, Montreal Protocol on Substances that Deplete the Ozone Layer, 1987.
- The African Convention on the Conservation of Nature and Natural Resources, 1968.
- Convention on the Elimination of All Forms of Discrimination against Women (CEDAW)
- Human and Peoples' Rights on the Rights of Women in Africa in 2005
- Civil and Political Rights Covenant
- Economic, Social and Cultural Rights Covenant
- Convention on the Elimination of All Forms of Violence Against Women
- Convention on the Rights of the Child
- ILO Occupational Safety and Health Convention, 1981

1.5 Scope of Work

The goal of the Consultancy is to conduct an EIA by identifying and evaluating potentially significant environmental effects and risks of the proposed facilities, in order not to undermine critical resources and ecological functions or wellbeing, lifestyle and livelihood of communities and people of the affected locations. Therefore, The National Consultant will undertake the following major tasks:

A. Preliminary Activities including but not limited to:

i. Review of existing legislations on the siting of facilities for collection, storage and treatment of hazardous materials.

ii. Preparation of an interim and a final report of legislative review including proposed actions in line with the reviewed legislations

B. Conducting the EIA study

The EIA study shall include the following activities:

i. Collection of background data and information

ii. Public Involvement

iii. Identification of impacts in terms of magnitude and significance

iv. Socio-economic analysis of project effects/impact

v. Recommending mitigation action for each impact identified

vi. Environmental and economic analysis of alternatives of the proposed facilities

vii. Development of training requirements of the proposed facilities

viii. Development of a monitoring plan

ix. Preparation of interim and final EIA Reports.

c. Stakeholders Review and Endorsement of EIA Report

Consultant is expected to prepare and make a presentation of the EIA Report to relevant stakeholders during an EIA evaluation meeting to be organized by the UNDP and the PCB-PMU. Selection and participation of stakeholders (government, public and private) is the sole discretion of the Project Management Unit.

1.6 OUTLINE OF THE REPORT

The EIA Report is presented in eight chapters.

- **CHAPTER ONE** is an introduction containing relevant background information and the legal and administrative framework for EIA in Nigeria among other information, international conventions ratified by Nigeria and the World Bank environmental and social sustainability policies.
- The **CHAPTER TWO** presents the project justification, the need/value and its envisaged sustainability as well as the project development and site/route options considered.
- **CHAPTER THREE** contains detailed description of the proposed project including its location, overall layout, basis for design, type and specifications of equipment/facilities to be installed and operation/maintenance of the proposed power project.
- In **CHAPTER FOUR** the baseline, ecological and socio-economic status of the study area respectively is described. Information on consultation with stakeholders is presented in this chapter.
- **CHAPTER FIVE** discusses the identified potential and associated environmental impacts of the proposed project.
- **CHAPTER SIX** presents the various mitigation measures the proponent is committed to implement against the identified significant impacts.
- **CHAPTER SEVEN** provides a cost-effective environmental and social managemental plan that would be adopted throughout the project's lifecycle. It also enumerates the environmental monitoring programme, the waste management programme
- **CHAPTER EIGHT** contains project's decommissioning/remediation plan.
- **CHAPTER NINE** concludes the report and requests approval for project implementation.

The preliminary sections of the report include status page, the table of contents, list of tables, list of figures, list of plates, list of abbreviations and acronyms, list of EIA preparers, acknowledgement page and the executive summary. The concluding sections include the references and various appendices.

CHAPTER TWO

2.0 PROJECT JUSTIFICATION

2.1 NEED FOR THE PROJECT

The elimination of PCB on a global scale remains a significant challenge. Developing countries and countries with economies in transition in particular, but also a number of developed countries, still have many obstacles in identifying their PCB burden, removing PCB from use, and achieving environmentally sound waste management of liquids containing PCB and equipment contaminated with PCB.

Stakeholder commitment is also limited because there is a lack of understanding of the PCB issues by the general populace.. As for the responsible government agencies, developing countries in particular often lack trained and dedicated staff to undertake the inventory. While the PCB inventories often do not take into account the informal sector. Additionally, industry and small consumers are often hesitant to provide the requested information or to allow authorities access to their sites for the fear of being sanctioned if PCB is found on their premises, and the costs associated with the environmentally sound management of PCB.

The following reasons serve as need for this project to address:

- instituting an enabling policy and regulatory environment for managing PCB contaminated substances;
- Strengthening the monitoring capacity for POPs;
- Providing an effective mechanism for orienting R&D towards Stockholm Convention implementation;
- An effective mechanism for technology transfer (especially for underdeveloped or developed or developing countries
- Enhancing availability and access to information
- Strengthening institutional capacity for planning, guiding and enforcement for the Convention compliance
- Increasing public awareness on POPs;
- Lack of qualified human resources.

2.2 VALUE AND BENEFITS OF THE PROJECT

The project on PCB will be properly valued because it shall address the following issues:

- Responsibilities of the various stakeholders;
- Prohibition of production and use;
- Instruction on performing PCB inventories and identification of contaminated sites;

- instruction on field-and laboratory identification of PCB content in dielectric oils and other materials;
- Regulation on statistical reporting on PCB wastes, products, installations and contaminated sites;
- Recommendations for safe usage of PCB materials;
- Management, labeling, storage and transport of contaminated equipment and oils;
- Management of abandoned storehouses and contaminated sites;
- Import/export and transboundary movement of PCB; and
- Instruction on disposal of PCB-contaminated oil and equipment.

Furthermore, the project will create jobs during the nationwide inventory, construction and operation stages. About 20 workers will be needed on each site during construction. And about 16 per site (48 in total) during the operations phase, three Plant Managers, 3 Operators, 3 Maintenance Personnel, 2 Laboratory Personnel and 3 Factory Assistants and 3 Admin/Accounts staff.

2.3 JUSTIFICATION FOR THE PROJECT

The fact that PCB had been dumped indiscreetly in our environment and disposed improperly and its currently been used by some power company and private sectors, makes its availability and project sustainability eminent. Reasons that justify the project:

- available human resources and related ministries for implementation (issuing of permits, monitoring, reporting, etc.);
- planned economic instruments (i.e., user taxes; waste disposal fees, packaging fee/taxes, etc.);
- required institutional arrangements (on national and local level);
- required additional investments in public and private sector monitoring and reporting;
- needed supporting guidelines, stakeholders awareness and information campaign to stakeholders.
- Establish and well-defined cooperation among governmental authorities involved in environmental protection and industrial development including local authorities, the relevant Ministry, the private sector, universities/research institutions and Non-Governmental Organization (NGOs).
- Accountability of the project related work and expenditures of all involved parties;
- Transparency through clearly defined monitoring indicators and evaluation
- Methodologies including data generation throughout the project implementation.
- Furthermore, the project is supported by UNDP and will after a while, private investors will take over, hence the project will be financially viable
- Some factors are important to consider to reaching project sustainability. They are related to practical aspects linked to economic profitability, technical resources, and

all, with an efficient management. The growth in electricity demand has occurred over the last decades, resulting in more PCB contaminated oils generation. Therefore, the sustainability of the project was analysed based on the four factors of sustainable development -technical, economic, environment and social factors.

2.4 ENVISAGED SUSTAINABILITY

2.4.1 Technical Sustainability

The proposed project shall be technically viable because, it shall be professionally designed, and the technology employed is readily available. The proposed project enjoyed technical support from UNDP. Project monitoring unit (PMU) for environmentally sound management (ESM) of PCBs in Nigeria has been established by the Federal Ministry of Environment. The PMU have qualified and experienced personnel to handle the construction, operation and maintenance of the project. Moreover, where additional personnel are needed, they can be recruited among qualified Nigerians.

2.4.2 Economic Sustainability

The proposed project shall be economically sustainable because the project will be funded by UNDP with additional financing from Global Environmental Facility (GEF) after which private investors will take over since it is a viable business.

2.4.3 Environmental Sustainability

The PCB management sites have been carefully selected by considering sensitive ecosystems. In addition, practical mitigation measures have been proffered for the identified environmental impacts and the PMU is fully committed to comply with the relevant applicable national environmental laws, applicable international conventions and world bank environmental safeguard policies. Furthermore, the PMU is also committed to implementing the ESMP developed to further guarantee the environmental sustainability. The PMU being designated in Ministry of Environment also has access to additional resources to mitigate the impacts should the need arise.

2.4.4 Social Sustainability

The project has secured its first social license – the host communities' acceptance of the proposed project shows their eagerness to see it succeed. The proposed project shall create job opportunities for unemployed indigenes and Nigerians.

In addition, PMU is committed to effective and continuous stakeholders' engagements and consultations and effective implementation of the ESMP.

The PMU is committed to comply with applicable national social laws, relevant international conventions and world bank social safeguard policies.

2.5 PROJECT ALTERNATIVES

2.5.1 Do Nothing Option

This option pre-supposes that the status quo remains, the proposed PCB collection, storage and treatment facilities will not be established. This alternative was rejected because transformer oils containing PCBs will continue to litter around transformers, some of which are located in street corners around our neighbourhoods. PCBs are known to be persistent in the environment and very toxic and carcinogenic.

2.5.2 Delayed Option

This option implies postponing or delaying initialization of the planned project to a later date. This option is usually considered when prevailing conditions will adversely affect project implementation, for instance during a conflict, or when host communities have reservation for the project, or if the economics of the project are objectionable and unappealing.

As it is, there is no conflict or any other unpleasant situation at the proposed site. It is worthy of note that both the socio-economic and the political situation are favourably disposed to the execution of the project.

Furthermore, a delayed project option will lead to a delay in sound disposal of PCBs in Nigeria. There is also a risk of Nigeria not being able to meet its obligations timely on the Stockholm Convention.

In view of the economic trend globally amongst other factors, the delayed option is not attractive, thus it is not been considered for the envisaged project.

2.5.3 Alternative Technologies

The treatment technologies considered are as follows (See Section 3.3)

1. Alkali metal reduction
2. Base-catalysed decomposition (BCD)
3. Catalytic hydrodechlorination (CHD)
4. Cement kiln co-incineration
5. Hazardous-waste incineration
6. Photochemical dechlorination (PCD) and catalytic dechlorination (CD) reaction
7. Plasma arc
8. Potassium tert-Butoxide (t-BuOK) method
9. Supercritical water oxidation (SCWO) and subcritical water oxidation

CHAPTER THREE

3.0 PROJECT DESCRIPTION

The Environmentally Sound Management (ESM) and Disposal of PCB project is a response to the (NIP) and seeks to meet the commitments of Nigeria for PCBs under the Stockholm Convention. The objective of the project is to reduce Nigeria's population exposure to PCBs and associated risks. The Project consists of 5 major components;

Component 1: *Institutional capacity and training on PCBs;*

Component 2: *Inventory of PCBs in 22 states not previously covered by other inventories;*

Component 3: *Establishment of PCB collection and treatment centres;*

Component 4: *Environmentally sound disposal of identified PCBs;*

Component 5: *Monitoring, Learning, Adaptive Feedback and Evaluation.*

3.1 PROJECT LOCATION

The project, which is driven by UNDP show the location in Nigeria.

Figure 3.1 Location of Nigeria in West Africa

The project is located in three centers -Epe in Lagos State, Neke-Uno in Enugu State and Sheda in the FCT. Figure 3.1 is a map of Nigeria showing location of the three sites.

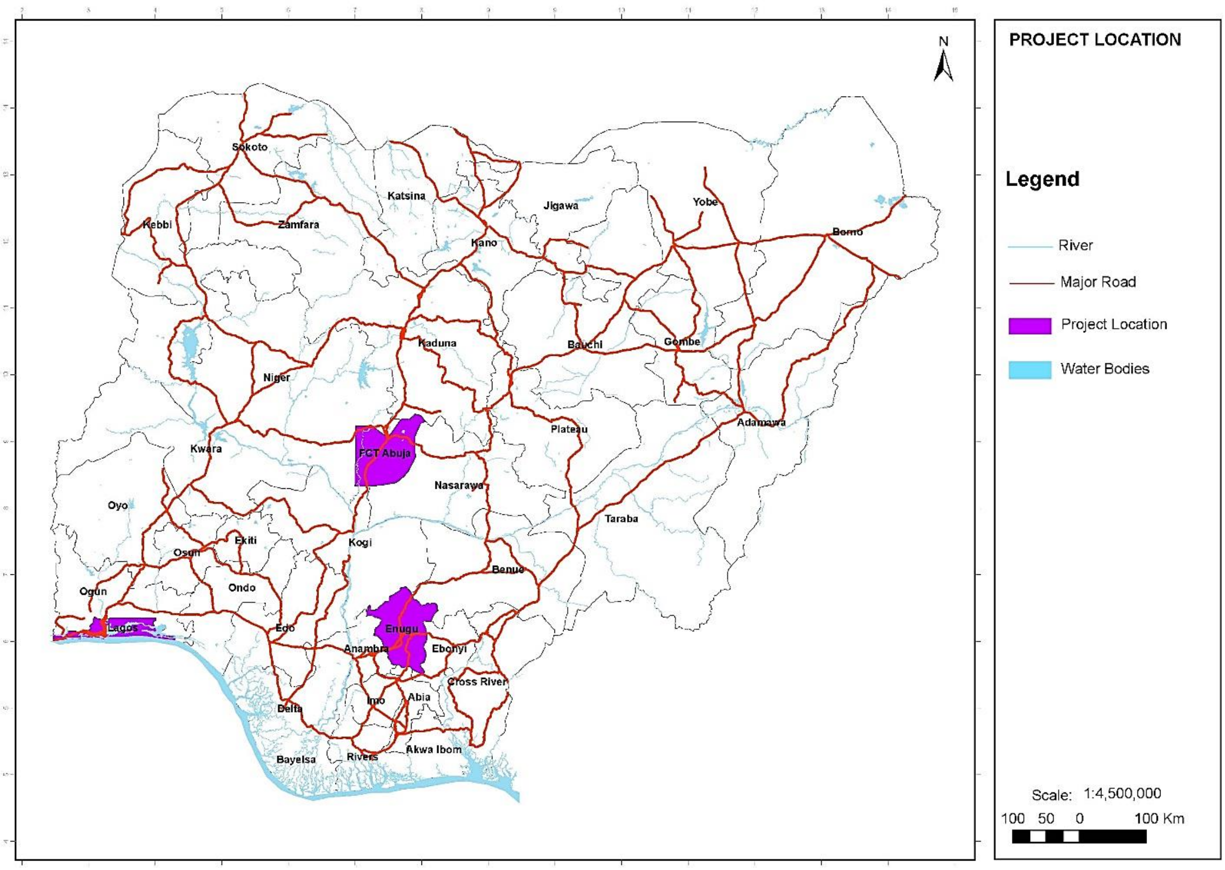


Figure 3.1 Location of the Three Project Sites

3.1.1 Proposed Epe Site in Lagos State

The selected PCBs site for Lagos State is located on Latitude 06.62809^{O}N and Longitude 3.92080^{O}E in Shala Village in Epe Local Government Area (LGA) of the state. It is about 80 kilometres from Alausa and accessed by driving along the Ikorodu-– Itokin – Ijebu-Ode road, there is a spur at Itokin which connects Epe town. The site is presently a virgin land, bounded in the front by the paved Ikorodu-Epe Road, on the left by a car crushing plant and breakers yard, while it is bounded to the right and rear by forested land and overgrown tall grasses and trees. Figure 3.2 shows the location of Epe site on a Lagos map.

The site has a gentle slope and no sign of flooding was observed at the time of site visit. The nearest water body is the Lagos Lagoon and this is located more than one kilometre away from the site on the opposite side of the road. The site is outside the floodplain of the Lagos lagoon. Electric power distribution lines passed directly in front of the site along the Ikorodu-Epe Road. The total land area acquired for the PCBs ISF is 17,063 m^2. The land has been purchased with the required documentation.

Plate 3.1 Proposed Site in Epe, Lagos State

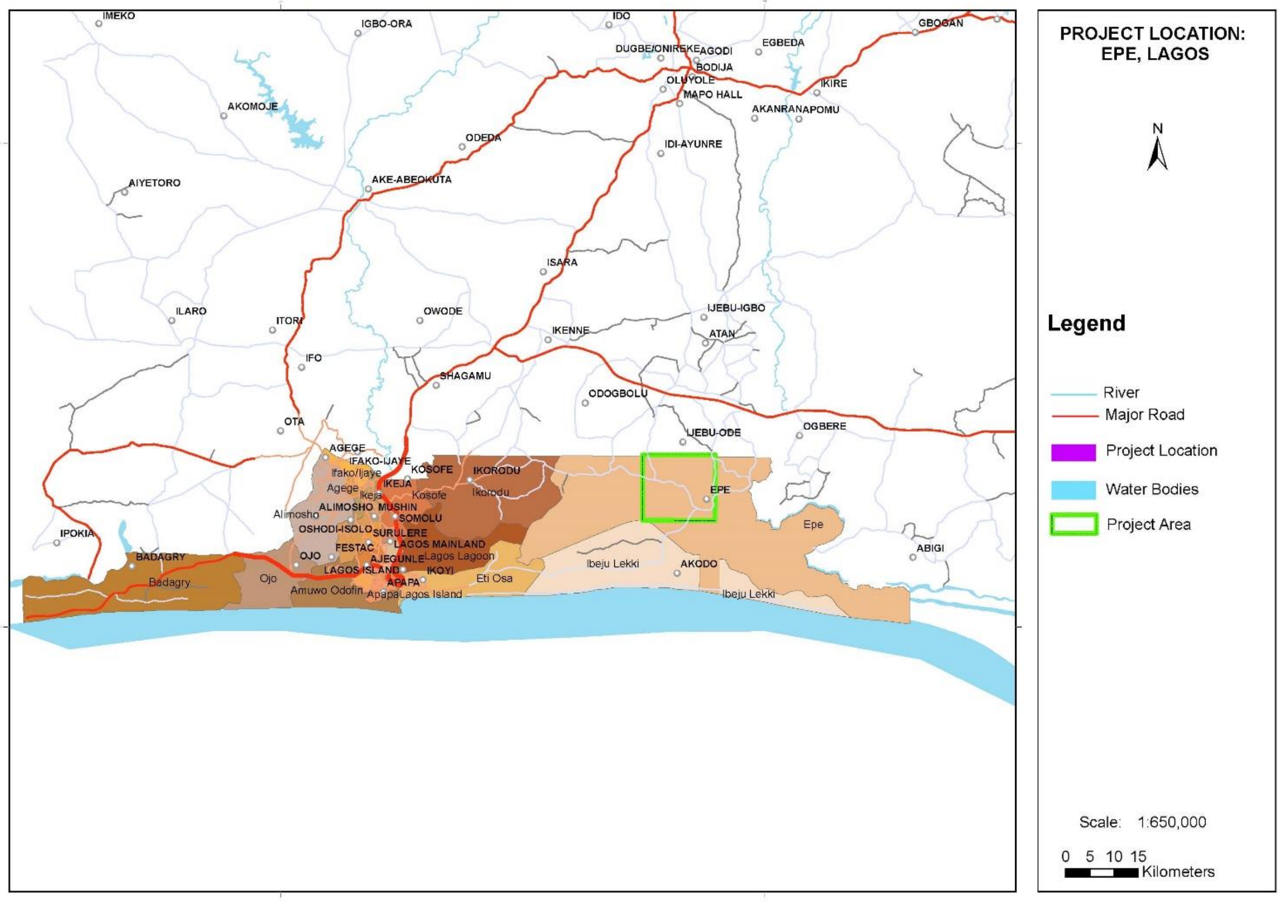


Figure 3.2 Location of the Epe Site, Lagos State

3.1.2 Proposed Neke-Uno Site in Enugu State

The selected PCBs management site for Enugu State is located on Latitude 6.65768^0 and Longitude 7.54436^0 in Neke Uno, Enugu East LGA of the State. It could be accessed by road through Akpakpa Neke area (Neke Lake Resort Area) and it is about 20km from Neke Lake Resort. The site is located about 300m from a very good access road. Figure 3.3 shows the location of the site in Enugu State.

The site has a relief that is flat to low (less than 20m) with a very gentle slope. There was no evidence of soil erosion and the surface water, a seasonal stream, is more than 2 km away from the site. There was no evidence of flooding, landslide, rock falls and subsidence at the site. The total land area acquired for the PCBs site in Neke Uno is 16,904 m^2. The land has been purchased with the required documentation.

Plate 3.2 Proposed Site in Neke Uno, Enugu State

Plate 3.1 shows the pictorial representation of the proposed site at Neke Uno (see the signboard at the back, pointing to the project under study).

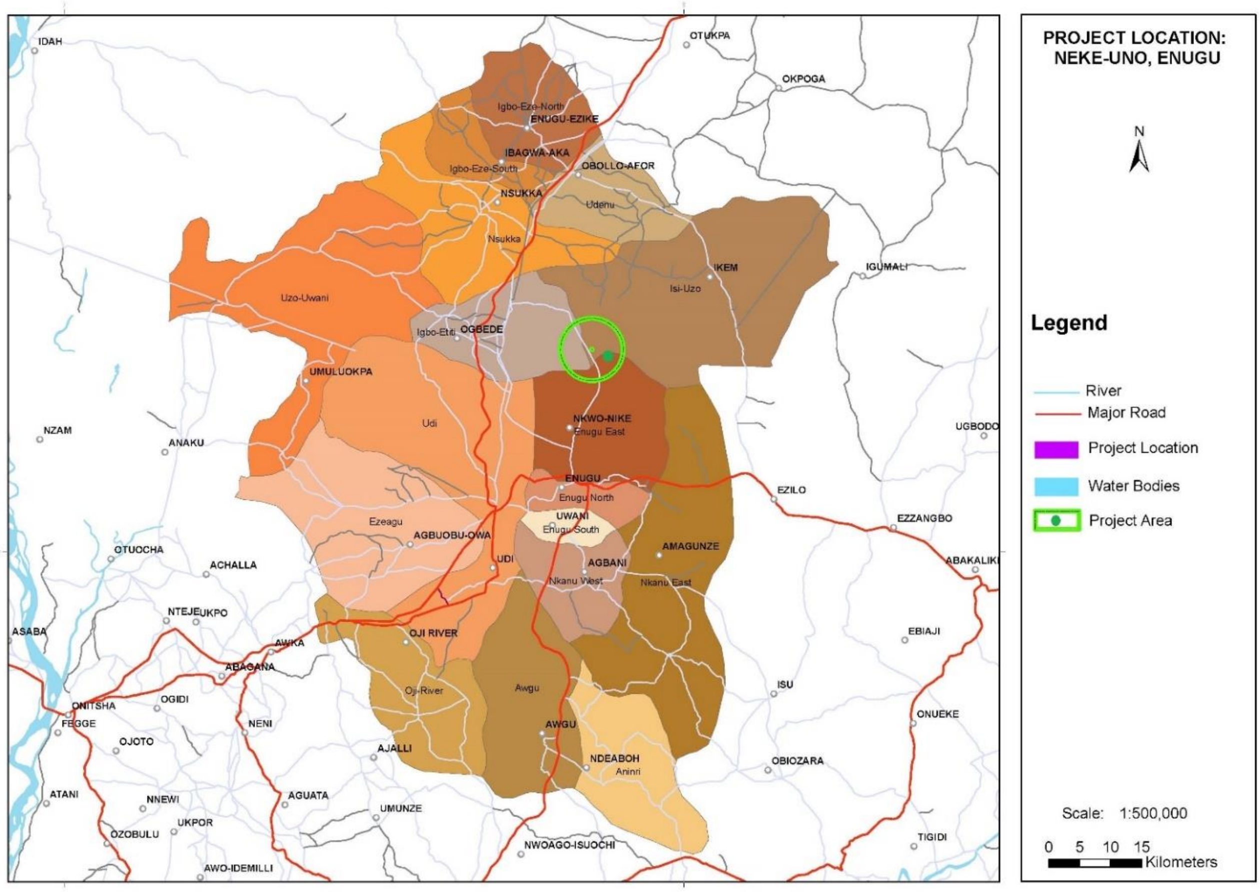


Figure 3.3 Location of the Neke Uno, Enugu State

3.1.3 Proposed Sheda Site in the FCT

The selected PCBs ISF site for Abuja is located on Latitude 8.84844^0 and Longitude 7.04119^0 in Sheda Science and Technology Complex (SHESTCO), Sheda, Abuja, Nigeria. A Parastatal under the Federal Ministry of Science and Technology, established by Act Cap S5 (Formerly Decree No.95 of 1993), having its permanent head office at Km 70 Abuja - Lokoja Expressway, Sheda, FCT. The site is presently a virgin land. Figure 3.4 shows the location of the FCT site at Sheda.

Plate 3.3 Proposed Site in Sheda, FCT

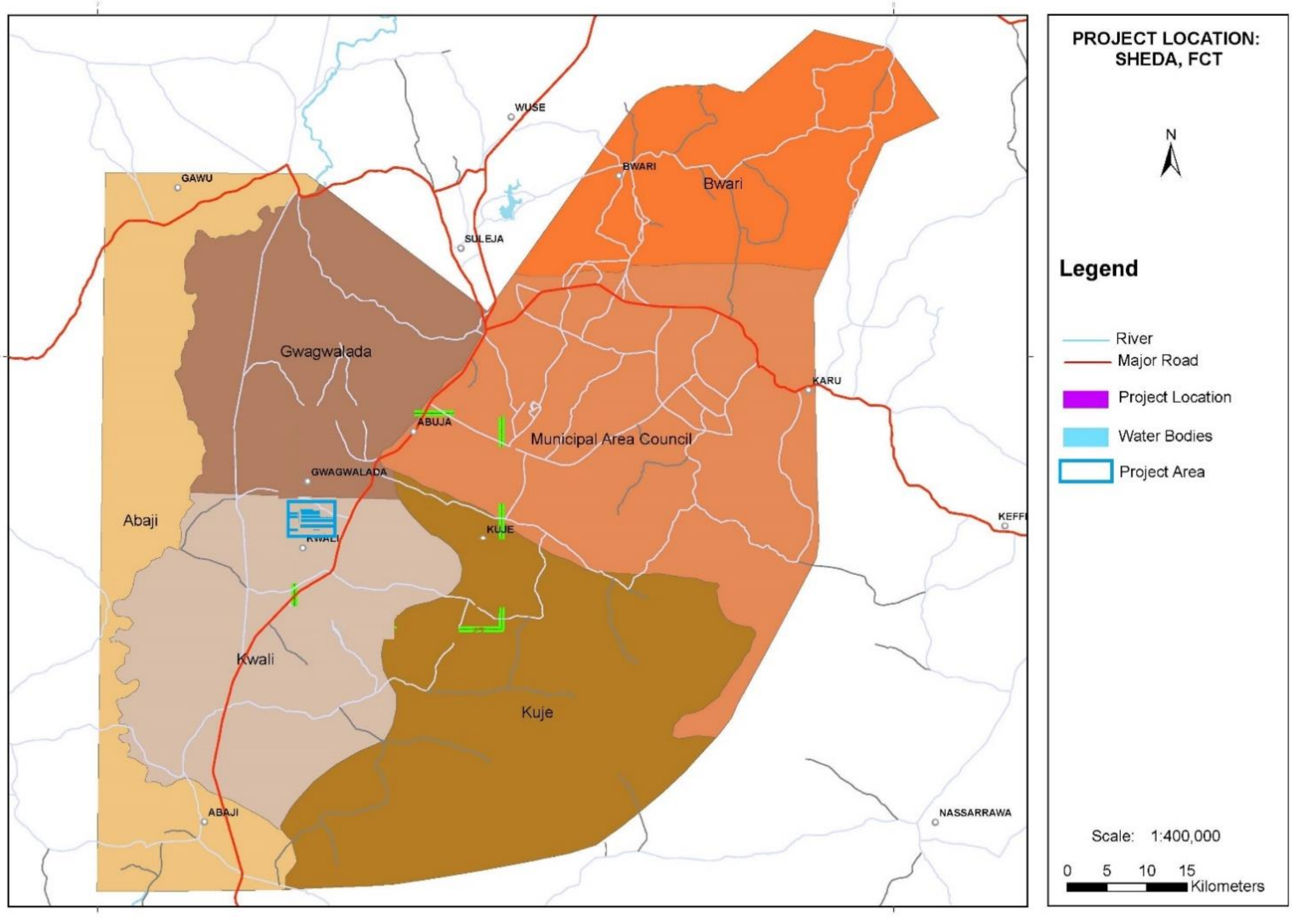


Figure 3.4 Location of the Sheda Site, FCT

3.2 COLLECTION OF PCB

The PCBs will be collected from power installations (transformers/Equipment having PCB levels above 50ppm) through inventory and will be stored in interim storage facilities which will be monitored by who own the equipment.

3.3 CURRENT TREATMENT OF PCB

There are various methods in the open literature applied by several countries in an attempt to reduce the concentration of PCB that eventually ends-up in the ecosystem. They are as follows:

i. Alkali metal reduction
ii. Base-catalysed decomposition (BCD)
iii. Catalytic hydrodechlorination (CHD)
iv. Cement kiln co-incineration
v. Hazardous-waste incineration
vi. Photochemical dechlorination (PCD) and catalytic dechlorination (CD) reaction
vii. Plasma arc

viii. Potassium tert-Butoxide (t-BuOK) method
ix. Supercritical water oxidation (SCWO) and subcritical water oxidation

The PCBs Dechlorination Technology (modular and mobile) will be based on the Alkaline Polyethylene Glycol (APEG) process. The APEG reagent dehalogenates PCBs, to form glycol ether (mineral oil) and/or a hydroxylated compound and an alkali metal salt. The mineral oil is further subjected to beneficiation process and reused as dielectric fluid in electrical equipment (such as transformers and capacitors). Residual waste to be properly disposed of.

Local capacity will also be built for decontamination and dismantling of the carcasses of the equipment and valorisation of usable components (copper coil, metal parts, etc).

Alternative Technology

The choice of this particular technology was driven by a number of factors not restricted to the economy/ limited funds, accessibility of the technology etc Most of the other technologies are emerging technologies and hazardous waste incineration would have been the other option but there would still be some hazardous discharges in the atmosphere.

Table 3.1 Project Results Framework

This project will contribute to the following Sustainable Development Goals: Sustainable Development Goals 1 (end poverty in all its forms everywhere), 3 (good health and well-being), 5 (gender equality), 6 (clean water and sanitation), 9 (resilient infrastructure, inclusive and sustainable industrialisation), 11 (sustainable cities), 12 (sustainable consumption and production), 13 (climate change), 14 (ocean and marine resources), 15 (life on land) and 17 (partnerships).
This project will contribute to the following country outcome included in the UNDAF/Country Programme Document: Balanced and equitable regional economic growth based on sustainable planning and use of natural resources that will provide high quality of life and long-term economic opportunities for its inhabitants.
This project will be linked to the following output of the UNDP Strategic Plan: Output 1.3: Solutions developed at national and sub-national levels for sustainable management of natural resources, ecosystem services, chemicals and waste.

Project Objective:	Objective and Outcome Indicators	Baseline	Mid-term Target	End of Project Target	Assumptions
Reducing Nigeria's population exposure to PCB effects and associated risks	***Mandatory Indicator 1:*** *Number of new partnership mechanisms with funding for sustainable management solutions of natural resources, ecosystem services, chemicals and waste at national and/or subnational level.*	*No public private partnership exists in Nigeria dedicated to the management and disposal of PCBs waste in Nigeria.*	*An agreement is reached between the Federal Ministry of the Environment and at least one Private company for the management and operation of the storage facilities and the operation of the mobile dechlorination and solid decontamination systems.*	*The 3 temporary PCB storage facilities, the mobile dechlorination and solid decontamination systems are fully operational and managed by a Private company under a public-private partnership (PPP) arrangement*	*There is at least one private company in Nigeria willing to undertake the responsibility to manage and operate the PCB storage facilities and the treatment technologies to be acquired by the project.* *The public-private partnership established to operate the PCB dechlorination system and the transformer decontamination facilities is effective and sustainable and will continue to offer PCB treatment services to PCB owners in Nigeria after project closure.*
	Mandatory Indicator 2: *Number of new jobs created through solutions for management of natural resources, ecosystem services, chemicals and waste.*	*As there is not any environmentally sound system for the management and disposal of PCBs in Nigeria, no job has been created yet*	*The implementation of this PCB project has created at least 20 jobs by mid-term*	*Fifty new permanent jobs to manage and operate the temporary storage facilities, operate the PCB treatment facilities, to manage the PCB programs within the electrical*	*The PCB owners and other stakeholders have the proper resources to manage and phase out the PCBs from Nigeria.*

Project Objective:	Objective and Outcome Indicators	Baseline	Mid-term Target	End of Project Target	Assumptions
				utilities, and to provide transportation and analytical support have been created by the full implementation of this PCB project.	
	Mandatory Indicator 3. *Pure PCBs and of PCB-contaminated equipment safely managed and disposed or decontaminated by the end of the project, reducing worker exposure and the potential for unintentional release of these materials into the environment.*	*People and workers are currently exposed to the risk posed by PCB-containing equipment stored or in-service. PCB contaminated oil is being used, burnt or disposed without the proper care that is required. No Financial resources are allocated to properly manage and dispose of PCB containing wastes.*	*Capacity of PCB owners have been built; Conditions are in place at the national level to identify, store and prepare PCB waste for disposal*	*The mobile dechlorination and solid decontamination systems are fully operational within Nigeria and ready to be operated beyond the project.* *Environmentally sound system for management and disposal of PCBs has been demonstrated.* *Laws and regulations are in place enabling this safe management practices.* *Lessons are available for similar treatment of other types of hazardous waste / dangerous chemicals; support and awareness is achieved at the public level, including a good understanding of advantages of safe management; differentiated impact on men and women of PCB exposure is demonstrated and widely known.*	*The PCB owners make their PCB-containing equipment available for the environmentally safe solutions being proposed by the project.* *Identified PCB contaminated equipment are under control and secured for disposal until technologies or service delivered by the project are available.* *PCB dechlorination and solid decontamination systems for PCB- contaminated solids are acquired, demonstrated and fully operational in the planned timeframe.* *Handling of PCB equipment and disposal activities are carried out in an environmentally safe way without any harm to the individual health and the environment.*

Project Objective:	Objective and Outcome Indicators	Baseline	Mid-term Target	End of Project Target	Assumptions
Meeting targets for women inclusion and participation in project implementation, including training, recruitment and specific project activities and in stakeholders' jobs created	*Women's share of positions at project level:* ***Indicator 1:*** *Women's share of positions within Project Board*	*There is not any program in place to ensure women are given equal opportunities in the workplace in the context of PCB management activities*	*At least two women members of the Project Board*	*At least two women are in the Project Board*	*UNDP, the government of Nigeria and project's stakeholders are committed to increase empowerment of women in the country* *Women with technical and management skills as required for the implementation of the projects are available (among government officials and electrical/service company staff) and willing to be part of this project within Nigeria*
	Indicator 2: *Number of project consultants that are women*	*There is not any program in place to ensure women are given equal opportunities in the workplace in the context of PCB management activities*	*At least 20% (minimum 1) of project consultant are women*	*At least 40% representation of women in project consultancies*	*There are women with technical expertise to provide consultancy services*
	Indicator 3: *Number and percentage of women and men who receive training, by type of training earmarked within project components*	*There is not any program in place to ensure women are given equal opportunities in the workplace in the context of PCB management activities*	*At least 6 (20%) government enforcement officers and 20 (20%) operators from electrical and other service companies are women*	*15 (50%) government enforcement officers and 50 (50%) operators from electrical and other service companies are women*	*There are sufficient number of women with technical background interested in this area of work*
	Indicator 4: *Number of training sessions targeted which include a differentiated gender message/component*	*There is not any program in place to ensure women are given equal opportunities in the workplace in the context of PCB management activities*	*Two training sessions on the new regulations and environmentally sound management of PCBs to be completed, that include a differentiated gender message/component*	*Five training sessions on the new regulations and environmentally sound management of PCBs to be completed, that include a differentiated gender message/component*	*There are sufficient number of women and men with technical background interested in getting trained*
	Indicator 5: *Number of awareness activities providing targeted*	*There is not any program in place to provide information to*	*At least 5 public meetings to provide information on the risks and proper*	*At least 15 public meetings in the country to provide information on the risks and*	*There are sufficient number of women interested in getting*

Project Objective:	Objective and Outcome Indicators	Baseline	Mid-term Target	End of Project Target	Assumptions
	information, on risks of exposure to hazardous chemicals, with a differentiated gender message/component	*women on the toxic effects of PCBs*	*management of PCBs are completed with a differentiated gender message/component*	*proper management of PCBs are completed, with a differentiated gender message/component.*	*knowledge of the toxic effects of PCBs in women*
Component/Outcome 1 ***Institutional Capacity and Training on PCBs***	***Indicator 6:*** *Key technical and procedural guidance documents compliant with Stockholm Convention and national regulation completed and endorsed.*	*No or insufficient guidelines for the ESM for PCB exists.* *There is no ESM for PCBs in the country.* *Regulations regarding disposal of PCBs as a toxic waste are not fully enforced.* *No or insufficient technical level guidance material on ESM for PCB management exists.* *Some of the electrical companies have, at best, a voluntary and partial program to test some of the transformers removed from service, but results of this testing program are not automatically shared with government officials.*	*Guidance documents for the ESM including the testing of PCBs in in-service and out-of-service equipment, labelling, transportation, handling, storage and disposal of PCBs drafted and in initial stage of implementation.*	*Guidance documents for the ESM including the testing of PCBs in in-service and out-of-service equipment, labelling, transportation, handling, storage and disposal of PCBs adopted and fully implemented.*	*Environmental and health benefits regarding compliance with Guidance documents and ESM for PCBs are promoted in the country.* *The project staff spends significant efforts with government, and key stakeholders on the environmental and human health merits of the new ESM for PCBs and social, technical, legal and financial impact of the adoption of the new ESM system for these toxic wastes.*
	Indicator 7: *Number of operators of the electric sector and of the environmental control authority trained and feeling confident in practically applying the ESM system for PCBs*	*No training on PCB issued delivered to operators in the electric sector countrywide.*	*Two Training sessions for government officials and electrical utility completed.* *10 government enforcement officers and 30 operators from electrical companies are trained on the new PCB regulations and the proper management of PCBs.*	*Five training sessions covering at least 30 government enforcement officers and 100 equipment operators (engineers and technicians) in the electric power sector representing all states in Nigeria on the ESM for PCBs are successfully completed.*	*Senior management in electrical utilities approve participation of their workers in training and adopt ESM for PCBs in their respective organizations.*

Project Objective:	Objective and Outcome Indicators	Baseline	Mid-term Target	End of Project Target	Assumptions
	Indicator 8: *Gender Dimension in the context of PCBs issue in Nigeria completed, strategies for better Gender Mainstreaming in POPs related activities identified.*	*No gender dimension study ever carried out on PCBs in Nigeria.*	*One study to investigate the effect of PCBs in women, particularly lactating mothers, is completed.*	*One study to investigate the effect of PCBs in women, particularly lactating mothers is completed.* *Gender Mainstreaming for POPs management fully included to curricula of trainings above.*	*Enabling environment is achievable to ensure proper regulatory support.*
	Indicator 9: *Level of enforcement of Nigeria's law on PCB management strengthened, measured by number of inspection visits and high level of compliance observed.*	*Only staff at the central level in FMEnv and research institutions is knowledgeable about POPs in general and PCB issues in particular.*	*Gap analysis with special reference to enforcement needs completed at mid-term.* *Technical assistance to the environmental and Customs authorities on the enforcement of the law and technical regulation related to PCBs delivered through specialized trainings and joint participation of project staff and government representatives in at least 5 site inspections followed by assessment of the cases.* *Five company-wide PCB management plans drafted by participating companies.*	*Government inspectors for checking compliance with new ESM are fully trained and carrying site inspections in country-wide locations: joint participation of project staff and government representatives in at least 10 site inspections followed by assessment of the cases and documentation of the cases for the project.* *Training program curricula for new inspectors are fully developed.* *Annual report provided from year 3 of the project on implementation of PCB laws by Customs authorities.* *Ten company-wide PCB management plans drafted by participating companies.*	*Government sets as a priority ESM of PCBs and requests and ensures that it is integrated within work programmes and training curricula of Customs and enforcement authorities in Nigeria.*
Component/ Outcome 2 ***Inventory of PCBs in 22 States not***	***Indicator 10:*** *First nationwide inventory of PCBs completed. Government officials, electrical companies*	*Electrical equipment in important parts of the country have never been tested for PCB contamination.*	*Initiation of sampling and testing 11,000 pieces of equipment in 22 states not previously covered by other*	*Testing of 11,000 pieces of electrical equipment completed and all those transformers found to contain*	*Owners of electrical equipment in the 22 states are ready and willing to facilitate access to their facilities and*

Project Objective:	Objective and Outcome Indicators	Baseline	Mid-term Target	End of Project Target	Assumptions
previously covered by other Inventories	*and other stakeholders reach a better understanding of the extent of the PCB problem in Nigeria and are able to plan and implement treatment and disposal activities.*	*There is no systematic approach in identifying and recording PCB- contaminated equipment in the country.* *There is no consistent procedure to test and manage PCB-contaminated transformers in Nigeria.*	*studies, with at least 5,500 transformers already tested, those found to contain above 50 mg/kg properly identified and labelled; and the owners informed of the findings.* *Sampling and analytical procedures for testing PCB content in electrical equipment fully documented and adopted by electrical utilities and other owners of transformers.* *Management Information System (MIS) for PCB-contaminated transformers in Nigeria developed and fully implemented.*	*PCBs above the threshold level of 50 mg/kg are properly labelled.* *MIS fully operational and containing data with the results of the 11,000 transformers covered by this study already and those from the previous work already recorded and analysed.* *Owners of PCB- contaminated transformers properly informed and aware of the need to manage these contaminated equipment appropriately, with a differentiated approach.*	*the sampling of their transformers, including by providing staff when required for these operations.*
	Indicator 11: *An analytical laboratory is equipped and commissioned to carry out PCB analysis in transformer oil and solid components*	*There is not any analytical laboratory in Nigeria able to provide analytical services of PCB in transformer oil and solid components*	*At least one analytical laboratory gets established to provide PCB analysis using GC-ECD technique*	*In addition to the establishment of a fixed laboratory able to carry out PCB analysis in oil and solid material, a mobile laboratory to be mounted on the mobile PCB dechlorination system is acquired and commissioned*	*Central African Economic and Monetary Community (CEMAC) has the resources available to acquire the necessary equipment and hire the proper personnel*
	Indicator 12: *An innovative public-private partnership for the management of PCB contaminated equipment and waste is established and effectively supports national*	*No public-private partnership established in the country for the management of PCBs.* *Cooperation with private sector is not strong to support effective national PCB disposal/decontamination effort.*	*A public / private partnership for management of PCB contaminated equipment and waste established to conduct the activities related to ESM system on PCBs (completed at mid-term).* *Business plan and sustainability plan for the*	*Business plan and sustainability plan for the public/private partnership verified and amended based on experience gathered in the 1st and 2nd years of the project's activities.*	*A public private partnership to conduct ESM of PCB is more effective than a purely private or public institution due the fact that most PCB holders are public/private companies.* *Public institutions and private industry willing to establish a*

Project Objective:	Objective and Outcome Indicators	Baseline	Mid-term Target	End of Project Target	Assumptions
	PCB disposal/decontamination effort.		*public/private partnership drafted.* *Appropriate level national communication on the PCB management plan ensured for better cooperation with the private sector.*		*partnership to conduct ESM of PCB.* *Possibility exists that a foreign, international private company is willing to take part in the public-private partnership, to ensure international standards and expertise are shared.*
Component/ Outcome 3 ***Establishment of PCBs Collection and Treatment Centre***	***Indicator 13:*** *Temporary Storage facilities for PCB- contaminated equipment designed, built and fully operational.*	*The country does not have any dedicated storage facilities for PCB contaminated equipment. These pieces of equipment when removed from service are stored in the open yards without any special precautions and clear disposal avenues.*	*Storage facilities for the temporary storage of PCB contaminated equipment are designed and built.* *Transportation and consolidation of PCB-contaminated equipment in temporary storage facilities in the initial stage of implementation.*	*Three facilities for the temporary storage of PCB wastes are fully operational*	*Sites for the temporary storage facilities are identified and approved.* *Site for the construction of treatment facility for the decontamination PCB-contaminated transformers is identified and government approval obtained in time.* *UNDP experts and national stakeholders establish cooperation so that the technical specification and selection of proper technologies are really suited to the specific country situation and needs.* *Site for demonstration of mobile PCB dechlorination system is found and agreed by stakeholders.* *Operating Entity for the management and operation of PCB decontamination and dechlorination facilities identified.*

Project Objective:	Objective and Outcome Indicators	Baseline	Mid-term Target	End of Project Target	Assumptions
	Indicator 14: *Mobile PCB dechlorination unit procured and in use in the country*	*The country does not have any PCB dechlorination technology to treat the PCB contaminated oil*	*UNDP issued the contract for the design and construction of treatment facility for the mobile PCB dechlorination system*	*One mobile PCB dechlorination system is acquired and fully operational*	*Technologies for the safe decontamination of PCB-contaminated in a mobile dechlorination system is commercially available and vendors of these technologies submit bids to UNDP tenders within the project's budget.*
	Indicator 15: *Treatment facility for the decontamination of PCB-contaminated transformers designed, built and fully operational*	*The country does not have any treatment facility for the decontamination of PCB contaminated transformers*	*UNDP issued the contract for the design and construction of treatment facility for the decontamination of PCB-contaminated transformers*	*One treatment facility for the decontamination of PCB-contaminated transformers is built and fully operational.*	*Technologies for the safe decontamination of PCB-contaminated transformers are commercially available and vendors of these technologies submit bids to UNDP tenders within the project's budget.*
Component/ Outcome 4 ***Environmentally Sound Disposal of Identified PCBs***	***Indicator 16:*** *200 tons of pure PCBs are safely managed and disposed*	*No records of PCB wastes exported for disposal in acceptable facilities exist. Therefore, any PCB-contaminated equipment removed from service has been disposed as non-PCBs and thereby releasing the PCBs into the environment and exposing humans to these toxic materials.*	*The 200 MT of pure PCB electrical equipment to be disposed of as part of the project are identified.* *Options for the disposal of 200 MT of pure PCB electrical equipment are discussed and planned.*	*Disposal of 200 MT of pure PCB electrical equipment is completed.*	*PCB owners are willing to provide PCB wastes* *Disposal options for pure PCB electrical equipment is available and accessible to the project.*
	Indicator 17: *1,500 tons of PCB-contaminated equipment are safely managed and disposed*	*Nigeria does not have any treatment or disposal facility for the proper decontamination or disposal of PCB wastes. Therefore, any PCB-contaminated equipment removed from service has been disposed as non-PCBs and thereby releasing the PCBs into*	*The 1,500 MT of PCB-contaminated equipment to be treated have been identified and at least 75% of the equipment have already been consolidated by transportation to treatment centres in its early stage.*	*Treatment and decontamination of the 1,500 MT of PCB contaminated equipment are completed.* *Plans to continue the dechlorination of PCB-contaminated oil are*	*PCB owners are willing to provide PCB wastes* *Mobile PCB dechlorination is approved and able to be sited in different locations within the country.*

Project Objective:	Objective and Outcome Indicators	Baseline	Mid-term Target	End of Project Target	Assumptions
		the environment and exposing humans to these toxic materials	*Plan to use dechlorination system and decontamination system for PCB-contaminated transformers is prepared and discussed and agreed with PCB owners*	*completed and ready for implementation.*	
Component/ Outcome 5 ***Monitoring, Learning, Adaptive feedback and Evaluation***	***Indicator 18:*** *Documentary evidence that project's results are sustained and replicated through proper M&E and Knowledge Management actions.*	*N/A*	*Inception activities carried out, project management structure implemented,* *project reporting and planning established and implemented* *Midterm Evaluation and auditing activities carried out.*	*Project reporting and planning continued until project end* *Terminal and auditing activities carried out; terminal reporting completed and submitted to Government of Nigeria, UNDP and GEF.* *Lessons learned and best practices are properly documented and disseminated at national level and at least in two other developing countries that are interested in this experience.*	*All the relevant stakeholders are well aware of GEF/UNDP rules as well as National Legislation, and willing to cooperate in the timely establishment of project management structures* *Project reporting and planning mechanisms and templates are timely communicated and agreed with project management staff at all levels.* *Project stakeholders actively cooperating in all evaluation and auditing activities.* *Evaluations and auditing are carried out in an independent and professional way, with the purpose to enhance project activities and generate recommendations for project success and sustainability after project closure.*

3.4 FACILITY DESCRIPTION

When completed, the proposed PCB facilities in Epe, Sheda and Neke-Uno are expected to have:

a. storage facility, including the main building part and matching facilities;
b. special facilities, such as anti-infiltration and anti-adsorption structures, waste storehouse, storage platform, etc.; the municipal engineering, such as power supply, street lighting, landscaping, heating, ventilation and air-condition; water supply and drainage; fire prevention and control; computer system installation and network design;
c. Power supply, distribution and illumination; Communication network and channel.

Office and Computerized waste management system including software for waste tracking, acceptance, labelling meeting the Nigerian or international hazardous waste requirements; Gas monitoring alarm device (Indoor and outdoor environments); Equipment, materials and articles for emergency response; Weighing and measurement device; Staff bathroom and toilet facilities and clothes changing; Road and vehicle parking; and Surrounding landscaping.

In addition, the Sheda facility will have a treatment plant, while a mobile treatment plant will be used for Neke Uno and Epe depending on demand.

The detailed specifications of the facilities are not available at this stage. These will be determined at the design stage, which will be done after the EIA approval and completion of inventory survey of PCB locations across the country.

3.5 WASTE MANAGEMENT

Waste envisaged to be generated are the residual wastes after decontaminating all PCB materials brought to the center. These include sludge, rags and absorbent soaked with oil, metallic containers and decontaminated equipment. The disposal options depend on the nature of waste, PCB content and quantities as well as period of PCB usage. In the case of transformers, the PCB components shall be reduced to the bearest minimum and if above 5000ppm, it will be scraped, cleaned to an extent and then the metal parts will be sent to a foundry for smelting. The wooden and paper components can be disposed at regular dumpsites and if treated to a level below 50ppm. The specific quantities cannot be estimated at this stage until the inventory is fully completed. Table 3.2 shows types of waste, their sources, associated project phase, disposal method and location. Before disposing any wastes, approval shall be obtained from the State Government Agency responsible for waste management.

Table 3.2 Proposed Project Waste and Disposal Plan

Project Phase	Type of waste	Form of Waste	Source of Waste	Disposal company	Disposal method	Disposal location
Site clearing	Degradable	Vegetation, kitchen waste	Camp,	Community members	Timber, fuelwood, compost	-
Construction	Degradable	Kitchen waste	Camp, construction site	Waste Contractor Approved by State Agency responsible for Waste Management	Compost	Waste Management Authority approved site
	Mixed	Metal scrap, wood, Nylon/plastics, spilled concrete	Construction Site	Waste Contractor Approved by State Agency responsible for Waste Management	Reuse, recycle	Scrap buyers/ reuse location
	Sewage	Camp sites	Personnel	Waste Contractor Approved by State Agency responsible for Waste Management	Vacuum-sucked into septic tanked trucks	Waste Management Authority approved site
Operations	Degradable	Vegetation	House keeping	Community members	Fuelwood, compost	-
	Mixed	Metal scrap, wood, Nylon/plastics, spilled concrete	Empty cans, packaging, decontaminated equipment	Waste Contractor Approved by State Agency responsible for Waste Management	Reuse, recycle	Scrap buyers/ resuse locations
	Hazardous	Spent oils	Equipment maintenance	Waste Contractor Approved by State Agency responsible for Waste Management	incineration	On site
		Sludge	Oil/water API gravity separator	Waste Contractor Approved by State Agency responsible for Waste Management	incineration	On site
		Rags and soaked absorbents	Loading and off-loading	Waste Contractor Approved by State Agency responsible for Waste Management	incineration	On site
Decommissioning & Dismantling	Mixed	Demolished concrete	Plant decommissioning	Waste Contractor Approved by State Agency responsible for Waste Management	Backfill	Waste Management Authority approved site
	Mixed	plastics, metallic, strings, wires	Plant decommissioning	Waste Contractor Approved by State Agency responsible for Waste Management	Reuse, recycle	Scrap buyers/ reuse location

Note:

1. Quantities of wastes cannot be estimated at this stage until national inventory is completed.
2. Disposal permit shall be obtained from the relevant State Government Agency responsible for waste management in the FCT or Lagos and Enugu State as the case may be.

CHAPTER FOUR

4.0 DESCRIPTION OF ENVIRONMENT AND SOCIAL BASELINE

4.1 GENERAL

The prevailing ecological conditions of the environment within which the proposed project will be sited, as well as the socio-economic and health profiles of the affected settlements are presented in this chapter. Components described include the physico-chemical environment (meteorology, geology, sediment/soil type and distribution, surface/groundwater characteristics), biological environment (location and distribution of benthos, plankton, fisheries, flora and fauna characteristics), as well as human (socio-economic and health conditions describing the demographic structure, culture, heritage sites, social and health status of the people and their environment), including outcomes of consultations held with stakeholders at the various sites.

The summary of baseline conditions is based on information sourced from literatures (see relevant sections) as well as findings from a one season (dry) field sampling program supplemented by secondary data from approved report (wet season), laboratory analyses of samples obtained and socio-economic and health surveys specific to this ESIA. The data acquired will be used in further environmental management decisions and future monitoring of changes, if any, in the environmental components.

This chapter also discusses the results obtained from laboratories analyses of our various samples i.e. air, water and soil, as well as the data generated from the socio-economic analysis.

Field studies and data collection for characterization of the baseline conditions of the proposed project environment covered, in line with the approved TOR by the FMEnv.

- Climate and meteorology
- Rainfall, Temperature, Cloud, Relative humidity and Sunlight
- Wind speed and wind direction
- Air quality and noise levels
- Geology/hydrogeology
- Surface and ground water
- Soil and sediment
- Topography
- Hydrobiology

- Vegetation & fauna wildlife
- Hydrobiology, fisheries and
- Socio economics/health impact, demography and community characteristics

4.2 BASELINE DATA ACQUISITION METHODS

The acquisition of data basically involved field data gathering, measurements and the collection of representative samples used to establish the environmental conditions of the study area. This exercise involved a multi-disciplinary approach and was executed within the framework of a QHSE management system approach. This approach assured that the required data and samples were collected in accordance with agreed requirements (scientific and regulatory) using the best available equipment, materials and personnel. Elements of this approach include:

- review of existing reports that contain environmental information on the study area;
- designing and development of field sampling strategies to meet work scope and regulatory requirements;
- pre-mobilization activities (assembling of field team, sampling equipment/materials calibrations/checks, review of work plan and schedule with team, and job hazard analysis);
- mobilization to field; fieldwork implementation - sample collection (including positioning and field observations), handling, documentation and storage protocols and procedures; and
- demobilization from field; transfer of sample custody to the laboratory for analyses.

4.2.1 Spatial Boundary and Size

A 5km wide spatial boundary from the proposed PCB sites in Sheda, Neke Uno and Epe was adopted for this project, as required by the EIA Procedural Guideline.

4.2.2 Desktop Studies

Desktop studies involved the acquisition of relevant background information on the environment of the study area. Materials that were consulted included approved reports on previous environmental surveys in the area, publications, textbooks, articles, maps, etc. on the area and similar environments. The list of materials consulted is specified in relevant sections.

4.2.3 Field Sampling/Measurement

In order to effectively characterize the ecology and meteorology of study area and determine seasonal variations of specific environmentally related parameters, rainy season field data gathering exercise was performed between 22nd October through 29th October, 2018 and the dry season from 6th through 12th January, 2019. The specific objectives of the ecological field sampling were to determine:

i. ambient air quality and noise level of the study area;
ii. physico-chemical and microbiological characteristics of the soil within the study area;
iii. physico-chemical and biological characterization of water and sediment samples within the study area;
iv. hydrobiology and fisheries resources of the study area;
v. wildlife abundance and diversity of the study area and environs;
vi. vegetation characteristics of the area; and
vii. establish the socio-economic and health status of the host and impacted communities.

Table 4.1 presents an inventory of the biophysical and socioeconomics/health details collected during field studies, while Table 4.2 presents the sampling stations and their GPS co-ordinates. Figures 4.1a, 4.1b and 4.1c shows the spatial locations of the sampled points.

Table 4.1 Inventory of Biophysical and Social Samples

S/N	Environmental Component	Parameter/Details	No of samples collected
1	Surface water &Sediments	Physico chemical & microbial	12 points
2	Ground water	Physico chemical & microbial	6 points
3	Soil	Physico chemical & microbial	36 points + 12 controls
4	Ambient air quality	Criteria pollutants	30 points + 6 controls
5	Noise	Sound/pressure level	30 points + 6 controls
6	Meteorology	Rainfall, Relative Humidity, Sunshine, Windspeed	3points
7	Biodiversity	Taxa	Sampling with quadrats (plots of a standard size)
8	Socio economics	Human and infrastructures	136 questionnaires in 3 communities

Table 4.2 Sampling Stations and their GPS Co-ordinates

LOCATION ID	LATITUDE (N^0)	LONGITUDE(E^0)
	SOIL SAMPLING FOR SHEDA	
A	007.04127	08.84683
B	007.04205	08.84746
C	007.04253	08.84811
D	007.04099	08.84822
SOIL SAMPLING FOR EPE		
A	06.62556	003.92069
B	06.62727	003.92111
C	06.62681	003.92070
D	06.62753	003.92158
SOIL SAMPLING FOR NEKE-UNO		
A	06.65787	007.54535
B	06.65720	007.54530
C	06.65664	007.54513
D	06.65884	007.54459
SURFACE WATER SAMPLING FOR SHEDA		
A (Downstream)	007.04704	08.84409
B(Upstream)	007.04782	08.86043
SURFACE WATER SAMPLING FOR EPE		
A	003.9211	06.62727
B (Lagoon)	003.9449	06.57574
C (Sala River)	003.9246	06.62620
SURFACE WATER SAMPLING FOR NEKE-UNO		
A	06.65684	007.54460

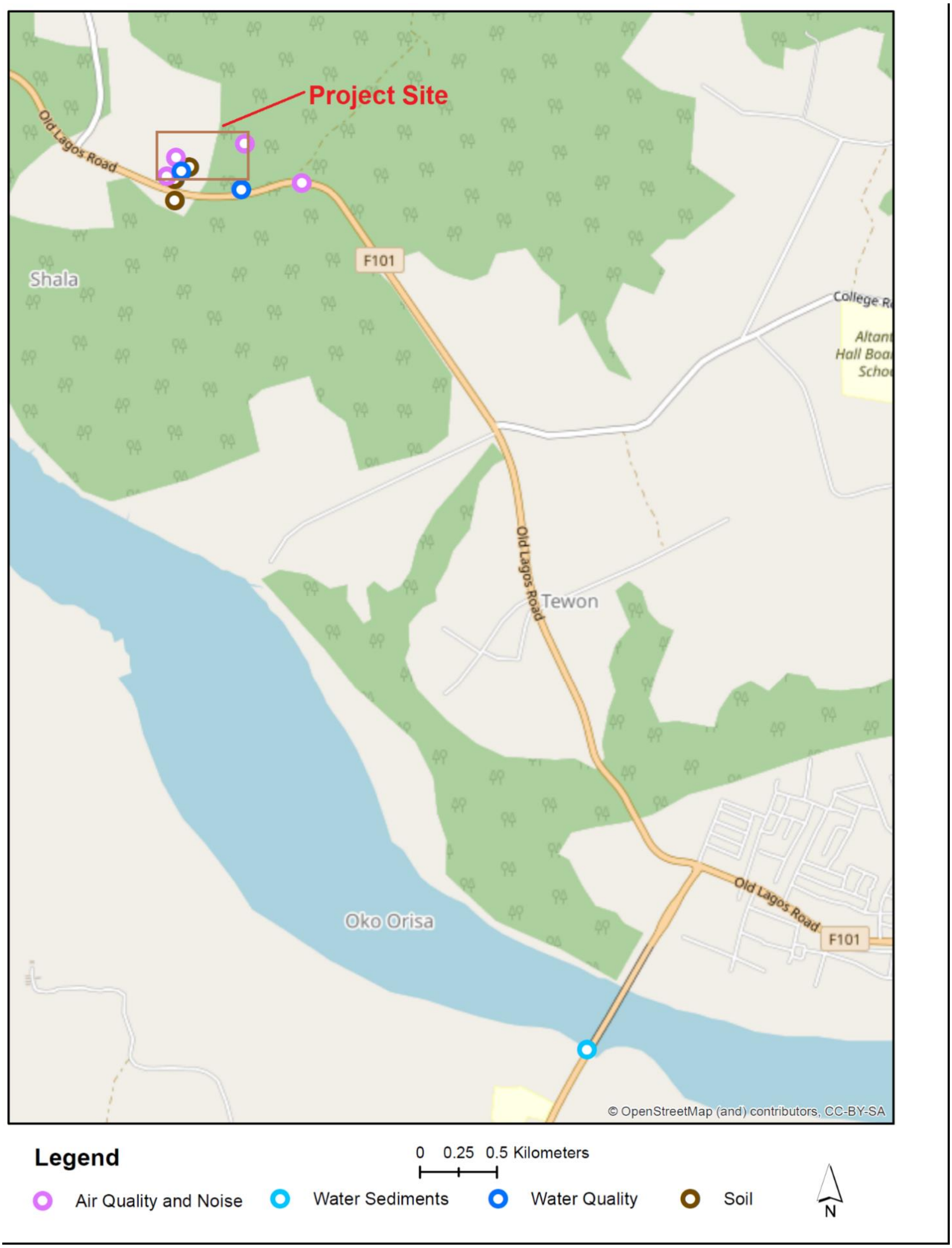


Figure 4.1a Sampling Map for Epe Site -Lagos State

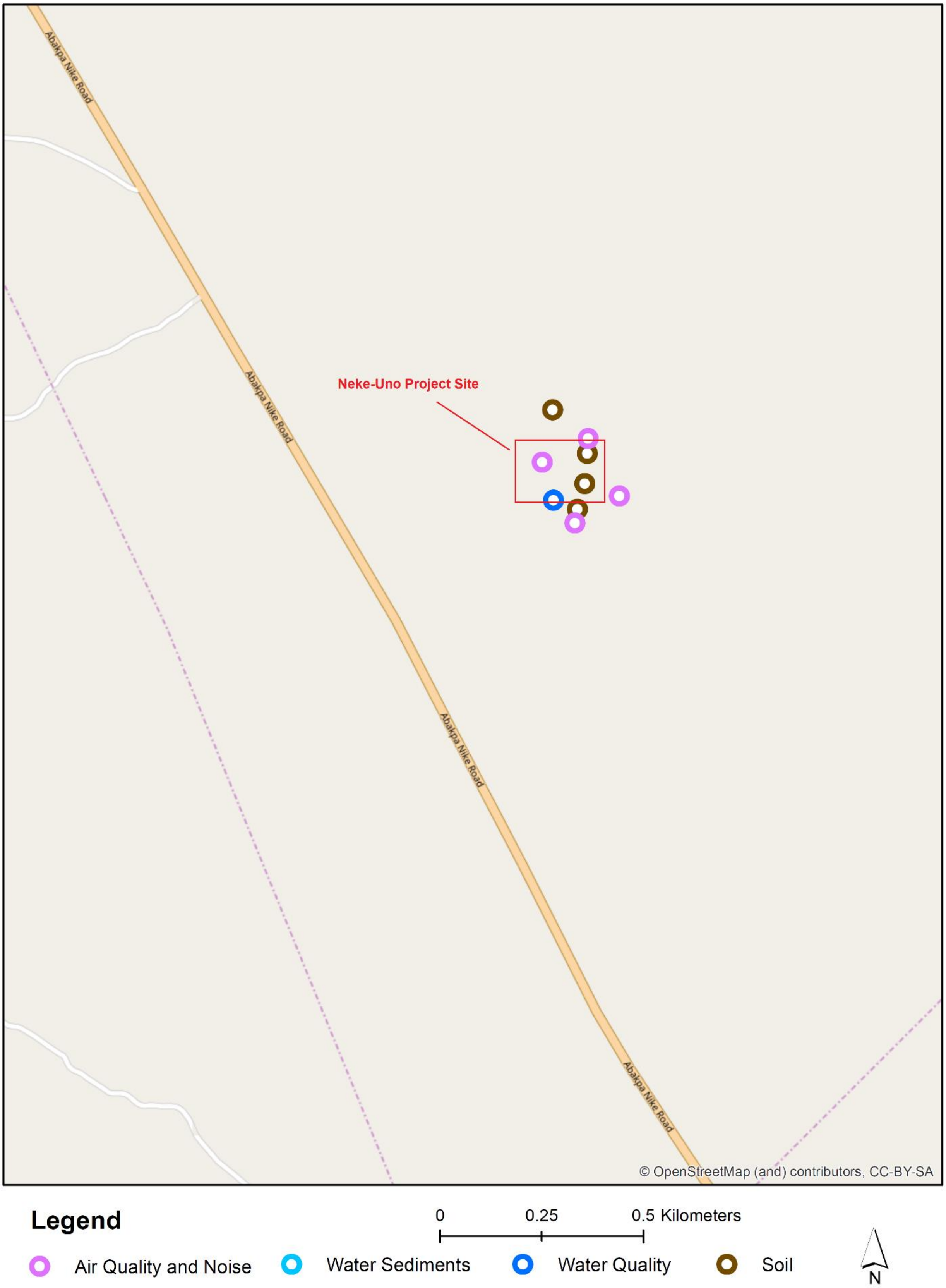


Figure 4.1b Sampling Map for Neke-Uno Site, Enugu State

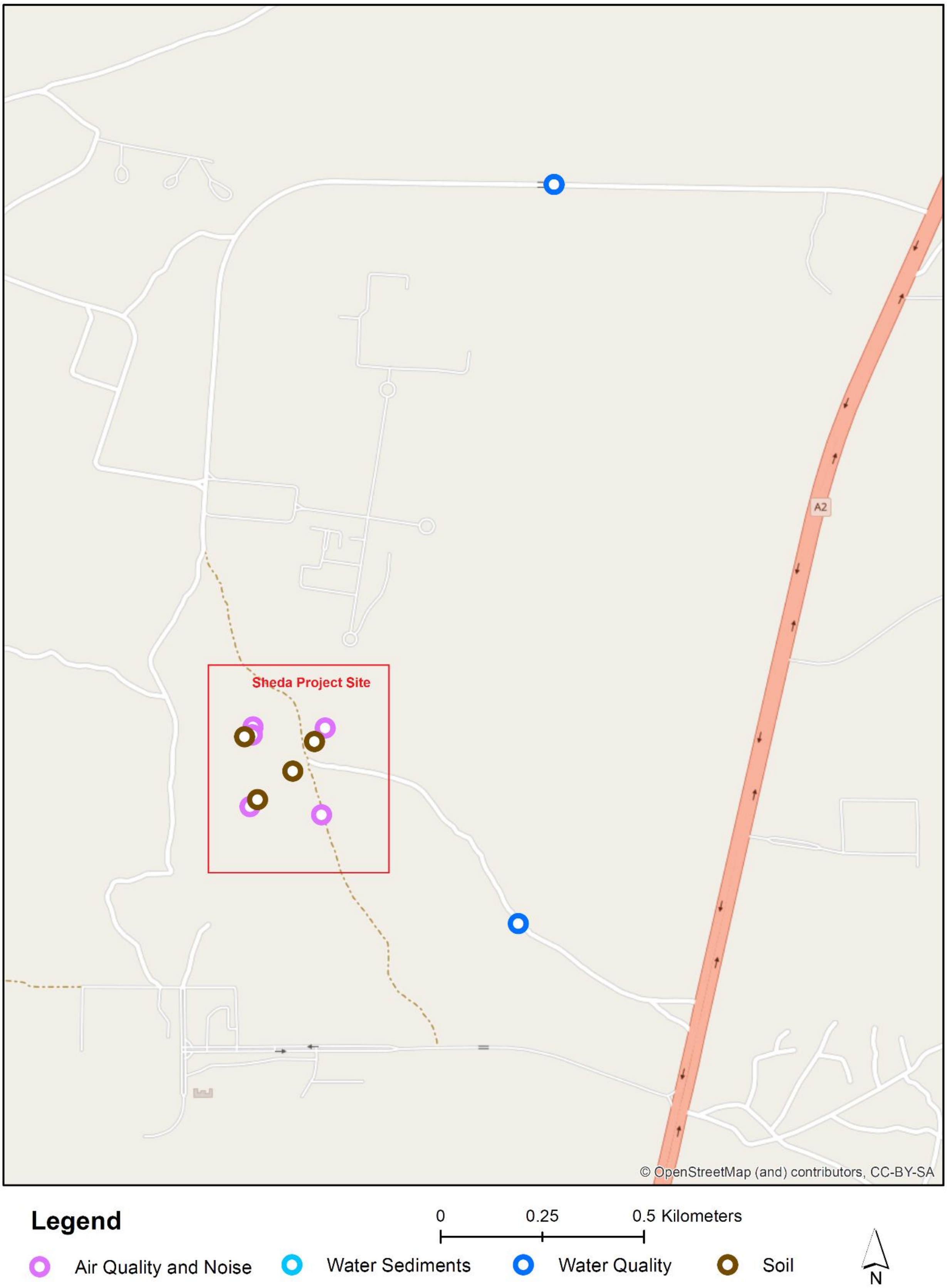


Figure 4.1c Sampling Map for Sheda Site -FCT

4.3 PHYSICAL ENVIRONMENT

4.3.1 Climate and Meteorology.

Climate and Meteorology encompasses the statistics of temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle count and other meteorological elements in a given region over long period (30-35 years) of time. The climate of a location is affected by its latitude, terrain, altitude, as well as nearby water body and their currents. Climates can be classified according to the average and typical ranges of different variables, most commonly temperature and rainfall. The climate of Nigeria is characterized by two regimes-the dry season and the wet season. These are dependent on two prevailing air-masses blowing over the country at different times of the year: the north-easterly air mass of Sahara origin (the tropical continental air mass) and the humid maritime air-mass blowing from the Atlantic (the tropical maritime air mass). The two air masses blowing from nearly opposite directions meet along a slanting surface (the Inter-Tropical Front). The area about this front, where the air masses to some extent mix, is called the Inter-Tropical Discontinuity (ITD) or the Inter- tropical Convergence Zone (ITCZ). The data presented are for the period the project was conducted, namely 2018 for Sheda, Epe and Neke Uno, in Abuja, Lagos and Enugu State, respectively. The study areas are characterised by two distinct conditions of wet and dry seasons, while the wet season occurs between April and October with a brief break in August, and the dry season occurs between November and March.

Abuja is situated at 9.06° North latitude, 7.49° East longitude and 536 meters elevation above the sea level. Epe town is situated in southwestern Nigeria; it lies on the north bank of the coastal Lagos Lagoon and its geographical coordinates are 6° 35' 0" North, 3° 59' 0" East covering an area of 965 km². It is located 6.58 latitude and 3.98 longitude and it is situated at elevation 170 meters above sea level. Neke Uno town is situated in southwestern Nigeria and its geographical coordinates are 6° 27' 35.8704'' N and 7° 32' 56.2164'' E covering an area of 556 km^2, at elevation 160 meters above sea level. The latitude of Neke Uno is 6.459964, and the longitude is 7.548949. k

4.3.1.1 Rainfall

The rainfall within the study area for the period measure, ranged from 24mm to 386mm for Epe, 10mm to 283mm for Sheda and 9mm to 298mm for Neke Uno. The annual mean of 185.8mm, 162mm and 125mm for Epe, Sheda and Enugu, respectively. Rainfall distribution was observed to be highest in the month of July and Sept and lowest in November to February for all the locations considered (Figure 4.2).

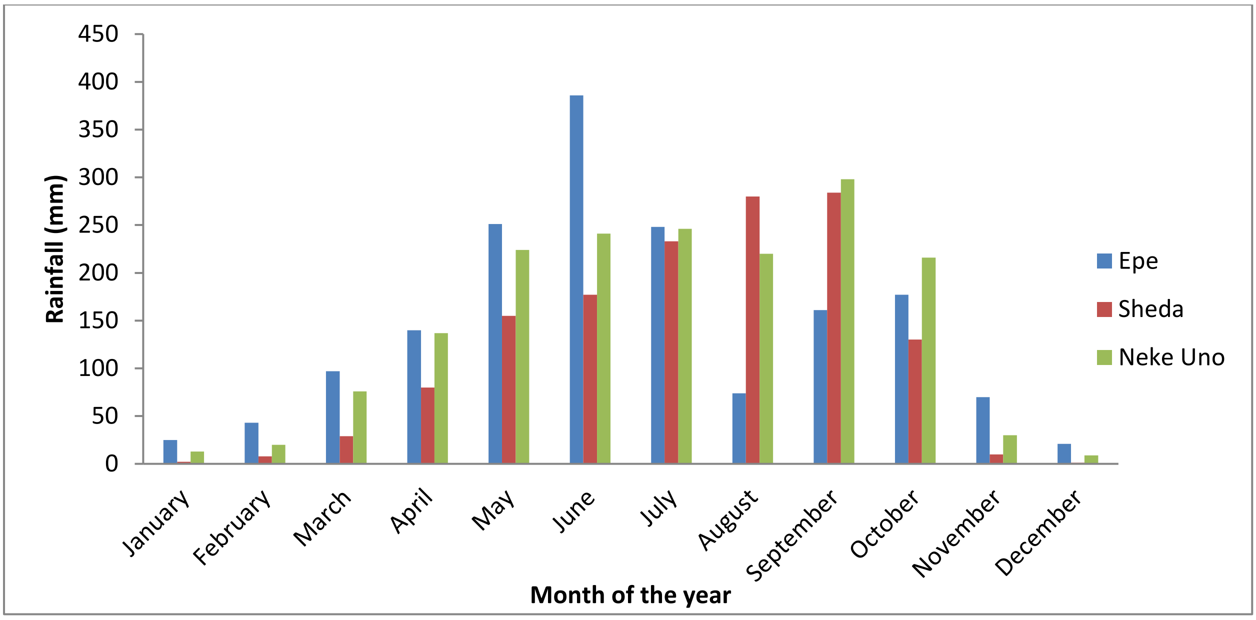


Figure 4.2 Average Rainfall for all the storage sites (NIMET, 1990-2018)

4.3.1.2 Temperature

The average temperatures recorded for the three sites by the Nigerian Meteorological Agency (NIMET) over same climatic period is shown in Figure 4.3. From the data obtained the maximum temperature was recorded highest in the month of March for all the sites and the values were conveniently closed, while lowest in July. Epe seems to have the highest temperature in all the months as depicted in Figure 4.3. More delicate measures should be taken in Epe after the commission of the PCB storage facility.

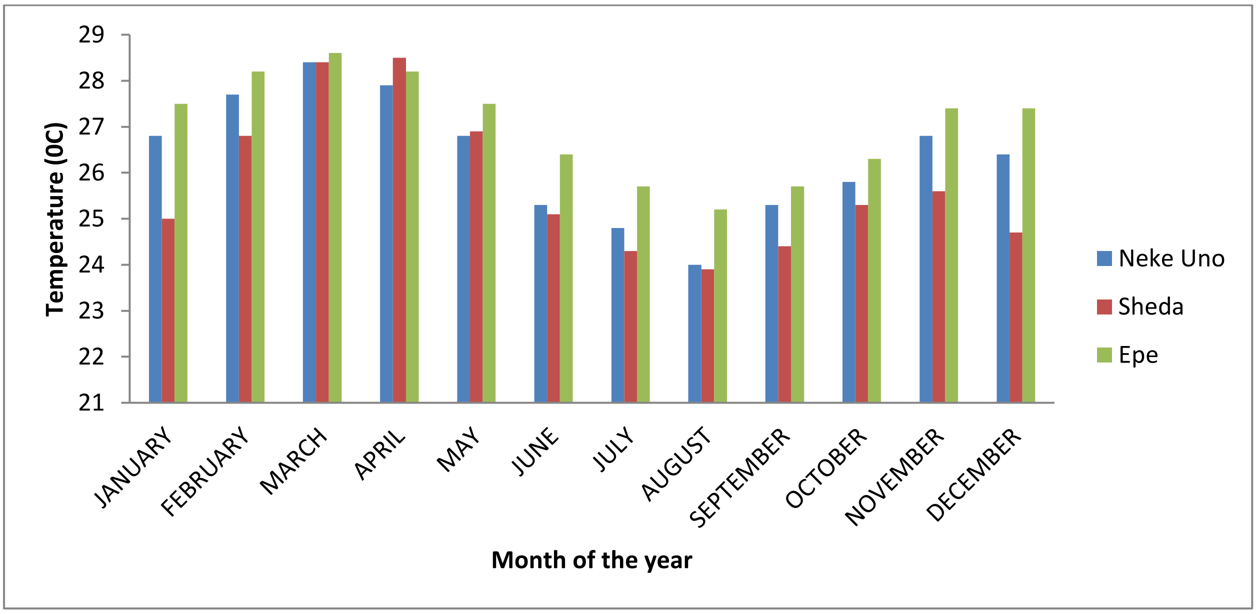


Figure 4.3 Average Temperatures for the sites (NIMET-1990-2018)

4.3.1.3 Sunlight

Nigerian is richly blessed with sunlight which happens to follow similar pattern across the year in different locations in the country. Data obtained from NIMET indicates that Sheda is the most intense site compared to the others. The sunlight per hour is seen to be lower (ranging between 5 and 6) between the month of June and September for all the sites. Average sunlight hours for all the sites, ranged between 4.5 and 6.7 hours with an annual average of 5 hours (Figure 4.4). The month with most sunshine is November (Average sunshine: 7.3h). Months with least sunshine are July and August (Average sunshine: 3.8) for Nene Uno. Epe recorded most sunshine are November and December (Average sunshine: 6.2h). The month with least sunshine is July (Average sunshine: 3.2h). Sheda had the most sunshine in November and December (Average sunshine: 9h) while months with least sunshine are July and August (Average sunshine: 5).

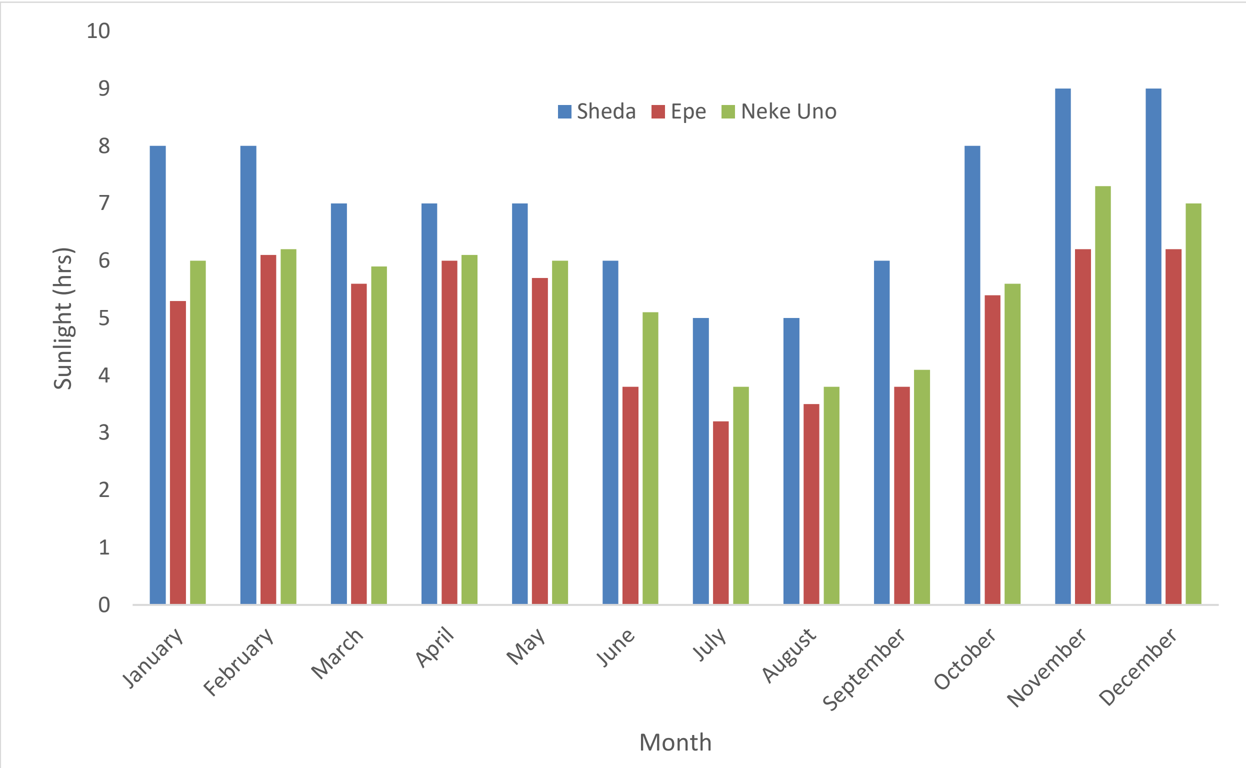


Figure 4.4 Mean Monthly sunlight for all the proposed storage sites (1990 - 2016)

Source: https://www.weather-nga.com/en/nigeria , 2019

4.3.1.4 Wind speed

Wind speed for the proposed study area was observed to be highest in the months of March and August for all the sites. The lowest speed was observed in December and January. Expectedly, Epe recorded the highest wind speed throughout the year in comparison with other sites. PCB pollution will spread faster in Epe region in case of any incident as the speed of the wind will serve as transport agent for the pollutant. Rapid respond is advised in areas where the wind speed is high in case of any volatile pollutant in the environment. (Figure 4.5).

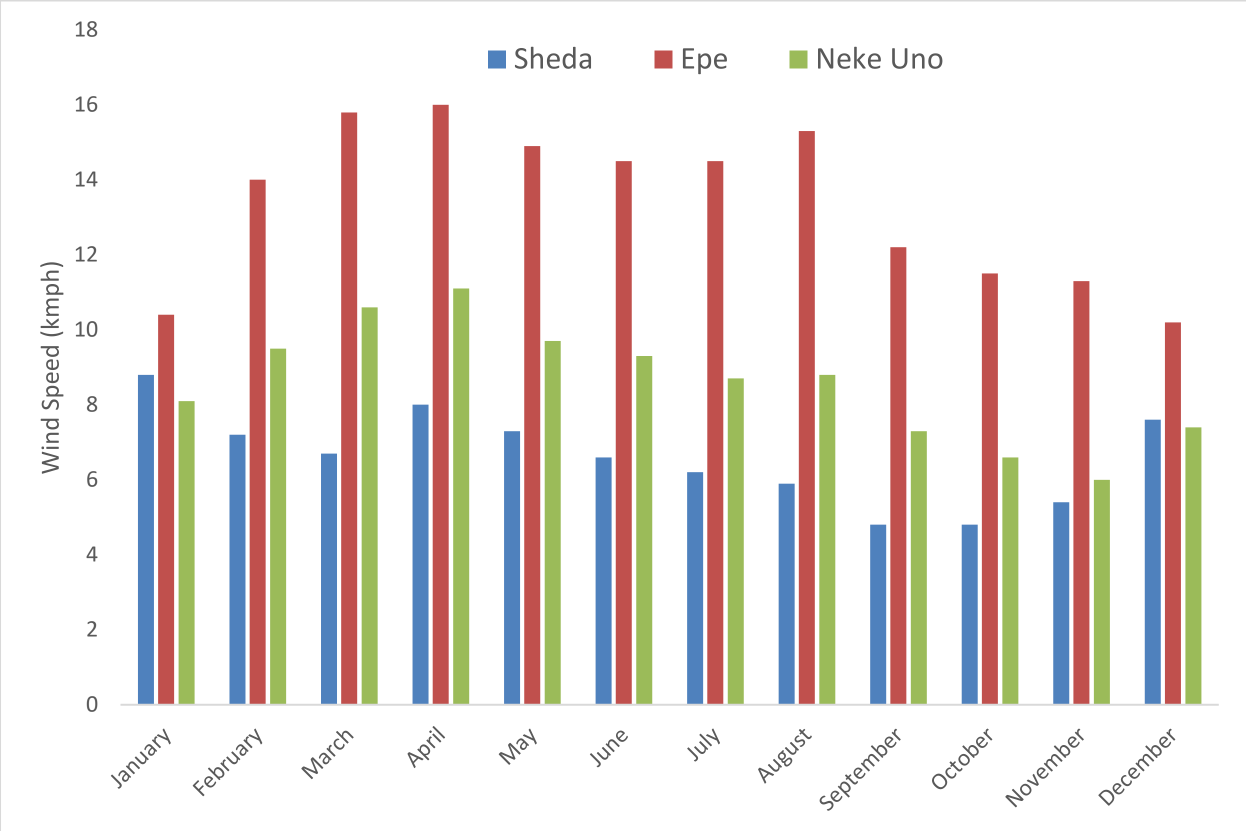
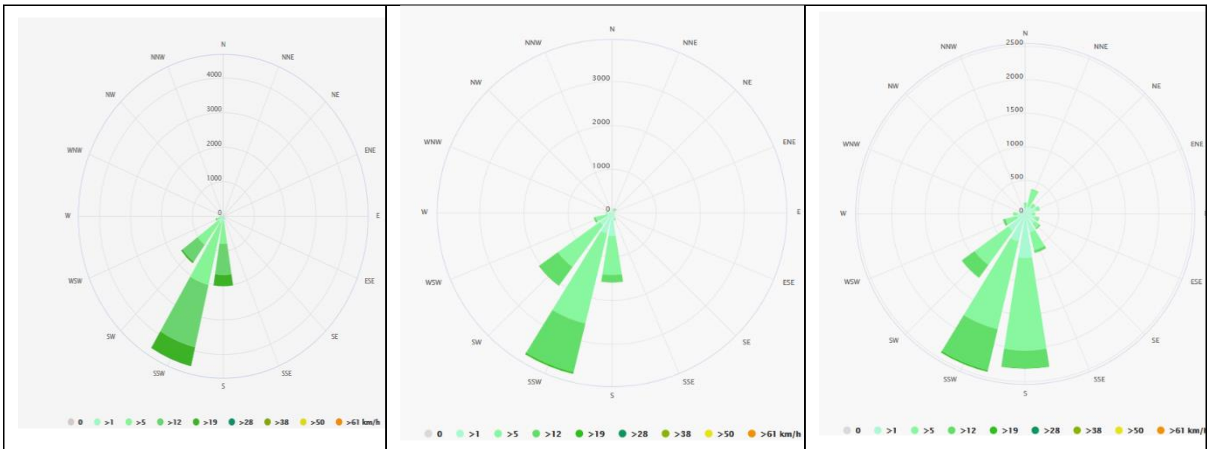


Figure 4.5 Mean Monthly wind speed for all the sites (1990 - 2018) Source: NIMET, 2018

4.3.1.5 Wind Direction

Data obtained from NIMET revealed that south westerly wind direction is prevalent in the study area throughout the year (NIMET, 1990-2018). However, during dry season, winds are distributed in all directions, but predominantly South-Southwest direction during the raining season in all the sites under consideration. Figure 4.6 shows the windrose representative for Epe, Neke Uno, and Abuja proposed sites, respectively.



Lagos	Enugu	Abuja

Figure 4.6 Windrose for Lagos, Enugu and Abuja (October, 2018)

4.3.1.6 Relative Humidity

Relative humidity is the ratio of the amount of water vapour in the air at a specific temperature to the maximum amount that the air could hold at that temperature, expressed as a percentage. For example, a reading of 100 percent relative humidity means that the air is totally saturated with water vapour and cannot hold any more, creating the possibility of rain. Relative humidity is usually higher in the wet season than the dry season because of rainfall caused by precipitation of vapour in the atmosphere. Relative humidity was highest in the months of July and October for all the sites. It was however, least in November to January for Sheda. (Figure 4.7). The relative humidity for Epe was observed to above 65% for all the months in the year. This might be responsible for high rainfall observed in this region.

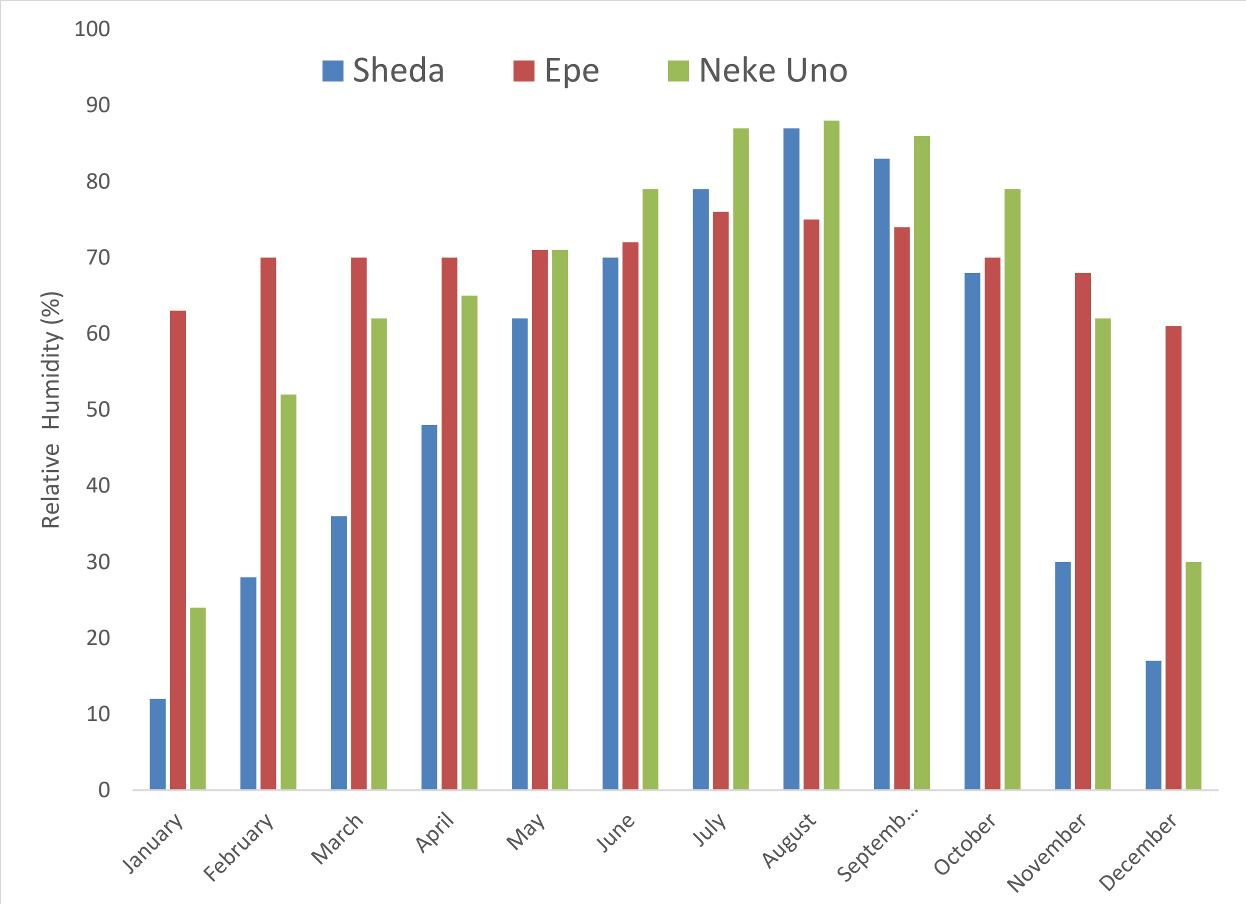


Figure 4.7 Annual Relative Humidity for all the sites (1990-2018) Source: NIMET, 2018

4.3.1.7 Cloud Cover

Solar radiation, temperature and humidity have direct relationship with cloud development and thus precipitation. Cloud formation is preceded by upward movement of humid air, which leads to its expansion (against the diminishing resistance of the lowering pressure of the surrounding atmosphere), and cooling. This cooling will lead to immediate condensation in saturated air or to eventual condensation if the cooling is sufficiently prolonged. As the rainy season approaches, there is a trend towards increased cloudiness. Decline in sunshine hours (and radiation) becomes more intense as the rainy season progresses. On comparison basis, Neke Uno recorded the highest percentage cloud, especially in the months of June to September. The lowest values were noticed in the months of December and January, as depicted by Figure 4.8.

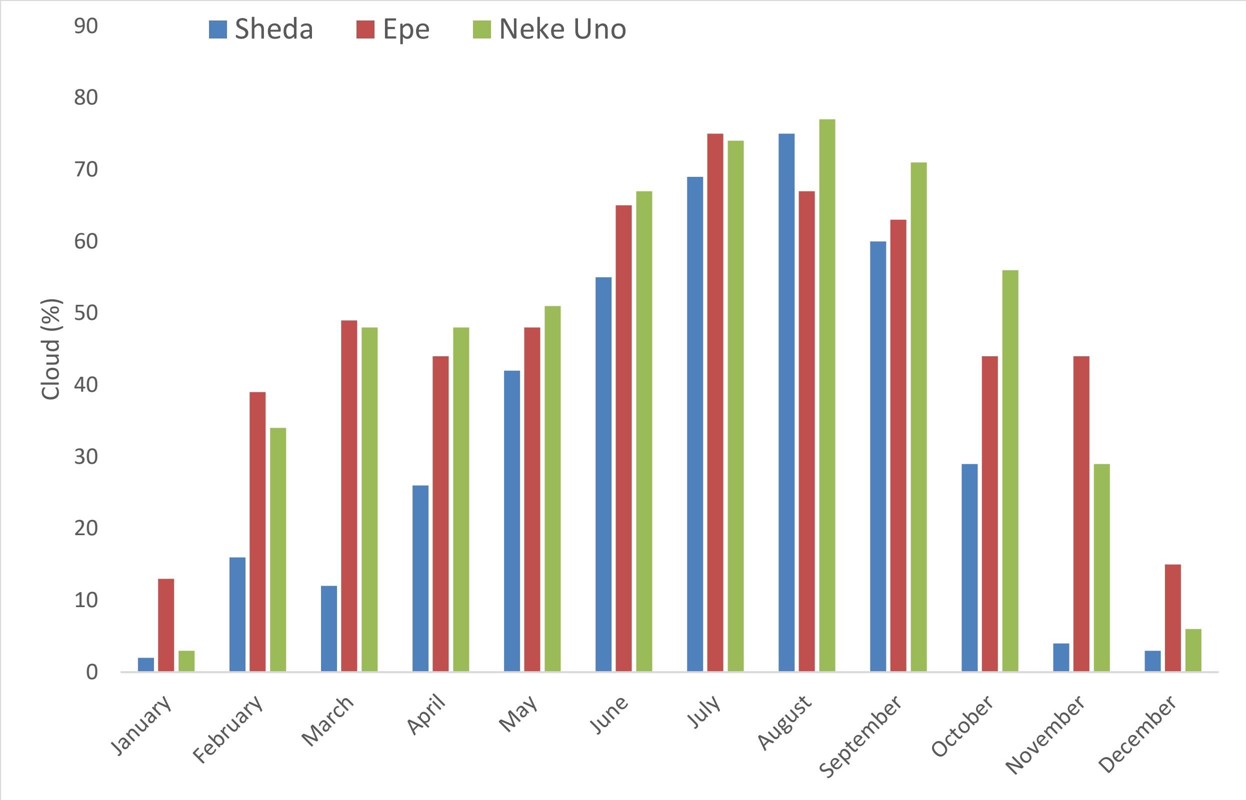


Figure 4.8 Annual Cloud Cover (1990-2018) Source: NIMET, 2019

4.3.2 Ambient Air Quality

Air generally contains water vapour, gases, and particulate matter in small but very variable quantities (Oguntoyinbo and Derek, 1987). Air pollution is the presence in the atmosphere of one or more contaminants in such quantities, characteristics, duration as to make them actually or potentially injurious to human, plant, or animal life or to property, or which unreasonably interfere with the comfortable enjoyment of life and property.

4.3.2.1 Ambient Air Quality Measurement

Atmospheric gases were measured using GrayWolf Advanced Sense IAQ Plus Indoor/Outdoor Air Quality Survey with IQ-610 Probe. The value of the atmospheric concentrations of each gaseous pollutant was read off directly on the equipment screen and data documented. The equipment is shown on Plate 4.1, with EEMS staff on site using it.

Measurements were conducted between 07:00 and 19:00hrs Nigerian time, for air measurements. Specific locations for measurements were selected with consideration for concentrations of human receptors such as residential areas, commercial areas, hospitals, churches, mosques, recreation centres, schools and farmlands. The co-ordinates of the sampled locations for air quality are presented in Table 4.3 and the map in Figures 4.1a-c.

Plate 4.1 Air quality sampling and In-situ Measurements.

Source: EEMS survey, 2019

Table 4.3 Air Quality and Noise Level Measurement Locations

LOCATION CODE	Latitude (°N)	Longitude (°E)	Description
			Sheda, Abuja
A	8.84844	7.04117	Farm land 800m to the SHESTCO admin block
B	8.84827	7.04115	North of the Proposed Site
C	8.84826	7.04115	North West of the Proposed Site
D	8.84668	7.04111	South West of the Proposed Site
E	8.84649	7.04269	South of the Proposed Site
F	8.84841	7.04277	East of the Proposed Site
Stream	8.86043	7.04782	Stream
control	8.85674	7.04405	SHESTCO Admin Block
			Epe, Lagos
A	3.9208	6.62809	West of the Proposed site
B	3.92025	6.62699	North of the site towards the Crusher company
C	3.92817	6.6266	South of the demarcated site towards the swamp
D	3.92481	6.6289	East of the Site beside the Epe -Ikorodu road
Control	3.9285	6.6267	Sunrise Global Hitech Estate Across the road from the site
			Neke Uno, Enugu
A	7.54436	6.65768	A point outside the perimeter fence North of the demarcated farm land
B	7.54537	6.6582	A point outside the perimeter fence South of the demarcated farm land
C	7.54508	6.65634	A point outside the perimeter fence West of the demarcated farm land
D	7.54607	6.65693	A point outside the perimeter fence East of the demarcated farm land
Control	7.54313	6.64443	The chief's house where consultation took place

4.3.2.2 Ambient Air Quality Result

Result of this study was presented according to the various sites considered as presented in Table 4.4 displayed ambient air quality for both wet and dry seasons. Particular attention was paid to the Greenhouse gases (GHG) like CO_2 and NO_2.

Table 4.4 Ambient Air Quality for Wet and Dry Season

LOCATION/ SEASON	TSP (mg/m3)		NH_3 (ppm)		SO_2 (ppm)		NO_2 (ppm)		CO_2 (ppm)		VOC (ppm)		HCl (ppm)		CO (ppm)		Wind Speed	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Sheda Site																		
Location A	0.18	0.20	0.06	0.03	0.0	0.0	0.00	0.00	342	352	0.22	0.21	0.0	0.0	0	0	3.0	4.2
Location B	0.19	0.21	0.07	0.03	0.0	0.0	0.00	0.00	339	367	0.28	0.25	0.0	0.0	0	0	4.0	4.5
Location C	0.19	0.21	0.09	0.03	0.0	0.0	0.00	0.00	341	381	0.23	0.27	0.0	0.0	0	0	3.0	5.3
Location D	0.19	0.21	0.1	0.03	0.0	0.0	0.00	0.00	362	391	0.24	0.28	0.0	0.0	0	0	2.0	5.5
Location E	0.19	0.21	0.11	0.04	0.0	0.0	0.00	0.00	361	315	0.29	0.24	0.0	0.0	0	0	4.0	4.7
Location F	0.19	0.21	0.09	0.03	0.0	0.0	0.00	0.00	331	354	0.36	0.29	0.0	0.0	0	0	3.0	4.4
Stream	0.19	0.19	0.09	0.02	0.0	0.0	0.00	0.00	332	361	0.32	0.26	0.0	0.0	0	0	2.0	4.0
Epe Site																		
Location A	0.10	0.17	0.04	0.02	0.0	0.0	0.00	0.00	352	333	0.42	0.36	0.0	0.0	4	5	2.7	3
Location B	0.10	0.19	0.03	0.02	0.0	0.0	0.00	0.00	367	346	0.38	0.30	0.0	0.0	4	4	2.9	3.2
Location C	0.11	0.14	0.03	0.02	0.0	0.0	0.00	0.00	381	364	0.41	0.35	0.0	0.0	2.8	4	3.4	3.3
Location D	0.11	0.14	0.03	0.02	0.0	0.0	0.00	0.00	393	352	0.4	0.32	0.0	0.0	3.6	4	2.1	3.3
Neke-Uno Site																		
Location A	0.16	0.17	0.02	0.03	0.0	0.0	0.00	0.00	316	332	0.31	0.34	0.0	0.0	0	0	0.6	1.0
Location B	0.16	0.17	0.02	0.02	0.0	0.0	0.00	0.00	318	345	0.32	0.30	0.0	0.0	0	0	0.7	1.1
Location C	0.17	0.17	0.03	0.03	0.0	0.0	0.00	0.00	321	401	0.31	0.31	0.0	0.0	0	0	0.3	1.8
Location D	0.16	0.17	0.02	0.03	0.0	0.0	0.00	0.00	361	385	0.31	0.31	0.0	0.0	0	0	0.4	1.3

Suspended Particulate Matter

These are finely divided particles (solid and liquid) of 0.01 to over 100 microns in diameter, suspended in ambient air (Larry and Loren, 1977). These particles when exist above tolerable limit in the atmosphere can initiate a variety of respiratory diseases (bronchitis, emphysema and cardiovascular diseases). Also fine particles may cause cancer and aggravate morbidity and mortality from respiratory dysfunctions (CCDI, 2001).

The result showed that TSP10 concentrations were generally below WHO/FMEnv regulatory limits of 0.15-0.25ppm for the various section of the study area. This result indicated a non-contaminated air in the various sections of the study area, irrespective of the seasonal changes noticed.

Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless and tasteless gas produced by the incomplete combustion of carbonaceous materials or fossil fuels - gas, oil, coal and wood. Adverse health effect has been observed with carbon monoxide concentrations of 12 - 17ppm for 8 hours (Canter and Hill, 1977) while prolonged (45 minutes to 3 hours) exposure to concentrations of CO between 200ppm and 800ppm often results in severe headache, dizziness, nausea and convulsions (CCDI, 2001).

The result indicated concentrations below WHO/FMEnv regulatory limits, hence, no health or environmental concern shall be posed. However, increase in CO levels is projected during all phases of the project for which mitigation measures are proffered. This observation might subsequently affect the proposed storage site at Epe, which currently recorded relatively higher value of CO for both dry and wet season.

Sulphur Dioxide

Sulphur dioxide (SO_2) is a colourless gas produced from biological decay and forest fire releases. It is also produced from the combustion of sulphur-containing fuels, smelting, manufacture of sulphuric acid and incineration of refuse and production of elemental sulphur.

SO_2 gas is known to be a harsh irritant, and is capable of aggravating asthma, bronchitis and emphysema (CCDI, 2001). Also, sulphuric acid aerosols (formed from dissolved sulphur dioxide) will readily attack building materials, especially those containing carbonates such as marble, limestone, and mortar.

From the result SO_2 was not detected in all the three sites investigated for either of the two seasons considered. This could be attributed to either low traffic hence lower fossil fuel emissions during times of the day and/or less industrial activities or compliance with the regulatory standards. Accordingly, the SO_2 level is not projected to exceed the regulatory limits during all phases of the project life cycle.

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a member of the family of highly reactive gases called nitrogen oxides or oxides of nitrogen, which are formed during combustion processes. NO_2 results when fuel is combusted at high temperatures and occurs mainly from motor exhaust and stationary sources such as electric utilities and industrial boilers (Canter and Hill, 1977, SIEP, 1995). It is the only oxide of nitrogen that has been shown to have significant human health effects, with exposure to concentrations higher than 0.5ppm (1mg/m^3) triggering changes in pulmonary function in healthy people (SIEP, 1995).

Concentration of NO_2 in the various study section was observed to be below equipment detection limit and thus below WHO/FMEnv regulatory limits. Hence it poses no health implication in the study area. However, corona effect is projected to increase NO_2 levels during the operation phase for which mitigation measures have been established. Our suggestion for undetectable SO_2 concentration also holds here.

Hydrogen chloride (HCl)

Hydrogen chloride is a gas at room temperature. Solution of hydrogen chloride in water forms hydrochloric acid.

Hydrogen chloride is formed in the air during the burning of plastics. Other releases of hydrogen chloride into the atmosphere are however removed by rainfall, limiting the chances of exposure to high levels of this compound by breathing ambient air (Hlavay and Guilbault, 1978). According to Hlavay and Guilbault (1978) air concentrations above 5ppm can cause irritation. However, concentrations recorded for the various sections of the study area were below equipment detection limits and standards, thus posed no health implication in the study area and environs.

Volatile Organic Compounds

Volatile organic compounds (VOCs) are organic chemicals that have a high vapour pressure at ordinary, room-temperature conditions. VOCs are numerous, varied, and ubiquitous. They include both human-made and naturally occurring chemical compounds. VOCs play an important role in communication between plants. Some VOCs are dangerous to human health or cause harm to the environment. Anthropogenic VOCs are regulated by law, especially indoors, where concentrations are highest. Harmful VOCs are typically not acutely toxic, but instead have compounding long-term health effects. Because the concentrations are usually low and the symptoms slow to develop, research into VOCs and their effects is difficult. Volatile organic compounds are produced naturally through biological mechanisms such as metabolism. Industrial use of fossil fuels produces VOCs either directly as products (e.g. gasoline) or indirectly as by-products (e.g. automobile exhaust). In addition to their indirect impacts through photochemical ozone formation, some VOCs directly affect human senses through their odour; some others exert a narcotic effect while certain species are toxic with particular concern on cancer induction (Ajao, 1989).

Concentration of VOCs in the various study sites and for both seasons were far below WHO/FMEnv regulatory limits. Ironically, Epe recorded the highest concentrations of VOC, which might be alluded to increased human activities in the area as well emergence of industrial development.

Carbon dioxide (CO_2)

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. The main human activity that emits CO_2 is the combustion of fossil fuels (coal, natural gas and oil) for energy and transportation, although certain industrial processes and land-use changes also emit CO_2.

Sheda and Neke Uno had zero level of CO_2 concentrations for both seasons, which likely implies low industrial activities and little or no fossil fuel combustion machine or industries. Epe, on the contrary recorded relatively high values of CO_2 concentrations measured in the study areas during both the dry and wet seasons, though the values were below WHO/FMEnv permissible limits of 5000ppm. This result indicates no health/environmental concern in all the study areas.

4.3.3 Noise Levels

4.3.3.1 Noise Quality Measurement

Noise is a periodic fluctuation of air pressure causing unwanted sound. Apart from causing disturbance to the affairs of man, long term exposure to excessive noise can damage health and have psychological effects (SIEP, 1995). The effects of noise on residents generally relate to the annoyance/nuisance caused by the short and long term high noise levels. Also, disturbance to wildlife is significant especially during breeding seasons and/or when rare species are present. The rate at which these fluctuations of air pressure occur is the frequency, expressed in hertz (cycles per second). The range of sound pressures encountered is very large and to keep numbers in manageable proportions, noise levels are measured in decibels (dB), which have a logarithmic scale. Most legislations and measurements refer to the ‘A' frequency weighting, dB(A) which covers the range audible to the human ear. A 10dB (A) typically represents a doubling of loudness.

Sound pressure or acoustic pressure is the local pressure deviation from the ambient (average, or equilibrium) atmospheric pressure caused by a sound wave. Sound pressure in air can be measured using a microphone, and in water using a hydrophone. The SI unit for sound pressure p is the Pascal (symbol: Pa). Sound pressure level (SPL) or sound level is a logarithmic measure of the effective sound pressure of a sound relative to a reference value. It is measured in decibels (dB) above a standard reference level. The commonly used "zero" reference sound pressure in air is 20µPa RMS, which is usually considered the threshold of human hearing (at 1 kHz). Noise levels are usually altered during installation and servicing of the project. The regulatory limit for noise provided by the FMENV is specific to the workplace (90dB (A). However, noise due to construction and installation of the plant and associated facilities are expected to rise. The IFC, WHO and FMEnv limits shall be used to benchmark the ambient noise levels measured in the project area. Table 4.5 presents the WHO guidelines for community noise.

Noise measurements were conducted in accordance with IFC 2012 standard. The document implies measurement of noise with respect to the various micro-habitats present in a given area. In this study the micro-habitats present are houses, farmlands, religious grounds and hospitals.

The ambient noise level was measured in different stations (selection criteria was earlier explained) with the aid of a hand held Pulsar Sound Level Meter about 1.9 m high during the day and night. Night measurements were imperative since trucks are also expected to move at night time. This meter has a Liquid Crystal Detector (LCD) where readings are displayed for observation. The noise level was read off from the LCD after about 2 to 3 minutes of display. It is expected that the measured ambient noise levels and the regulatory guidelines will be the standards against which noise will be assessed during the course of construction. Plate 4.2 shows EEMS' staff using the LCD for measurement of noise level.

Table 4.5 WHO Guidelines for Community Noise

Specific Environment	Critical Health Effect(s)	LAeq (dB)	Time base (hours)	LAmax, fast (dB)
Outdoor living area	Serious annoyance, daytime and evening.	55	16	-
	Moderate annoyance, daytime and evening.	50	16	-
Dwelling, indoors	Speech intelligibility and moderate annoyance at daytime and evening.	35	16	45
Inside bedrooms	Sleep disturbance at night.	30	8	
Outside bedrooms	Sleep disturbance, window open (outdoor values).	45	8	60
School classroms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication.	35	During class	-
Pre-schools bedrooms, indoors	Sleep disturbance	30	Sleeping time	45
School, playground outdoors	Annoyance (external source)	55	During play	-
Hospitals, wardrooms, indoors	Sleep disturbance at nighttime	30	8	40

	Sleep disturbance at daytime and evenings.	30	16	
Hospitals, treatment rooms, indoors.	Interference with rest and recovery.	#1	-	-
Industrial, commercial shopping and traffic areas, indoors and outdoors.	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events.	Hearing impairment (patrons:<5 times/year)	100	4	110
Public address, indoors and outdoors	Hearing impairment	85	1	110
Music through headphones/earphones	Hearing impairment (free-field value)	85#4	1	110
Impulse sounds from toys, fireworks and firearms.	Hearing impairment (adults) Hearing impairment (children)	-	-	140#2 120#2
Outdoors in parkland and conservation areas	Disruption of tranquility	#3		

#1: as low as possible;

#2: peak sound pressure (not LAmax, fast), measured 100mm from the ear;

#3: existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background so should be kept low; and #4: under headphones, adapted to free-field values.

Plate 4.2 Noise level Measurement at Neke-Uno

4.3.3.2 Noise Quality Result

Table 4.6 shows the summarized average result of noise level taken for both wet and dry seasons.

Table 4.6 Noise Measurement Results in the Study Area

Sample Code	Noise (dBA)	
	Wet Season	Dry Season
Sheda		
Location A	55.8	59
Location B	57	58.2

Location C	53	55.1
Location D	58	59
Location E	55	58
Location F	56.1	60.1
Stream	57.2	55.2
Epe		
Location A	67.2	69.1
Location B	55.6	57.3
Location C	50.1	54.2
Location D	57.3	59.1
Enugu		
Location A	45	45
Location B	48	48
Location C	49	49
Location D	51	59

WHO/FMEnv Regulatory daily limit for Noise	
General Noise Level limit	105 db(A) per hour or 90dB(A) per day for prolonged
School	45 (day) 35 (night)
Hospital	30 for day and Night
Residential	45 for Day and 35 for Night time
Farmlands	40 for Day and 45 for Night

Source: EEMS survey, 2019

The results as presented in Table 4.6 indicated an elevated noise level above the day time threshold stipulated for the various environments (school, hospital, residential and farmlands) for all the sections. This might be attributed to the activities surrounding the study areas and expectedly, Location A in Epe of Lagos site recorded the highest noise level. Gladly, these results were within the general noise level of short exposure of 105dB (A) or that of prolonged exposure of 90dB (A). Independently of the seasonally changes, the noise level remained very close in values for all the sites considered.

4.3.4 Topography

Figure 4.9 shows the elevation map of Abuja, Nigeria, which displays range of elevation with different colours. The elevation map of Abuja, Nigeria is generated using elevation data from NASA's 90m resolution SRTM data. The maps also provide idea for topography and contour of Abuja displayed at different zoom levels.

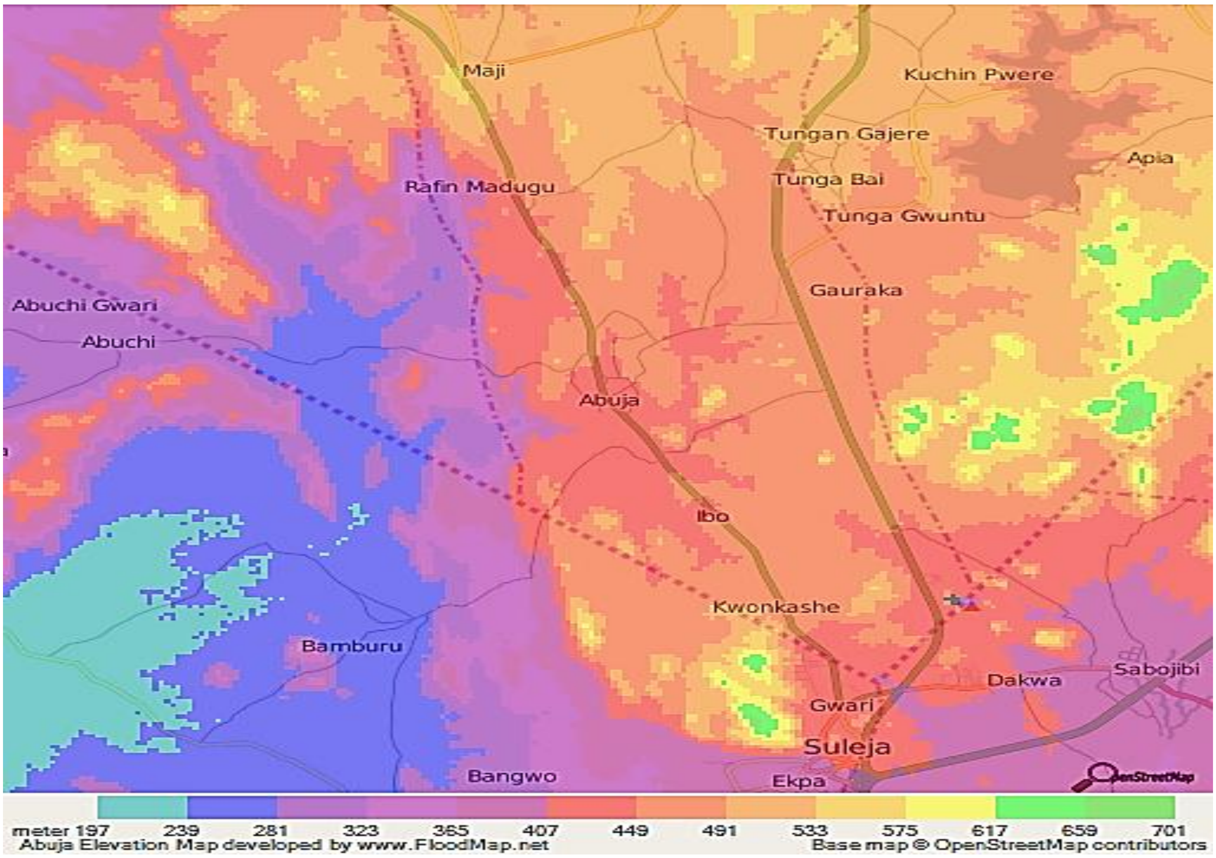


Figure 4.9 Abuja Elevation Map

Source: (www.floodmap.net)

Figure 4.10 shows the elevation map of Lagos, Nigeria, which displays range of elevation with different colours. The elevation map of Lagos, Nigeria is generated using elevation data from NASA's 90m resolution SRTM data. The maps also provide idea for topography and contour of Lagos displayed at different zoom levels.

A similar elevation map for Enugu, Nigeria is depicted by Figure 4.11

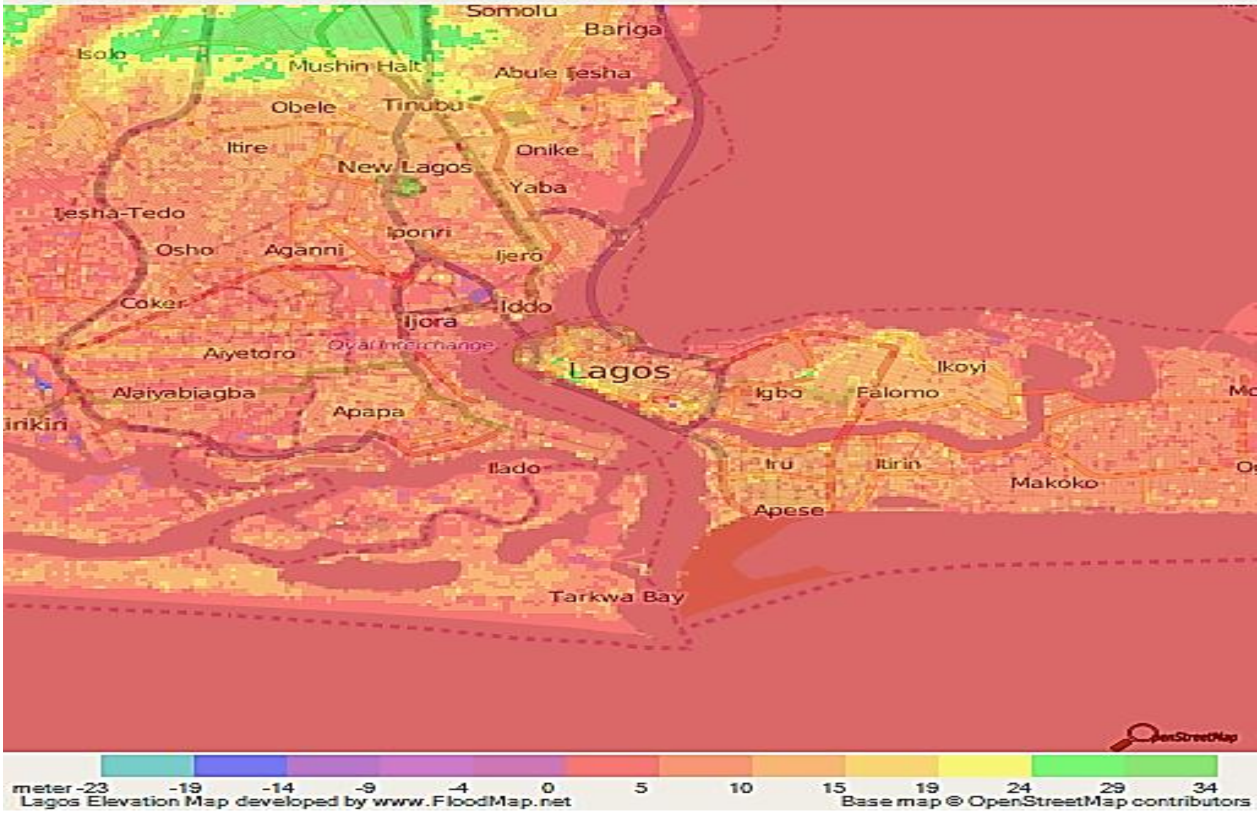


Figure 4.10 Lagos elevation map

Source : (www.floodmap.net)

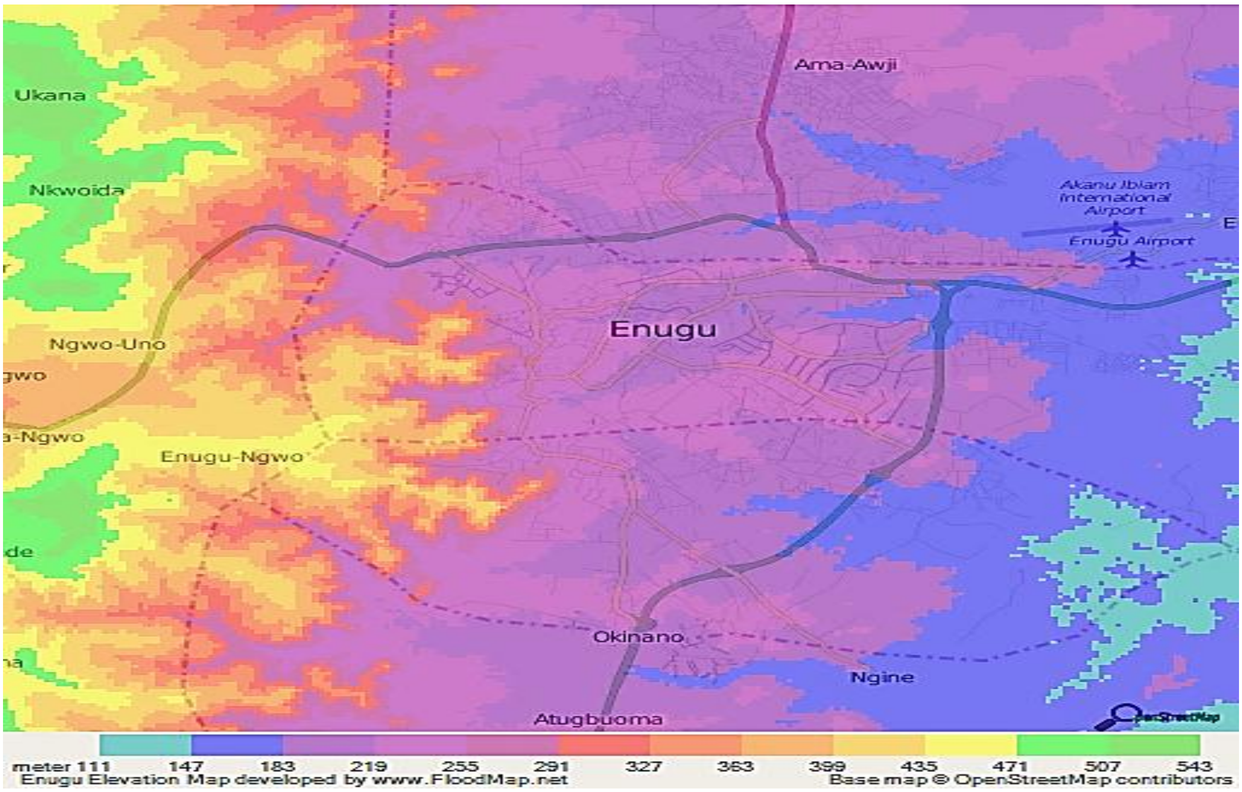


Figure 4.11 Enugu elevation map Source: (www.floodmap.net)

4.3.5 Geology and Hydrogeology of Neke Uno (Enugu)

The study area falls within one of the sedimentary Basins in Nigeria with geological coordinates of 06.65768^0 N, 007.54436^0 E, 06.65820 N, 007.54537^0 E, 06. 65634^0 N, 007.54508^0 E, 06.65693^0 N, 007.54607^0 E on an average altitude of 202m above sea level as shown in the aerial view using 2018 Digital globe-DE/BKG Version. The aerial view shown in figure 4.12 gave a pictorial glance of Nene Uno region in Enugu.

Figure 4.12 Aerial view of the proposed site at Nene Uno Relative to Settlement

The methodology adopted for this study includes field studies and high impact papers of previous researches carried out within the geologic basin. These researches addressed various aspects such as basin evolution and tectonics, biostratigraphy, sedimentology, sequence stratigraphy etc.

Regional Geology

The study area falls within the Lower Benue trough (precisely in Anambra Basin) of Nigeria (Figure 4.13). Nigeria is underlain by seven major sedimentary basins, viz: (from the oldest), the Calabar Flank, the Benue Trough, the Chad Basin, Sokoto Basin, the Dahomey Basin, and the Niger Delta Basin (Olade, 1975). Sedimentary successions in these basins are of middle Mesozoic to recent in age. According to Ojoh 1990, older sedimentary deposits were not preserved, probably because during the Paleozoic - early Mesozoic regional basement uplift, there was no major basin subsidence for sediment accumulation.

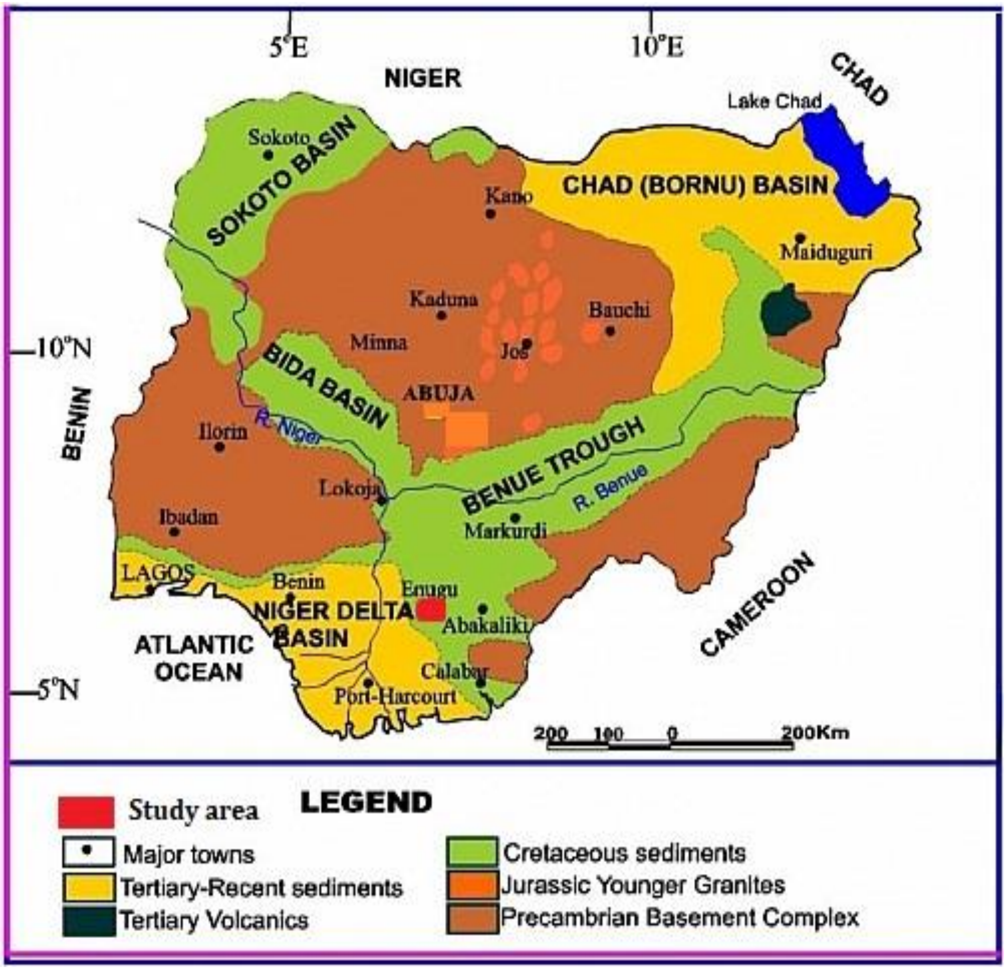


Figure 4.13 Map of Nigeria showing the sedimentary basins of Nigeria (Source: Obaje, 2009)

The Benue Trough of Nigeria is a rift basin formed under similar tectonic conditions and sedimentary environments that form other sedimentary basins of Nigeria (Nwachukwu, 1972). It extends NNE-SSW for about 800 km in length and 150 km in width. The southern limit is the northern boundary of the Niger Delta, while the northern limit is the southern boundary of the Chad Basin (Adeigbe and Salufu, 2010). The trough contains up to 6,000 m of Cretaceous - Tertiary sediments of which those pre-existing mid-Santonian sediments have been compressionally folded, faulted, and uplifted in several places. The Santonian thermo tectonic event uplifted the Albian-Coniacian sediments of Benue Trough into Abakaliki Anticlinorium with Anambra basin to the west and Afikpo Synclinorium to the east, and were filled with post-Santonian sediments (Nwajide and Reijers, 1996).

Sedimentation in the Anambra Basin commenced with the Campanian-Maastrichtian marine shales of the Enugu and Nkporo Formations, overlain by the coal measures of the Mamu Formation. The fluvio-deltaic sandstones of the Ajali and Owelli Formations lie on the Mamu Formation (Maastrichtian) and the marine shales of the Imo and Nsukka Formations were deposited during the Paleocene age, overlain by the tidal Nanka Sandstone of Eocene age (Nwajide, 2005).

Local Geology

The study area lies within the sedimentary environment of Anambra Basin whose thickness increases from north to south (down dip) and from east to west, located on the western part of Abakaliki Anticlinorium in South Eastern part of Nigeria. The surface geology is made up of undulating topography with a maximum height of 220m and different lithology as shown in figure 4.14, which are deposited during Early Campanian to Oligocene period.

Million years (m.y)	GEOLOGIC AGE	FORMATIONS	
30	Oligocene	Ogwashi-Asaba Formation	ANAMBRA SEDIMENTARY BASIN (STUDY AREA)
54	Eocene	Nsugbe Sandstone Nanka Formation (Ameki Group)	
65	Paleocene	Imo Formation Nsukka Formation	
73	Maastrichtian	Ajali Formation/ Mamu Formation	
83-87.5	Campanian	Nkporo Formation/ Enugu Shale	
	Santonian		LOWER BENUE TROUGH
88.5	Coniacian	Agbani Sandstone/Agwu Shale	
	Turonian	Eze Aku Group	
93 100 119	Cenomanian-Albian	Asu River Group	
Precambrian		Basement Complex	

Figure 4.14 Early Cretaceous-Tertiary strata in southeastern Nigeria

(modified; Nwajide, 1990)

Nsukka Formation: The Nsukka formation, described by Murat (1970) as the upper coal measures deposited during Late Maastrichtian - Early Paleocene, lies conformably on the Ajali sandstone. The lithology which serves as an Aquitard consists of dark gray interbedded shelly sandstone and siltstone which have become laterized in many places.

Obi *et al*, (2001) provides the sedimentological evidence that the Nsukka formation represented a phase of fluvio-deltaic sedimentation that began close to the end of the Maastrichtian and continued during the Paleocene. The depositional environment of the formation has been suggested to be in many ways similar to that of the Mamu formation (that is transitional/shoreline, deposited during regressive phase).

Mamu Formation: The deposits of the transgressive Nkporo cycle was overlain by the Lower Maastrichtian shales and the interbedded coal seams of Mamu formation in most parts of the

Anambra Basin [Akande *et al.,* 2011]. The Mamu formation was deposited as the broad shallow sea that existed at the time of deposition of the Nkporo/Enugu formation and gradually became shallower. Predominance of regression resulted to the deposition of the continental sequence of Ajalli formation on top of the Mamu formation, followed by a partially paralic conditions that were responsible to the deposition of Nsukka formation. The Mamu formation is restricted to the Anambra Basin and Afikpo Syncline in southeastern Nigeria [Kogbe, 1989].

Sedimentary Structures: These are visible features within sedimentary rocks that are formed at the time of deposition of sediments and processes that operate within the depositional environment. Some of the sedimentary structures encounter within the study area includes plane beddings and Laminated shales. Stratification is subsidized into plane bedding and lamination (laminar formation) depending upon the thickness of the strata, settings and pressure. Plates 4.3 and 4.4 shows plane bedding and laminar, respectively.

Plate 4.3 Plane Bedding

(N06.64902^0, E007.54422^0)

Plate 4.4 Laminar

(N06.63242^0, E007.54185^0)

Hydrogeology

The region has an undulating topography and the elevation varies between 201 and 313 m above sea level. The major land forms typical of this area are the residual hills and dry valleys. These two major geomorphic structures are the resultant effect of weathering and differential erosion of clastic materials which are remnant of Nsukka Formation. Ofomata (1980) recognized five types of these residual hills according to their shapes. These residual hills sometimes form outliers on the Ajali Sandstone and are capped by thick deposit of red earthy material and laterite. These laterites are permeable, particularly those of Ajali sandstone thereby allowing easy water percolation into the groundwater table during the rainy season. The Ajali Sandstone consists mainly of medium to coarse grained, characteristically white coloured sandstone but may be occasionally iron stained. The sandstone is very permeable and readily recharged in its outcrop belt around the Nsukka-Enugu escarpment (Agagu *et al.,* 1991). Nsukka formation has a significant groundwater potential and hosts a number of low to moderate yield wells within the study areas. A number of perched aquifer emerges from it and quite a number of low yield wells also tap the perched aquifer (Ezeigbo and Ozioko, 1997). The laterite capping in the area is aquiferous due to their vesicular nature, hence it is porous and permeable. These lateritic caps may be underlain by a less pervious clay beds leading to the formation of perched aquifer in some areas.

Table 4.7 Types of Aquifers around the Study Areas

Geologic formation	Hydrostratigraphic	Lithology	Aquifer type
Nsukka Formation	Nsukka aquitard	Clayey, sandstone,	Perched aquifer
Ajali sandsone	Ajali sandstone aquifer	Coarse-medium sand with clay interbed	Aquiferrous artesian
Mamu Formation	Mamu aquiclude	Siltstone, shale	Aquitard
Agwu shale	Agwu aquitard	Shale and siltsone alteration	Aquitard

Source: EEMS LIMITED, FIELDWORK, 2018

Groundwater flows generally from north to south, which is the regional flow direction in the Anambra basin. The major source of recharging of groundwater is by precipitation, Nnyrenke River System is the main drainage system within the study area.

4.3.6 Geology and Hydrogeology for Sheda (Abuja)

The study area falls within the northcentral Nigerian Basement Complex with geological coordinates of 08.8467^0 N, 007.04111^0 E, 08.84649^0 N, 007.04269^0 E, 08.84841^0 N, 007.04277^0 E, 08.84827^0 N, 007.04115^0 E, 08.84826^0 N, 007.04115^0 E, 08.84844^0 N, 007.04119^0 E on an average altitude of 198m above sea level as shown in the aerial view below using 2018 Digital globe-DE/BKG Version, shown in Figure 4.15.

Figure 4.15 Aerial View of the Proposed site at Sheda

Crystalline Formation: The study area is underplayed by migmatites, paragneisses, quartzites, calc-silicate rocks, biotite-hornblende schist and amphibolites which can be referred to as Migmatite-Gneiss complex (Dada, 2006). The Migmatite-Gneiss Complex displays ages varying from Pan African to Eburnean with three main geological phenomena recorded (Rahaman and Lancelot, 1984); The first at 2,500 Ma, involved in initiation of crust forming process and of crustal growth by sedimentation and orogeny; the second event was the Eburnean; 2,000 + 200 Ma, marked by the granite gneisses, which structurally obliterated the older rocks and re-set the geochronological clock to give rise to granite gneisses, migmatites and other similar lithological units (Adelana *et al*., 2008).

Plate 4.5 Geologic Features observed within the study area

Plate 4.5 shows the physical feature of the earth's surface or rocks exposed at the surface, depicting the landforms and ecosystems of the study area.

The lithological cross section observed in the study area are best described through the results of VES studies (e.g. Amadi *et al.,* 1990). Typical resulting curves are of QHA, KHA, KH, KQA or HKHK type showing 4 – 6 layers. These curves serves as indication to resistivity variations with depth and lithology. The first two uppermost layers are interpreted as possibly lateritic topsoil underlain by dry regolith of layers 3 and 4, which lie over wet weathered basement. The geoelectric substratum could possibly be of undifferentiated basement units. Sometimes, the top layer reflects a micaceous fine earthy material that is then underlain by regolith that makes up the geoelectric layers. These layers contain water with downward decreasing saturations and a characteristic clayey nature.

Hydrogeology

Groundwater in the study area occurs in the soft overburden aquifer and fractured bedrock aquifer. Hand dug well (08.8650^{0}N, 007.0596^{0}E) within the study area are shallow therefore they tap water only from soft overburden aquifer. It is only some boreholes that tap water from fractured bedrock aquifer because they are drilled with mechanized equipment. The thickness of soft overburden aquifer in the study area is between 10 m (Olorunfemi, 1993).

Water Table Configuration and Directions of Groundwater

Movement of water is strongly influenced by topography; recharge is mainly by percolating rainwater and in some places by seepages from adjacent surface water. Recharge areas consists of decomposed and fractured rocks in which pressure heads quickly spread through local water-bearing fissures and interconnected voids, thereby leading to abrupt rise in discharges in response to precipitation (Abdulsalam and Ologe, 2013). Surface topography dictates groundwater flow directions. This may reflect varying degrees of weathering at different groundwater fronts and the occurrence of the fresh basement at different depths at different locations.

The depth of groundwater in the area is dependent on the topography, climate, thickness, and depth of aquifer at a certain point in time. The aquifers lack recharge during dry season due to lack of rain and capacity utilization of groundwater, which brings about fluctuation of depth in groundwater level.

As for the deep-seated weathered basement aquifer, the depth to the water table ranges from 10- 30m with water level of 20m in the wet season. In the shallow overburden aquifer, the water level during the wet season is between the surface in lowland areas and about 10-15m in highland areas.

Aquifer Properties

The porosity of the study area varies from the highly porous and permeable overburden to the less porous and permeable weathered basement rock. The weathered migmatites are rich in clay minerals hence less permeable. Permeability of different types of soils by Todd (1959) gives the soil in the weathered basement aquifer a coefficient of permeability value of 100-102 gal/day (poor) while that of the overburden ranges from 102- 104 gal/day (Good), the deeper fractured rock aquifer (if so confirmed) is characterized by high permeability and high flow rate. The two main types of aquifer in the study area are the weathered basement and the joint fractured basement aquifer with the latter sometimes occurring below the former. Areas such as this hold more potential for ground water than areas with only weathered basement.

4.3.7 Geology and Hydrogeology for Epe

The study area falls within one of the sedimentary basins in Nigeria with geological coordinates of 6.628458° N, 3.920790°E, 6.628260° N, 3.921228° E, 6.627878° N, 3.921060° E, 6.628060° N, 3.920561° E on an average altitude of 8m above sea level as shown in the aerial view below using 2018 Digital globe-DE/BKG Version. The ariel view shown in Figure 4.16 gave a pictorial glance of the site, near Epe in Lagos State.

Figure 4.16 Aerial view of the proposed site at Epe

The methodology adopted for this study includes field studies and high impact papers of previous researches carried within the geologic basin. These researches addressed various aspects such as basin evolution and tectonics, biostratigraphy, sedimentology, sequence stratigraphy etc.

Regional Geology

The study area falls within one of the sedimentary basins of Nigeria, Dahomey Basin as shown in Figure 4.17. The Basin covers the southern areas of Lagos, Ogun and Ondo States in Nigeria and stretches into Benin Republic (Amadi *et al*., 1990). Dahomey basin constitutes part of a system of West African margin developed during a brief period of rifting in the late Jurassic to Early Cretaceous, associated with the Benin Trough Complex. It was accompanied by an extended period of thermally induced basin subsidence through the Middle to Upper Cretaceous to Tertiary times as the South American and African plate entered a drift phase (Omatosola & Adegoke, 1981). The basin stretches along the coast of Nigeria and is separated from the Niger delta by Benin Hinge Line and Okitipupa Ridge (Onuoha,1999). It is bounded to the west by the Romanche Fracture Zone (Burke *et al.,* 2003). Dahomey basin is made up of structural elements such as Onshore, the Okitipupa structure and Offshore (Billman 1992). According to Haack *et al.,* (2000), these structural elements have gone three main stages of basin evolution; predrift phase, prolonged transitional phase and open marine (drift phase).

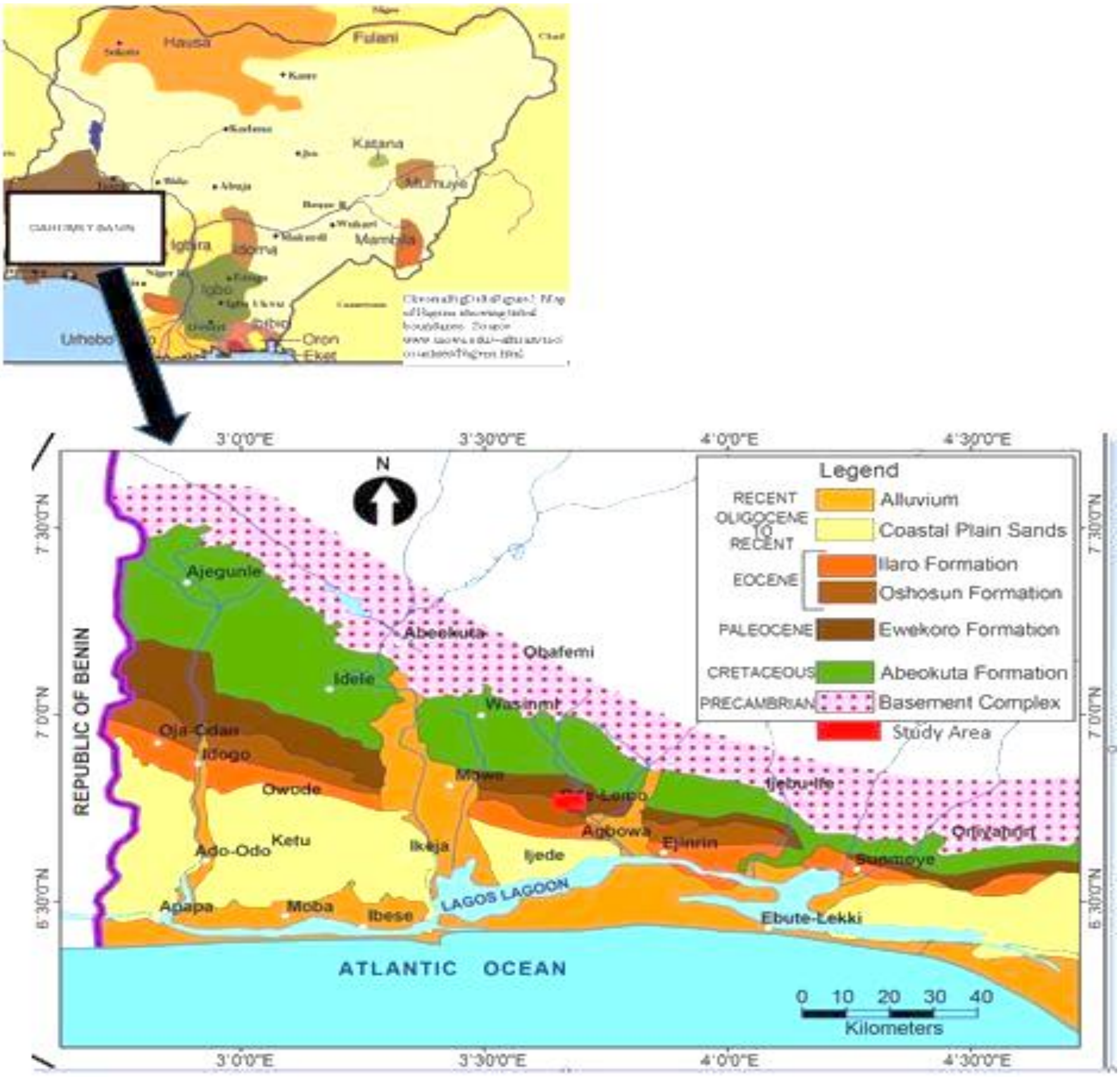


Figure 4.17 Geologic map of dahomey basin showing the study area. (Obaje, 2009)

The lithology of the Dahomey basin as outlined in table 1 are mainly sands, clays and limestones (Longe *et al*., 1987). The basement complex which forms the basement rocks in the basin is overlain in succession by the cretaceous Abeokuta formation which is sandy with interbedded shales and limestone formation, followed by the Tertiary Ewekoro formation comprising of limestone, clays and shales and the Ilaro formation consisting of clays and shales followed by the poorly sorted coastal plain sands and recent alluvial deposits.

Local Geology

The PCB site lies within the sedimentary environment of Dahomey basin. The surface geology is made up of lithoral and lagoonal sediments of the coastal belt (unconsolidated sandstone) which are deposited during the Quanternary Era as shown using the geologic time scale (Table 4.8).

Table 4.8 Geologic Time Scale of Dahomey Basin Showing the Study Area

ERA	EPOCH	LITHOLOG	
QUATERNARY	Holocene to Pleistocene	Coastal Plain Sands	Study Area
	Pliocene	Sandstone and Clay conglomerates	
	Miocene		
	Oligocene	Siltstone	
	Eocene	Shale and Limestone	
TERTIARY	Paleocene		

(modified from Omotasola *et al* 1981)

Coastal Plain Sands: This consists of fine to medium poorly sorted sands with lenses of clays. The sandstones are white to light grey which shows nearshore depositional environment. The formation age covers the Holocene to Late Pliocene periods. The pictorial view of coastal plain sands at Epe site is depicted in plate 4.6.

Plate 4.6 Plain sands observed within the study area

(6.626709°, 3.914204°)

Hydrogeology

The study area is drained by tributaries of Lekki Lagoon in a dendritic flow pattern. it is located about 2.4km to the bank of River Lagos which undergo significant shifting during flood periods. The area is a rolling plain with variable elevations from 9meters above sea level and is subject to periodic flooding.

The PCB project site is characterized by Mangrove (saltwater) and freshwater swamps where aquifers, though readily recharged by rainfall are however vulnerable to saline water intrusion. Given the variability of the sedimentary deposition and energy of the surface waterway flows, the existence of two types of aquifers (multilayer and monolayer aquifers) can be hypothesised.

A multi-layer aquifer is made up of several overlapping water bearing layers, hydraulically separated by less permeable clayey layers. Figure 4.18 gives an example of an alluvial aquifer of the multi-layer type, with continuous impermeable strata which defines a hydraulic separation. The sedimentary formations hosts several strata hydraulically separated by impermeable strata as seen in the Figure 4.18 by the various piezometric loads with hypothetical measuring pipes positioned at various depths.

Thus, a monolayer aquifer is made up of one sedimentary body in which there is absence of less- permeable separation strata; the sedimentary body hosts a single water-bearing layer. In this case, the hydraulic loads measured at different levels are identical. In the case of multi-layer aquifer, the supply to the 1st aquifer is given by the direct recharge produced by rainfall in the area where the clayey cover is absent and by the exchange with surface waterways. The groundwater circulation of the 1st aquifer is strictly connected to the fluvial regime. Depending on the season, the Lagoon may drain or be drained by the groundwater of the 1st aquifer. The mono-layer aquifer is fed by direct recharging due to rainfall and by the exchange with the surface waterways.

The previously described lithofacies have different permeability characteristics depending on the content of clay or lime components. The presence of a medium-low permeable clayey layer favors the formation of swampy areas during the wet season. This layer offers protection to the underlying aquifer against any percolation of surface water, even though the degree of protection depends on the thickness of the strata and its permeability. The Coastal Plain Sands were the major aquifers exploited in the past but presently, drilling for water supply target the deeper Abeokuta Formation. This is because of excessive drawdown (progressive decline in head) associated with boreholes tapping the phreatic aquifers of the Coastal Plain Sands and the consequent problem of saline water intrusion already manifested within the study area.

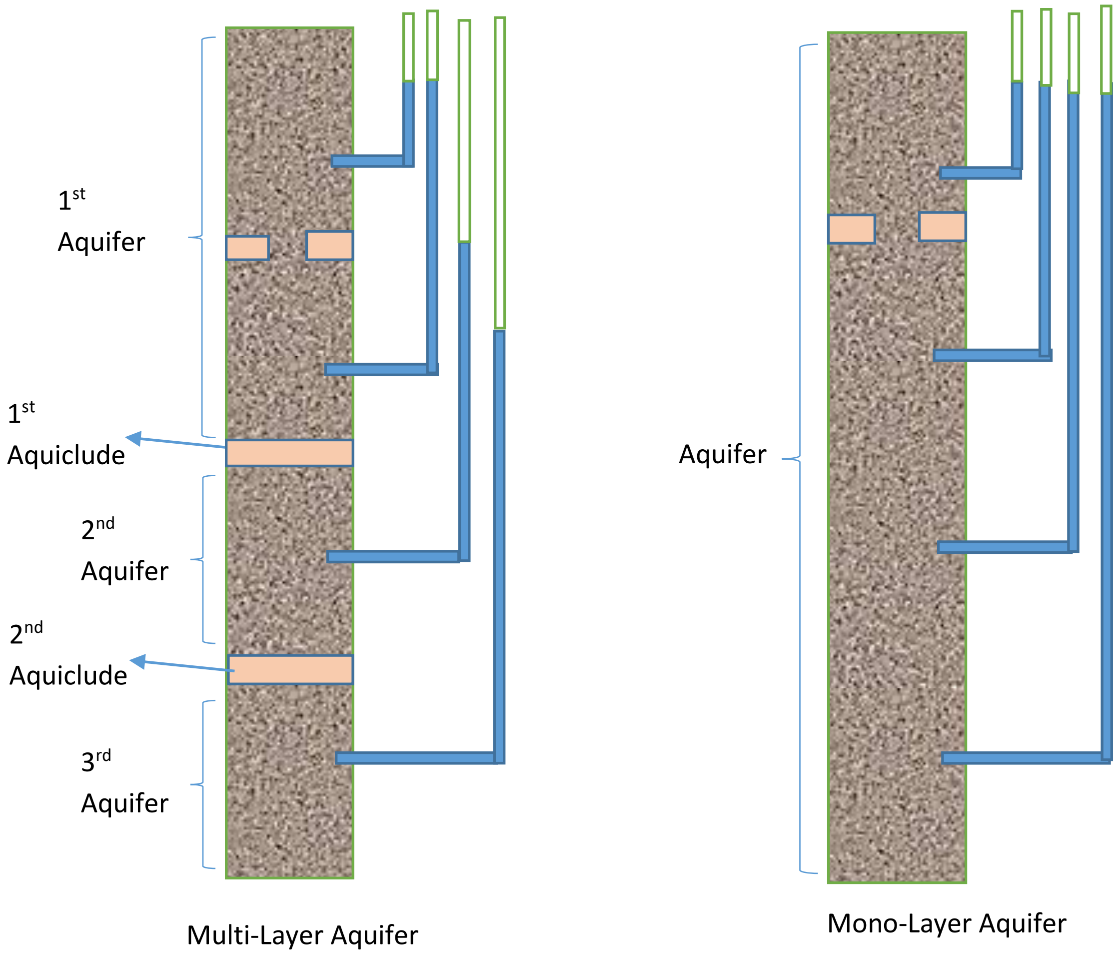


Figure 4.18 Multi-layer and Mono-layer Aquifer System

4.3.8 Soil Quality and Land Use

The soil baseline survey component of the environmental impact assessment was carried out to achieve the following stated objectives.

- Establish base line data of soil properties on the three selected sites at Neke Uno in Enugu State, Epe in Lagos State, and Sheda along Abuja-Lokoja Expressway for the plans to establish PCBs Collection, Storage and Treatment Centres in Nigeria.
- Identify possible impact of the project on soils of the PCBs centre.
- Proffer mitigation measures related to the identified impact of the project on soils of the PCBs centre.

To achieve the stated, the following baseline soil data was obtained during the field survey across the study areas.

- Topographical, soil and land use data
- Collection of soil samples at three points within each of the three locations with one control point outside the corridor.

- The sampling points shall be geo-referenced with geographic positioning system (GPS) and picture of environmental activities along the corridor.
- The soil samples will be use to analyze both physical and chemical parameters relevant to the project.
- Provide soil and land use information to allow further analysis of the impacts of the project.
- Propose soil management measures; identify costs of the measures and monitoring indicators.

4.3.8.1 Description of Survey Areas

The Sheda site within Kwali Development Council consists of gently undulating high plains developed on basement complex rocks that comprised of undifferentiated granite, migmatite and granite gneiss. Inselbergs of older granites and low hills of schists rise conspicuously above the plains (Ojanuga, 2006). The climate of Sheda site is sub-humid with mean annual rainfall greater than 1016 mm, with rains substantially between April and October (150 – 210 days), with ustic soil moisture regime. The mean annual temperature ranged between 25 and 27 ^{o}C. Sheda area is situated within wooded savanna. A wide range of crops are grown within the area and consists of cassava, maize, millet, groundnut, sorghum and rice (Ojanuga, 2006).

The survey area at Epe, Lagos State is characterized by relatively flat to very gently undulating plains developed on sedimentary rocks and littoral deposits (deep sands and mud). It is occupied by coastal strips of land consisting of creeks, lagoons, freshwater and saline swamps, raised alluvium flats, shale and limestone (Ojanuga, 2006). The area elevation is mostly less than 10m above sea level. The area at Epe is mostly poorly drained and characterised by deciduous forest, freshwater forest and swamp forest vegetation. Lagos site (Epe) is located within very humid lowland. The area is mostly poorly drained. The climate consists of rainfall period between 240 and 300 days, and 1520 to 2000 mm mean annual rainfall amount. Land of Epe area consists of tree crops, oil palm, cassava and fish farming.

The study area at Neke Uno, Enugu East LGA consists of flat to rolling plains developed on cretaceous (shales and mudstone) sediment referred to as sedimentary formation of Nkporo group (NGSA, 2004). Rising above the plains is steep sided escarpments (scarplands) capped with concretionary ironstones or ironstone boulders (Ojanuga, 2006). Elevation of the area is generally less than 200m above sea level. The Neke Uno survey area is within the very humid lowland and scarpland with agroecological zone that is characterised by 1,520 to 2,000 mm mean annual rainfall. The rainfall pattern is bimodal and ranged between 240 and 300 days per annum, hence has udic soil moisture regime (Ojanuga, 2006). The mean annual temperature varied between 26 and 27 ^{o}C. It is situated within semi deciduous forest and derived savanna. Farming activities are characterised by arable crop production of maize, cassava and yam (on mounds), and rice cultivation on both floodplain and upland areas.

4.3.8.2 Soil Sampling Techniques

Soils samples were collected by simple random sampling system at three (3) different points (A, B and C) within the PCBs proposed sites. Soil sampling was conducted along the field slope direction and in a diagonal traverse to ensure the different soils distribution within the proposed PCB sites were sampled as representative of the entire area. The sampling distance was fairly equal across the entire area. Fourth soil sample was collected outside the PCBs site adjacent to the center of the area serving as control point (D).

Two (2) soil samples were collected at each point at 0 – 15 cm and 15 – 30 cm depths using auger (see Plates 4.7a – 4.7c). The soil sampling locations were georeferenced with a handheld geographic positioning system (GPS) (*Garmin Etrex 20* model). A total of eight (8) soil samples were collected at each PCBs proposed site making a total of 24 samples for wet and 24 samples for dry season.

Selected soil morphological characteristics and physiographic (environmental) features of the locations recorded include: locality, local relief in terms of slope, erosion hazard, land use, extent of vegetation, texture, and drainage conditions (FAO, 2006).

Parameters Investigated

The following parameters were analysed according to standard procedures adopted by established standard organs at Juwara Environmental Services Limited, Lagos and SHESTCO Sheda Abuja, in order to characterize the soil.

- Particle size distribution and texture using USDA textured triangle.
- Soil reaction (pH) in water.
- Exchangeable bases (Ca, Mg, K and Na)
- Exchange Acidity
- Effective cation exchange capacity (ECEC)
- Organic carbon
- Phosphorus.
- Total nitrogen, nitrate.
- Available micronutrients (Zn, Fe, Mn and Cu) and heavy metals (Ni, Cd, Cr and Pb) determined and read by atomic adsorption spectrophotometer (AAS).

Plate 4.7 shows how EEMS' staff employed Auger in collecting soil sample at Epe, Neke-Uno and Sheda sites. The site at Sheda was observed to be very useful in the growth of useful crops like sorghum and beans as depicted in plate 4.8

(a) Epe Site (b) Neke-Uno Site (c) Sheda Site

Plate 4.7 Soil Sample Collection Using Auger

Plate 4.8 Sorghum and Beans Cultivation on the Sheda Site

DESCRIPTION OF SOIL PROPERTY AND LAND USE FOR SITE AT EPE

This sub-section gives a detailed description of physical, chemical, physiographic and morphological properties of soil samples taken at Epe site.

Soil Physiographic and Morphological Properties

The landscape physiographic and soil morphological characteristics are presented in Table 4.9. Soils of the PCBs project site at Epe are located within middle slope (Point C) to lower slope (Point A and B) position, whereas the control (Point D) falls within floodplain (swamps).

The soils were well drained within the sampling depth of 0 to 30 cm, except for the control point that was very poorly drained with water table virtually close to surface and some portions were inundated (Plate 4.9). The area within the project site was generally on gently / undulating slope (2 - 4%), while the control point (Point D) was nearly level (0 – 2 %; Table 4.9). The thick forested vegetation covered the soil surface from erosion soil degradation. Large portion of the upland soil surface was not characterized by any form of erosion.

Physical Properties

Sand dominated particle size of soils within the PCBs project site at Epe with values varied between 700 to 800 g kg^{-1}, and did not vary with depth, However the highest value was recorded at the control sampling area (Point D). Silt content was constant across the landscape, and was recorded as 100 g kg^{-1} (Table 4.10). Clay content ranged between 100 and 200 g kg^{-1} in the soils and increased from Point D (Control) to Point A and C where the maximum was recorded.

The trend of particle size distribution within the project area was quiet similar resulting in similar soil texture of sandy loam across the entire area.

Chemical Properties

Chemical properties of the soils collected at Epe are presented in Table 4.11. Soil reaction varied between moderately acid and slightly acid (Soil Science Division Staff, 2017), with pH values ranging between 5.60 and 6.45. The soil reaction is within range of most nutrient availability for crops. The soil unit may not likely develop salinity or sodicity as the values are quiet low. Exchangeable calcium (Ca) and magnesium (Mg) were generally low and varied between 0.16 and 0.33 cmol/kg and 0.13 and 0.19 cmol/kg respectively. Sodium (Na) and potassium (K) were varied between low and medium (Table 4.11).

Plate 4.9 Swamp Forest Showing Inundated Soil Surface at Epe Area

Table 4.9 Physiographical and Morphological Properties of Project Site at Epe, Lagos State

Location Description	Sample Code	Depth (cm)	Co-ordinate		Topography		Drainage	Erosion	Land Use
			Latitude (°N)	Longitude (°E)	Position (Elevation m ASL)	Gradient (%)			
Point A	SS-2210-EPE-01	0 - 15	06.62556	003.92069	Lower slope (5.0)	Gently/ Undulating (2 - 4)	Well drained	None	Forest
Point A	SS-2210-EPE-02	15 - 30	06.62556	003.92069	Lower slope (5.0)	Gently/ Undulating (2 - 4)	Well drained	None	Forest
Point B	SS-2210-EPE-03	0 - 15	06.62727	003.92111	Lower slope (9.0)	Gently/ Undulating (2 - 4)	Well drained	None	Forest
Point B	SS-2210-EPE-04	15 - 30	06.62727	003.92111	Lower slope (9.0)	Gently/ Undulating (2 - 4)	Well drained	None	Forest
Point C	SS-2210-EPE-05	0 - 15	06.62681	003.92070	Middle slope (12.0)	Gently/ Undulating (2 - 4)	Well drained	None	Forest
Point C	SS-2210-EPE-06	15 - 30	06.62681	003.92070	Middle slope (12.0)	Gently/ Undulating (2 - 4)	Well drained	None	Forest
Point D (Control)	SS-2210-EPE-07	0 - 15	06.62753	003.92158	Flood plain (swamps) (4.0)	Nearly level (0-2)	very poorly drained	None	Cleared forest
Point D (Control)	SS-2210-EPE-08	15 - 30	06.62753	003.92158	Flood plain (swamps) (4.0)	Nearly level (0-2)	very poorly drained	None	Cleared forest

Table 4.10 Physical Properties of Project Site at Epe, Lagos State

Sampling Point	Sample Code	Depth (cm)	Co-ordinate		Particle Size Distribution (gkg^{-1})			Soil Texture
			Latitude	Latitude	Sand	Silt	Clay	
Point A	SS-2210-EPE-01	0 - 15	06.62556	003.92069	700	100	200	SL
Point A	SS-2210-EPE-02	15 - 30	06.62556	003.92069	700	100	200	SL
Point B	SS-2210-EPE-03	0 - 15	06.62727	003.92111	750	100	150	SL
Point B	SS-2210-EPE-04	15 - 30	06.62727	003.92111	750	100	150	SL
Point C	SS-2210-EPE-05	0 - 15	06.62681	003.92070	700	100	200	SL
Point C	SS-2210-EPE-06	15 - 30	06.62681	003.92070	700	100	200	SL
Point D (Control)	SS-2210-EPE-07	0 - 15	06.62753	003.92158	800	100	100	SL
Point D (Control)	SS-2210-EPE-08	15 - 30	06.62753	003.92158	800	100	100	SL

SL = Sandy loam

Calcium and Sodium decreased with depth across the soils, while Mg and K variation was irregular with increase in soil depth. The somewhat low content of exchangeable bases in these soils may be attributed to leaching process contributed by high sand content and high amount of rainfall in the area. The values of exchangeable bases were far below critical limit of toxicity set by NESREA (2007). Exchangeable acidity was constant across the soils with value recorded as 0.02 cmol/kg.

Effective cation exchange capacity (ECEC) was summed from the exchangeable bases and acidity, and ranged between 0.66 and 0.98 cmol/kg and was rated as low (Enwezor *et al.,* 1989). Base saturation was rated as high and varied from 98.75 to 98.95 %.

High vegetative cover of the area significantly contributed to organic matter content of these soils and varied between medium to high with values of 14.00 to 45.00 g/kg. The organic matter is expected to contribute to the cation exchange capacity (CEC) of the soils for adsorption and retention of soil chemical pollutants as the sand content was reportedly high in the soils. The content of total nitrogen and nitrate were very low, and varied from 0.40 to 0.80 gkg^{-1} and 0.02 to 0.30 $mgkg^{-1}$ respectively. Phosphorus and sulphate were high (Table 4.11), but did not exceed the critical limit of NESREA (2007). The PCBs site was reported not to have oil and grease (0.00 mg/kg), and may be due to non-spillage or Below Detectable Limit (BDL) of the analytical equipment.

Table 4.11 Chemical Properties of Project Site at Epe, Lagos State

Parameter	**Unit**	**Point A**		**Point B**		**Point C**		**Point D (Control)**	
Sample Code		SS-2210-EPE-01	SS-2210-EPE-02	SS-2210-EPE-03	SS-2210-EPE-04	SS-2210-EPE-05	SS-2210-EPE-06	SS-2210-EPE-07	SS-2210-EPE-08
Depth	cm	0 - 15	15 – 30	0 – 15	15 – 30	0 - 15	15 - 30	0 – 15	15 – 30
Soil pH	-	6.05	6.10	6.10	6.05	6.40	6.45	5.60	5.75
Calcium	cmol/kg	0.33	0.18	0.18	0.16	0.20	0.18	0.18	0.16
Magnesium	cmol/kg	0.16	0.15	0.13	0.19	0.16	0.15	0.13	0.19
Sodium	cmol/kg	0.14	0.11	0.15	0.11	0.13	0.11	0.15	0.11
Potassium	cmol/kg	0.35	0.33	0.20	0.23	0.35	0.33	0.20	0.23
Exchangeable Acidity	cmol/kg	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
ECEC	cmol/kg	0.98	0.80	0.66	0.72	0.84	0.80	0.66	0.72
Base Saturation	%	98.80	98.95	98.80	98.75	98.80	98.85	98.80	98.75
Organic Carbon	g/kg	42.50	41.70	25.00	14.00	45.00	41.70	25.00	14.00
Total Nitrogen	g/kg	0.70	0.60	0.50	0.40	0.80	0.60	0.50	0.40
Nitrate	mg/kg	0.02	0.02	0.30	0.25	0.02	0.02	0.30	0.25
Phosphorus	mg/kg	140.15	115.50	130.10	127.40	135.10	115.50	130.10	127.40
Sulphate	mg/kg	13.20	8.60	20.40	18.70	11.25	8.60	20.40	18.70
Oil &Grease	mg/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Micronutrients									
Copper	mg/kg	0.47	0.64	0.43	0.84	0.45	1.60	9.43	0.69
Iron	mg/kg	34.20	31.80	35.62	31.06	30.81	32.65	30.80	32.71
Manganese	mg/kg	42.26	47.26	28.10	25.20	22.04	20.16	22.10	15.70

Zinc	mg/kg	0.88	1.27	5.48	4.11	1.00	21.89	4.02	0.68
Heavy Metals									
Lead	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8.05	<0.001
Nickel	mg/kg	0.10	0.11	0.05	0.03	0.20	0.15	0.05	0.03
Cadmium	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.40	<0.001
Chromium	mg/kg	0.10	0.11	0.16	<0.001	0.32	<0.001	2.54	<0.001

Micronutrient contents of the soils are presented in Table 4.11. The content of Fe and Mn were generally high ranging between 30.80 and 35.62 mg kg^{-1} and 15.70 and 47.26 mg kg^{-1}, respectively. Copper and zinc were rated as medium to high and very low to high respectively. The values of most of the micronutrients were adequate for purpose of crop production. However, toxicity or pollution is not expected within the soil of this area as the values have not attained or exceed the critical desirable limits for pollution within soil as reported in literatures (NESREA, 2007; Kabata-Pendias, 2011; Alloway, 1995).

The values of lead (Pb) and cadmium (Cd) were mostly in trace quantity (<0.001 mg kg^{-1}), except in the surface horizon (0 – 15 cm) Point C that was recorded as 8.05 mg kg^{-1} and 0.04 mg kg^{-1} respectively. The values accounted for in Point C may be associated with anthropogenic activity on the exchange site. The content of nickel (Ni) and chromium (Cr) ranged between 0.03 and 0.20 mg kg^{-1}, and between <0.001 (trace) and 2.54 mg kg^{-1} (Table 4.11). The values were below critical limits in soil reported by NESREA (2007) and Kabata-Pendias (2011) that may be regarded as polluted soil. In the future, there is need for environmental audit to ascertain the status of these heavy metals in soils, as anthropogenic activities have been reported to cause soil pollution.

Land Use

The site is characterised by thick forested area (Plate 4.10), however presence of dump car parts and scraps were found around point A indicating the previous use of the area for dumping of car scraps and parts by the adjacent company. The control point was a recently cleared of its thick vegetation (Plate 4.11).

Plate 4.10 Forested land use within PCB fenced site at Epe site

Plate 4.11 Swamp forest within control sampling point at Epe, Lagos State

DESCRIPTION OF SOIL PROPERTY AND LAND USE FOR SITE AT NEKE UNO

This sub-section gives a detailed description of physical, chemical, physiographic and morphological properties of soil samples taken at Neke Uno site.

Soil Physiographic and Morphological Properties

The soils within the PCB project area were on a gentle / undulating topography with slope between 2 % and 4 %, and occupy upper (Points B, C and D) to middle slope (Point A) positions within the landscape (Table 4.12). The soils were well drained with no erosion of any form characterizing the surface of the study area as was covered by the vegetation of the present land use.

Physical Properties

The soils of Neke-Uno-Neke were enriched by deposited material eroded from the surrounding hill, and sand dominated the particle size distribution with values ranging between 750 and 800 g kg^{-1} in the soils which slightly increased from surface to subsurface horizon (Points A and D) in Table 4.13 or remained constant (Points B and C; Table 4.13). Silt was constant across the landscape and with soil depth with value recorded as 100 g kg^{-1}. Clay content varied between 100 and 150 g kg^{-1} in the soils and decreased from surface to subsurface horizon (Points A and D), while Points B and C were constant (Table 4.13). Soil texture was similar across the entire project area, and was recorded as sandy loam.

Chemical Properties

Soil reaction was rated as moderate to slightly acid, and the pH ranged between 5.80 and 6.25. The values of pH were considered to be within range of most nutrient availability for crops. The soils in this area may not likely develop salinity or sodicity in the near future as the pH values were quiet low and the sand content was high with adequate rainfall to permit leaching of any excess salt applied within the environment. Exchangeable Ca and Mg were generally low across the soils of the PCB project area (Table 4.14) (Enwezor *et al.,* 1989). Sodium and K ranged between 0.10 and 0.15 cmol/kg and 0.14 and 0.30 cmol/kg respectively, and were rated medium and low to medium. The values decreased with increase in soil depth.

Table 4.12 Physiographical and Morphological Properties of Neke Uno Site

Location Description	Sample Code	Depth (cm)	Co-ordinate		Topography		Drainage	Erosion	Land Use
			Latitude (N°)	Longitude (E°)	Position (Elevation m ASL)	Slope Gradient (%)			
Point A	SS-2310-NUN-01	0 - 15	06.65787	007.54535	Middle slope (202)	Gently/ Undulating (2 - 4)	Well drained	None	Oil palm, Maize and Cassava
Point A	SS-2310-NUN-02	15 - 30	06.65787	007.54535	Middle slope (202)	Gently/ Undulating (2 - 4)	Well drained	None	Oil palm, Maize and Cassava
Point B	SS-2210-NUN-03	0 - 15	06.65720	007.54530	Upper slope (203)	Gently/ Undulating (2 - 4)	Well drained	None	Cassava
Point B	SS-2210-NUN-04	15 - 30	06.65720	007.54530	Upper slope (203)	Gently/ Undulating (2 - 4)	Well drained	None	Cassava
Point C	SS-2210-NUN-05	0 - 15	06.65664	007.54513	Upper slope (204)	Gently/ Undulating (2 - 4)	Well drained	None	Cassava
Point C	SS-2210-NUN-06	15 - 30	06.65664	007.54513	Upper slope (204)	Gently/ Undulating (2 - 4)	Well drained	None	Cassava
Point D (Control)	SS-2210-NUN-07	0 - 15	06.65884	007.54459	Upper slope (204)	Gently/ Undulating (2 - 4)	Well drained	None	Fallow
Point D (Control)	SS-2210-NUN-08	15 - 30	06.65884	007.54459	Upper slope (204)	Gently/ Undulating (2 - 4)	Well drained	None	Fallow

Table 4.13 Physical Properties of Neke Uno Site

Sampling Point	Sample Code	Depth (cm)	Co-ordinate		Particle Size Distribution (gkg^{-1})			Soil Texture
			Latitude (N^o)	Longitude (E^o)	Sand	Silt	Clay	
Point A	SS-2310-NUN-01	0 - 15	06.65787	007.54535	750	100	150	SL
Point A	SS-2310-NUN-02	15 - 30	06.62556	003.92069	800	100	100	SL
Point B	SS-2210-NUN-03	0 - 15	06.65720	007.54530	800	100	100	SL
Point B	SS-2210-NUN-04	15 - 30	06.65720	007.54530	800	100	100	SL
Point C	SS-2210-NUN-05	0 - 15	06.65664	007.54513	750	100	150	SL
Point C	SS-2210-NUN-06	15 - 30	06.65664	007.54513	750	100	150	SL
Point D (Control)	SS-2210-NUN-07	0 - 15	06.65884	007.54459	750	100	150	SL
Point D (Control)	SS-2210-NUN-08	15 - 30	06.65884	007.54459	800	100	100	SL

SL = Sandy loam

The values of exchangeable bases were far below critical limit of toxicity set by NESREA (2007). Exchangeable acidity was constant across the soils with value recorded as 0.02 cmol/kg. Effective CEC ranged between 0.45 and 0.80 cmol/kg and was rated low (Enwezor *et al.,* 1989). Base saturation was rated high and varied between 98.30 and 98.80 %.

The contents of organic carbon (OC) varied between medium to high with values of 13.00 to 41.00 g/kg, is expected to contribute to CEC of the soils for adsorption of soil chemical pollutants as the sand content was reportedly high in the soils. Total nitrogen (TN) and nitrate were very low, and ranged between 0.80 and 1.20 $mgkg^{-1}$ and 0.02 and 0.10 $mgkg^{-1}$ respectively. Phosphorus was high, while sulphate was low to high (Table 4.14). The values of OC, TN, nitrate, phosphorus and sulphate decreased with depth, and were generally below the critical limit of NESREA (2007). The PCB site did not experience any deposition or spillage of oil and grease pollutant, and values were determined as 0.00 mg/kg across the area.

Table 4.14 Chemical Properties at Neke-Uno Site

Parameter	Unit	Point A		Point B		Point C		Point D (Control)	
Sample Code		SS-2310-NUN-01	SS-2310-NUN-02	SS-2310-NUN-03	SS-2310-NUN-04	SS-2310-NUN-05	SS-2310-NUN-06	SS-2310-NUN-07	SS-2310-NUN-08
Depth	cm	0 - 15	15 – 30	0 - 15	15 – 30	0 - 15	15 – 30	0 – 15	15 – 30
Soil pH	-	6.10	5.80	6.20	6.15	6.25	6.10	6.10	6.20
Calcium	cmol/kg	0.20	0.18	0.27	0.26	0.20	0.22	0.20	0.18
Magnesium	cmol/kg	0.18	0.15	0.13	0.15	0.13	0.15	0.18	0.15
Sodium	cmol/kg	0.12	0.11	0.11	0.10	0.15	0.10	0.12	0.11
Potassium	cmol/kg	0.30	0.25	0.18	0.14	0.30	0.25	0.30	0.25
Exchangeable Acidity	cmol/kg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
ECEC	cmol/kg	0.80	0.69	0.69	0.45	0.78	0.72	0.80	0.69
Base Saturation	%	98.70	98.60	98.70	98.80	98.70	98.30	98.70	98.60
Organic Carbon	g/kg	20.50	13.00	24.50	24.00	41.00	37.00	20.05	13.00
Total Nitrogen	g/kg	1.10	1.00	1.10	0.80	1.20	1.10	1.10	1.00
Nitrate	mg/kg	0.10	0.05	0.02	0.02	0.03	0.02	0.10	0.05
Phosphorus	mg/kg	110.30	95.10	118.00	115.00	110.00	95.20	110.30	95.10
Sulphate	mg/kg	11.50	10.60	10.40	9.50	11.25	20.50	11.50	10.60
Oil &Grease	mg/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Micronutrients									
Copper	mg/kg	0.72	0.80	0.74	0.86	2.10	1.40	0.72	0.80
Iron	mg/kg	41.24	40.08	41.00	40.55	180.00	140.00	41.24	40.08
Manganese	mg/kg	38.00	40.22	26.98	25.93	120.00	110.30	38.00	40.22
Zinc	mg/kg	0.61	<0.001	<0.001	<0.001	23.50	20.40	0.61	<0.001
Heavy Metals									
Lead	mg/kg	8.74	7.27	10.58	10.74	1.50	1.20	8.74	7.27
Nickel	mg/kg	<0.001	<0.001	<0.001	<0.001	0.10	0.05	<0.001	<0.001
Cadmium	mg/kg	1.33	0.50	0.93	0.71	<0.001	<0.001	1.33	0.50
Chromium	mg/kg	<0.001	<0.001	<0.001	<0.001	0.01	0.02	<0.001	<0.001

The content of Cu, Fe, Mn and Zn varied between 0.72 and 1.40 mg kg^{-1}, 40.08 and 180.00 mg kg^{-1}, 25.93 and 120.00 mg kg^{-1}, and <0.001 and 23.50 mg kg^{-1} respectively. The values of the micronutrients were rated as medium to high for Cu, high for Fe and Mn, and low to high for Zn. The soils are considered not toxic or polluted with regards to Cu, Zn, Mn and Fe as the values have not attained the critical desirable limits within soils (NESREA, 2007; Kabata-Pendias, 2011; Alloway, 1995). Soil sampling point C had highest values of the micronutrients in this area, and may be associated with corroded metals of the dumped car parts and scraps.

The values of nickel (Ni) and chromium (Cr) were mostly in trace quantity (<0.001 mg kg^{-1}), except in soils of Point C that ranged between 0.05 and 0.10 mg kg^{-1} and 0.01 and 0.02 mg kg^{-1} respectively (Table 4.14). The trace content may be associated with the nature of parent material from which the soil was formed and could be attributed to the high sand and low clay content that may affect retention of Ni and Cr, while the value accounted for in Point C may be associated with anthropogenic activity on the exchange site. The content of lead (Pb) and cadmium (Cd) ranged between 1.02 and 10.78 mg kg^{-1}, and between <0.001 (trace) and 1.33 mg kg^{-1}. The values of these heavy metals were far below the desirable critical limits in soil reported by NESREA (2007), Kabata-Pendias (2011) that may be regarded as toxic or polluted soil. However, anthropogenic activities have been reported to cause contamination in soils. Therefore, in the future there is need for monitoring or environmental audit to ascertain their status in the soils.

Land Use

The land use within Point A included intercropping of Oil palm, Maize and Cassava (Plate 4.12), while Point B and C were characterised by cultivation of Cassava (Plate 4.13). The control sampling point was previously cultivated to cassava, but left fallow, within sampling point SS-2310-NUN-01 and 02 area.

Plate 4.12 Land Use for Agricultural Purpose at Neke-Uno.

Plate 4.13 Land use for Manihot esculenta Neke Uno, Enugu State.

DESCRIPTION OF SOIL PROPERTY AND LAND USE FOR SITE AT SHEDA, ABUJA

This sub-section gives a detailed description of physical, chemical, physiographic and morphological properties of soil samples taken at Sheda, Abuja site.

Soil Physiographic and Morphological Properties

Soils of the PCB project site at Sheda FCT Abuja are located between upper slope (Points A, B and D) and middle slope (Point C) positions (Table 4.15). The soils were generally well drained and situated along level to nearly level slope (0 – 2 %) for sampling points A, B and D; while soils within sampling Point C were on a gently/undulating slope (2 – 3 %). The cultivation practice exposed the soils to slight sheet erosion. The area around Point A was characterised by scattered petroplinthites, older granite boulders and rock outcrops, while the surface of Point C is characterised by petroplinthic gravels.

Physical Properties

The content of sand within Sheda project site ranged between 440 and 560 gkg^{-1} in the soils. The content mostly increased from surface to subsurface horizon, except at sampling point B where there was a decrease in sand content with increase in soil depth. Silt values ranged between 150 and 260 gkg^{-1} and there was no clear trend of silt distribution between surface and subsurface horizons (Table 4.16). Clay content ranged between 210 and 340 gkg^{-1}in the soils and tend to increase from surface to subsurface horizon, except in Point C where it decreased with increase in soil depth. The soils were dominated by sandy clay loam texture except in the surface horizon of Point D (Control) recorded as clay loam.

Chemical Properties

Chemical properties of the soils are presented in Table 4.17. Soil pH ranged between 5.68 and 6.19 and rated as moderately to slightly acid (Soil Science Division Staff, 2017). The values of pH were found to be within optimum range of most nutrient availability for crop production. Soil salinity and alkalinity are not anticipated within these soils as pH values were quiet low.

Table 4.15 Physiographical and Morphological Properties of Project Site at Sheda

Location Description	Sample Code	Depth (cm)	Co-ordinate		Topography		Drainage	Erosion	Land Use
			Latitude (N°)	Longitude (E°)	Position (Elevation m ASL)	Slope Gradient (%)			
Point A	SS-2510-SHD-01	0 - 15	007.04127	08.84683	Upper slope (197)	Level to nearly level (0 - 2)	Well drained	Slight	Millet
Point A	SS-2510-SHD-02	15 - 30	007.04127	08.84683	Upper slope (197)	Level to nearly level (0 - 2)	Well drained	Slight	Millet
Point B	SS-2510-SHD-03	0 - 15	007.04205	08.84746	Upper slope (197)	Level to nearly level (0 - 2)	Well drained	Slight	Sorghum
Point B	SS-2510-SHD-04	15 - 30	007.04205	08.84746	Upper slope (197)	Level to nearly level (0 - 2)	Well drained	Slight	Sorghum
Point C	SS-2510-SHD-05	0 - 15	007.04253	08.84811	Middle slope (196)	Gently/ Undulating (2 - 3)	Well drained	Slight	Cassava and Cowpea
Point C	SS-2510-SHD-06	15 - 30	007.04253	08.84811	Middle slope (196)	Gently/ Undulating (2 - 3)	Well drained	Slight	Cassava and Cowpea
Point D (Control)	SS-2510-SHD-07	0 - 15	007.04099	08.84822	Upper slope (198)	Nearly level (1 - 2)	Well drained	Slight	Millet
Point D (Control)	SS-2510-SHD-08	15 - 30	007.04099	08.84822	Upper slope (198)	Nearly level (1 - 2)	Well drained	Slight	Millet

Table 4.16 Physical Properties of Project Site at Sheda

Sampling Point	Sample Code	Depth (cm)	Co-ordinate		Particle Size Distribution (gkg^{-1})			Soil Texture
			Latitude (N°)	Longitude (E°)	Sand	Silt	Clay	
Point A	SS-2310-NUN-01	0 - 15	06.65787	007.54535	520	230	250	SCL
Point A	SS-2310-NUN-02	15 - 30	06.62556	003.92069	560	150	290	SCL
Point B	SS-2210-NUN-03	0 - 15	06.65720	007.54530	490	200	310	SCL
Point B	SS-2210-NUN-04	15 - 30	06.65720	007.54530	470	210	320	SCL
Point C	SS-2210-NUN-05	0 - 15	06.65664	007.54513	520	250	230	SCL
Point C	SS-2210-NUN-06	15 - 30	06.65664	007.54513	530	260	210	SCL
Point D (Control)	SS-2210-NUN-07	0 - 15	06.65884	007.54459	440	240	320	CL
Point D (Control)	SS-2210-NUN-08	15 - 30	06.65884	007.54459	510	150	340	SCL

SCL = Sandy clay loam, CL = Clay loam

Exchangeable bases Ca, Mg, K and Na were generally high (Enwezor *et al.,* 1989) and ranged between 11.02 and 12.99 cmol/kg, 7.35 and 9.00 cmol/kg, 1.35 and 3.67 cmol/kg and 2.97 and 5.86 cmol/kg, respectively (Table 4.17). The exchangeable bases varied irregularly with increase in soil depth. The high content of exchangeable bases in these soils compared to Epe and Neke Uno may be attributed to less leaching process attributed to lower sand content and amount of rainfall in the area compared to the other areas in southern Nigeria. The values of exchangeable bases were far below critical limit of toxicity set by NESREA (2007).

Total nitrogen was very low, and varied from 0.24 to 0.56 gkg^{-1}. Chloride ranged between 65.37 and 89.66 mg/kg. There was no oil and grease recorded as the values was 0.00 mg/kg across the soils in the PCB site and control point.

The content of Fe, Mn and Zn varied from 4.65 to 6.97 mg kg^{-1}, 2.30 to 4.89 mg kg^{-1} and 2.36 to 5.21 mg kg^{-1} respectively (Table 4.17). Iron and Zn were rated high and Mn was medium in the soils. The micronutrient values were adequate for purpose of crop production. The soils are considered not polluted as the values were below permissible level reported in literatures (NESREA, 2007; Kabata-Pendias, 2011; Alloway, 1995).

Table 4.17 Chemical Properties of Project Site at Sheda

Parameter	Unit	Point A		Point B		Point C		Point D (Control)	
Sample Code		SS-2510-SHEDA-01	SS-2510-SHEDA-02	SS-2510-SHEDA-03	SS-2510-SHEDA-04	SS-2510-SHEDA-05	SS-2510-SHEDA-06	SS-2510-SHEDA-07	SS-2510-SHEDA-08
Depth	cm	0 – 15	15 – 30	0 – 15	15 – 30	0 - 15	15 - 30	0 – 15	15 – 30
Soil pH	-	5.68	6.02	6.09	6.13	6.11	6.19	6.05	6.18
Calcium	cmol/kg	12.36	11.25	11.02	12.95	12.45	13.55	12.99	12.05
Magnesium	cmol/kg	8.51	9.00	7.42	7.35	7.86	8.66	8.02	8.85
Sodium	cmol/kg	3.15	3.25	2.97	5.86	4.51	4.88	4.00	4.25
Potassium	cmol/kg	1.35	2.65	2.03	3.55	3.67	2.95	3.61	3.25
*Exchangeable Acidity	cmol/kg	1.24	1.31	1.51	2.18	2.09	1.87	1.93	1.54
ECEC	cmol/kg	10.1	7.5	8.9	6.8	12.3	10.4	11.8	9.7
Organic Carbon	g/kg	1.23	2.31	2.56	2.08	2.38	1.94	2.87	2.34
Total Nitrogen	g/kg	0.24	0.45	0.39	0.56	0.46	0.51	0.52	0.49
Nitrate	mg/kg	1.25	0.97	1.30	1.55	1.40	1.66	1.34	1.53
Chloride	mg/kg	89.65	87.95	68.95	77.95	65.37	89.66	75.85	86.10
Phosphorus	mg/kg	12.5	16.5	17.8	15.2	14.2	19.6	15.8	17.9
Micronutrients									
Copper	mg/kg	0.2013	0.1689	0.1856	0.1794	0.1855	0.1965	0.2014	0.1864
Iron	mg/kg	4.65	6.67	5.66	5.01	5.33	6.97	4.98	5.00
Manganese	mg/kg	2.30	2.66	2.55	4.16	3.67	3.01	4.51	4.89
Zinc	mg/kg	2.36	3.27	3.34	4.51	4.01	4.77	5.21	4.45
Heavy Metals									
Lead	mg/kg	0.2153	0.0564	0.0845	0.0765	0.1104	0.1032	0.0475	0.1249
Nickel	mg/kg	0.0254	-	0.0301	-	0.2104	0.0125	0.0212	-
Cadmium	mg/kg	0.1235	0.1487	0.2014	0.1845	0.1964	0.1322	0.0849	0.1845
Chromium	mg/kg	0.6352	0.4521	0.6421	0.4867	0.5124	0.5029	0.4521	0.4356

Land Use

The land use within the Sheda PCBs project site was characterised by Millet (Point A and D), Sorghum intercropped with millet at Point B (Plate 4.14) and Cassava and Cowpea at Point C (Plate 4.15). Some of these land uses did not provide early soil cover to protect the land from degradation by erosion.

Plate 4.14 Land use of Millet and sorghum at at Sheda Abuja

Plate 4.15 Land use showing harvested Cassava and planted late Cowpea at Sheda

SOIL STATUS AND PROPERTIES AT THE SITES

Status of soil quality can be evaluated by many variables (Mausbach and Seybold 1998). In addition to physicochemical variables, biotic variables also reflect soil quality (Pankhurst *et al*., 1997). Soil variables often show different patterns of response to the same impact (Jha *et al.,* 1992).

Tables 4.18 to 4.20 shows the physicochemical variables of soil at Epe, Neke Uno and Sheda, respectively.

pH: The soil solution can be neutral, acid, or alkaline. This is called the soil pH. The pH measures the concentrations of positively charged hydrogen ions (H^+) in the soil solution on a logarithmic scale ranging from 0 to 14. The pH of the soils in all the sampling sites (1 to 8) as well as the 3 different locations (Table 4.18 to 4.20), were mildly acidic as they all ranged from 5- 6.5, going by the following ranges; acidic (<5), mildly acidic (5- 6.5), neutral (7.5- 8.5) and strongly alkaline (8.5), as adopted by (Ababo *et al*., 2018). The level of acidity or alkalinity in a soil affects the availability of soil nutrients and the activity of soil micro- organisms and can also affect the level of exchangeable aluminium.

Soil Texture: Solid phase of the mineral soil mainly consists of discrete mineral particles as the amount of amorphous material including organic matter is usually small. Mineral particles are not exactly spherical but vary widely in their shape, therefore, these particles are usually classified into three conveniently separable groups according to certain size range based on their equivalent diameter. The groups of different size range of mineral particles are known as soil separates, primary particles or textural fractions, namely: sand, silt and clay and indicates a normal soil (Phogat *et al.*, 2015). The sites have varied form of soil texture, though SS-2510-SHEDA have the highest deposition of clay compared to SS-2210-EPE and SS-2310-NUN (Table 4.18 to 4.20).

Calcium: Calcium is an extremely important mineral in plant nutrition. Many soils, particularly in humid regions, contain this element in amounts so small that plant growth is limited. Some plant groups are able to tolerate low levels of calcium; however, abnormal growth has been observed with extremely low levels. One of the primary roles assigned to calcium in the plant is the key role it plays in the cell walls. Calcium is also important in root development, since short roots are observed on calcium deficient plants. The level of this nutrient was observed to decease according to depth at which the soil was collected at all sites (Table 4.18 to 4.20).

Magnesium, Sodium and Potassium: Like potassium, magnesium is important for plant metabolic processes, especially in chlorophyll production and in the uptake of phosphorous. Too much magnesium can “bind up” your soil so that water and nutrients do not penetrate well. Excessively high magnesium can cause high pH. The problem with excess salt in soil is the effects of sodium on plants. Buildup of sodium in plants causes toxic levels that cause stunted growth and arrested cell development (Bonnie, 2019). Sodium in soil is measured by extracting the water in a laboratory, but you can just watch your plant for wilting and reduced growth. Potassium plays an important role in different physiological processes of plants, it is one of the important elements for the development of the plant. It is involved in many plant metabolism reactions, ranging from lignin and cellulose used for the formation of cellular structural components, for regulation of photosynthesis and production of plant sugars that are used for various plant metabolic needs.

ECEC and Base Saturation: Soils ability to attract, retain, and exchange cation elements. It is reported in millequivalents per 100 grams of soil (meq/100g). In order for a plant to absorb nutrients, the nutrients must be dissolved, and these nutrients when dissolved they are in a form called "ions". This simply means that they have electrical charges. Many soil fractions have a large number of negative charges on their surface, thus they attract cation elements and contribute to a higher CEC. At the same time, they also repel anion nutrients (Phogat *et al.*, 2015). The ECEC and Exchangeable Acidity (Table 4.18) of the sites (SS-2210-EPE) were more or less uniform and a bit higher compared to (SS-2310-NUN). Though, phosphates are unique among the negatively charged anions, in that they are not mobile in the soil. This is because they are highly reactive, and nearly all of them will combine with other elements or compounds in the soil, other than clay and organic matter (Jiang *et al*., 2007).

Organic Carbon: Soil organic carbon and nitrogen are the main nutrition used for vegetation growth, and are also used as indexes of soil quality assessment and sustainable land use management. Soil organic carbon not only affects the soil fertility, but also has influence on releasing or holding CO2 from the atmosphere through various channels, thereby possibly affecting the atmosphere–soil carbon balance (Jiang *et al*., 2007).

Nitrate, Total Nitrogen and Phosphorus: Nitrogen is the most critical element obtained by plants from the soil and is a bottleneck in plant growth. About 80% of the atmosphere is nitrogen gas. Nitrogen gas diffuses into water where it can be “fixed” (converted) by blue-green algae to ammonia for algal use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia. Because nitrogen can enter aquatic systems in many forms, there is an abundant supply of available nitrogen in these systems. Phosphorus is a most important element present in every living cell and it is one of the most important micronutrients essential for plant growth. Phosphorus most often limits nutrients remains present in plant nuclei and act as an energy storage. Though SS-2210-EPE has the highest deposition of phosphate compared to SS-2310-NUN and both nutrients have demonstrated decrease as depth of sample collection increases (Table 4.18 to 4.20).

Copper: Copper is an essential element for plant growth. Soils naturally contain copper in some form or other, ranging anywhere from 2 to 100 parts per million (ppm) and averaging at about 30 ppm. Most plants contain about 8 to 20 ppm. Without adequate copper, plants will fail to grow properly. Therefore, maintaining fair amounts of copper for the garden is important (Anon. 2018).

Iron: Iron is an essential element to all living things, from micro-organisms to humans and can be found in meat, potatoes and vegetables (Eze and Hilary, 2008). Man absorbs iron from animals faster than plant products. Iron is an important part of the heamoglobin, which acts as oxygen transporter in the body (Fatoki, 2003). Chronic inhalation of excessive concentrations of iron oxide fumes or dusts may result in development of a benign pneumoconiosis called siderosis, which is observable as an X-ray change and can also cause cancer of the lung when inhale in excess (Govil *et al*., 2008).

Zinc: Zinc is a lustrous bluish-white metal. It is found in group IIb of the Periodic Table. It is used principally for galvanizing iron, but is also important in the preparation of certain alloys and for roofing. Zinc is a very common substance that occurs naturally. Many foodstuffs contain certain concentrations of zinc. Drinking water also contains certain amounts of zinc, which may be higher when it is stored in metal tanks, which in other way may lead to harm in humans (Ezekiel *et al.,* 2013). Zinc is a trace element that is essential for human health. When people absorb too little zinc they can experience a loss of appetite, decreased sense of taste and smell, slow wound healing and skin sores. It can also cause problems such as skin irritations, vomiting, nausea and anaemia (Okunola *et al*., 2007).

Manganese: Manganese (Mn) is an essential plant mineral nutrient, playing a key role in several physiological processes, particularly photosynthesis. Manganese deficiency is a widespread problem, most often occurring in sandy soils, organic soils with a pH above 6 and heavily weathered, tropical soils.

Lead: Lead, at certain level of concentration, is a poisonous substance to animals, including humans. It damages the nervous system and causes brain disorders when it is in excess. Lead also causes blood disorders in mammals (Ene *et al*., 2010). Lead may be absorbed by the body through inhalation, ingestion or dermal (skin contact). It can be transferred to the fetus through the placenta (Goyer, 1990). The amounts found in this study are all within the normal threshold and cannot pose negative effect on soil, plants and animals.

Nickel: Nickel is a relatively abundant and naturally occurring metal, widely distributed in the earth's crust. Its status in soils is highly dependent on the nickel concentration of the parent rocks, but in surface soils, its content is also a reflection of soil- forming processes and pollution. The amounts found in this study are all within the acceptable limits (1.63mg/kg) of WHO/FAO, (2001). Hence, cannot cause any pollution.

Cadmium: Cadmium (Cd) is an element with atomic number 48. It has some chemical similarities with zinc and it occurs together with zinc. It is used in manufacture of nickel-cadmium batteries and can also protect steel from rusting (Liang *et al.,* 2011). Human beings are exposed to cadmium via food, water and cigarette smoke. It is very poisonous and is excreted in minute amounts in urine. Its continuous accumulation in the body leads to high blood pressure and destroys the immune system (Yusuf *et al.,* 2011). The amounts of cadmium found in this study are all within the permissible limits (0.20 mg/kg) of WHO/FAO, (2007). Hence, Cadmium cannot cause health hazards.

Chromium: Human exposure to chromium occurs from both natural and anthropogenic sources. Chromium is present in the Earth's crust, with the main natural source of exposure being continental dust present in the environment (WHO, 2003). The acceptable amounts chromium up to 15 mg/kg in line with WHO/FAO, (2001). Hence, it is within the normal thresholds.

Electrical conductivity: Electrical conductivity is also a very important property of the soil, it is used to check the quality of the soil. It is a measure of ions present in solution. The electrical conductivity of a soil solution increases with the increased concentration of ions. Electrical conductivity is a very quick, simple and inexpensive method to checking health of soils. It is a measure of ions present in solution. The electrical conductivity of a soil solution increases with the increased concentration of ions.

Table 4.18 Physicochemical Variables of Soil at Epe (SS-2210-EPE)

PARAMETERS	Sampling Sites								WHO/ FAO LIMITS
	1	2	3	4	5	6	7	8	
pH (10% Solution)	6.05	6.1	6.1	6.05	6.4	6.45	5.6	5.75	NA
% Sand	70	70	75	75	70	70	80	80	NA
% Silt	10	10	10	10	10	10	10	10	NA
% Clay	20	20	15	15	20	20	10	10	NA
Calcium (meq/100g)	0.33	0.18	0.18	0.16	0.2	0.18	0.18	0.16	NA
Magnesium (meq/100g)	0.16	0.15	0.13	0.19	0.16	0.15	0.13	0.19	NA
Sodium (meq/100g)	0.14	0.11	0.15	0.11	0.13	0.11	0.15	0.11	NA
Potassium (meq/100g)	0.35	0.33	0.2	0.23	0.35	0.33	0.2	0.23	NA
Exchangeable Acidity (meq/100g)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	NA
ECEC (meq/100g)	0.98	0.8	0.66	0.72	0.84	0.8	0.66	0.72	NA
Base Saturation (%)	98.8	98.85	98.8	98.75	98.8	98.85	98.8	98.75	NA
Organic Carbon (%)	4.25	4.17	2.5	1.4	4.5	4.17	2.5	1.4	NA
Total Nitrogen (%)	0.07	0.06	0.05	0.04	0.08	0.06	0.05	0.04	NA
Nitrate (mg/Kg)	0.02	0.02	0.3	0.25	0.02	0.02	0.3	0.25	NA
Phosphorus (mg/Kg)	140.15	115.5	130.1	127.4	135.1	115.5	130.1	127.4	NA
Sulphate (mg/Kg)	13.2	8.6	20.4	18.7	11.25	8.6	20.4	18.7	NA
Oil & Grease (mg/Kg)	-	-	-	-	-	-	-	-	NA
Copper (mg/Kg)	0.47	0.64	0.43	0.84	0.45	1.6	9.43	0.69	100.0
Iron (mg/Kg)	34.2	31.8	35.62	31.06	30.81	32.65	30.8	32.71	NA
Zinc (mg/Kg)	0.88	1.27	5.48	4.11	1	21.89	4.02	0.68	27.3
Manganese (mg/Kg)	42.26	47.26	28.1	25.2	22.04	20.16	22.1	15.7	NA
Lead (mg/Kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8.05	<0.001	50.0
Nickel (mg/Kg)	0.1	0.11	0.05	0.03	0.2	0.15	0.05	0.03	1.63
Cadmium (mg/Kg)	<0.001	<0.001	<0.001	<0.001	<0.001	0.12	0.4	<0.001	0.20
Chromium (mg/Kg)	0.1	0.11	0.16	<0.001	0.32	<0.001	2.54	<0.001	15.0

Table 4.19 Physicochemical Variables of Soil At Neke Uno (SS-2310-NUN)

PARAMETERS	Sampling Sites								
	01	02	03	04	05	06	07	08	WHO/ FAO LIMITS
pH (10% Solution)	6.1	5.8	6.2	6.15	6.25	6.1	6.1	6.2	NA
% Sand	75	80	80	80	75	75	75	80	NA
% Silt	10	10	10	10	10	10	10	10	NA
% Clay	15	10	10	10	15	15	15	10	NA
Calcium (meq/100g)	0.2	0.18	0.27	0.26	0.2	0.22	0.2	0.18	NA
Magnesium (meq/100g)	0.18	0.15	0.13	0.15	0.13	0.15	0.18	0.15	NA
Sodium (meq/100g)	0.12	0.11	0.11	0.1	0.15	0.1	0.12	0.11	NA
Potassium (meq/100g)	0.3	0.25	0.18	0.14	0.3	0.25	0.3	0.25	NA
Exchangeable Acidity (meq/100g)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	NA
ECEC (meq/100g)	0.8	0.69	0.69	0.45	0.78	0.72	0.8	0.69	NA
Base Saturation (%)	98.7	98.6	98.7	98.8	98.7	98.3	98.7	98.6	NA
Organic Carbon (%)	2.05	1.3	2.45	2.4	4.1	3.7	2.05	1.3	NA
Total Nitrogen (%)	0.11	0.1	0.11	0.08	0.12	0.11	0.11	0.1	NA
Nitrate (mg/Kg)	0.1	0.05	0.02	0.02	0.03	0.02	0.1	0.05	NA
Phosphorus (mg/Kg)	110.3	95.1	118	115	110	95.2	110.3	95.1	NA
Sulphate (mg/Kg)	11.5	10.6	10.4	9.5	20.5	15.3	11.5	10.6	NA
Oil & Grease (mg/Kg)	-	-	-	-	-	-	-	-	NA
Copper (mg/Kg)	0.72	0.8	0.74	0.86	2.1	1.4	0.72	0.8	100.0
Iron (mg/Kg)	41.24	40.08	41	40.55	180	140	41.24	40.08	NA
Zinc (mg/Kg)	0.61	<0.001	<0.001	<0.001	23.5	20.4	0.61	<0.001	27.3
Manganese (mg/Kg)	38	40.22	26.98	25.93	120	110.3	38	40.22	NA
Lead (mg/Kg)	8.74	7.27	10.58	10.74	1.5	1.2	8.74	7.27	50.0
Nickel (mg/Kg)	<0.001	<0.001	<0.001	<0.001	0.1	0.05	<0.001	<0.001	1.63
Cadmium (mg/Kg)	1.33	0.5	0.93	0.71	<0.001	<0.001	1.33	0.5	0.20
Chromium (mg/Kg)	<0.001	<0.001	<0.001	<0.001	0.01	0.02	<0.001	<0.001	15.0

Table 4.20 Physicochemical Variables of Soil at Sheda (SS-2510-SHEDA)

PARAMETERS	Sampling Sites							
	1	2	3	4	5	6	7	8
pH	5.68	6.02	6.09	6.13	6.11	6.19	6.05	6.18
Total Nitrogen	0.24	0.45	0.39	0.56	0.46	0.51	0.52	0.49
Chloride (mg/100g)	89.645	87.945	68.9452	77.9462	65.3658	89.6644	75.8541	86.0966
Conductivity (MS)								
Zn (mg/100g)	2.3561	3.2653	3.3373	4.5123	4.0127	4.769	5.214	4.449
Fe (mg/100g)	4.6544	6.6685	5.6598	5.0124	5.3349	6.9654	4.9768	5.0034
Mn (mg/100g)	2.3013	2.6635	2.548	4.163	3.6652	3.0149	4.5124	4.8879
Ca(mg/100g)	12.3564	11.2457	11.0224	12.9465	12.4475	13.5464	12.9946	12.0476

Na (mg/100g)	3.1452	3.2547	2.9658	5.8647	4.5124	4.8766	3.9976	4.2458
Mg (mg/100g)	8.5124	8.9975	7.4215	7.3496	7.8649	8.6645	8.0167	8.8477
K (mg/100g)	1.3456	2.6497	2.0315	3.5514	3.6673	2.9467	3.6095	3.2466
Cr(mg/100g)	0.6352	0.4521	0.6421	0.4867	0.5124	0.5029	0.4521	0.4356
Cu(mg/100g)	0.2013	0.1689	0.1856	0.1794	0.1855	0.1965	0.2014	0.1864
Ni(mg/100g)	0.0254	-	0.0301	-	0.2104	0.0125	0.0212	-
Cd (mg/100g)	0.1235	0.1487	0.2014	0.1845	0.1964	0.1322	0.0849	0.1845
Pb(mg/100g)	0.2153	0.0564	0.0845	0.0765	0.1104	0.1032	0.0475	0.1249
Organic carbon	1.23	2.31	2.56	2.08	2.38	1.94	2.87	2.34
CEC (meq/100g)	10.1	7.5	8.9	6.8	12.3	10.4	11.8	9.7
P(mg/100g)	12.5	16.5	17.8	15.2	14.2	19.6	15.8	17.9
EA (cmol/kg)	1.24	1.31	1.51	2.18	2.09	1.87	1.93	1.54

4.3.9 Surface Water

Surface water is water on the surface of the planet such as in river, lake, wetland or ocean.It can be contrasted with groundwater and atmospheric water. Table 4.21 and 4.22 shows the physicochemical variables of surface water at study areas, downstream and upstream, respectively.

Plate 4.16 Surface Water Sampling at Neke-Uno ***Plate 4.17 Benthos Sampling at Neke-Uno***

Temperature

Temperature is a significant factor of great importance for aquatic ecosystem, as it directly or indirectly affects the metabolic and physiological activities of the organisms, as well as the physical and chemical characteristics of water (FOEN, 2011). It also influences the rate of photosynthesis by algae and aquatic plants. Here, water temperature ranged between 25 – 27.5^{0}C for downstream samples and 25 – 27.6^{0}C for upstream samples, with the SW-2210-SHEDA-01 (27.5^{0}C) and SW-2210-SHEDA-02 (27.6^{0}C) samples having the highest temperature. Overall, all samples were found to be within the tolerable limit of the WHO sustaining aquatic lives and within secondary data reviewed for this parameter.

Turbidity

Turbidity is a vital indicator of potential pollution, due to the presence of inorganic materials (colloidal and extreme fine dispersions of particulates clay, silt e.t.c.) and organic materials (like algae, planktons e.t.c.). In extreme cases, turbid water can harm animals and deposit heavy sediment on leaves, reducing photosynthesis (Mezgebe *et al.,* 2015). Results of this study shows a variation in turbidity between downstream and upstream stations of SW-2210-EPE and SW-2210-NUN while a fairly similar turbidity was recorded for SW-2210-SHEDA samples. However, all samples are within the limits of WHO and secondary data of ICCL.

Conductivity

Conductivity measurements are routinely used as a fast, inexpensive and reliable way of measuring the dissolved ionic content in a solution (Gray, 2005), water in this case. It is also an invaluable indicator as a range into which other parameters like hardness, temperature, pH, alkalinity values e.t.c. are likely to fall. Results here reveals higher electric conductivity in all downstream samples than the upstream samples. Both the downstream and upstream samples of SW-2210-SHEDA-02 are above the ICCL secondary data reviewed for this parameter and the WHO permissible limts. However, all other samples fall within the acceptable limits.

pH, Acidity and Alkalinity

pH expresses the intensity of the acidity or alkalinity of the water. The pH values of water samples varied between 6.81 to 7.78 for downstream samples and 6.73 to 6.89 for the upstream samples. All samples are within the WHO limits for sustenance of Aquatic Lives excluding the SW-2210-EPE-01 downstream sample which is only within the ICCL secondary data reviewed for pH. Alkalinity is usually due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium. Total alkalinity and acidity values for all the investigated samples were found to be within the standard permissible limits of WHO/NAFDAC/SON.

Total Hardness, Calcium and Magnesium Hardness

The hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The total hardness values range from 5.99 to 35.78 mg/L and 6.35 to 26.83 mg/L for downstream and upstream surface water samples respectively, and were all within the NSDW/WHO limits. To emphasize, Calcium and Magnesium are directly related to hardness. In the present study, calcium and magnesium contents recorded are within the permissible limit of WHO and ISI.

Total Solids, Total suspended solids (TSS) and Total dissolved solids (TDS)

The total solids include the suspended and dissolved solids in the water samples. A range of 3.88 to 8 mg/L and 2.63 to 10 mg/L was obtained for the total solids in downstream and upstream samples respectively, with the downstream samples bearing higher concentrations and a general decrease recorded upstream. The decay of solids produces unpleasant odour, thus, allowing the flourishing of disease-causing microorganisms like bacteria. High concentrations of suspended solids can cause many problems for aquatic life and humans as well. The low TDS and TSS values for all samples obtained are within the secondary data reviewed for this parameter and the WHO/ISI/NSDW limits. In the presence of high total solids, water will heat up more rapidly and hold more heat, this in turn, adversely affects aquatic life that has been adapted to a lower temperature regime.

Nutrients (Nitrate, Sulphate and Phosphate)

The nitrogen in water occurs as bound forms like nitrate, nitrite, ammonia and organic forms of nitrogen such as urea, amino acids etc. Nitrate is less toxic than the other forms of nitrogen in the aquatic environment. It's concentration in surface water is normally low, but Surface water contains nitrate due to leaching of nitrate with the percolating water (agricultural runoff), sewage and other wastes rich in nitrates. Its potential health risk above the threshold may give rise to a condition known as methaemoglobinemia in infants (Blue-baby syndrome) and pregnant women (Mezgebe et al., 2015). The concentration of nitrate in the water samples analyzed were very low and found within the prescribed permissible limits of WHO/FAO/ISI/SON. Sulphate occurs naturally in water as a result of leaching from gypsum, and other common minerals (Shrinivasa and Venkateswaralu, 2000). Discharge of industrial wastes and domestic sewage tends to increase its concentration. The sulphate concentrations here varied between 6.1 to 8.4 mg/L. These minute concentrations are within the permissible limit set by WHO, ISI and FAO. Phosphate can be found as a free ion in water and may occur in surface water as a result of domestic sewage, detergents, and agricultural effluents with fertilizers. The phosphate content in all samples were within the WHO and FAO limits except for both upstream and downstream of SW-2210-SHEDA with a 2.36 and 4.15 mg/L content respectively that exceeds the aforementioned standard limits.

Chloride and Sodium chloride

The chloride concentration serves as an indicator of pollution by sewage. The values recorded were in the range of 15.79 to 101.1 mg/L with SW-2210-SHEDA-02 upstream bearing the highest concentration. The concentrations of chloride for all samples were below WHO and ISI critical permissible value (250mg/L). This is acceptable because high concentration of chloride can make water unpalatable and therefore unfit for drinking, livestock watering and irrigation of sensitive crops (Papafilippaki *et al.*, 2008). Chlorine has also been noted as a potential carcinogen (Fakayode, 2005). A sodium chloride range of 0.2105 - 65.16 mg/L was obtained in all samples here, falling within the limits for domestic use.

Chemical Oxygen Demand (COD) and Biological oxygen demand (BOD) (mg/L)

Both BOD and COD are key indicators of the environmental health of a surface water supply, commonly used in waste water treatment but rarely in general water treatment. Biological oxygen demand (BOD) is taken as a measure of the concentration of organic matter or extent of pollutant present in any water. The greater the decomposable matter present, the greater the oxygen demand and the greater the BOD values (TVA, 1995). Results shows a BOD range within the WHO standard and EPA guidelines for all samples. COD is a water quality measure used not only to measure the amount of biologically active substances such as bacteria but also biologically inactive organic matter in water (Khuhawari *et al*., 2009). All the COD values obtained in this study satisfy the EPA standard guidelines and within the limits of WHO and secondary data of ICCL, hence bears no risk for sustenance of aquatic lives

Iron (Fe)

Iron concentrations ranged from 0.02 to 0.6534 mg/L. The highest concentrations of Fe (0.5231mg/L downstream and 0.6534 mg/L upstream) was found in the SW-2210-SHEDA-01 water samples exceeding the 0.3 mg/L WHO/SON permissible standard. However, all other sample are within the limits set by WHO and SON.

Lead (Pb)

Exposure to lead is cumulative over time even at levels below the limits. High concentrations of lead in the body can causes huge public health complications and hazardous effects, as previously discussed. It is considered the number one health threat to children, and the effects of lead poisoning can last a lifetime (Keke *et al*., 2015). For its immense effects, the WHO/SON set a 0.01 mg/L while the USEPA set a 0.015 mg/L standard limit for Pb. The concentration of Pb in this study fall within the limit of SON/USEPA. Only the samples from SW-2210-SHEDA-02 (both upstream and downstream) exceed those limits with high concentrations of 0.0512 and 0.0459 mg/L. More so, all samples are within the ICCL secondary data and WHO's limits for sustenance of Aquatic Lives.

Copper (Cu)

Copper (Cu) is an essential substance to human life but elevated Cu levels in drinking water causes serious health issues like mental diseases such as Alzheimer's, liver and kidney damage e.t.c. (Wanga et al., 2010). The SON, USEPA/ICCL and WHO (for drinking water) have set up a 1, 1.3 and 2 mg/L permissible limits for Cu respectively. Cu concentration was found in the range of <0.001 to 0.123 mg/L In all samples analyzed, falling within the SON/USEPA/WHO limits. Additionally, all samples are within WHO's limits for sustenance of Aquatic Lives.

Cadmium (Cd)

Dumping of agricultural wastes, addition of impure chemicals during water purification, leaching of metals and water run-off could be responsible for high concentrations of Cd in water. Cadmium concentration was generally low in all the water samples with SW-2210-EPE-01 downstream bearing the highest concentration of 0.001 mg/L. The concentrations of Cd in all samples were found much within the WHO/ICCL permissible limits.

Zinc (Zn)

Zinc is present approx 0.05 g/kg in the earth crust. Zinc concentrations ranged from <0.001 to 0.0447mg/L in all surface water samples upstream and downstream. The highest Zn concentration (0.0447mg/L) was noticed in the SW-2210-SHEDA-01 downstream sample. However, all concentrations from all samples were found to be within the WHO/SON acceptable limits and the ICCL Secondary Data.

Chromium (Cr)

In aquatic environment, Cr is one of the bio-chemically active transition metals. As such, is of special concern because they produce chronic poisoning to aquatic animals. Results obtained here, revealed a very low Cr Concentration, ranging from <0.001 to 0.0369 mg/L in all samples. Conversely, all the waters samples analyzed have a Cr concentration below the SON limit of 0.05 mg/L and WHO limits (0.1mg/L) for sustenance of Aquatic Lives.

Manganese (Mn)

Mn plays several roles in physiological processes in living organisms but can constitute a nuisance if present in a high concentration with a characteristic metallic taste and staining properties. Result of this study of all samples indicates concentration below the WHO/SON permissible limits, demonstrating no risk to both aquatic and human lives, except for the SW-2210-SHEDA-01 downstream and upstream samples which are both above the limits, indicating risk of sustenance to Aquatic Lives and humans.

Table 4.21 Physicochemical Parameters of Surface Water At Study Areas (Downstream)

VARIABLE	SW-2210-EPE-01	SW-2310-NUN-01	SW-2510-SHEDA-01	WHO Limits for drinking water	FMEnv Limits for aquatic lives
Appearance	Colorless & Clear	Colorless with Particles	A bit turbid	-	-
Temperature(0C)	25	25.0	27.5	35	40
Turbidity (FTU)	0	6.0	3.22	10	25
Conductivity (µS/cm)	37.9	5.85	456	900	-
pH	7.78	6.86	6.81	6.5-8.5	4.8-9.2
Acidity (mg/L)	20.49	20.49	0.84		
Alkalinity (mg/L)	100	50.0	1.32		
Total Hardness (mg/L)	35.78	18.73	5.99		
Calcium Hardness (mg/L)	16.1	16.22	4.5212	200	-
Magnesium Hardness (mg/L)	19.68	2.55	1.6636	200	-
Total Solids (mg/L)	25	8.0	3.55		
Total Suspended Solids (mg/L)	0	1.0	0.35		
Total Dissolved Solids (mg/L)	25	7.0	2.51	500	-
Phosphate (mg/L)	0.03	0.02	4.15		
Nitrate (mg/L)	0.01	0.01	1.3		
Sulphate (mg/L)	8.3	8.40	-		
Chloride (mg/L)	15.79	39.49	-	600	230
Sodium Chloride (mg/L)	26.06	65.16	0.2105		
Chemical Oxygen Demand (mg/L)	8	7.30	2.35	125	20
BOD (mg/L)	3	3.40	4.51	10	-
Iron	0.02	0.02	0.5231		
Lead	<0.001	<0.001	0.0512	0.05	25
Copper	<0.001	<0.001	0.123	1500	1500
Cadmium	0.001	<0.001	-	5	5
Zinc	<0.01	<0.001	0.0447	5000	5000
Chromium	<0.01	<0.001	-	50	50
Manganese	0.07	0.01	0.4152	50	100

Note: FMEnv- Federal Ministry of Environment, DS-Down Stream, SW- Surface water, WHO- World Health Organization

Table 4.22 Physicochemical Variables of Surface Water at Study Areas (Upstream)

VARIABLE	SW-2210-EPE-02	SW-2310-NUN-02	SW-2510-SHEDA-02	WHO Limits for drinking water	FMEnv Limits for aquatic lives
Appearance	Faint Brown	Colorless & Clear	A bit turbid	-	-
Temperature(0C)	25	25	27.6	35	40
Turbidity (FTU)	5	0	3.36	10	25
Conductivity (µS/cm)	10.15	4.6	302	900	-
pH	6.81	6.73	6.89	6.5-8.5	4.8-9.2
Acidity (mg/L)	10.24	40.98	0.23		
Alkalinity (mg/L)	40	50	0.91		
Total Hardness (mg/L)	26.83	16.83	6.35		
Calcium Hardness (mg/L)	25.04	11.45	7.2362	200	-
Magnesium Hardness (mg/L)	1.79	5.38	1.2354	200	-
Total Solids (mg/L)	10	7	2.63		
Total Suspended Solids (mg/L)	2	0	0.14		
Total Dissolved Solids (mg/L)	8	7	2.31	500	-
Phosphate (mg/L)	0.06	0.05	2.36		
Nitrate (mg/L)	0.03	0.02	1.25		
Sulphate (mg/L)	7.5	6.1	-		
Chloride (mg/L)	13.16	36.2	101.1	600	230
Sodium Chloride (mg/L)	21.72	59.73	0.2354		
Chemical Oxygen Demand (mg/L)	8.5	10.3	2.06	125	20
BOD (mg/L)	2.8	4.3	3.65	10	-
Iron	0.03	0.03	0.6534		
Lead	<0.001	<0.001	0.0459	0.05	25
Copper	<0.001	<0.001	0.1032	1500	1500
Cadmium	<0.001	<0.001	-	5	5
Zinc	<0.001	<0.001	-	5000	5000
Chromium	0	<0.001	0.0369	50	50
Manganese	<0.001	0.04	0.5362	50	100

Note: FMEnv- Federal Ministry of Environment, DS-Down Stream, SW- Surface water, WHO- World Health Organization

4.3.10 Ground Water

Groundwater is found almost everywhere. Water table may be deep or shallow and may rise or fall depending on many factors. Heavy rain may lead to water table to rise or excessive pumping of groundwater may cause the water table to fall. Rain and groundwater supplies are replenished, or recharged, by rain that seeps down into the cracks and crevices beneath the land's surface. In some areas people face serious water shortage due to excessive use of groundwater faster than it is naturally replenished. In other areas groundwater is polluted by human activities (GF, 2019).

The status of the groundwater depends on a large number of individual physico-chemical parameters, heavy metals and microbial analysis. Pollutants are added to the ground water system through anthropogenic activities (that ranged from domestic, agricultural and industrial activities) and natural processes.

Table 4.23 shows the physicochemical variables of ground water at study areas, namely; Sheda, Neke Uno and Epe.

Appearance

The appearance of water depicts its physical look, colour and clarity. This is because of the presence dissolved and suspended organic materials (e.g. humus fraction) and compounds of calcium and iron or the presence of iron and other metals, either as natural impurities or as corrosion products. Hence, the WHO recommends that any water suitable for drinking must be clear and colourless. In this study, all samples are clear and colourless, denoting its conformity to WHO standard for this parameter.

Temperature

Temperature is one of the most important parameters in water and for aquatic environment because it governs all the physical, chemical and biochemical properties. The increase in ground water temperature causes the increase in the rate of chemical reactions, oxygen depletion and affects the solubility of oxygen, dissolving of inorganic materials from the rocks and an increase in electric conductance. Also, the increased temperature may directly or indirectly increase the taste, odour, appearance and corrosion problems (UNICEF, 2008). Temperature above ambient level is therefore an index of groundwater pollution. Results obtained showed a range between 25-27.6^{0}C throughout the sampling points with an average of 25.9^{0}C falling within the standard acceptable limits for drinking and domestic activities.

Turbidity

Turbidity, describes the cloudiness of water caused by the presence of very finely divided and suspended particles (e.g. clay and silts), chemical precipitates (e.g. manganese and iron), organic particles (e.g. plant debris) and other microorganisms (APHA/AWWA/WEF, 2012), which are not filterable by routine methods. It can have both water safety and aesthetic implications. Direct health effects depend on the precise composition of the turbidity-causing materials which does not always represent a direct risk to public health. However, it can indicate the presence of hazardous chemical and pathogenic microorganisms and be an effective indicator of hazardous events (e.g. heavy rain, spills or contamination of groundwater). Turbidity affects the appearance and acceptability of water. High turbidity reduces the clarity of water and promotes microbial proliferation, thus affecting negatively the microbiological quality of water that results to substantial cases of water-borne diseases globally. It also affects the chemical quality of drinking water through the formation of complexes between the turbidity causing humic matter and heavy metals (WHO, 2008). More so, Turbidity also affects other water quality parameters such as colour, when it is imparted by colloidal particles as well as rise in temperature. The groundwater turbidity results obtained, ranged between 0 -2.65 FTU, which is within the permissible limits for Nigerian Standard of FMEnv and WHO.

Conductivity (µS/cm)

Conductivity is the measurement of the ability of a solution, water in this case, to carry electric current. The presence of dissolved solids such as calcium, chloride, and magnesium in water samples carries the electric current through water. Its ability is dependent upon the presence of ions in solution and its measurement is an excellent indicator of the total dissolved solid in matter. Conductivity does not have direct impact on human health. It is determined for several purposes such as determination of mineralization rate (existence of minerals such as potassium, calcium, and sodium) and estimating the amount of chemical reagents used to treat this water. Water with high conductivity may cause corrosion of metal surface of equipment. High conductivity may lead to lowering the aesthetic value of the water by giving mineral taste to the water. Pure water suitable for drinking should contain less or no organic salt making it an excellent insulator and should have a conductivity below the WHO/FMEnv/ Nigerian Standard for Drinking Water Quality limits (1000µS/cm and 1200 µS/cm respectively) (IFC, 2007). The results here, show that the measured conductivity of all water samples ranges from 8.07 to 399 µS/cm, with the GW-2510-SHEDA-02 site having a significantly higher conductivity. The wide differences of the conductivity values might be due to various factors such as agricultural and industrial activities and land use, which affect the mineral contents and thus the electric conductivity of the water. However, all samples were within the WHO/FMEnv/SON permissible limits and suitable for drinking.

pH, Acidity (mg/L) and Alkalinity (mg/L)

pH is classed as one of the most important water quality parameters. Measurement of pH relates to the acidity or alkalinity of the water and determines the solubility of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals. A sample is considered to be acidic if the pH is below 7.0. Acidic water can cause corrosion of metal pipes and plumbing system and increases the toxic level and fowl smelling hydrogen sulphide. but has no direct health implication on humans (Chindo *et al.,* 2013). The pH values obtained ranged from 5.89 – 6.84 with 2(66.67%) are within the permissible level recommended by WHO and suitable for drinking and other domestic use. The low pH of GW-2310-NUN-02 (5.89) may be attributed to the discharge of acidic products into this source by the agricultural, industrial and domestic activities.

The Acidity of water is its base-neutralizing capacity. The alkalinity of water is its acid-neutralizing capacity. Both parameters are related to the buffering capacity of water. Acidity is a net effect of the presence of several constituents, including dissolved carbon dioxide, dissolved multivalent metal ions, strong mineral acids such as sulfuric, nitric, and hydrochloric acids, and weak organic acids such as acetic acid. The acidity of a water will affect its corrosiveness and also the speciation1 of some of its other constituents. Alkalinity is often a good indicator of the total dissolved inorganic carbon (bicarbonate and carbonate anions) present. Low alkalinity (i.e. high acidity) causes deterioration of plumbing and increases the chance for many heavy metals in water are present in pipes, solder or plumbing fixtures. EPA guidelines recommend a minimum alkalinity level of 20 mg/L, meaning, an alkalinity greater than 20 mg/L is beneficial to water quality. Results showed an acidity and alkalinity ranges of 0.57 - 61.47 mg/L and 1.22 - 60mg/L respectively. With GW-2510-SHEDA-02 showing the least acidity and alkalinity values while the GW-2310-NUN-02 showed has the highest values. Here, 2 (66.67%) within the EPA limit.

Total Hardness (Calcium and Magnesium Hardness)

This is the degree to which water contains mineral salts, which affects its ability to form leather with soap. The primary reason of the hardness in groundwater is the presence of dissolved calcium and magnesium ions (i.e. Ca^{2+}, Mg^{2+}), referred to as calcium hardness and magnesium hardness. According to WHO, groundwater with concentration ranging from 0 to 60 mg/L is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and >180 mg/L as very hard. The results obtained here conforms to the soft group WHO standard, ranging between 5.41 – 17.89 mg/L, with an average of 11.34mg/L. More so, all samples are safe and suitable for use for its compliance to the FMEnv permissible limits of 150mg/L.

Also, results here confirms the less variability of hardness in groundwater, with magnesium hardness most prevalent in samples GW-2210-EPE-02 and GW-2310-NUN-02 while the calcium hardness was higher in GW-2510-SHEDA-02.

Total Solids mg/L (Total suspended solids (TSS) and Total dissolved solids (TDS))

The total solids in a water sample is the sum of the TSS and DSS in that sample. The TSS is the measure of the amount of particulate solids that are in the water while TDS is the measure of the amount of ions in solution, comprising of inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates) and small amounts of organic matter that are dissolved in water. Its measurement is an excellent indicator of the total dissolved solid in matter. Pathogens are often aggregated or adherent to suspended solids in water, and pathogen concentrations vary in time. The WHO (2008) gave the palatability of drinking water according to its TDS level as less than 500 mg/l excellent level and greater than 1700 mg/l as unacceptable. Results shows a relatively low TDS levels and no TSS in Samples GW-2210-EPE-02 and GW-2310-NUN-02. The values for Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) were within the WHO/FMEnv permissible limit set for drinking water.

Nutrients (Nitrate, Sulphate and Phosphate)

Water is the most essential supporting element providing medium for nutrients cycle and these nutrients however, have proved vital for the growth of microorganisms in groundwater. Their high levels are mostly due to excessive fertilizer use and industrial discharge. Nitrite exists normally in very low concentrations, because nitrogen tend to exist in the more reduced (ammonia) or more oxidized (nitrate) forms and Phosphorus gaining access to groundwater is perhaps unlikely. The WHO has set a 0.03 mg/dm^3 permissible limits for Nitrite due to its huge public health implications. Rocks and geological formation have been largely the source of sulphate in underground water. Sulphate has a laxative effect, especially in combination with magnesium and/or sodium. The utility of water for domestic purposes is hampered by high sulphate concentrations, hence the limit of 200 mg/dm3 set by WHO (1993). Results here revealed nutrients levels for all samples, were within the WHO/FMEnv limits with only GW-2210-SHEDA-02 having a higher Nitrite concentration (1.55 mg/L) and hence not suitable for drinking.

Chloride

Chloride exists in all-natural waters in varying concentrations Chloride does not pose a health hazard to humans only that the principal consideration is in relation to palatability and corrosion in hot water systems. At levels above 250 mg/dm^3, water will begin to taste salty and will become increasingly objectionable as the concentration rises further. The concentrations of the chloride in all the water samples here, were below the WHO permissible limit.

Sodium Chloride

The incomplete flushing of soluble minerals produces groundwaters which are generally of the sodium chloride type. Consumption of sodium chloride-rich water can abolish the blood pressure reduction induced by dietary salt restriction (Schorr *et al.,* 1996). A range of 16.26 - 97.9 mg/L was obtained in the samples here, falling within the limits for domestic use.

Chemical Oxygen Demand (COD) and Biological oxygen demand (BOD)

BOD is the amount of dissolved oxygen needed by aerobic organisms in water to break down organic material present while COD is the measure of the oxygen equivalent of the organic matter content that represents potential consumption of oxygen within the receiving water body. Both parameters are inversely linked to dissolved oxygen and an indicator of the water quality (WHO, 1993). The WHO has set a 10mg/L limits for both BOD and COD. Results of all the samples are within the constraint of WHO/FMEnv for drinking.

Iron

Being the second most abundant metal in earth's crust have make it vastly available in groundwater. Though toxic, affects taste and colouration of water, increases turbidity and enhances iron-bacteria growth that clog pipes at high concentrations, it is regarded essential, in small quantities, for human health (likewise copper, manganese and zinc). In fact, the deficiency of these essential metals may increase susceptibility to heavy metal poisoning (Choudhory, 2011). Also, high concentration of iron could cause haemasiderosis. The WHO has set a 0.1mg/L and 1.0mg/L as the highest desirable level and maximum permissible level of drinking water for iron. Also, 0.3mg/L set as the Nigerian standard. Iron concentrations for GW-2210-EPA-02 and GW-2310-NUN-02 are within the WHO/FMEnv desirable limits. The GW-2510-SHEDA-02 sample exceeds the WHO/FMEnv desirable limits but below the WHO maximum permissible level of drinking water.

Lead

Lead causes a huge detrimental impact on human health even at small concentrations, that include the reduction of mental capacity, interference with kidney and neurological functions, hearing loss, blood disorders, abdominal pains, anemia, hypertension, gradual paralysis and death at high levels. A 0.05 and 0.02 mg/L represent the FMEnv and WHO limits for lead in drinking water respectively. Lead concentration was high (0.0496mg/L) in GW-2510-SHEDA-02 exceeding the WHO limits and approximately equaling the FMEnv limits and hence, not suitable for drinking or a treatment is proffered. However, all other samples fall below the WHO/FMEnv limits. It is to note that, cumulative toxicity effects of lead have been recognized.

Copper (Cu)

Cu is an essential heavy metal even though a water contaminant, whose groundwater concentrations vary due to varying water parameters like pH, hardness and its availability in pipes and natural deposits. At higher concentrations, Cu causes liver damage, mucosal irritation, renal damage and depression and restricts growth of aquatic plants (WHO, 2008). Copper concentrations obtained at the sampling points are within the WHO/FMEnv recommended limits except for SW-2510-SHEDA-02 that exceeds the desired limit of 0.05mg/L but below the permissible limit (1.5mg/L).

Cadmium (Cd)

Cd occurs naturally in rocks and soils in metals, but it is due nearly exclusively to industrial discharges and landfill leachates. Cd is highly toxic and exposure to it causes 'itai-itai' disease-painful rheumatic condition, physiological effects (leading to bone damage, chronic kidney disease, cancer and hypertension) cardio vascular system issues and gastrointestinal upsets

(Hanaa *et al*., 2000). Cd is also highly toxic to aquatic life. Cd concentration in all water samples here, are within FMEnv/WHO exposure limits.

Zinc (Zn)

Zinc is an essential metal but ingestion in large amounts has an purgative effect. Additionally, it causes gastro intestinal irritation, dehydration, abdominal pain, nausea and dizziness. However, the concern for its level in water supply is not in regard to toxicity but taste (causing astringent taste and opalescence to water), and quite high levels are permissible (15mg/L) (WHO, 1993). The zinc levels for all the samples in this study are generally low (<0.001 - 0.0359 mg/L) and are below the FMEnv/WHO permissible limits.

Chromium (Cr)

Chromium is also an essential metal and a key component for the glucose tolerance factor. In addition to being carcinogenic, it damages the nervous system, circulatory system, liver, lungs, causes ulcerations, respiratory problems, skin irritation, skin and nasal ulcers and accumulates in the spleen, bones, kidney and liver. Chromium concentrations obtained here, are within recommended WHO limit.

Manganese (Mn)

Manganese is a widely distributed constituent of soils, ores and rocks. Generally, toxicity is not a factor, but presence of Mn above the limits is its unacceptable taste and/or aesthetic factor (like staining property laundry and fixtures). Mn plays several roles in physiological processes in living organisms. Result of this study of all samples indicates concentration below WHO/FMEnv permissible limits except for GW-2210-SHEDA-02 sample which has a higher Mn concentration (0.4867mg/L) exceeding the limits for drinking.

Table 4.23 Physicochemical Variables of Ground Water at the Study Areas

PARAMETERS	GW-2210-EPE-02	GW-2310-NUN-02	GW-2510-SHEDA-02
Appearance	Colorless & Clear	Colorless & Clear	Colorless and clear
Temperature(0C)	25	25	27.6
Turbidity (FTU)	0	0	2.65
Conductivity (µS/cm)	10.14	8.07	399
pH	6.5	5.89	6.84
Acidity (mg/L)	10.24	61.47	0.57
Alkalinity (mg/L)	50	60	1.22
Total Hardness (mg/L)	17.89	10.73	5.41
Calcium Hardness (mg/L)	7.15	5.36	5.2264
Magnesium Hardness (mg/L)	10.74	5.37	1.2245
Total Solids (mg/L)	10	7	1.25
Total Suspended Solids (mg/L)	0	0	0.22
Total Dissolved Solids (mg/L)	10	7	1.12
Phosphate (mg/L)	0.02	0.02	4.21
Nitrate (mg/L)	0.01	0.01	1.55
Sulphate (mg/L)	7.4	6.4	-
Chloride (mg/L)	9.87	39.49	97.9
Sodium Chloride (mg/L)	16.29	65.16	97.9
Chemical Oxygen Demand (mg/L)	-	-	-
BOD (mg/L)	-	-	-
Iron	0.02	0.03	0.5455
Lead	<0.001	<0.001	0.0496
Copper	<0.001	<0.001	0.1109
Cadmium	<0.001	<0.001	-
Zinc	<0.001	<0.001	0.0359
Chromium	<0.001	<0.001	-
Manganese	<0.001	0.03	0.4867

Footnote: GW: Ground Water

4.3.11 PCB concentration analysis

The PCB was analyzed in all the three sites, namely Sheda, Enugu, Epe. The soil, air and water sample were analyzed using both Arocol method and Congener specifics analysis for better accuracy. The Congener method is based on EPASW846 method (EPA 1996) which allows guarantee measurement of about 28 PCB congeners using high resolution gas chromatography with electron capture detection, as depicted in Tables 4.24 to 4.26.

Sheda Site

Table 4.24 showed the concentration distributions for PCB congeners in Sheda. The highest value was recorded for PCB209 with 8.71µg/ml (ppb), followed by PCB18-2.03ppb, PCB105-1.71ppb, PCB44-1.50ppb all were observed to be within the OSHA

PEL of 1ppb for PCB in soil sample (OSHA, 1988). This was also found to conforms with the former USSR Ministry of Health (1991) allowable level of 60 µg kg^{-1} for PCBs in ambient soil. It should also be noted that the standard varies for PCB congeners based on its chlorine content (OSHA, 1988). Sheda recorded the highest PCB congeners compared to the other selected sites. This might be attributed to increase in population (migration) and industrial activities in Sheda and its environment as well as fugitive emissions from electrical transformers and capacitors containing PCBs or bioaccumulate and biomagnify as they move up the food chain, as the case may be.

Table 4.24 PCB Concentration for Sheda- Abuja Test Result*

S/N	Target Compound	Retention Time	Ion	Response	Concentration	Unit	Dev(Min)
1.	PCB 8	18.002	57	1783	0.44	ug/ml	41
2.	PCB 18	18.048	71	3416	2.03	ug/ml	53
3.	PCB 28	18.283	222	725	0.47	ug/ml	42
4.	PCB 44	19.084	256	1699	1.50	ug/ml	13
5.	PCB 52	19.994	256	1285	0.76	ug/ml	31
6.	PCB 66	20.474	292	343	0.22	ug/ml	30
7.	PCB 77	21.235	292	158	0.11	ug/ml	1
8.	PCB 81	21.699	292	64	0.03	ug/ml	1
9.	PCB 101	22.082	326	172	0.09	ug/ml	23
10.	PCB 105	22.317	498	169	1.71	ug/ml	1
11.	PCB 114	22.637	292	227	0.11	ug/ml	1
12.	PCB 118	22.941	292	781	0.41	ug/ml	1
13.	PCB 123	23.290	326	214	0.09	ug/ml	1
14.	PCB 126	23.290	326	214	0.07	ug/ml	1
15.	PCB 128	23.558	326	90	0.03	ug/ml	1
16.	PCB 138	23.810	360	178	0.07	ug/ml	33
17.	PCB 153	23.879	326	184	0.07	ug/ml	23
18.	PCB 156	24.388	360	153	0.07	ug/ml	24
19.	PCB 157	24.754	394	89	0.03	ug/ml	19
20.	PCB 167	25.332	360	346	0.07	ug/ml	10
21.	PCB 169	26.099	360	97	0.04	ug/ml	1

22.	PCB 170	26.099	360	97	0.04	ug/ml	1
23.	PCB 180	26.431	396	605	0.27	ug/ml	14
24.	PCB 187	27.341	360	290	0.16	ug/ml	33
25.	PCB 189	27.489	394	642	0.32	ug/ml	19
26.	PCB 195	28.771	396	269	0.12	ug/ml	29
27.	PCB 206	29.361	430	524	0.25	ug/ml	20
28.	PCB 209	30.419	430	243	8.71	ug/ml	1

Source: Richflood Laboratory; August, 2019.

*The analysis was done using gas chromatography equipment, having the following terms:

Retention Time: Show the amount of time taken for the analysis to pass through the column and reach the mass detector. It depicts the differences in a polarity of a sample with the volatility of the analytes or sample depending on boiling point. ***Concentration***: Is a reflection of the amount of specific analyte that is present. ***Response***: In chromatography, a response is defined as the ratio between the concentration of a compound being analyzed and the response of the detector to that compound.

A chromatogram will show a response from a detector as a peak while there are several ways to quantify the peak, one of the most common is peak area, thus:

Response factor=Peak Area/Concentration.

Ion: Any atom or group of atoms that bears one or more positive or negative electric charges.

Deviation in min Dev(min): The measure that determines, or quantifies the amount of variation of the result values. It was calculated by GC Statistics software. ***Unit***: Unit of measurement is a means of quantifying.

PCB209 was selected for air and water analysis since it recorded the highest value in this region. The values obtained for PCB in air and water are 1.29 and 5.04ppb, respectively, as shown in Figure 4.19. These values are indicator for the diffusivity and solubility properties of PCB. The content is lower in air due to high volatility and ease of mass transfer of PCB in air, while it remained higher in water due to the fact that its not soluble in water. Note that the PCB value dropped because of its relative solubility in organic solvent which are already established to be present in Sheda water body.

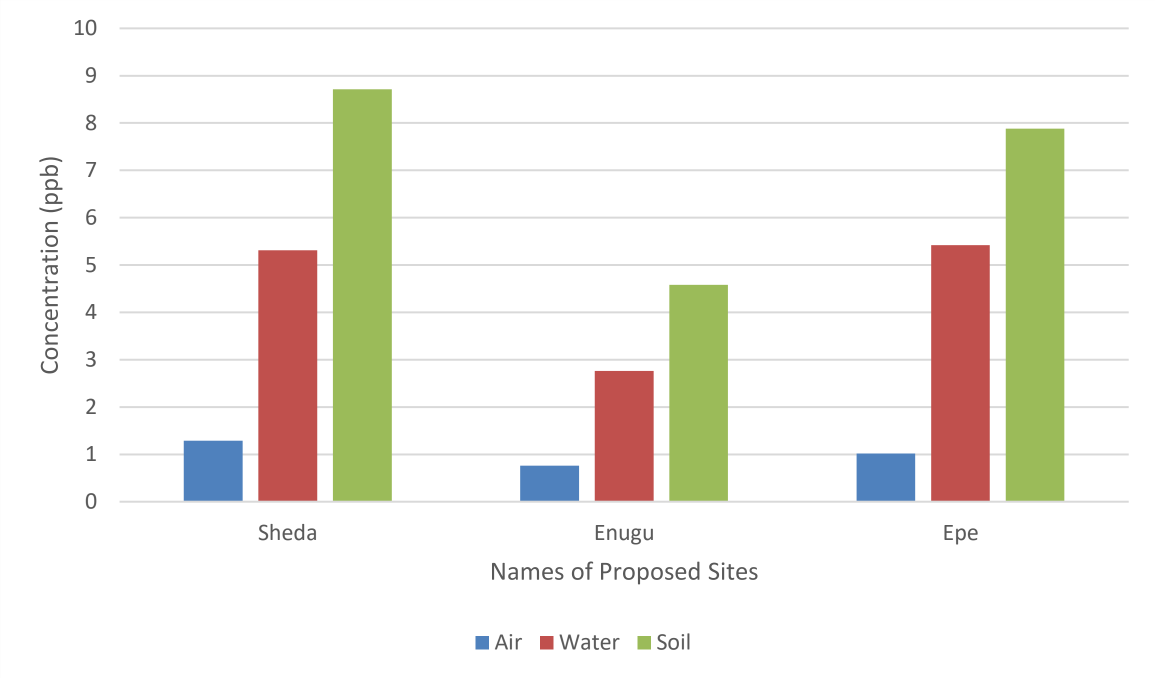


Figure 4.19 PCB values for air, water and soil in all the sites.

Neke Uno

Table 4.25 depicts the PCB congeners in soil sample from Neke Uno, with PCB105 having 4.55ppb followed by PCB209- 1.99ppb and PCB8- 1.74ppb.

Table 4.25 PCB Concentration for Neke Uno Enugu 003 Test Result

S/N	Target Compound	Retention Time	Ion	Response	Concentration	Unit	Dev(Min)
1.	PCB 8	18.008	57	1723	1.74	ug/ml	24
2.	PCB 18	18.065	71	1272	0.23	ug/ml	18
3.	PCB 28	18.306	222	375	0.24	ug/ml	1
4.	PCB 44	19.221	256	466	0.41	ug/ml	42
5..	PCB 52	19.976	256	1592	0.95	ug/ml	18
6.	PCB 66	20.314	292	361	0.23	ug/ml	28
7.	PCB 77	20.909	292	802	0.56	ug/ml	40
8.	PCB 81	0.000	0	0	N.D	ug/ml	0

9.	PCB 101	21.830	326	499	0.25	ug/ml	28
10.	PCB 105	22.694	498	450	4.55	ug/ml	23
11.	PCB 114	22.792	292	355	0.18	ug/ml	1
12.	PCB 118	22.866	292	445	0.23	ug/ml	1
13.	PCB 123	22.940	326	357	0.14	ug/ml	1
14.	PCB 126	22.940	326	357	0.11	ug/ml	11
15.	PCB 128	0.000	0	0	N.D	ug/ml	0
16.	PCB 138	0.000	0	0	N.D	ug/ml	0
17.	PCB 153	0.000	0	0	N.D	ug/ml	0
18.	PCB 156	0.000	0	0	N.D	ug/ml	0
19.	PCB 157	24.817	394	382	0.15	ug/ml	18
20.	PCB 167	0.000	0	0	N.D	ug/ml	0
21.	PCB 169	0.000	0	0	N.D	ug/ml	0
22.	PCB 170	26.465	360	591	0.22	ug/ml	20
23.	PCB 180	26.173	396	309	0.14	ug/ml	14
24.	PCB 187	27.787	360	337	0.18	ug/ml	16
25.	PCB 189	27.678	394	1068	0.53	ug/ml	39
26.	PCB 195	28.788	396	320	0.14	ug/ml	7
27.	PCB 206	29.441	430	341	0.16	ug/ml	15
28.	PCB 209	30.385	430	502	1.99	ug/ml	1

ND= Not Detected ***Source:*** Richflood Laboratory; August, 2019

In contrary to Sheda site, lower PCB concentration were recorded and for different congener. This probably is due to either activities currently ongoing at the sites or dumping of PCB related waste near the site in the past. Kodavanti and Loganathan (2014) reported mobility and stability of PCB once it gets to the soil. Kodavanti (2017) emphasis also on period that PCB can stay in the ecosystem and its cycle between air and water.

According to Figure 4.19 depicts the air and water sample for Neke Uno targeted at PCB 105, having values of 0.76 for air and 2.76 for water.

Epe.

28 PCB congeners were detected in Epe site with PCB18 recording the highest concentration of 7.88ppb followed by PCB209-1.40 while PCB60 and PCB105 were not detected, as depicted in Table 4.26.

Table 4.26 PCB Concentration for Epe -Lagos 001 Test Result

S/N	Target Compound	Retention Time	Ion	Response	Concentration	Unit	Dev (Min)
1.	PCB 8	18.002	57	3552	0.48	ug/ml	37
2.	PCB 18	18.042	71	1514	7.88	ug/ml	1
3.	PCB 28	18.374	222	1179	0.77	ug/ml	41
4.	PCB 44	19.015	256	492	0.43	ug/ml	1
5..	PCB 52	20.022	256	1310	0.78	ug/ml	1
6.	PCB 66	0.000	0	0	N.D	ug/ml	0
7.	PCB 77	21.161	292	520	0.36	ug/ml	48
8.	PCB 81	21.264	292	416	0.19	ug/ml	1
9.	PCB 101	22.082	326	382	0.19	ug/ml	2
10.	PCB 105	0.000	0	0	N.D	ug/ml	0
11.	PCB 114	22.694	292	951	0.48	ug/ml	14
12.	PCB 118	22.837	292	807	0.42	ug/ml	1
13.	PCB 123	23.404	326	435	0.18	ug/ml	1
14.	PCB 126	23.404	326	435	0.13	ug/ml	50
15.	PCB 128	23.576	326	914	0.32	ug/ml	23
16.	PCB 138	24.056	360	317	0.12	ug/ml	4
17.	PCB 153	23.993	326	457	0.17	ug/ml	44
18.	PCB 156	24.056	360	317	0.14	ug/ml	11
19.	PCB 157	24.915	394	771	0.30	ug/ml	69

20.	PCB 167	24.829	360	437	0.08	ug/ml	1
21.	PCB 169	26.048	360	413	0.16	ug/ml	47
22.	PCB 170	26.048	360	413	0.15	ug/ml	44
23.	PCB 180	26.339	396	468	0.21	ug/ml	14
24.	PCB 187	27.707	360	313	0.17	ug/ml	1
25.	PCB 189	27.341	394	300	0.15	ug/ml	1
26.	PCB 195	28.817	396	462	0.20	ug/ml	14
27.	PCB 206	29.378	430	1457	0.68	ug/ml	26
28.	PCB 209	30.408	430	681	4.40	ug/ml	10

ND= Not Detected ***Source:*** Richflood Laboratory; August, 2019.

Epe recorded the highest PCB in water probably due to the soil texture coupled with large water bodies motivating easy movement of the insoluble PCB (Zheng *et al*, 2013). Despite the high PCB value in soil, the value was relatively low in air, probably due to the wind speed and direction recorded for Epe site. These values for Epe site are depicted in Figure 4.19.

4.4 BIOLOGICAL ENVIRONMENT

4.4.1 Ecology and Biodiversity

Ecological surveys are surveys for habitats (terrestrial/aquatic) and species. These surveys are important especially when carried out due to developments (Dam constructions. Treatment plants, Industrial constructions etc.). The primary objective is usually to identify any potential constraints to such development, which may result from the presence of important habitats or species. Other objectives may be to inform an evaluation of the nature conservation value of the site, to facilitate an assessment of significance on impacts of the development for biodiversity, and status of such habitats in terms of abiotic factors, to inform the master plan process and to help identify opportunities to enhance the biodiversity of the site (Richard, 2017).

Convention on Biological Diversity defines Biodiversity as the variability among living organisms from all sources including terrestrial (land), Aquatic (water), and other ecological ecosystems complexes of which they are part; this includes diversity within species, between species and of ecosystems. In simpler terms, Biodiversity is all the living creatures, plants and animals, on and in the earth, water and air in a particular place. Biodiversity also describes the interaction between these living creatures and the area (ecosystem) in which they live (Swanson, 1997). Biodiversity supports human life and livelihoods in that it provides a number of 'ecosystem services': Being a source of food, medicine, fuel, grazing for livestock, and building materials. It also contributes to food supply, for example the pollination of commercially viable crops, such as citrus, grapes and apples; the continued productivity of soils, and the control of pests and diseases is essential for the regulation or control of natural processes that support human life, for example, soil formation, reduction of carbon that contributes to global warming (the potential increase in the temperature of the earth's atmosphere caused by pollution), recycling of nutrients, and the supply and purification of water it helps to regulate floods and protects against storm surges provides space for leisure and tourism has social, health and spiritual benefits for humans, and contributes to their quality of life (WRI, 1992). Developments due to constructions can affects habitats by; Habitat loss and degradation, for example, the destruction of wetlands, grasslands and indigenous forests for housing estates or low-cost housing, habitat fragmentation - ecosystems and the species therein, need a certain amount of interconnectivity for processes to continue. If a specific natural area is broken up into smaller pieces, eventually species disappear and certain functions are lost. For example, a large intact wetland can fulfil its functions far better than a wetland that is divided into two pieces. Loss of species, for example the plants and animals endemic to a particular habitat will not be able to survive if that habitat is been destroyed or altered by development (constructions). Natural processes, such as continued river flow, water purification, and erosion control, are affected. This can lead to an accumulated effect on both habitat and species. Or, this can continue to affect habitats and therefore species into the long-term which may lead to extinction.

Pollution effects on ecosystems and thus species biological diversity, or the variability among living organisms at the genetic, species, and ecosystems levels, is our life support system. The existing endowment of biodiversity is a non-renewable resource that we are unable to duplicate or substitute by technological innovation (Swanson, 1997). This alarming loss is widely attributed to the spread of unsustainable human development and specifically to: habitat loss and fragmentation; introduced species; overexploitation of plant and animal species; pollution of soil, water, and atmosphere; global climate change; and industrial agriculture and forestry (WRI, 1992). The causes of biodiversity loss are "embedded in the way we live" (WRI, 1992) and halting or slowing this loss requires a shift in the path of human development. This in turn depends on fundamentally integrating biodiversity concerns into decisions made in every facet of our lives. Base on this background the ecological survey of these three sites demarcated purposely for PCB collection, Storage and Treatment Centers namely; Sheda (Abuja), Epe (Lagos) and Neke Uno (Enugu) was carried out to serve as environmental Impact Assessment for the proposed project.

This section summarizes the common and sensitive vegetation, terrestrial wildlife, and aquatic biological resources that are available during the survey at the project site. Biological resources which include; common vegetation and habitat types, sensitive plant communities, status plant and animal species. Potential impacts of the proposed alternatives are analyzed, and mitigation measures are provided for those impacts determined to be significant.

Biodiversity of Flora and Fauna

Available evidence shows that biodiversity is being lost at a disturbing rate in Nigeria. The causes of biodiversity loss are largely related human factors. These are due to interaction with the environment for development, improved quality of life resulting from industrialization, technological advancement and rapid growth in urbanization (NRB, 2001).

4.4.2 Flora Diversity

Floral diversity refers to the diversity of plants occurring in a specific region during particular era. It generally refers to the diversity of naturally occurring indigenous or native plants. A total of 215,644 species of plants out of 298,000 predicted have been catalogued on earth till-date.

Survey Methodology

Sampling with quadrats (plots of a standard size) was used for most plant communities. Estimated plants counted were listed. Quadrats were established randomly within a study site. Methods of Barbour *et al.,* (1987), Greg-Smith (1983) Cox (1990) were adopted.

Floral Diversity of Epe

The floral diversity of Epe during the survey encountered 16 species. Though, Elephant grass (*Pennisetum purpureum*) has the highest distribution of 13.38% no any cultivation / farming activity was observed in the demarcated area (Table 4.24). Epe Demarcated area was the only on among the three (EPE, SHEDA and NEKE UNO) that was not under used for farming activity. Biodiversity has been reported to be the major source of food, fibre, fuel, fodder and other useful things needs adequate attention and increased knowledge for its conservation and wise use in a sustainable manner. Therefore, conservation of ecospecific biodiversity through conservation such as demarcating land for such purposes. Cassava and Maize were observed to be cultivated at the Control site, which was observed to enable comparison with Demarcated site.

Table 4.27 Floral Diversity Within Epe Site and Control Areas

Plant Diversity at Epe			Project Site		Control	
			Coordinates: **LAT:** 6.62727°N **LOG:** 3.92110°E **ELV:** 9M		**Coordinates:** **LAT:** 6.62699°N **LOG:** 3.92035°E **ELV:** 2M	
SN	**Species**	**Common Name**	**NO**	**% Distr.**	**NO**	**% Distr.**
1.	*Rhizophora racemosa*	-	4	2.55	4	14.81
2.	*Albizia zygia*	West African albizia	12	7.64	1	3.70
3.	*Acrostichum aureum*	-	5	3.18	-	-
4.	*Carapa procera*	Crabwood	11	7.01	2	7.41
5.	*Cassytha filiformis*	Climber	7	4.46	3	11.11
6.	*Caladium bicolor*	heart of Jesus	4	2.55	-	-
7.	*Baphia nitida*	Sandalwood	13	8.28	1	3.70
8.	*Bridelia micrantha*	Bridelia	9	5.73	-	-
9.	*Alchornia cordifolia*	Christmas bush	5	3.18	-	-
10	*Ficus capensis*	Broom cluster	-	-	3	11.11
11	*Albizia lebbeck*	Frywood	12	7.64	2	7.41
12	*Pennisetum purpureum*	Elephant grass	21	13.38	5	18.52
13	*Diodia scandens*	Buttonweed	10	6.37	2	7.41
14	*Ficus asperifolia*	-	2	1.27	-	-
15	*Ficus capensis*	-	4	2.55	-	-
16	*Manihot esculenta*	Cassava	-	-	Cultivated	Cultivated
17	*Cladrastis kentukea*	-	8	5.10	-	-
18	*Zea mays*	Maize	-	-	Cultivated	Cultivated
19	*Chromolaena odorata*	Siam weed	6	3.82	3	11.11
20	*Macaranga barteri*	-	2	1.27	-	-
21	*Milicia excelsa*	African teak	9	5.73	1	3.70
22	*Panicum virgatum*	Switchgrass	13	8.28	-	-
Total			**157**	**100**	**27**	**100**

Foot Note: LAT: Latitude, **LOG:** Longitude, **ELV:** Elevation, **% Distr.:** Percentage Distribution

***Floral Diversity at* Neke Uno**

Two species were found to be cultivated in the Demarcated site *Zea mays* and *Manihot esculenta*, the cultivated crops are therefore found to be dominant in the area. Though, *Echinchloa colonum* recorded 38.33% distribution among other plant species and African locust beans has the least distribution of 3.33%, all of which in the Demarcated area. While in Control site *Musa acuminate* has the highest distribution (Table 4.25), and there wasn't any cultivation in the Control area.

Table 4.28 Floral Diversity at Neke Uno Site and Control Areas

Plant Diversity of NEKE UNO			Demarcated Area		Control	
			Coordinates: **LAT:** 6.65787°N **LOG:** 7.54535°E **ELV:** 202M		**Coordinates:** **LAT:** 6.6515°N **LOG:** 7.54533°E **ELV:** 191M	
SN	**Species**	**Common Name**	**NO**	**% Distr.**	**NO**	**% Distr.**
1.	*Elaeis guineensis*	African oil palm	6	10.00	4	9.76
2.	*Manihot esculenta*	Cassava	Cultivated	-	-	-
3.	*Psidium quajava*	Guava	4	6.67	-	-
4.	*Musa acuminata*	Banana	-	-	9	21.95
5.	*Anacardium occidentale*	Cashew	-	-	5	12.20
6.	Zea mays	Maize	Cultivated	Cultivated	-	-
7.	*Cola acuminata*	Bitter cola	5	8.33	-	-
8.	*Persea americana*	Avocado tree	3	5.00	-	-
9.	*Dioscorea alata*	Water yam	7	11.67	-	-
10.	*Parkia biglobosa*	African locust beans	2	3.33	-	-
11.	*Mangifera indica*	Mango		0.00	3	7.32
12.	*Carica papaya*	Pawpaw	-	-	4	9.76
13.	*Musa paradisiaca*	Plantain	-	-	6	14.63
14.	*Abelmoschus esculentus*	Okra	-	-	8	19.51
15.	*Myristica fragrans*	-	4	6.67	-	-
16.	*Telfairia occidentalis*	Pumpkin	6	10.00	-	-
17.	*Vitellaria paradoxa*	Sheanut tree	-	-	2	4.88
18.	*Echinochloa colonum*		23	38.33	-	-
Total			**60**	**100**	**41**	**100**

Floral Diversity of Sheda

Sheda was the most diverse sites among the three proposed sites of the project (Epe, Neke-Uno and Sheda). A total of 292 floral species were observed. Though, there was lot and active framing activities going on in the site. Species under cultivation were found to include; *Panicum sumatrnse* (Little millet), *Zea mays* (Maize), *Sesamum indicum* (Sesame), Okra, Sorghum, Pepper, Groundnut, Moringa, Cassava, Sweet Potatoes and *Vigna unguiculate* (Beans). Research has suggested that urban forest and urban green areas could be another effective means of biodiversity conservation (Konijnendijk *et al*., 2006), in which this site could have be one of those. Though Sheda is the only Southern Guinea Savanna among the sites it's known with diverse floral species. The present survey also reveals *Corchorus olitorius* with the highest distribution (7.88%) apart from the cultivated crops found the Demarcated Site. The Control Site in Sheda (Table 4.26) has much similarity with Demarcated Site *Abelmoschus* *esculentus* (Okra) and *Vigna unguiculate* were cultivated in Control site compared to Demarcated. Though there was less diversity also unlike Demarcated Site.

Table 4.29 Floral Diversity at Sheda and Control Areas

Plant Diversity of SHEDA			Sheda Site Area Coordinates: LAT: 8.84683°N LOG: 7.04127°E ELV: 197m		Control Coordinates: LAT: 8.848.22°N LOG: 7.04099°E ELV: 198m	
SN	**Species**	**Common Name**	**NO**	**% Distr.**	**NO**	**% Distr.**
1.	*Pericopsis laxiflora*	African Teak	13	4.45	-	-
2.	*Uvaria chamae*	-	11	3.77	-	-
3.	*Sarcocephalus latifolius*	African Peach	2	0.68	3	4.76
4.	*Parkia biglobosa*	African locust beans	7	2.40	3	4.76
5.	*Detarium microcarpum*	Detar	19	6.51	-	-
6.	*Panicum sumatrnse*	Little Millet	Cultivated	Cultivated	Cultivated	Cultivated
7.	*Echinochloa colona*	Millet weed	23	7.88	15	23.81
8.	*Zea mays*	Maize	Cultivated	Cultivated	Cultivated	Cultivated
9.	*Sesamum indicum*	Sesame	Cultivated	Cultivated	Cultivated	Cultivated
10.	*Corchorus olitorius*	-	23	7.88	-	-
11.	*borreria articularis*	-	12	4.11	-	-
12.	*Piliostigma thonningii*	Camel's foot	18	6.16	-	-
13.	*Hymenocardia acida*	-	21	7.19	-	-
14.	*Abelmoschus esculentus*	Okra	Cultivated	Cultivated	-	-
15.	*Sorghum bicolor*	Sorghum	Cultivated	Cultivated	Cultivated	Cultivated
16.	*Cyperus rotundus*	Nut Sedge	22	7.53	-	-
17.	*Capsicum baccatum*	Locoto (Pepper)	Cultivated	Cultivated	-	-
18.	*Pennisetum pedicellatum*	Deenanath grass	17	5.82	-	-
19.	*Arachis hypogaea*	Groundnut	Cultivated	Cultivated	Cultivated	Cultivated
20.	*Anacardium occidentale*	Cashew	6	2.05	2	3.17
21.	*Vitellaria paradoxa*	Sheanut tree	3	1.03	1	1.59
22.	*Moringa oleifera*	Moringa	Cultivated	Cultivated	-	-
23.	*Dioscoreae cayennensis*	Yam	Cultivated	Cultivated	-	-
24.	*Manihot esculenta*	Cassava	Cultivated	Cultivated	Cultivated	Cultivated
25.	*Solanum tuberosum*	Sweet potatoes	Cultivated	Cultivated	Cultivated	Cultivated
26.	*Talinum triangulare*	Water leaf	21	7.19	-	-
27.	*Mangifera indica*	Mango	5	1.71	-	-
28.	*Calotropis procera*	Giant milk	13	4.45	-	-
29.	*Ageratum conyzoides*	billygoat-weed	18	6.16	13	20.63
30.	*Chromolaena odorata*	Siam weed	11	3.77	9	14.29

31.	*HeliotroPMUm indicum*	-	3	1.03	-	-
32.	*Psidium guajava*	Guava	10	3.42	-	-
33.	*Launaea taraxacifolia*	Wild lettuce	12	4.11	17	26.98
34.	*Eragrostis chloromela*	Blue Love Grass	2	0.68	-	-
35.	*Vigna unguiculate*	Cowpea	Cultivated	Cultivated	-	-
Total			**292**	**100**	**63**	**100**

Foot Note: LAT: Latitude, **LOG:** Longitude, **ELV:** Elevation, **% Distr.:** Percentage Distribution

4.4.3 Faunal Diversity

Diversity of animal species is not only confined to specific habitats but also utilize various habitats in search of food, shelter, and reproduction. No matter how small a habitat can be its said to constitute life in it (animals and plants). An ecosystem rich in fauna species such as birds, reptiles, mammals, amphibians, invertebrates etc., is expected to be natural, whereby energy follow through the foodchain (Strahan,1995).

Faunal Survey Methodology

Methods employed were direct evidence (sighting) and indirect evidences. ***Direct observations (visual)***-visual encounter survey during nocturnal and diurnal expeditions and recognizing evidence of wildlife species presence through vocalization was undertaken. The Capture-recapture method was used for small mammals and some invertebrate fauna. ***Indirect Observations***- Indirect signs such as footprints, droppings, feeding activity, nests, tracks, holes, scratching, carcass found etc. The recorded evidences were represented both by direct (collections and observations) and indirect signs were evaluated for identification by local residents (Caughley, 1977; Krebs, 1989; Strahan,1995).

Faunal Diversity of Epe

The loss of biodiversity has been taking place since humans first learned to harvest natural resources and to manage the land to increase its productivity. Depletion of natural resources and rapid loss of biodiversity have occurred over time to meet the basic needs of the growing population (Husain, 1992). The present survey reveals Soja ants (*Macrotermes subhyalinus*) were found to be the dominant species with 69.64% distribution. There were two separate colonies encountered the demarcated site (Table 4.27). The distribution was followed by *Nylanderia bourbonica* and *Colias eurytheme* which recorded 7.24 % both. The least fauna recorded in demarcated site was *Naja melanoleuca*, compared to Control that 1.96% distribution for both Vinaceous dove and Cricket (Table 4.27).

Table 4.30 Faunal Diversity at Epe Site and Control Areas

Animal Diversity of EPE			**Demarcated Area**		**Control**	
			Coordinates: **LAT:** 6.62727°N **LOG:** 3.92110°E **ELV:** 9m		**Coordinates:** **LAT:** 6.62699°N **LOG:** 3.92035°E **ELV:** 2m	
SN	**Species**	**Common Name**	**NO**	**% Distr.**	**NO**	**% Distr.**
1.	*Macrotermes subhyalinus*	Soja ant	250	69.64	2	3.92
2.	*Nylanderia bourbonica*	Brown ant	26	7.24	15	29.41
3.	*Opheodrys vernalis*	Green snake	2	0.56	-	-
4.	*Naja melanoleuca*	Cobra	1	0.28	-	-
5.	*Papio cynocephalus*	Yellow Baboon	2	0.56	-	-
6.	*Tettigonia viridissima*	Cricket	5	1.39	1	1.96
7.	*Turtur tympanistria*	Singin bird	3	0.84	-	-
8.	*Pterocles Namaqua*	Wild Dove	2	0.56	2	3.93
9.	*Litocranius walleri*	African Antelop	2	0.56	-	-
10.	*Colias eurytheme*	Orange sulphur	26	7.24	15	29.41
11.	*Junonia coenia*	Common buckeye	15	4.18	6	11.76
12.	*Papilio demodocus*	Swallowtail	5	1.39	9	17.65
13.	*streptopelia vinacea*	Vinaceous dove	3	0.84	1	1.96
14.	*Gryllodes sigillatus*	Tropical house cricket	12	3.34	-	-
15.	*Perdix perdix*	Grey Perdix	5	1.39	-	-
Total			**359**	**100**	**51**	100

Foot Note: LAT: Latitude, ***LOG:** Longitude, **ELV:** Elevation, **% Distr.:** Percentage Distribution*

Faunal Diversity of Neke Uno

One of the uniqueness of this survey was that all Demarcated areas were found constitute more species abundance than Control sites, just as reported by Husain (1992) that depletion of natural resources and rapid loss of biodiversity can occur over time to meet the basic needs of the growing population, that is by any anthropogenic activity. A colony of *Carduelis cannabina* birds were encountered which has the highest distribution among the animal species, while *Guttera pucherani* (Guineafowl) has the least distribution in Demarcated area. But in control area *Chevre naine* (Dwarf goat) has the highest distribution (Table 4.28) from the 39 individuals recorded during the survey.

Table 4.31 Faunal Diversity of Neke Uno Site and Control Areas

Animal Diversity of NEKE UNO			Demarcated Area		Control	
			Coordinates: **LAT:** 6.65787°N **LOG:** 7.54535°E **ELV:** 202m		**Coordinates:** **LAT:** 6.6515°N **LOG:** 007.545.33°E **ELV:** 191m	
SN	**Species**	**Common Name**	**NO**	**% Distr.**	**NO**	**% Distr.**
1.	*Oryctolagus cuniculus*	Rabbit	0	0.00	6	15.38
2.	*Rattus norvegicus*	Rat	1	0.85	0	0.00
3.	*Rattus rattus*	Domestic Rat	0	0.00	2	5.13
4.	*Saxicola rubetra*	-	3	2.56	0	0.00
5.	*Nylanderia bourbonica*	Brown ant	24	20.51	0	0.00
6.	*Setophaga angelae*	-	5	4.27	0	0.00
7.	*Papilio demoleus*	Multicolored butterfly	12	10.26	3	7.69
8.	*Leptidea sinapis*	Wood white butterfly	6	5.13	1	2.56
9.	*Guttera pucherani*	Guineafowl	2	1.71	0	0.00
10.	*Columba livia*	Rock Dove	4	3.42	2	5.13
11.	*Turtur tympanistria*	Singing bird	1	0.85	1	2.56
12.	*Pterocles Namaqua*	Wild Dove	2	1.71	0	0.00
13.	*Carduelis cannabina*	Small birds	27	23.08	6	15.38
14.	*Colias eurytheme*	Orange Sulphur	5	4.27	0	0.00
15.	*Junonia coenia*	Common buckeye	3	2.56	0	0.00
16.	*Aedes albopictu*	Biting insect	8	6.84	2	5.14
17.	*Streptopelia vinacea*	Vinaceous dove	4	3.42	0	0.00
18.	*Musca domestica*	housefly	1	0.85	6	15.39
19.	*Chevre naine*	Dwarf goat	0	0.00	6	15.39
20.	*Capra hircus*	-	2	1.72	0	0.00
21.	*Pieris brassicae*	Cabbage butterfly	6	5.14	3	7.69
22.	*Canis papuensis*	Domestic Dog	0	0.00	1	2.56
23.	*Lenothrix canus*	Wild rat	1	0.85	0	0.00
Total			**117**	**100**	**39**	**100**

Foot Note: LAT: Latitude, ***LOG:*** *Longitude,* ***ELV:*** *Elevation,* ***% Distr.:*** *Percentage Distribution*

Faunal Diversity of **SHEDA**

There were 19 different species in SHEDA, though 17 were encountered in the Demarcated area. *Turdus merula* (Black bird) that usually fly in colony were the dominant species encountered. Though they were found on tree, but most likely under migration. Therefore 128 individuals were encountered compared to Control site that recorded just 45 individual fauna. *Bos Taurus indicus* (cow) was observed to be grazing in the Control site and therefore recorded a highest distribution of 58%, which was followed by a stink bug 11% (Table 4.29).

Table 4.32 Faunal Diversity at Sheda Site and Control Areas

Animal Diversity at Sheda			Demarcated Area Coordinates: **LAT:** 08.84683°N **LOG:** 007.04127°E **ELV:** 197m		Control Coordinates: **LAT:** 08.84822°N **LOG:** 007.04099°E **ELV:** 198m	
SN	**Species**	**Common Name**	**NO**	**% Distr.**	**NO**	**% Distr.**
1.	*Perdix perdix*	Grey perdix	3	2	-	-
2.	*Guttera pucherani*	Guineafowl	-	-	3	7
3.	*Oryctolagus cuniculus*	Rabbit	1	1	-	-
4.	*Rattus norvegicus*	Rat	2	2	-	-
5.	*Halyomorpha halys*	Stink bug	12	9	5	11
6.	*Columba livia*	Wild pigeon	4	3	-	-
7.	*Turdus merula*	Black bird	30	23	2	4
8.	*Odontotaenius disjunctu*	Bess bug	12	9	-	-
9.	*Terpsiphone viridis*	Flycatcher	3	2	-	-
10	*Aedes albopictu*	Biting insect	11	9	-	-
11	*Musca domestica*	Housefly	8	6	2	4
12	*Bos taurus indicus*	Cow	-	-	26	58
13	*Passer melanurus*	Sparrow	3	2	-	-
14	*Leptidea sinapis*	Wood white butterfly	13	10		-
15	*Oudah bicolor*	Udah	-	-	3	7
16	*Streptopelia roseogrisea*	Collared Dove	2	2	-	-
17	*Acigona ignefusalis*	Millet insect	9	7	-	-
18	*Quelea quelea*	Millet pest Bird	4	3	2	4
19	*Papilio demoleus*	Multicolored butterfly	11	9	2	4
Total			128	100	45	100

Foot Note: LAT: Latitude, ***LOG:*** *Longitude,* ***ELV:*** *Elevation,* ***% Distr.:*** *Percentage Distribution*

4.4.4 Plankton

The term 'plankton' refers to the group of organisms which float on the surface waters of the rivers, lakes and oceans (Sampathkumar and Ananthan, 2007). The great majority of the floating plants in water bodies are unicellular microscopic organisms collectively called phytoplankton. Among the planktonic organisms, algae dominate the waterbodies, occurring as a defined seasonal succession of species in temperate rivers, lakes etc. During the annual cycle, phytoplankton blooms correspond to peaks in algal biovolume and chlorophyll-a concentration, and troughs in turbidity (Bellinger and Sigee, 2010). Plankton are the diverse collection of organisms that live in large bodies of water and are unable to swim against a current. The individual organisms constituting plankton are called plankters. They provide a crucial source of food to many large aquatic organisms, such as fish and whales.

Methodology of Plankton Sample Collection and Identification

The plankton were collected with standard plankton net (25µm mesh size) and transferred to 1 litre capacity plastic bottles containing 4% Lugol's iodine solution and kept for identification of plankton species. Each sample bottle analyzed was shaken before pipeting two drops on a slide, this was mounted on a light microscope. Each plankton identified was compared with the plankton identification charts of (Hötzel and Croome 1999; Botes, 2003; Perry, 2003; Janse-van *et al.*, 2006; Yamaguchi, and Gould, 2007; Bellinger and Sigee, 2010), all features were compared with the identification chart, the species were counted and recorded.

Plankton Diversity of Epe

Plankton composition for both phytoplankton and zooplankton were diverse, though diversity was recorded more on phytoplankton with 13 species for Cyanophyta, 4 species for Euglenophyta, 28 for Bacillariophyta, 3 for Dinophyta and 9 for Chlorophyta (Table 4.30). Zooplankton has 25 species recorded; 9,5, and 11 for Copepoda, Cladocera and Rotifera respectively. Though, *Cyclopina longicornis* and *Lecane climacois* has the highest percentage distribution of 13% each (Table 4.31).

Table 4.33 Phytoplankton Specie Composition at Epe (PLK-2210-EPE-01)

SN	Cyanophyta	Cells/liter	% Distr.
1.	*Chroococcus turgidus*	7	5.38
2.	*Microcystis aureginosa*	9	6.92
3.	*Merismopedia gluca*	10	7.69
4.	*Anabaena constricta*	11	8.46
5.	*Anabaena spiroides*	4	3.08
6.	*Lynbgya martensiana*	9	6.92
7.	*Oscillatoria chalybea*	3	2.31
8.	*Oscillatoria curviceps*	12	9.23
9.	*Oscillatoria formosa*	8	6.15
10.	*Oscillatoria limnosa*	9	6.92
11.	*Oscillatoria tenius*	10	7.69
12.	*Spirulina platensis*	22	16.92
13.	*Trichodesmium thiebautii*	16	12.31
	Total	**130**	**100**
	Euglenophyta		
1.	*Euglena acus*	12	29.27
2.	*Phacus acuminatus*	9	21.95
3.	*Phacus curvicauda*	15	36.59
4.	*Phacus acuminatus*	5	12.20
	Total	**41**	**100**

	Bacillariophyta		
1.	*Aulacoseira granulata*	11	2.61
2.	*Actinoptychus splendens*	18	4.28
3.	*Aulacoseira granulata*	8	1.90
4.	*Aulacoseira granulata*	11	2.61
5.	*Aulacoseira islandica*	15	3.56
6.	*Melosira moniliformis*	19	4.51
7.	*Melosira nummuloides*	15	3.56
8.	*Ditylum brightwelli*	21	4.99
9.	*Cyclotella menighiniana*	22	5.23
10.	*Chaetoceros convolutus*	12	2.85
11.	*Leptocylindricus danicus*	16	3.80
12.	*Hemidiscus cuneiformis*	21	4.99
13.	*Bacillaria paxillifer*	15	3.56
14.	*Fragillaria construens*	22	5.23
15.	*Gomphonema parvulum*	18	4.28
16.	*Gyrosigma balticum*	21	4.99
17.	*Gyrosigma spenceri*	22	5.23
18.	*Gyrosigma scalproides*	23	5.46
19.	*Hantzschia amphioxys*	3	0.71
20.	*Navicula cryptocephala*	17	4.04
21.	*Navicula mutica*	11	2.61
22.	*Navicula rhynchocephala*	8	1.90
23.	*Nitzschia closterium*	11	2.61
24.	*Pinnularia major*	17	4.04
25.	*Pinnularia gibba*	11	2.61
26.	*Synedra ulna*	8	1.90
27.	*Synedra ulna*	11	2.61
28.	*Surirella ovata*	14	3.33
	Total	**421**	**100**
	Dinophyta		
1.	*Ceratium macroceros*	11	28.21
2.	*Ceratium tripos*	20	51.28
3.	*Peridinium africana*	8	20.51
	Total	**39**	**100**
	Chlorophyta		
1.	*Microspora flocca*	9	9.09
2.	*Spirogyra africana*	12	12.12
3.	*Cladophora glomerata*	19	19.19
4.	*Ankistrodesmus falcatus*	5	5.05
5.	*Scenedesmus obliquus*	6	6.06
6.	*Closterium ehrenbergii*	13	13.13
7.	*Gonatozygon monotaenium*	14	14.14

8.	*Staurastrum paradoxum*	6	6.06
9.	*Chrysotepphanosphaera globulifera*	15	15.15
	Total	**99**	**100**

Table 4.34 Zooplankton Species Composition of Epe (PLK-2210-EPE-01)

SN	COPEPODA	Cells/liter	% Distr.
1.	*Acartia spp.*	11	12.64
2.	*Cyclopina longicornis*	13	14.94
3.	*Euchaeta aequatorialis*	12	13.79
4.	*Euterpina acutifrons*	10	11.49
5.	*Microsetella norvegica*	11	12.64
6.	*Paracalanus parvus*	6	6.90
7.	*Parathelestris croni*	5	5.75
8.	*Temora turbinata*	11	12.64
9.	*Oithona spp.*	8	9.20
	Total	**87**	**100**
	CLADOCERA		
1.	*Bosmina spp.*	3	6.67
2.	*Chydorus eurynotus*	12	26.67
3.	*Penilia avirostris*	11	24.44
4.	*Moina macropa*	9	20.00
5.	*Podon sp.*	10	22.22
	Total	**45**	**100**
	ROTIFERA		
1.	*Brachionus falcatus*	8	8.33
2.	*Dipleuchlanis propatula*	11	11.46
3.	*Dicranophorus sp*	7	7.29
4.	*Lecane climacois*	13	13.54
5.	*Keratella cochlearis*	5	5.21
6.	*Keratella tropica*	7	7.29
7.	*Brachionus urceolaris*	12	12.50
8.	*Lecane curvicornis*	6	6.25
9.	*Lecane lunaris*	5	5.21
10.	*Oxygyrus keraudreni*	12	12.50
11.	*Filinia terminalis*	10	10.42
	Total	**96**	**100**

Plankton Diversity at Sheda

The site was unique with accessible Upstream and Downstream water bodies, which made the survey comprehensive for comparison. A total of 23 species and 732 individual's cell/liter were encountered for phytoplankton during the survey. Though, *Spirogyra gracilis* recorded highest percentage distribution and the least recorded was *Oscillatoria limosa* 4.39% (Table 4.32). Downstream was observed to be more abundant with individual distribution of species. Zooplankton species recorded 519 individuals belonging to 13 species and 3 taxa namely Copepoda, Cladocera and Rotifera (Table 4.33)

Table 4.35 Phytoplankton Species Composition at Sheda

S/No	SPECIES COMPOSITION	(PLK-2510-SHEDA-01) Upstream	(PLK-2510-SHEDA-01) Downstream	Total	% Distr.
	CHLOROPHYTA				
1.	*Oedogonium undulatum*	12	19	31	13.54
2.	*Cladophora albida*	14	24	38	16.59
3.	*Ulothrix tenuissima*	17	26	43	18.78
4.	*Spirogyra gracilis*	23	23	46	20.09
5.	*Mougeotia capucina*	19	14	33	14.41
6.	*Zygnema pectinatum*	22	16	38	16.59
	Total	**107**	**122**	**229**	**100**
	BACILLIAROPHYTA				
1.	Coscinodiscus alienus	10	18	28	18.18
2.	*Aulacoseira granula ta*	13	17	30	19.48
3.	*Fragillaria acus*	11	25	36	23.38
4.	*Nitzschia Palea*	20	16	36	23.38
5.	*Navicula cremeri*	14	10	24	15.58
	Total	**68**	**86**	**154**	**100**
	CYANOPHYTA				
1.	*Merismopedia angularis*	23	18	41	35.96
2.	*Chroococcus turgidu s*	17	21	38	33.33
3.	*Oscillatoria princeps*	12	18	30	26.32
4.	*Oscillatoria limosa*	13	15	5	4.39
	Total	**65**	**72**	**114**	**100**
	DINOPHYTA				
1.	*Dinophysis caudata*	12	21	33	100.00
	EUGLENOPHYTA				

1.	*Euglena gracilis*	14	18	32	17.88
2.	*Euglena viridis*	22	16	38	21.23
3.	*Phacus longicauda*	18	23	41	22.91
4.	*Phacus circulatus*	12	16	28	15.64
5.	*Phacus anomalus*	19	21	40	22.35
	Total	**85**	**94**	**179**	**100**
	CHRYSOPHYTA				
1.	*Synura klebsiana*	3	4	7	30.43
2.	*Synura glabra*	4	12	16	69.57
	Total	**7**	**16**	**23**	**100**

Table 4.36 Zooplankton Species Composition at Sheda

S/N	ROTIFERA	(PLK-2510-SHEDA-01) Upstream	(PLK-2510-SHEDA-01) Downstream	Total	% Distr.
1.	*Branchionus plicatilis*	18	21	39	24.38
2.	*Trichocerca longiseta*	13	19	32	20.00
3.	*Asplanchna priodonta*	11	23	34	21.25
4.	*Testudinella mucronata*	10	16	26	16.25
5.	*Rotaria neptunia*	13	16	29	18.13
	Total	**65**	**95**	**160**	**100**
	CLADOCERA				
1.	*Daphnia pulex*	23	19	42	16.34
2.	*Daphnia magna*	10	16	26	10.12
3.	*Nauplius* Sp.	22	22	44	17.12
4.	*Simocephalus serrulatus*	18	11	29	11.28
5.	*Chydorus sphaericus.*	29	34	63	24.51
6.	*Ceriodaphnia quadrangula*	31	22	53	20.62
	Total	**133**	**124**	**257**	**100**
	COPEPODA				
1.	*Metacyclops deserticus*	23	33	56	54.90
2.	*Dileptus margaritifer*	26	20	46	45.10
	Total	**49**	**53**	**102**	**100**

4.4.5 Fisheries

Structured questionnaire was used to evaluate the fishing practices and fish diversity of the three proposed sites according to description of Rattray and Jones (2007).

Various methods were found to be used by the inhabitants for fishing, these were among others; Setting net traps, spearing, thrown netting, demarcating shallower part of the water bodies at late raining seasons etc.

The diverse extant species are listed (Table 4.34). Epe was found to be more diverse among the sites with 15 species, which may likely be due to the location of the site, Neke Uno has 14 species and Sheda ah the least number of species.

Table 4.37 Fish Species Around the Proposed Sites

SN	EPE	NEKE UNO	SHEDA
1.	*Caranx senegallus*	*Clarias anguillaris*	*Auchenoglanis occidentalis*
2.	*Callinectes amnicola*	*Clarias lazera*	*Barbus occidentalis*
3.	*Dentex gibbosus*	*Heterobranchus bidorsalis*	*Barilius loati*
4.	*Elops lacerta*	*Lates niloticus*	*Barilius niloticus*
5.	*Ethmalosa fimbriata*	*Synodontis nigrita*	*Clarias gariepinus*
6.	*Galeoides decadactylus*	*Synodontis clarias*	*Heterobranchus bidorsalis*
7.	*Lisa falcipinnis*	*Synodontis gobroni*	*Mormyrus macropthalamus*
8.	*Mormyrus rume*	*Synodontis membranaceus*	*Oreochromis niloticus*
9.	*Mytilus edulis*	*Synodontis batensoda*	*Tilapia zilli*
10.	*Pomadasys jubelini*	*Pristopoma jubeleni*	*Tilapia mariae*
11.	*Penaeus notialis*	*Tilapia zillii*	*Tilapia guineensis*
12.	*Pseudotolithus elongates*	*Tilapia nilotica*	
13.	*Pseudolithus senegalensis*	*Tilapia galilaea*	
14.	*Scomber japonicas*	*Tetraodon fahake*	
15.	*Synodontus clarias*		
16.	*Tilapia guineensis*		

4.4.6 Ecosystem Services

Ecosystem services are the many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems. Such ecosystems include, for example, agroecosystems, forest ecosystems, grassland ecosystems and aquatic ecosystems (Daily *et al.*, 2000). Collectively, these benefits are becoming known as 'ecosystem services', and are often integral to the provisioning of clean drinking water (Ojea, 2010). While scientists and environmentalists have discussed ecosystem services implicitly for decades, the Millennium Ecosystem Assessment (MA) in the early 2000s popularized the concept (MA, 2005). Ecosystem services are grouped into four broad categories: provisioning, such as the production of food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and oxygen production; and cultural, such as spiritual and recreational benefits.

The proposed sites namely; Epe, Neke Uno and Sheda are considered of benefited by the inhabitants, among which fishing is one of many, timber for furniture and building materials, provision of water, food (this has been the common, as farming activities are all been observed in the areas with exception of Epe) fibre and medicine, pollinators (from the diverse insects species).

4.4.7 Microbiology

Microbiological analysis is the use of biological, biochemical, molecular or chemical methods for the detection, identification or enumeration of microorganisms. It represents one aspect of water quality. It is a microbiological analytical procedure which uses samples of water and from these samples determines the concentration of bacteria (EPA, 2002). It is then possible to draw inferences about the suitability of the water for use from these concentrations. This process is used, for example, to routinely confirm that water is safe for human consumption or waters is safe to be used.

Water samples were collected according to the WHO Guidelines for drinking water quality assessment (WHO, 1993). The samples were collected from surface and ground water sources that are used directly for drinking purpose in the community. Closed sterilized 500 ml glass containers were used to collect samples aseptically.

Faecal and total coliform counts were performed using the standard membrane filtration technique. The 100 ml water sample was filtered using 0.45 mm pore size, 47 mm diameter filter membrane as described by NOM-127-SSA1 (1994) and APHA (1992).

Multiple tube technique was used for the enumeration of Most Probable Number of coliform bacteria. The coliform bacteria were analyzed in two stages, by cultivation on liquid broths containing lactose as carbon sources, as presumptive and confirmation tests. By incubation at temperature of 37 ± 2°C, growth (turbidity) with gas production is a positive reaction, indicating the presence of coliforms.

Isolation of Pseudomonas Aeruginosa

Water sample (100ml) was filtered with a sterile membrane filter (0.45/µm). It was then placed aseptically on Pseudomonas agar base and incubated at 420C for 48hr (APHA, 1992: Balogun 2000).

Isolation of Microorganisms

Membrane filtration technique was used to isolate the microorganisms present in the water samples. The funnel of the membrane filtration unit has a capacity of 50ml and the funnel was mounted one receptacle fixed to the vacuum pump which allows the water to flow over the porous sterile membrane filter (0.45µm). Aseptically, the membrane filters were placed on each microbial growth medium using sterile forceps after passage of 100ml of water sample. The following media (Baired Parker agar, McConkey agar, Plate count agar, potato dextrose agar Pseudomonas agar base) were prepared and autoclaved at 121^{0}C for 15 minutes at 15Ib before being inoculated with membrane filters. (APHA, 1992).

Characterization and Identification of Microbial Isolates

Pure cultures of microbial isolates were identified based on cultural parameters, microscopic techniques and biochemical tests including carbohydrate utilization (Cruickshank *et al*., 1976). Identification of the bacterial isolates was accomplished by comparing the characteristics of the cultures with that of known taxa as in (Holt *et al*., 1994). Characterization and identification of fungal isolates was carried out as described by (Domsch *et al*., 1980; Barnet and Hunter, 1987). Actinomycetes were characterized and identified as described by (Eka and Fogathy, 1972).

Microbiology Analysis

In water, coliform bacteria have no taste, smell, or colour. They can only be detected through a laboratory test. Total coliform bacteria are not likely to cause illness, but their presence indicates that your water supply may be vulnerable to contamination by more harmful microorganisms. *Escherichia coli* (*E.coli*) is the only member of the total coliform group of bacteria that is found only in the intestines of mammals, including humans. The presence of *E.coli* in water indicates recent fecal contamination and may indicate the possible presence of disease causing pathogens, such as bacteria, viruses, and parasites. Although most strains of *E.coli* bacteria are harmless, certain strains, such as E.coli 0157:H7, may cause illness (WHO, 1998; WHO, 2004).

The majority of pseudomonas species are not harmful to humans but *Pseudomonas aeruginosa* can cause infections in immunosuppressed patients. But when this is present in water system it protects and harbours harmful bacteria such as pseudomonas and legionella and is difficult to remove (Hardalo and Edberg, 1997). Total coliforms are a group of bacteria commonly found in the environment, for example in soil or vegetation, as well as the intestines of mammals, including humans. Of the many infectious microorganisms found in the environment, bacteria (such as *Shigella, Escherichia coli, Vibrio, and Salmonella*), viruses (such as Norwalk virus and rotaviruses), and protozoans (such as *Entamoeba, Giardia, and Crypto.* The present results of microbiology analysis are presented (Table 4.35 to 4.43) which shows that the water is within the WHO, SON and NESREA's limits.

Table 4.39 Microbiological Analysis of Surface Water (Epe Site -Downstream)

Total Plate Count (cfu/ml)	1.5 x 10^2		
Faecal Coliforms Count (cfu/ml)	Nil		
Pseudomonas Count (cfu/ml)	Nil		
Coliform Count (cfu/100ml)	MPN (100ml)	L	U
	3.0	1.0	10.0

Table 4.40 Microbiological Analysis of Surface Water (Epe Site -upstream)

Total Plate Count (cfu/ml)	2.0×10^1		
Faecal Coliforms Count (cfu/ml)	Nil		
Pseudomonas Count (cfu/ml)	Nil		
Coliform Count (cfu/100ml)	MPN (100ml)	L	U
	4.0	1.0	15.0

Table 4.41 Microbiological Analysis of Ground Water (Epe Site)

Total Plate Count (cfu/ml)	1.8×10^2		
Faecal Coliforms Count (cfu/ml)	Nil		
Pseudomonas Count (cfu/ml)	Nil		
Coliform Count (cfu/100ml)	MPN (100ml)	L	U
	<2	-	-

Table 4.42 Microbiological Analysis of Surface Water (Neke Uno Site -Upstream)

Total Plate Count (cfu/ml)	1.0×10^2		
Faecal Coliforms Count (cfu/ml)	Nil		
Pseudomonas Count (cfu/ml)	Nil		
Coliform Count (cfu/100ml)	MPN (100ml)	L	U
	<2	-	-

Table 4.43 Microbiological Analysis of Surface Water (Neke Uno Site -Downstream)

Total Plate Count (cfu/ml)	4.0×10^2		
Faecal Coliforms Count (cfu/ml)	Nil		
Pseudomonas Count (cfu/ml)	Nil		
Coliform Count (cfu/100ml)	MPN (100ml)	L	U
	<2	-	-

Table 4.44 Microbiological Analysis of Ground Water (Neke Uno Site)

Total Plate Count (cfu/ml)	6.0×10^2		
Faecal Coliforms Count (cfu/ml)	Nil		
Pseudomonas Count (cfu/ml)	Nil		
Coliform Count (cfu/100ml)	MPN (100ml)	L	U
	<2	-	-

Table 4.45 Microbiological Analysis of Surface Water (Sheda Site -Downstream)

Hydrocarbon utilizing fungi (cfu/100ml)	ND
Total coliforms (MPN/100ml)	146
Total Heterotrophic fungi (cfu/100ml)	0.8×10^2
Faecal coliforms (MPN/100ml)	162
Hydrocarbon utilizing Bacteria (cfu/100ml)	1.1×10^2
Total Heterotrophic bacteria (cfu/100ml)	3.5×10^2

Table 4.46 Microbiological Analysis of Surface Water (Sheda Site -upstream)

Hydrocarbon utilizing fungi (cfu/100ml)	ND
Total coliforms (MPN/100ml)	124
Total Heterotrophic fungi (cfu/100ml)	1.0×10^2
Faecal coliforms (MPN/100ml)	120
Hydrocarbon utilizing Bacteria (cfu/100ml)	1.4×10^2
Total Heterotrophic bacteria (cfu/100ml)	1.5×10^2

Table 4.47 Microbiological Analysis of Ground Water (Sheda)

	Sample 1	Sample 2
Hydrocarbon utilizing fungi (cfu/100ml)	ND	ND
Total coliforms (MPN/100ml)	128	108
Total Heterotrophic fungi (cfu/100ml)	0.8×10^2	1.1×10^2
Faecal coliforms (MPN/100ml)	104	98
Hydrocarbon utilizing Bacteria (cfu/100ml)	1.0×10^2	1.6×10^2
Total Heterotrophic bacteria (cfu/100ml)	2.5×10^2	1.7×10^2

4.4.8 Alien (Invasive) Species

An invasive species is a species that is not native to a specific location (an introduced species), and that has a tendency to spread to a degree, believed to cause damage sometimes to the environment, human economy or human health. The criteria for invasive species have been controversial, as widely divergent perceptions exist among researchers as well as concerns with the subjectivity of the term "invasive" (Joan 2010). Several alternate usages of the term have been proposed. The term as most often used applies to introduced species (also called "non-indigenous" or "non-native") that adversely affect the habitats and bioregions they invade. Such invasive species may be either plants or animals and may disrupt by dominating a region, wilderness areas, particular habitats, interface land from loss of natural controls, such as predators or herbivores (Robert, 2004). The diversity of both flora and fauna of the proposed sites was considered to be intrude with few species, *Rhizophora racemose* was the only plant species considered as invasive in Nigeria according IUCN (2015). There were some animal species also considered as invasive in Nigeria; *Opheodrys vernalis, Tettigoma viridissima, Gryllodes sigillatus* both of which found in Epe site. While *Oryctolagus cuniculus* and *Columba livia* were all found in Neke Uno and Sheda as alien species. *Saxicola rubetra, Carduelis cannabina* and *Pieris brassicae* also considered to have intrude to Nigeria as invasive species which were presently available in Neke Uno site.

4.4.9 Red List Status of Species

The IUCN Red List of Threatened Species (also known as the IUCN Red List or Red Data List), founded in 1965, has evolved to become the world's most comprehensive inventory of the global conservation status of biological species. These criteria are relevant to all species and all regions of the world, including the areas covered in this study.

The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. The general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk (IUCN, 2015). However, while the Red List may focus attention on those taxa at the highest risk, it is not the sole means of setting priorities for conservation measures for their protection. These categories are;

1. Extinct (EX): extinct when there is no reasonable doubt that the last individual has died.
2. Critically Endangered (CR): when there is extremely high risk of extinction in the wild
3. Endangered (EN): when there is very high risk of extinction in the wild in the immediate future
4. Vulnerable (VU): when facing a high risk of extinction in the wild
5. Near Threatened (NT): Any species which is likely to become endangered
6. Least Concern (LC): when it has been evaluated against the criteria and still abundant
7. Data Deficient (DD): when no adequate information to make assessment risk of extinction
8. Not Evaluated (NE): when it has not yet been evaluated against the criteria and recorded on IUCN
9. Extinct in the Wild (EW): when it is known only to survive in cultivation, in captivity or as a naturalized

The IUNC status of the diverse floral and fauna in the proposed sites namely Epe, Neke Uno, Sheda were assessed on the IUCN web and their status are presented on the (Table 4.48 to 4.52). African teak was the only plant was found to be NT meaning Nearly Threatened (Table 4.48). Though Mango, Pawpaw and *Myristica fragrans* (Table 4.48) were considered DD (Deficient in Data), so also *Vitellaria paradoxa* was considered deficient in data (Table 4.49).

The animal species encountered in the proposed sites were mostly evaluated according to IUCN records. Though, African Antelope NT (Nearly Threatened) in Epe (Table 4.50), so also *Oryctolagus cuniculus* in Neke Uno (Table 4.51). Majority of the fish species were found to evaluated (Table 4.53), but *Galeoides decadactylus* and *Tilapia galilaea* considered Nearly Threatened.

Table 4.48 IUCN Status of Plant Species at EPE Site

SN	Species	Common Name	STATUS	Remarks
23.	*Rhizophora racemosa*	-	LC	Decrease in population trend
24.	*Albizia zygia*	West African albizia	NE	But catalogued
25.	*Acrostichum aureum*	-	LC	Stable population trend
26.	*Carapa procera*	Crabwood	LC	Unspecified population trend

27.	*Cassytha filiformis*	Climber	NE	But catalogued
28.	*Caladium bicolor*	heart of Jesus	NE	But catalogued
29.	*Baphia nitida*	Sandalwood	LC	Stable population trend
30.	*Bridelia micrantha*	Bridelia	LC	Stable population trend
31.	*Alchornia cordifolia*	Christmas bush	NE	But catalogued
32.	*Ficus capensis*	Broom cluster	NE	But catalogued
33.	*Albizia lebbeck*	Frywood	NE	But catalogued
34.	*Pennisetum purpureum*	Elephant grass	LC	Stable population trend
35.	*Diodia scandens*	Buttonweed	NE	But catalogued
36.	*Ficus asperifolia*	-	NE	But catalogued
37.	*Manihot esculenta*	Cassava	NE	But catalogued
38.	*Cladrastis kentukea*	-	NE	But catalogued
39.	*Zea mays*	Maize	NE	But catalogued
40.	*Chromolaena odorata*	Siam weed	NE	But catalogued
41.	*Macaranga barteri*	-	NE	But catalogued
42.	*Milicia excelsa*	African teak	NT	Unspecified population trend
43.	*Panicum virgatum*	Switchgrass	LC	Stable population trend

KEY: LC: Least Concern, NS: No Status, NT: Nearly threatened, DD: Data deficient, VU: Vulnerable, NA: Not Applicable

Table 4.49 IUCN Status of Plant Species at Neke Uno Site

SN	Species	Common Name	STATUS	Remarks
1.	*Elaeis guineensis*	African oil palm	LC	Unknown population trend
2.	*Manihot esculenta*	Cassava	NE	But catalogued
3.	*Psidium quajava*	Guava	NE	
4.	*Musa acuminata*	Banana	LC	Unknown population trend
5.	*Anacardium occidentale*	Cashew	NE	
6.	Zea mays	Maize	NE	But catalogued
7.	*Cola acuminata*	Bitter cola	NE	But catalogued
8.	*Persea americana*	Avocado tree	LC	Unknown population trend
9.	*Dioscorea alata*	Water yam	NE	
10.	*Parkia biglobosa*	African locust beans	NE	But catalogued
11.	*Mangifera indica*	Mango	DD	Unspecified population trend
12.	*Carica papaya*	Pawpaw	DD	Global population trend decreasing
13.	*Musa paradisiaca*	Plantain	NE	But catalogued
14.	*Abelmoschus esculentus*	Okra	NE	But catalogued
15.	*Myristica fragrans*	-	DD	Unspecified population trend
16.	*Telfairia occidentalis*	Pumpkin	NE	But catalogued
17.	*Vitellaria paradoxa*	Shea nut tree	VU	Unspecified population trend
18.	*Echinochloa colonum*		NE	

KEY: LC: Least Concern, NS: No Status, NT: Nearly threatened, DD: Data deficient, VU: Vulnerable, NA: Not Applicable

Table 4.50 IUCN Status of Plant Species at Sheda Site

SN	Species	Common Name	Status	Remarks
1.	*Pericopsis laxiflora*	African Teak	NE	But catalogued
2.	*Uvaria chamae*	-	NE	But catalogued
3.	*Sarcocephalus latifolius*	African Peach	NE	But catalogued
4.	*Parkia biglobosa*	African locust beans	NE	But catalogued
5.	*Detarium microcarpum*	Detar	LC	Stable population trend
6.	*Panicum sumatrnse*	Little Millet	NE	
7.	*Echinochloa colona*	Millet weed	LC	Unknown population trend
8.	*Zea mays*	Maize	NE	But catalogued
9.	*Sesamum indicum*	Sesame	NE	
10.	*Corchorus olitorius*	-	NE	But catalogued
11.	*Borreria articularis*	-	NE	But catalogued
12.	*Piliostigma thonningii*	Camel's foot	NE	But catalogued
13.	*Hymenocardia acida*	-	NE	But catalogued
14.	*Abelmoschus esculentus*	Okra	NE	But catalogued
15.	*Sorghum bicolor*	Sorghum	NE	But catalogued
16.	*Cyperus rotundus*	Nut Sedge	LC	Stable population trend
17.	*Capsicum baccatum*	Locoto (Pepper)	NE	But catalogued
18.	*Pennisetum pedicellatum*	Deenanath grass	NE	
19.	*Arachis hypogaea*	Groundnut	NE	But catalogued
20.	*Anacardium occidentale*	Cashew	NE	But catalogued
21.	*Vitellaria paradoxa*	Sheanut tree	VU	Unspecified population trend
22.	*Moringa oleifera*	Moringa	NE	But catalogued
23.	*Dioscoreae cayennensis*	Yam	NE	
24.	*Manihot esculenta*	Cassava	NE	But catalogued
25.	*Solanum tuberosum*	Sweet potatoes	NE	But catalogued
26.	*Talinum triangulare*	Water leaf	NE	
27.	*Mangifera indica*	Mango	DD	Unspecified population trend
28.	*Calotropis procera*	Giant milk	NE	But catalogued
29.	*Ageratum conyzoides*	billygoat-weed	LC	Stable population trend
30.	*Chromolaena odorata*	Siam weed	NE	But catalogued
31.	*Heliotropium indicum*	-	NE	But catalogued
32.	*Psidium guajava*	Guava	NE	But catalogued
33.	*Launaea taraxacifolia*	Wild lettuce	NE	But catalogued
34.	*Eragrostis chloromela*	Blue Love Grass	NE	But catalogued
35.	*Vigna unguiculate*	Cowpea	NE	But catalogued

KEY: LC: Least Concern, NS: No Status, NT: Nearly threatened, DD: Data deficient, VU: Vulnerable, NA: Not Applicable

Table 4.51 IUCN Status of Animal Species at Epe Site

SN	Species	Common Name	Status	Remarks
16.	*Macrotermes subhyalinus*	Soja ant	NE	But catalogued
17.	*Nylanderia bourbonica*	Brown ant	NE	But catalogued
18.	*Opheodrys vernalis*	Green snake	LC	Stable population trend
19.	*Naja melanoleuca*	Cobra	NE	But catalogued
20.	*Papio cynocephalus*	Yellow Baboon	LC	Stable population trend

21.	*Tettigonia viridissima*	Cricket	LC	Increase in population trend
22.	*Turtur tympanistria*	Singin bird	LC	Stable population trend
23.	*Pterocles Namaqua*	Wild Dove	LC	Stable population trend
24.	*Litocranius walleri*	African Antelope	NT	Decrease in population trend
25.	*Colias eurytheme*	Orange sulphur	NE	But catalogued
26.	*Junonia coenia*	Common buckeye	NE	But catalogued
27.	*Papilio demodocus*	Swallowtail	NE	But catalogued
28.	*streptopelia vinacea*	Vinaceous dove	LC	Stable population trend
29.	*Gryllodes sigillatus*	Tropical house cricket	NA	Increase in population trend
30.	*Perdix perdix*	Grey Perdix	LC	Decrease in population trend

KEY: LC: Least Concern, NE: Not Evaluated, NT: Nearly threatened, DD: Data deficient, VU: Vulnerable, NA: Not Applicable

Table 4.52 IUCN Status of Animal Species at Neke Uno Site

SN	Species	Common Name	Status	Remarks
24.	*Oryctolagus cuniculus*	Rabbit	NT	Decrease in population trend
25.	*Rattus norvegicus*	Rat	LC	Stable population trend
26.	*Rattus rattus*	House Rat	LC	Stable population trend
27.	*Saxicola rubetra*	-	LC	Decrease in population trend
28.	*Nylanderia bourbonica*	Brown ant	NE	But catalogued
29.	*Setophaga angelae*	Elfin Woods Warbler	EN	Decrease in population trend
30.	*Papilio demoleus*	Multicolored butterfly	NA	Unspecified population trend
31.	*Leptidea sinapis*	Wood white butterfly	NE	But catalogued
32.	*Guttera pucherani*	Guineafowl	LC	Stable population trend
33.	*Columba livia*	Rock Dove	LC	Unknown population trend
34.	*Turtur tympanistria*	Singing bird	LC	Stable population trend
35.	*Pterocles Namaqua*	Wild Dove	LC	Stable population trend
36.	*Carduelis cannabina*	Common Linnet	LC	Decrease in population trend
37.	*Colias eurytheme*	Orange Sulphur	NE	But catalogued
38.	*Junonia coenia*	Common buckeye	NE	But catalogued
39.	*Aedes albopictu*	Biting insect	NE	
40.	*Streptopelia vinacea*	Vinaceous dove	LC	Stable population trend
41.	*Musca domestica*	housefly	NE	But catalogued
42.	*Chevre naine*	Dwarf goat	NE	
43.	*Capra hircus*	Domestic goat	NA	Stable population trend
44.	*Pieris brassicae*	Cabbage butterfly	LC	Stable population trend
45.	*Canis papuensis*	Domestic Dog	NE	
46.	*Lenothrix canus*	Wild rat	LC	Unknown population trend

KEY: LC: Least Concern, NS: No Status, NT: Nearly threatened, DD: Data deficient, VU: Vulnerable, NA: Not Applicable

Table 4.53 IUCN Status of Animal Species at Sheda Site

SN	Species	Common Name	Status	Remarks
20.	*Perdix perdix*	Grey perdix	LC	Decrease in population trend
21.	*Guttera pucherani*	Guineafowl	LC	Stable population trend
22.	*Oryctolagus cuniculus*	Rabbit	NT	Decrease in population trend
23.	*Rattus norvegicus*	Rat	LC	Stable population trend

24. *Halyomorpha halys*	Stink bug	NE	But catalogued
25. *Columba livia*	Wild pigeon	LC	Decrease in population trend
26. *Turdus merula*	Black bird	LC	Increase in population trend
27. *Odontotaenius disjunctu*	Bess bug	NE	
28. *Terpsiphone viridis*	Flycatcher	LC	Stable population trend
29. *Aedes albopictu*	Biting insect	NE	But catalogued
30. *Musca domestica*	Housefly	NE	But catalogued
31. *Bos taurus indicus*	Cow	NE	But catalogued
32. *Passer melanurus*	Sparrow	LC	Stable population trend
33. *Leptidea sinapis*	Wood white butterfly	LC	Stable population trend
34. *Oudah bicolor*	Udah	NE	
35. *Streptopelia roseogrisea*	Collared Dove	LC	Stable population trend
36. *Acigona ignefusalis*	Millet insect	NE	
37. *Quelea quelea*	Millet pest Bird	LC	Stable population trend
38. *Papilio demoleus*	Lime Swallowtail	NA	Unspecified population trend

KEY: LC: Least Concern, NS: No Status, NT: Nearly threatened, DD: Data deficient, VU: Vulnerable, NA: Not Applicable

Table 4.54 IUCN Status of Fish Species Encountred

Species	IUCN Status	Remarks
Auchenoglanis occidentalis	LC	Stable population trend
Barbus occidentalis	DD	Unknown population trend
Barilius loati	LC	Stable population trend
Barilius niloticus	LC	Stable population trend
Callinectes amnicola	NE	But catalogued
Caranx senegallus	LC	Stable population trend
Clarias anguillaris	LC	Stable population trend
Clarias gariepinus	LC	Increase in population trend
Clarias lazera	LC	Stable population trend
Dentex gibbosus	LC	Stable population trend
Elops lacerta	LC	Stable population trend
Ethmalosa fimbriata	LC	Stable population trend
Galeoides decadactylus	NT	Decrease in population trend
Heterobranchus bidorsalis	LC	Increase in population trend
Lates niloticus	LC	Stable population trend
Lisa falcipinnis	NE	But catalogued
Mormyrus macropthalamus	LC	Stable population trend
Mormyrus rume	LC	Stable population trend
Mytilus edulis	NE	Stable population trend
Oreochromis niloticus	LC	Unspecified population trend
Penaeus notialis	NE	But catalogued
Pomadasys jubelini	LC	Stable population trend
Pseudolithus senegalensis	NE	But catalogued
Pseudotolithus elongates	NE	But catalogued
Scomber japonicas	NE	But catalogued

Synodontis batensoda	LC	Stable population trend
Synodontis clarias	LC	Stable population trend
Synodontis gobroni	LC	Stable population trend
Synodontis membranaceus	LC	Stable population trend
Synodontis nigrita	LC	Stable population trend
Tetraodon fahake	NE	But catalogued
Tilapia galilaea	NT	Decrease in population trend
Tilapia guineensis	LC	Increase in population trend
Tilapia mariae	LC	Stable population trend
Tilapia nilotica	LC	Stable population trend
Tilapia zilli	LC	Unspecified population trend

KEY: LC: Least Concern, NS: No Status, NT: Nearly threatened, DD: Data deficient, VU: Vulnerable, NA: Not Applicable

4.5 HUMAN ENVIRONMENT

4.5.1 General characteristics

4.5.1.1 Nigerian Political Context

Nigeria practices the presidential system of government with three tiers of government – Federal, State and Local Government. At all the three levels, there is the executive arm, legislature and judiciary, with separation of powers and checks and balances. The exception is that there are two legislative houses at the Federal Level – Senate and House of Representatives, and there is no judicial arm at the Local Government Level.

Three Senators are elected from each of the 36 States and one from the Federal Capital Territory. The number of house of representatives from each State depends on certain demographical data.

There are seven hundred and seventy-four (774) Local Government Areas (LGA). Each LGA is headed by a Chairman elected by the people, under the auspices of the State Independent National Electoral Commission.

Each tier of government has statutory defined roles within the national space as follows (Khemani, 2001).

TIER OF GOVERNMENT	RESPONSIBILITIES
Federal only	Defense; Shipping; Federal trunk roads; Aviation; Railways; Posts, telegraphs and telephones; Police and other security services; Regulation of labor, interstate

	commerce, telecommunications; Mines and minerals; Social Security; Insurance; National statistical system; National Parks; Guidelines for minimum education standards at all levels; Water resources affecting more than one state;
Federal and State (shared)	Antiquities and monuments; Electricity; Industrial, commercial and agricultural development; Scientific and technological research; Statistics and surveys; University, technological and post-primary education; Health and social welfare;
State-Local (shared)	Primary, adult and vocational education; Health services; Development of agriculture and non-mineral natural resources;
Local government	Economic planning and development; Cemeteries, burial grounds; Homes for the destitute and infirm; Markets; Sewage and refuse disposal; Roads, streets, street lighting, drains, other public facilities;

The judiciary is an independent arm of government which is headed by the Chief Judge of the state. It comprises three units, the High Court, Magistrate/Sharia/Customary and Area Courts. The High Court and Magistrate Courts are headed by judges and magistrates respectively; while the Sharia Court of Appeal is under the honourable Grand Khadi who is assisted by Khadis.

4.5.1.2 Socio-Economic Context

Nigeria's economy heavily depends on export of crude oil, which has been a dominant source of government revenues since the 1970s but regulatory constraints and security risks have limited new investment in oil and natural gas recently. Nevertheless, the Nigerian economy has continued to grow at a rapid 6-8% per annum (pre-rebasing), driven by growth in agriculture, telecommunications, and services. Despite the potential for resources exploitation, oil-rich Nigeria has been hobbled by inadequate power supply, lack of infrastructure, delays in the passage of legislative reforms, an inefficient property registration system, restrictive trade policies, an inconsistent regulatory environment, a slow and ineffective judicial system, unreliable dispute resolution mechanisms, insecurity, and pervasive corruption.

Available data from the national bureau for statistics (NBS) show and average GDP of about 423 billion USD over a period of 10 years (2008-2017), with an average growth rate of about 5% over the same period. The economy entered recession in 2016 due to significant dip in oil prices, and it is just starting to recovering, with growth rate predicted to reach 2.4% in 2019 (see Table 4.51).

Table 4.55 Nigeria's GDP and Growth Rate

YEAR	Annual GDP [billion USD]	GDP Growth (%)
2017	376	0.80%
2016	405	-1.60%
2015	494	2.70%
2014	568	6.30%
2013	515	5.40%
2012	461	4.30%
2011	414	4.90%
2010	369	11.30%
2009	297	8.40%
2008	330	7.20%

Source: (NBS, 2018)

The three communities selected to host the planned PCB sites – Neke Uno in Enugu State, Sheda in the Federal Capital Teritory and Epe in Lagos State - are semi urban-rural to rural.

Neke Uno, Enugu State

The Neke Uno people are Igbos, located in Enugu East Local Government of Enugu State. The Igbo society before the advent of colonization were known not to rely exclusively on a single head of a family with respect to decision taking. The eldest person in a family or community is obviously the figure-head leader of the family or community. At a wider level of the Igbo society, the leader is one person, old or young, collectively chosen to man the affairs of the society based on the person's birthright or perceived level of wisdom and understanding. Despite the level of trust and high level of confidence of the community or society on the figure-head leader, the Igbos are commonly ruled by committees of elders and well-selected groups. In the traditional Igbo society, the age grade groups, women groups etc are all important components of the trado-political system. This was why it was very difficult for the white men to penetrate the eastern zone until they instituted the warrant chiefs' structure.

But today, after the coming of the Europeans, the Igbos have developed a traditional political system from the warrant chiefs structure. Every Igbo society now has a traditional ruler addressed as the Igwe who governs his community with his council of chiefs.

Generally, Neke as a community is made up of 24 communities of which Neke-Uno (the host community for the project) is prominent. The communities (from the eldest) are; Ibagwa, Amokpo, Ogbeke, Ogui, Onyohu, Eziama, Nneokpa, Alulu, Amaowere, Amoji, Edem, Neke-Uno, Ako, Iji, Emene, Ugwogo, Agbogazi, Onuogba, Akpuoga, Nchatancha, Obinagu, Ugwuomu, Nkwubo and Neke Odenigbo. Traditional, the Igwe-in-council is the highest decision-making body in Neke community, as it is vested with the executive, legislative and judiciary powers. The Igwe is at the apex of this council and also has some veto powers.

The Igwe-in-council is made up of elders usually representative from different families (the eldest). Worthy to note that, two brothers cannot be in the council of elders at the same time even if the two brothers by virture of their ages are the eldest in the village which they represent. What this means is that, each village in the community always have representatives in the General council of elders. The council of elders (Oha) and the Igwe make up the traditional administrators and are always the decision-makers on issues affecting the community. The youth bodies are also present to see to the sanitation, labour and security needs of their respective communities. The women groups are also present although they have insignificant roles in the day to day running of the community. They preoccupy themselves with the family chores and farm works.

The economic base of the chieftaincy in the study area consists of tributes, gifts, fees, fines, compensations and money accruing from settlement of cases. A graphic representation of the traditional political governance structure of the host communities is presented in Figure 4.19.

The proposed PCB storage project is under Enugu-East Local Government area of Enugu state. The LGA administration is run by an elected Executive Chairman and appointees of the Chairman representing the executive arm of local government administration. There is also the legislature made up of counselors elected from the wards in the LGA. The proposed project site is under Ward 16.

Community Organisations*:* The traditional Neke-Uno community social life is based on mem bership in kinship groups and parallel but complementary dual-sex associations, which are of great importance to the integration of society. The associations take several forms, including age grades, men's societies, women's societies, and prestige-title societies such as the Nze o r Ozo for men and the Omu, Ekwe, or Lolo for women. The interlocking nature of these grou ps prevents the concentration of authority in any one association. Age sets are informally est ablished during childhood. Respect and recognition are accorded not only on the basis of age , but also through the acquisition of traditional titles. An individual may progress through at l east five levels of titles. One could liken the acquisition of titles to the acquisition of academi c degrees. Titles are expensive to obtain, and each additional title costs more than the prece ding one; they are therefore, considered a sure means to upward mobility in the trado-social ladder.

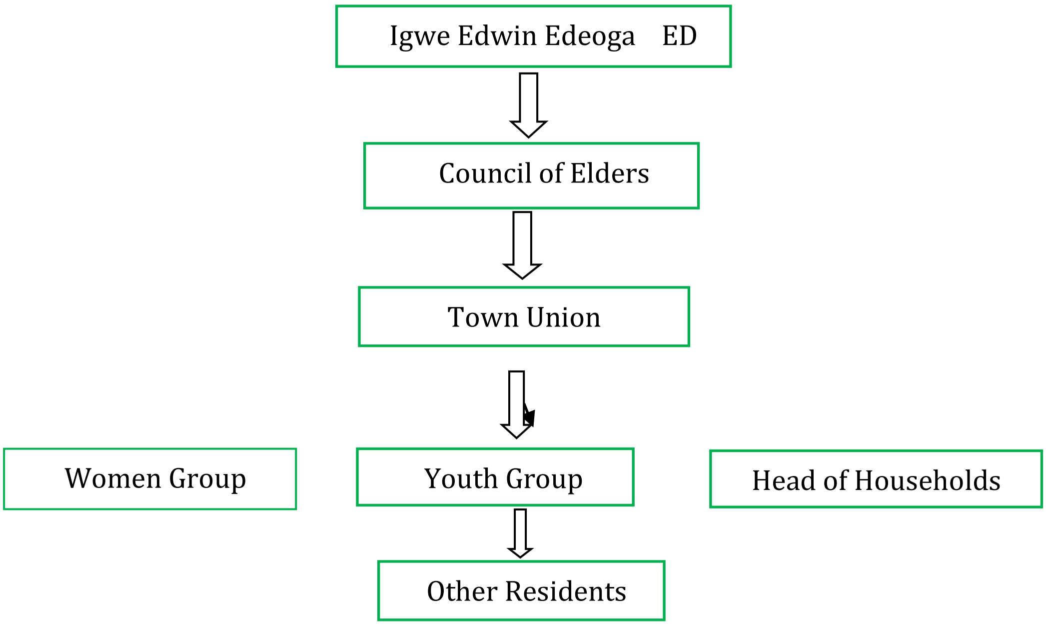


Figure 4.20 Traditional Administrative Structure in Neke Uno

The youth groups: The youth have over the years evolved to becoming an integral and essential part of every society. The Neke-uno Neke community has youth organizations that play vital role in the community policing and development. Some of the groups are age restricted, while others are open to all youths of the community irrespective of their age. The youth are organized and have a leadership structure similar to any other formal organization. Leadership is either by election or selection.

The youth associations are active players in the development of the various communities; this is evident in the number of projects executed by the various youths' association. They meet regularly to discuss issues concerning the development, unity and peace of the community. And the role they play in agricultural related activities and artisanal businesses cannot be over emphasized too. A larger proportion of these youths have however migrated to urban areas to seek apparent decent means of livelihood because of their productive and adventurous nature.

Sex and gender issues: It is imperative to note that while sex relates more to biological context and differences among the two dominant sexes, gender relates more affirmatively to the social meanings given to each of the sexes not without significant implications for social relations as social stratification confers honour on some and dishonour on others. In general, field observation from this study revealed that social relations in Neke uno are based on patriarchal relationship in which authority is vested in the male head of the household. The family is the smallest social unit. In these communities' women do not own major properties such as land, houses and therefore have little or no significant role to play in decision making and do not have inheritance rights over land, and other properties.

Also, division of labour in the family and in the community is based on gender and age. Further analysis revealed that ascribed roles and status are deeply rooted. Most of the domestic chores are undertaken by women and children in addition to other activities such as farming and small businesses. Women are more or less limited to playing the reproductive role of women and bearing the burden of taking care of the children, the old, the sick and even the men. Among domestic chores that are normally unpaid that women perform is fetching water, firewood, food preparation and sometime assisting at the farm among others. Due to the lack of recognition of women's contribution and involvement in economic activities as a result of the male-controlled nature of the family, there has been an increasing level of poverty among women. Women in the community are also constrained in terms of access to education, training opportunities, and appropriate technologies to simplify their work (i.e. heavy work load). Even among children, roles are distributed on the basis of gender.

In the household, the contribution of women to family survival and sustenance is well applauded by the male and children. Women provide the bulk of food eaten and are the driving force behind the children's (especially the girl-child) education.

In essence, the females have to be more effectively mobilized to form cohesive action-oriented groups. Incidentally, this may even be easier to achieve than trying to mobilize the males. The women are more sociable and socially oriented than the male as can be inferred by their tendency to adorn identical attires during festive occasions. Women are more involved in church-oriented groups and pre-cooperatives than the male.

Sheda Community (Federal Capital Territory)

The community hosting the Sheda site is called Shadna Village, which are predominantly Gbari. The community was founded on a river site populated with bamboo (known as Shadna in Gbari) after which it was named by Anize, the founder. Anize was the inaugural head (Etsu), reigning from 1875 to 1899. The throne was successively occupied by Etsu Zefu (1920 to 1933), Etsu Udu (1935 to 1944), Etsu Bwanba (1946 to 1968), Etsu Yeni (1969 to 1981) and Etsu Kizashi Landu (1983 to 2015). This represented pictorially in Figure……The sucession arising from 2015 till date may be due to a tradition rooted disagreement between the Kishashi and Yeni ruling houses.

Although the people of Shadna have been basically farmers they have, like other communities, been influenced by modern developments within, around and extended communities, leading to mixed occupations.

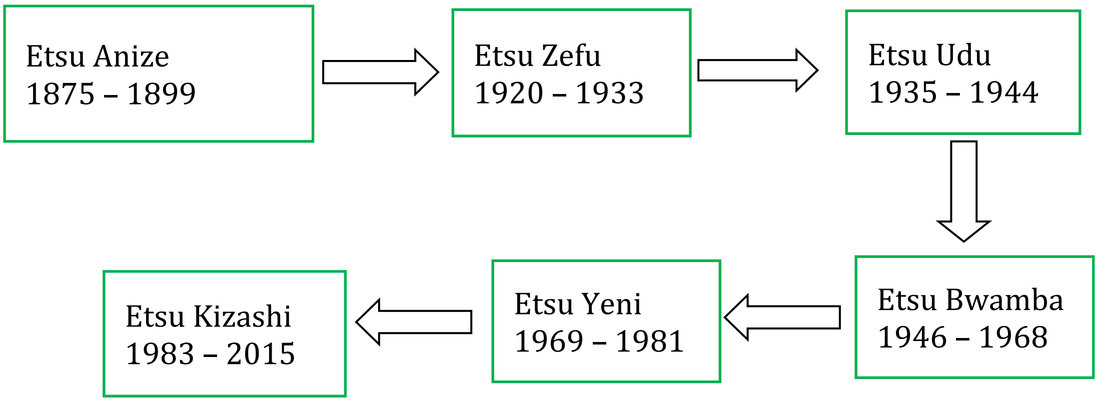


Figure 4.21 Ruling Succession in Shadna

Sala Community Epe (Lagos State)

Sala is a predominantly Yoruba community and is so administered. It is within the Ejinrin-Ikosi Local Council Development Area (LCDA) which is in turn within the Epe Local Government Authority (LGA). Sala lies close to Ejirin along the Ejinrin-Epe Trunk A road. Epe LGA is one out of the twenty (20), while Ejinrin-Ikosi LCDA is one out of thirty-seven (37), in Lagos State. Figure 4.21 presents the locational area of Sala within Lagos State.

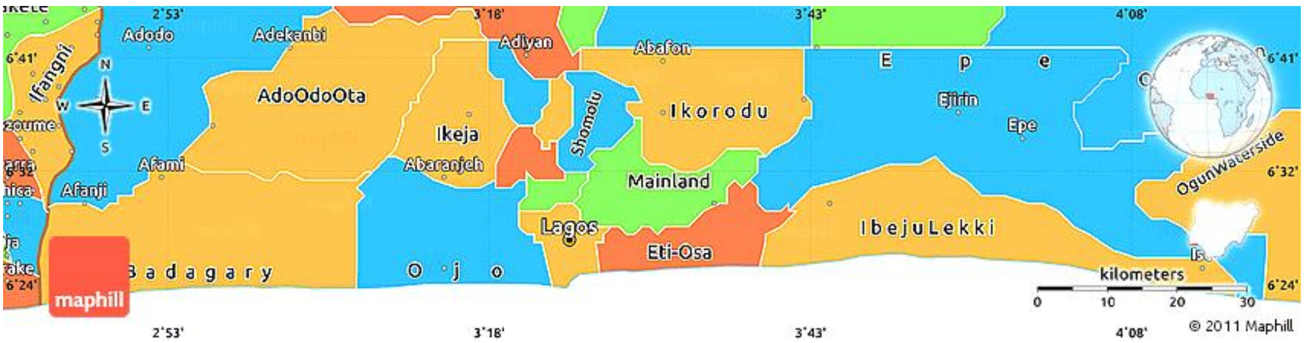


Figure 4.22 Political Map of Lagos State

Sala is headed by a Baale who is administratively responsible to the Elejinrin of Ejinrin who in turn takes directives from the Oba of Epe. The Elejinrin is the *de facto* Secretary to Epe Oba-in-Council. The Baale of Sala is selected in succession from three Ruling Famillies – Aragbadamu, Kula and Sangoira. The selection is conducted according to tradition by the Five King Makers of Sala – Otun Baale, Abore, Oloritun, Egbo and Agbon. The Baale's primary Advisory Council consists of Six Chiefs. They are supported by the Men, Women and Youths Leaders. The current Baale of Sala is Jimoh Olusegun Ogunniyi. The Cultural Hierarchy of Sala is presented in Figure 4.22.

Lagos State is bounded on the North and East by Ogun State. In the West, it shares borders with Benin Republic, and its South opens into the Atlantic Ocean. With a total area of 3,577 square kilometres, Lagos state is the smallest in Nigeria. But ironically, it is the most populous state, second most industralised and it houses the largest city in Africa. Lagoons and creeks take up a whopping 22% of the state's total area.

The population, administrative and industrial significance of Lagos State are highly concentrated in the Ojo, Ikeja, Lagos, Shomolu, Mainland and Eti Osa, thining into Ikorodu areas, with respect to Figure 4.22. Ibeju Lekki is competing very hard in this respect. The Badagry, and Epe areas are of lower signifiance in that realm but house the main agricultural developments in the state. The Sala people are mainly farmers and fishermen *inter alia*.

Socio Economics

Assessments carried out among a wide cross section of Sala resident using quetionaires revealed the following:

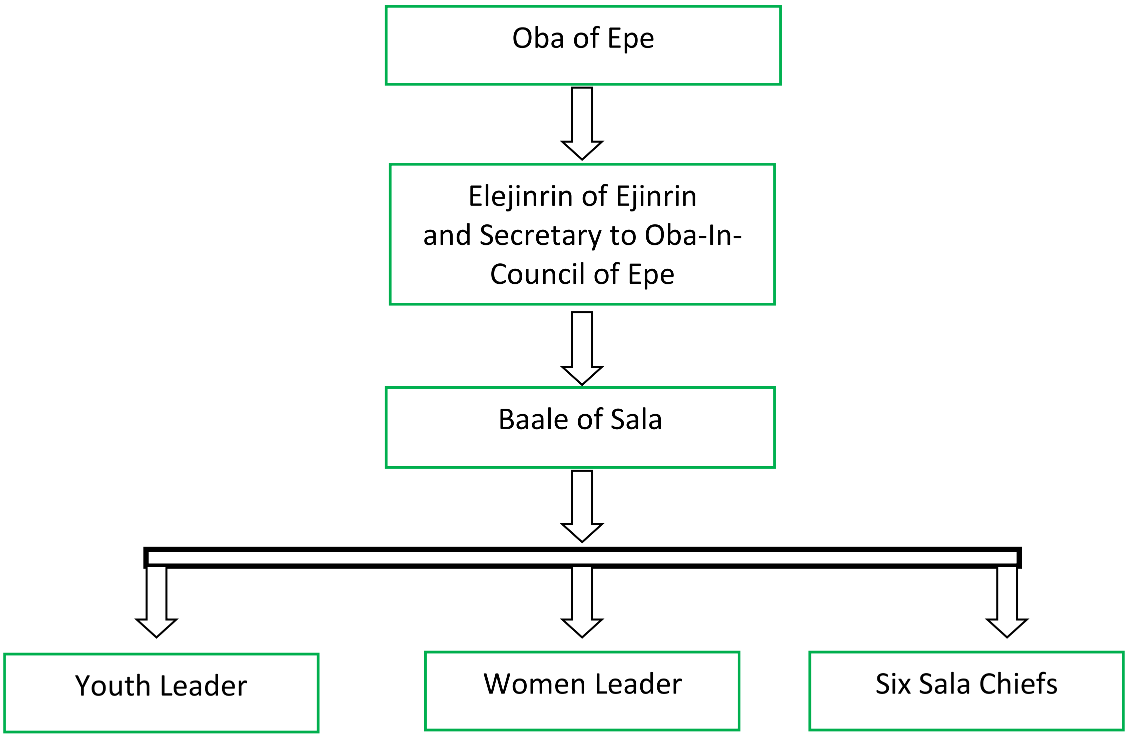


Figure 4.23 Cultural Hierarchy Of Sala

4.5.2 Socio Economics Survey

This section presents results of socio-economic survey conducted among households in the host communities of the project sites. Structured questionnaire was used for data collection (see Appendix 1.1). The number of questionnaires administered in each community and as well as responses received are summarised in Table 4.52. The data generated is in Appendix 1.2 while summary analysis in Sections 4.5.2.1 to 4.5.2.3 for Epe, Neke Uno and Sheda respectively.

Table 4.56 Questionnaire Administration

Community	Estimated Population affected	Questionnaires administered (sample population)	Questionnaires completed and returned	%Returned
Sala, Epe	550	60	47	78.3%
Neke Uno	500	55	48	87.2%
Sheda	300	50	41	82%
TOTAL	**1,350**	**165**	**136**	***82.4%**

**Not total but percentage returned.*

4.5.2.1 Socio-Economic Status of Epe Community

Age groups <45-65, <25-45 and <10-25 were 57%,29% and 14%, respectively, made up of of 71% male and 29% Female. All of them were married with one man to one wife.

Household sizes ranged between <1-10 and <11-20 86% and 14% respectively. The number of children ranged from <2-3, <1-3, <4-6 and <7-9 being 43%, 29%, 14% and 14% respectively constituted of 1.2:1 male: female ratio.

Occupation: 29% of the residents are farmers, 14% housewives, businessmen constitutes 14%, 14% are plumbers while 29% are engaged in miscellaneous types of commercial activities. All the residents are educated to secondary, primary and university level with a distribution of 72%, 14% and 14% respectively. Average annual income bracket of individuals ranges from, N500,000-4,499,999, N1,500,000-4,499,999, N250,000-499,999 and N1-249,999 at 20%, 40%,20% and 20%, respectively.

All adult residents live in own houses. All the houses are bungalows. 60% have courtyards while 20% are single flats and 20% semi detached flats. In terms of specific and general infrastructures houses with pit toilets are 3.27%, toilets with water closet inside 1.25%, outside 3.75%, bathroom inside 3.75%, outside 5%, kitchen single outside 2.50%, shared outside 3.75%, kitchen inside 3.50%, fireplace inside 3.75%, fireplace outside 3.75%, electric cooker 1.25%, gas cooker 7.50%, kerosene stove 3.75%, freezer 2.50%, fridge 2.50%, GSM phone 7.50%, television 8.75%, radio/cassette player 8.75%, CD player 3.75%, satellite dish 2.50%, video player 3.75%, air-conditioner 1.25%, fan 5%, car 2.50%, motor cycle 5% and bicycle 3.75%.

27% of the residents use the general hospital while the remaining 73% patronize the Federal Medical Centre and the University Teaching Hospital.

In direct relation to the PCB project all the residents claim that they have farmlands on, contiguous or close to the proposed site – this has to be further investigated. Distribution of expected benefits of the residents from citing the project in Neke Uno are provision of water

14%, provision of electricity 14%, support for schools including scholarship for students 14%, provision of jobs 14%, improved economic and general business activities 14%. Interestingly, 43% and 57% of the residents envisage negative and positive effects, respectively.

4.5.2.2 Socio-Economic Status of Neke Uno Community

Age groups <45-65 and <25-45 were 64% and 36%, respectively, made up of males only. All of them were married with one man to one wife.

Household sizes ranged between <1-10 and <11-20 73% and 27% respectively. The number of children ranged from <2-3, <1-3, <4-6 and <7-9 being 33%, 17%, 11% and 11% respectively constituted of 1.2:1 male:female ratio.

Occupation: 27% of the residents are farmers, 20% housewives, businessmen constitutes 9%, 9% are plumbers while 35% are engaged in miscellaneous types of commercial activities. All the residents are educated to secondary, primary and university level with a distribution of 13%, 75% and 134% respectively. Average annual income bracket of individuals ranges from N500,000-1,499,999 to above N10,000,000, N500,000-4,499,999, N1,500,000-4,499,999, N250,000-499,999 and N1-249,999 at 36%, 27%, 9%, 9% and 20%, respectively.

All adult residents live in own houses. All the houses are bungalows. 45% have courtyards while 55% are single flats. In terms of specific and general infrastructures houses with pit toilets are 3.27%, toilets with water closet inside 1.96%, outside 2.61%, bathroom inside 5.23%, outside 2.61%, kitchen single outside 1.31%, shared outside 0.65%, kitchen inside 3.27%, fireplace inside 2.61%, fireplace outside 1.31%, electric cooker 2.61%, gas cooker 3.27%, kerosene stove 5.88%, freezer 3.29%, fridge 5.29%, GSM phone 6.54%, television 5.23%, radio/cassette player 5.88%, CD player 3.92%, satellite dish 3.27%, internet access 1.96%, video player 4.58%, air-conditioner 2.65%, fan 5.88%, car 4.58%, motor cycle 5.88% and bicycle 3.92%.

27% of the residents use the general hospital while the remaining 73% patronize the Federal Medical Centre and the University Teaching Hospital.

In direct relation to the PCB project all the residents claim that they have farmlands on, contiguous or close to the proposed site – this has to be further investigated. Distribution of expected benefits of the residents from citing the project in Neke Uno are provision of water 9%, provision of electricity 9%, support for schools including scholarship for students 18%, provision of jobs 9%, improved economic and general business activities 18%. Interestingly, 43% and 57% of the residents envisage negative and positive effects, respectively with the citing of the project in Neke Uno.

4.5.2.3 Socio-Economic Status of Sheda Community

Age groups <45-65 and <25-45 were 33% and 67%, respectively, made up of males only. All of them were married with one man to one wife.

Household sizes ranged between <1-10 and <11-20 are 39% and 45% respectively. The number of children ranged from <2-3, <1-3, <4-6 and <7-9 being 86%, 48%, 10% and 12% respectively constituted of 1.2:1 male:female ratio.

Occupation: 40% of the residents are farmers, 0% housewives, businessmen constitutes 34%, 0% are plumbers while 0% are engaged in miscellaneous types of commercial activities. All the residents are educated to secondary, primary and university level with a distribution of 27%, 17% and 28% respectively. Average annual income bracket of individuals ranges from N500,000-1,499,999 to above N10,000,000, N500,000-4,499,999, N1,500,000-4,499,999, N250,000-499,999 and N1-249,999 at 7%, 32%, 13%, 0% and 26%, respectively.

All adult residents live in own houses. All the houses are bungalows. 75% have courtyards while 25% are single flats. In terms of specific and general infrastructures houses with pit toilets are 3.52%, toilets with water closet inside 5.63%, outside 4.23%, bathroom inside 4.23%, outside 5.63%, kitchen single outside 2.11%, shared outside 0.70%, kitchen inside 3.52%, fireplace inside 4.23%, fireplace outside 4.23%, electric cooker 1.41%, gas cooker 3.52%, kerosene stove 3.52%, freezer 3.52%, fridge 2.11%, GSM phone 5.63%, television 5.63%, radio/cassette player 2.82%, CD player 1.41%, satellite dish 1.41%, internet access 1.41%, video player 2.11%, air-conditioner 5.63%, fan 2.11%, car 8.45%, motor cycle 4.23% and bicycle 7.04%.

39% of the residents use the General Hospital, 16% patronize the Federal Medical Centre and the University Teaching Hospital, 10% patronize Dispensary, 3% patronize Pharmaceutical Chemist, 13% patronize Patent Medicine Store and 3% patronize Traditional Doctors/Herbs.

In direct relation to the PCB project all the residents claim that they have farmlands on, contiguous or close to the proposed site – this has to be further investigated. Distribution of expected benefits of the residents from citing the project in Sheda are provision of water 38%, provision of electricity 26%, support for schools including scholarship for students 3%, provision of jobs 3%, improved economic and general business activities 3%. Interestingly, 11% and 89% of the residents envisage negative and positive effects, respectively with the citing of the project in Sheda.

4.6 STAKEHOLDER CONSULTATIONS

This Section outlines the public information and consultation process that has accompanied the completion of the ESIA study for the PCB Project. Relevant national and international requirements for stakeholder engagement and public disclosure are first briefly discussed.

The main elements of the approach facilitate the informed participation of the project's stakeholders in the development of the studies are then elaborated. Finally, the public information and consultation activities performed at the different stages of the studies, the organizations reached and the concerns, expectations and recommendations made by the latter are reported.

4.6.1 Requirements for Stakeholder Engagement

National Requirements

- The Nigerian EIA act requires public participation in the EIA process at the following stages:
- **Scoping**: Meeting with communities and other stakeholders to document their concerns and obtain their views about the project for consideration for inclusion in the scope of the study.
- **Public Display/Meeting**: Report is displayed by the regulatory authority (Federal Ministry of Environment -EIA Division) at designated public centers for general public to review and submit. The dates and venue for display is announced in newspapers and on local radio stations. Review panel also sits in public to present their comments and views about the project. Date and location for meeting is advertised in newspapers and radio.

International Requirements

World Bank's Requirements: The World Bank's Environmental and Social Framework 2016, sets out the World Bank's commitment to sustainable development, with the aim of ending extreme poverty and promoting shared prosperity. The framework established ten (10) Environmental and Social Standards as requirements for Borrowers. ESS 1: Assessment and Management of Environmental and Social Risks and Impacts, requires and ESIA process, which shall include consultations with the project-affected groups and local NGOs about the project's environmental aspects and their views are taken into account.

ESS 10: Stakeholder Engagement and Information Disclosure, sets out requirements for meaningful consultations, with emphasises on the disclosure of relevant material in a timely manner and in a form and language that are understandable and accessible to the groups being consulted. For the initial consultation, it stipulates that a summary of the project's objectives, description, and potential impacts shall be disclosed. For consultation on the draft ESIA report, stakeholders need to be provided with a summary of the ESIA's conclusions. In addition, the proponent is expected to make the draft ESIA report available at a public place accessible to project-affected groups and local NGOs.

4.6.2 Stakeholder's Engagement Activities

Stakeholder Engagement Plan

The following section describes the methodology used for the information and consultation of stakeholders in the implementation of the ESIA. The objectives, targeted stakeholder groups and a framework program for information and public consultation activities are presented.

In general, consultation activities that will accompany the completion of the ESIA aim to:

- facilitate stakeholder engagement at key stages of the ESIA to influence and improve results, as well as increase the credibility of the process;
- ensure studies are compliant with national and international requirements, including those of the World Bank safeguard policies, on consultation and public disclosure of information for major development projects;
- support efforts of the PMU Office to establish long-lasting relationships with affected communities and other stakeholders.

Two rounds of stakeholder engagement were planned and implemented during the EIA study -one at scoping stage and the other for presentation of findings.

Target Stakeholder Groups

Stakeholder groups targeted by the information and consultation of stakeholders' program include the:

- People directly affected by the project
- traditional authorities and leaders of communities affected
- NGOs and community organisations.

Stakeholder Engagement Activities

The proposed program complies with World Bank and National EIA requirements and includes two rounds of consultations, which take place at key stages of the ESIA development, where the contributions of stakeholders are likely to have a significant influence on the current analysis. First stage is the environmental and social scoping (1st round), and presentation of results for stakeholder input and validation (2nd round) as shown in Table 4.57.

Table 4.57 Schedule for Stakeholders Consultations

ROUND	OBJECTIVES	TARGET GROUPS	PERIOD
ROUND 1: Environmental and social scoping	• Inform community leaders and people directly affected about the project and ongoing studies; • Identify key issues, concerns and expectations associated with the project and the study area; • Complete stakeholders list and validate the stakeholder's engagement activities • Identify national practices and requirements related to the release of the way leave and resettlement.	• Local government authorities (LGA). • Community leaders • Affected people	October, 2018
ROUND 2: Consultation on the preliminary results of the ESIA	• Present, validate and improve the preliminary results of the EIA, • Ensure compliance of proposed measures with the requirements and expectations of the authorities; • Assess the project's social acceptability and the proposed measures.	• Ministries and national agencies (federal and state); • Local government authorities (LGA). • Community leaders • Affected people • NGOs and civil society.	March, 2019

4.6.3 First Round Consultations

This first round of stakeholder information and consultation as part of the development of the ESIA has served to present the project to stakeholders and obtain issues of concern to them, their expectations and recommendations to be considered for inclusion in the scope of the studies.

In total, three meetings were held on between October 22nd to 25th 2018, meetings format consisted of a presentation of the project, followed by a question and answer (Q&A) period. The date, venue, grouping and number of participants at the first round of stakeholder's consultation is depicted in Table 4.54. Maps illustrating the location of the project were used as well. The issues of concerns and recommendations made were considered in defining the scope of the study. Meeting with an NGO was also part of the scoping consultations.

Attendance sheets, minutes of meetings, and photos taken during these meetings are available in Appendix 2.1.

Table 4.58 Schedule for Stakeholders Consultations (Round 1)

Groups consulted	Date	Venue	Number of participants
Epe Site in Lagos State	October 22nd, 2018	Baale of Sala's House, Sala Village, Epe, Lagos	10
Neke Uno Site in Enugu State	October 23rd, 2018	Office of the Chairman's of Neke-Uno LGA, Enugu	17
Sheda Site in the FCT	October 25th, 2018	Sheda Youth Leader's Residence, Sheda, Kwali LGA, FCT. Savannah Conservation (NGO)	12

Plate 4.16 to 4.18 respectively, showed selected pictures from meetings organized with Sheda community leaders, sale community leaders in Epe and Neke Uno's community leaders and Enugu East LGA representative.

Plate 4.18 Meeting with Sheda Community Leaders

Plate 4.19 Meeting with Sala Community Leader in Epe

Plate 4.20 Meeting with Neke Uno Community Leaders and Enugu East LGA Representative

Main concerns and observations raised

The main concerns and observations raised during the first round of stakeholder consultation are summarized as follows.

Sheda Site in the FCT: The community members requested employment for the youths during the construction stage of the project and after the project has commenced.

Epe Site in Lagos State: The community expressed concern about the effect of the PCB on their health, and requested that adequate measures should be put in place to protect them.

Neke Uno in Enugu State

- The community expressed concern about the effect of the PCB on their health, and requested that adequate measures should be put in place to protect them.
- Requested for jobs for the youths in the community
- Requested for a school in their community and roads.
- The agreement for the custody of the land was made with the last Chief of the community who is now late and there are some traditional rites to be done on the land before construction can take place.

4.6.4 Second Round Consultations

This second round of stakeholder information and consultation is to present to the Stakeholders the preliminary findings of the EIA for them to validate and improve the preliminary results of the EIA and ensure compliance of proposed measures with the requirements and expectations of the authorities as well as assess the project's social acceptability and the proposed measures.

In total three meetings were held on between March 5th and 19th 2019, meetings format consisted of a presentation of the report, followed by comments and recommendations from stakeholders. Maps illustrating the location of the project were used as well. The dates of each meeting and number of people that attended are in Table 4.59. The issues of concerns and recommendations made as well changes made to the report to addresse them are in Table 4.60.

Attendance sheets, minutes of meetings photos taken during these meetings are available in Appendix 2.2.

Table 4.59 Schedule for Stakeholders Consultations (Round 2)

Groups consulted	Date	Venue	Number of participants
Sheda Site in the FCT	March 5th, 2019	Kwali Area Council Secretariat	12
Epe Site in Lagos State	March 7th, 2019	M-Square Hotel, No 34A Remi Fani Kayode Street, Ikeja, Lagos	14
Neke Uno Site in Enugu State	March 19th, 2019	Blue Island Hotel, Independence Layout Enugu	11

Plate 4.21 Second Round Stakeholders Meeting in Kwali LGA

Plate 4.22 Second Round Stakeholders Meeting in Lagos

Plate 4.23 Stakeholders meeting in Enugu

Plates 4.19 to 4.21 showed the pictures of members in attendance at the meetings organized at Kwali (Sheda), Lagos (Epe) and Enugu (Nene Uno), respectively.

Main concerns and observations raised

The main concerns and observations raised during the second round of stakeholder consultation are summarized as follows.

Table 4.60 Outcome of Stakeholder Consultations (Round 2)

COMMENTS/RECOMMENDATIONS	MADE BY	RESPONSE(S)
Sheda Site in the FCT		
The timing of the consultation meeting made it almost impossible for us to make any meaningful contribution because we weren't able to go through the Report.	AEPB	And participants were given the opportunity to study the reports and send additional comments within a week.
Your presentation did not address ways of detecting PCB contaminated site.	AEPB	PCB contaminated sites across the country will be determined during the national inventory survey.
What is the specific technology adopted for treatment of the PCB's.	AEPB	A number of options are being considered, the final choice depends on the recommendations of the recommendations of design team (see Section 3.3)
Have you gotten approval from Development Control?	AEPB	The Sheda Site is located within SHESTCO premises and the PMU is working on the approval.
Is the project Government or Privately managed for sustainability	AEPB	The project is being implemented by the Federal Ministry of Environment in collaboration with UNDP and funding from GEF
There is need for wider consultations to include the Etsu Kwali and all district heads	Community	The District Head of Sheda who reports to the Etsu Kwali was represented at the meeting.
The National Standards on Hazardous & Pesticides Regulations 2014 should be included in the report	NESREA	This has been included in the report (see Section 1.2.3)
Epe Site		
Would the entire allocated land for the project be cleared?	FMEnv, Lagos	Only portion of the land needed for development will be cleared
Are there provisions to power some of the equipment designated for deployment in the course of the project with renewable sources?	FMEnv, Lagos	This recommendation for consideration of solar energy will be forwarded to the PMU it has been included in the report (See Section 6.3.2)
What is the capacity of the bunker and the PCB storage tank?	FMEnv, Lagos	Capacity will be determined after inventory is completed in all the States
There may be need to further address the reluctance of local cement manufacturers in the management of PCBs in Nigeria in order to safe foreign exchange flight	FMEnv, Lagos	Cement kiln is very effective in the destruction of PCB, we recommend that PMU to continue to explore this option.
There is need to address security and in inter/intra transportation system of PCBs wastes	FMEnv, Lagos	Traffic management plan as well as security management plan has been included in the report (See Section 7.6.2)

COMMENTS/RECOMMENDATIONS	MADE BY	RESPONSE(S)
What are some of the measures to prevent accidental pollution of the lagoon and underground water in the area?	FMEnv, Lagos	The key measure is to isolate all storage and processing areas from storm water drainage. Emergency response plan will also be prepared
Would the storage area ground/floor be lined?	FMEnv, Lagos	Impervious materials will be used to line the storage areas to prevent seepage into the soil.
What is the average number of skilled/unskilled staff to be employed?	FMEnv, Lagos	About 60 during construction and 45 during operations (See Section 2.2, last paragraph)
Would there be a decommissioning plan?	Salah Legal Officer	Decommissioning and Closure is in Chapter 8
Salah community has no knowledge of acquisition of the land allocated for the project	Salah Legal Officer	The land acquisition process is still ongoing in line with the Landuse Act.
Expressed deep concerns about potential negative impacts on the health of the Sala people	Salah Legal Officer	The Stockholm convention and subsequent progress made, provided clear guidelines on safeguarding public health. Mitigation Measures and the EMP in this report will also protect the environment and safeguard the community.
In what forms would the PCBs be received into the Sala system when established – solid, liquid or whole equipment such as transformer?	Salah Legal Officer	Liquids -oils retrieved as well as contaminated equipment.
How would the ultimate wastes from treatment of PCBs be managed?	LASEPA	No residual waste containing PCB above the safe limit of 50mm will remain. (See Section 3.5).
There is need to expand extant stakeholders	Lagos State Ministry of Environment	Lagos State Ministry of Environment was requested to recommend additional list of stakeholders to be invited subsequently
Neke Uno Site		
What will be the source of water for the project or are we depending on the community water supply, because if we are depending on the community water supply it can lead to conflict between the Host Community and Project Management unit.	Neighbourhood Environment Watch Foundation (NEWF) -an NGO	The project will not depend on the community source of water, there is provision for water supply source within the proposed project site using a borehole.
That the life span of the project was not captured in the presentation.	NEWF	The Life span of the project is 25 years
During the 1st consultation with the host communities, were they major stakeholders present, like the youth leader, women Leader and chiefs?	NEWF	Yes, we met with the youth chairman, chiefs and women leader during our 1st consultation with the host community (See Appendix 2.1).
Since it is a FMEnv Project, is it a money-making project or just for common interest of the public?	NEWF	The proposed project is for the interest of the public with the aim of protecting Nigeria's environment and the health of all Nigerians by eliminating the risks posed by the use of PCB by the year 2028.
Is the scope of the project only for Nigerians alone or will other countries benefit from it?	NEWF	It is for Nigeria alone. Each country in the Stockholm convention are supposed to develop theirs

COMMENTS/RECOMMENDATIONS	MADE BY	RESPONSE(S)
What are the measures to ensure that during operational phase of the project, the surface and groundwater will not be contaminated maybe as a result of leakage or spills during storage and transportation of the PCBs to the centre?	Health for the society, justice and peace Initiative (HSJPI) -NGO	Bundwall will be constructed around the storage areas and lined with Impervious materials to prevent seepage into the soil. Install oil/water separators Regular checking and maintenance of all plant and equipment to minimize the risk of fuel or lubricant leakages. Emergency response plan
In the presentation, you didn't mention any Emergency responds plan for the project in case of Emergency most especially health issues.	NESREA	Emergency responds plan for the proposed project shall be prepared before implementation commences
He also suggested that the timeline base for environmental Audit and Periodic monitoring of soil, air and water should be included in the report and assign duties to project staffs.	NESREA	These are in the report (see chapter 7)
Were the host community properly sensitized with respect to the project activities and its impacts?	NESREA	Yes, the host community was properly sensitized with respect to the project activities and its impacts.
It is necessary to Invite the Igwe of Neke Community during the next stakeholders meeting.	Neke Uno Community	We will Invite the Igwe of Neke Community during the next stakeholders meeting.
Is the proposed project going to be threat to their health and the community, that they are willingly to offer another alternative site that is very very far from their community settlement.	Neke Uno Community	We assured the host community that there is no cause for alarm with the migitative measures that have been highlighted in the presentation.
What are the measures put in place to ensure that their community expectations such as the Community Social Responsibility (CSR) are fully implemented and not just mere promises?	Neke Uno Community	There is no CSR attached to this project for now.
We should include Enugu State Ministry of Environment, Enugu state waste Management Authority, Enugu State Ministry of Lands and Enugu state capital territory development control as part of the institutional stakeholders and invite them to the next meeting.	NESREA	Enugu state Ministry of Environment and Enugu state waste Management Authority were invited (See Appendix 2.2). We didn't know about the existence of Enugu state capital territory development control, they will be invited subsequently.
The CSR to be given to the community should be with respect to scale of preference. She requested FMEnv to consider an equipped health centre as the best for the CSR because of the project-related health impacts to the community.	NESREA	Noted, we will request FMEnv to consider an equipped health centre as the best for the CSR because of the project-related health impacts to the community.
Deforestation and Afforestation Plan should be included in the report.	NESREA	Considering the total land take of less than 2Ha, and less than half of it will be developed. Impact on vegetation is minor, since only about half of a hectare will be cleared.

CHAPTER FIVE

5.0 ASSOCIATED AND POTENTIAL IMPACT

5.1 INTRODUCTION

This chapter provides information on the assessment of the associated and potential environmental and social impacts from the proposed Project. The impacts from both short-term construction phase and the long-term operational phase are being considered. A description of the assessment methodology used to assess the significance of impacts, taking into account impact magnitude and sensitivity of receptors and resources affected, is provided below.

The assessment considered project activities in the following phases of the project development. The detailed description of the activities in each phase is provided in Chapter 3.

- Pre-Construction Phase
- Construction Phase
- Operation and Maintenance Phase
- Decommissioning and Closure

The following environmental indicators, receptors or resources affected by potential impacts were also considered:

Biophysical Environment:

- Air quality;
- Noise,
- Soils and geology;
- Water resources;
- Terrestrial ecology.

Human Environment:

- Visual amenities;
- Community level impacts
- Community health, safety and security;
- Labour and working conditions;
- Infrastructure;
- Employment and economy; and
- Cultural Heritage.

For each of the above-mentioned environmental component, the associated with the potential impacts of Project activities are identified and evaluated of the significance of the impacts. A table of summary for all the potential impacts with their significance is presented in section 5.18

5.2 IMPACT ASSESSMENT METHODOLOGY

This section describes the overall approach used for the assessment of impacts. Topic-specific methodologies are described under each section of the impact assessment. In general, the assessment of impacts will pass through an iterative process involving the following four key elements:

- Prediction of potential impacts and their magnitude (i.e., the consequences of the proposals on the natural and social environment);
- Evaluation of the importance (or significance) of impacts taking the sensitivity of the environmental resources or human receptors into account;
- Development of mitigation measures to avoid, reduce or manage the impacts or enhancement measures to increase positive impacts; and
- Assessment of residual significant impacts after the application of mitigation and enhancement measures.

Where significant residual impacts remain, further options for mitigation may be considered and impacts re-assessed until they are as low as reasonably practicable for the Project.

5.2.1 Nature/Type of impacts

There are number of ways that impacts may be described and quantified. The definitions adopted for this ESIA are described in Table 5.1.

Table 5.1 Definition of Impacts

1	**NATURE OF IMPACT:** An impact is essentially any change to a resource or receptor brought about by the presence of a project component or by the execution of a project related activity. **Negative** – an impact that is considered to represent an adverse change from the baseline or to introduce a new undesirable factor. **Positive** – an impact that is considered to represent an improvement to the baseline or to introduce a new desirable factor.
2	**TYPE OF IMPACT:** **Direct (or primary)** – impacts that result from the direct interaction between a planned project activity and the receiving environment (e.g., between stack emissions and the ambient air quality). **Secondary** – impacts that result from the primary interaction between the Project and its environment as a result of subsequent interactions within the environment. **Indirect** – impacts that result from other activities that are encouraged to happen as a consequence of the Project.

3	**TEMPORAL SCALE OF IMPACT:** **Temporary** - impacts are predicted to be of short duration, reversible and intermittent/occasional in nature. The receptor will return to a previous state when the impact ceases or after a period of recovery. **Short-term** - impacts that are predicted to last only for a limited period (i.e., during construction) but will cease on completion of the activity, or as a result of mitigation measures and natural recovery (e.g., non-local construction workforce-local community interactions). **Long-term** - Impacts that will continue for the life of the project but cease when the project stops operating (i.e. 20 years). These will include impacts that may be intermittent or repeated rather than continuous if they occur over an extended time period.
4	**SPATIAL SCALE OF IMPACT:** **On-site** – impacts that are limited to the Project site. **Local** - impacts that affect locally important environmental resources or are restricted to a single (local) administrative area or a single community. For this ESIA, local impacts are restricted to the Project site and adjacent areas. **Regional** - impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries (i.e Ogun State). **National** - impacts that affect nationally important environmental resources; affect an area that is nationally important/protected; or have macro-economic consequences (ie Nigeria). **International** - impacts that affect internationally important resources such as areas protected by International Conventions. **Trans-boundary** - impacts that are experienced in one country as a result of activities in another.

5.2.2 Assessment of Significance

There is no statutory definition of ‘significance’ and its determination is therefore necessarily partially subjective. For the purposes of this ESIA, the following definition of significance has been adopted:

“An impact is significant if, in isolation or in combination with other impacts, it should, in the judgment of the ESIA team, be taken into account in the decision-making process, including the identification of mitigation measures (by the Project) and consenting conditions (from Regulators and Stakeholders).”

Criteria for assessing the significance of impacts stem from the following key elements:

- Status of **compliance** with relevant Nigerian legislation, policies and plans and any relevant Nigerian or industry policies, standards or guidelines;
- The **magnitude** (including nature, scale and duration) of the change to the natural or socio-economic environment (e.g. an increase in noise, an increase in employment opportunities), expressed, wherever practicable, in quantitative terms. The magnitude of all impacts is viewed from the perspective of those affected by taking

into account the likely perceived importance as understood through stakeholder engagement;

- The nature and **sensitivity** of the impact receptor (physical, biological, or human). Where the receptor is physical, the assessment considers the quality, sensitivity to change and importance of the receptor. For a human receptor, the sensitivity of the household, community or wider societal group is considered along with their ability to adapt to and manage the effects of the impact; and
- The **likelihood** (probability) that the identified impact will occur. This is estimated based upon experience and/or evidence that such an outcome has previously occurred.

For this assessment, significance has been defined based on five levels described as follows:

Positive impacts provide resources or receptors, most often people, with positive benefits. It is noted that concepts of equity need to be considered in assessing the overall positive nature of some impacts such as economic benefits, or opportunities for employment.

Negligible impacts (or Insignificant impacts) are where a resource or receptor (including people) will not be affected in any way by a particular activity or the predicted effect is deemed to be 'negligible' or 'imperceptible' or is indistinguishable from natural background variations.

An impact of minor significance ('Minor impact') is one where an effect will be experienced, but the impact magnitude is sufficiently small (with or without mitigation) and well within accepted standards, and/or the receptor is of low sensitivity/value.

An impact of moderate significance ('Moderate impact') is one within accepted limits and standards. Moderate impacts may cover a broad range, from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. Clearly to design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is ALARP. This does not necessarily mean that 'Moderate' impacts have to be reduced to 'Minor' impacts, but that moderate impacts are being managed effectively and efficiently.

An impact of major significance ('Major impact') is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An aim of ESIA is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long-term or extend over a large area. However, for some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (ie ALARP has been applied). It is then the function of regulators and stakeholders to weigh such negative factors against the positive ones such as employment, in coming to a decision on the Project.

For environmental impacts the significance criteria used in this ESIA is shown in

Table 5.**2**

Table 5.2 Overall Significance Criteria for Environmental Impacts

Receptor sensitivity (or resource value)	Impact magnitude		
	Low	Medium	High
Low	Minor	Minor	Moderate
Medium	Minor	Moderate	**Major**
High	Moderate	**Major**	**Major**

For social impact assessment, the perceptions of stakeholders, expressed as opinions around certain issues, can be as important as actual impacts. Consequently, the concept of perception is explicitly brought into the evaluation of significance after an impact is evaluated. When an impact is of significant stakeholder concern, this may be cause to raise the significance rating. This prompts the formulation of more rigorous and appropriate mitigation measures which focus on the source of the impact and also address stakeholder perceptions. The risk of not addressing stakeholder perceptions is that reputational damage could arise, resulting in the loss of a 'social license to operate'.

Magnitude of Impact

The term 'magnitude' covers all the dimensions of the predicted impact to the natural and social environment, including:

- the nature of the change (what resource or receptor is affected and how);
- the spatial extent of the area impacted, or proportion of the population or community affected;
- its temporal extent (ie duration, frequency, reversibility); and
- where relevant (accidental or unplanned events), the probability of the impact occurring.

For biophysical impacts, the definitions for the spatial and temporal dimension of the magnitude of impacts used in this assessment were provided in Table 5.1.

For social impacts, the magnitude considers the perspective of those affected by taking into account the likely perceived importance of the impact, the ability of people to manage and adapt to change and the extent to which a human receptor gains or loses access to, or control over socio-economic resources (1) resulting in a positive or negative effect on their well-being (a concept combining an individual's health, prosperity, their quality of life, and their satisfaction).

Sensitivity of resources and receptors

Sensitivities are defined as aspects of the natural or social environment which support and sustain people and nature. Once affected, their disruption could lead to a disturbance of the stability or the integrity of that environment.

For ecological impacts, sensitivity can be assigned as low, medium or high based on the conservation importance of habitats and species. For habitats, these are based on naturalness, extent, rarity, fragility, diversity and importance as a community resource.

For socio-economic impacts, the degree of sensitivity of a receptor is defined as ‘a stakeholder’s (or groups of stakeholders’) resilience or capacity to cope with sudden changes or economic shocks’. The sensitivity of a resource is based on its quality and value/importance, for example, by its local, regional, national or international designation, its importance to the local or wider community, or its economic value.

Likelihood

Terms used to define likelihood of occurrence of an impact are explained in Table 5.3

Table 5.3 Explanation of terms used for likelihood of occurrence

Definition of likelihood		
High probability	Refers to a very likely impact	Refers to very frequent impacts
Medium probability	Refers to a likely impact	Refers to occasional impacts
Low probability	Refers to a very unlikely impact	Refers to rare impacts
	As far as one-time events (e.g. air emissions) or slowly developing effects are concerned (e.g. impacts on local life style)	As far as possibly recurring impacts are concerned, such as accident or unplanned events (e.g. traffic accident, fire)

General impacts are those impacts that would be common to all the three sites. Site specific impacts are addressed later in this chapter.

5.3 AIR QUALITY

5.3.1 Construction Phase

(a) Emissions from vehicles and equipment (SO_2, CO, NOx, CO_2, PM)

The movement of vehicles for the construction will result in PM, SO_2, CO, NO_x, CO_2 emissions. It is noteworthy to mention that the quantity of emissions is dependent on the vehicle type, amount and their conditions. Light-duty petrol vehicles not equipped with pollution control devices have the highest exhaust emissions during acceleration, followed by deceleration and idling cycles. Frequent cycle changes characteristic of congested urban traffic patterns thus tends to increase pollutant emissions. At higher cruise speeds HC and CO emissions decrease, while NO_x and CO_2 emissions increase. Emissions from diesel-fuelled vehicles include particulate matter, NO_x, SO_2, CO and HC, the majority of which occurs from the exhaust. Operating at higher air-fuel ratios (about 30:1 as opposed to 15:1 characteristic of petrol-fuelled vehicles with electronic fuel injection engines), diesel-powered vehicles tend to have low HC and CO emissions, despite having considerably higher particulate emissions.

Particulates emitted from diesel vehicles consist of soot formed during combustion, heavy HC condensed or adsorbed on the soot and sulphates. In older diesel-fuelled vehicles the contribution of soot to particulate emissions is between 40% and 80%. The black smoke observed to emanate from poorly maintained diesel-fuelled vehicles is caused by oxygen deficiency during the fuel combustion or expansion phase. Particulate emissions from petrol-driven vehicles are usually negligible. Such emissions when they do occur would result from unburned lubricating oil, and ash-forming fuel and oil additives.

The impact of emissions arising from vehicles and equipment's associated with construction activities is considered to be **minor** due to the relatively low number of vehicles and equipment compared to the already existing traffic load on the roads and relatively short duration of the construction phase.

(b) Dust emission from land preparation and vehicle movements

The dust emissions arising from the construction activities of the Project are as a result of land preparation activities and vehicle movements. Dust emissions have the potential to create impact on the close receptors due to the physical appearance, deposition on the roof of the residential areas and creating nuisance for the surrounding community. Removal of material usually takes place with a bulldozer, cleared material is then stored in piles for later use or during rehabilitation procedures. Fugitive dust is generated during the clearing of material, as well as from wind-blown dust generated from cleared land and exposed material stockpiles. Dust problems can also be generated during the transportation of the material, usually by truck, to the stock piles. This dust can take the form of entrainment from the vehicle itself or due to dust blown from the back of the trucks during transportation.

The temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions. Construction consists of a series of different operations, each with its own duration and potential for dust generation. In other words, emissions from any single construction site can be expected (1) to have a definable beginning and an end and (2) to vary substantially over different phases of the construction process. This is in contrast to most other fugitive dust sources, where emissions are either relatively steady or follow a discernible annual cycle. Furthermore, there is often a need to estimate area wide construction emissions, without regard to the actual plans of any individual construction project. For these reasons, either area wide or site-specific emissions are not directly calculated and modelled.

The impact of this phase on air quality is of **minor** significance and consequence because of the relatively short duration of the construction, the limited earthworks required on the site and the involvement of a limited number of construction vehicles.

(c) Climate change impact due to construction activity

A series of stages are involved in estimating the climate change impact. During the construction stage, following activities are considered for climate change impact.

i. Process from material production:

GHG will be emitted from the manufacturing process of construction material though it is indirect impact of the project. But still necessarily considered as part of lifecycle of the project. Table 5.4 displayed the assumption used for the GHG emission calculation on this item, based on Global Emission Model of Integrated Systems (GEMIS) database (World Bank, 2010).

However, because final design has not been completed, details of of equipment specific are not available at this stage. Hence, the GHG associated with construction materials cannot be estimated at this stage.

ii. Energy use in the construction activity

There is on-site energy use in the actual construction of project, primarily in the form of transport fuel for construction vehicles and the shipping of components. This energy use could be considered a component of direct non-generation emissions, because it is at the project site, even though it occurs before the actual operation of the project. This source of emissions is likely to be very small compared to the lifetime energy and emissions impacts of the project.

The methodological approach to construction emissions is straightforward, but calculating this source is only possible if the underlying data are readily available, particularly data on the quantities of fuel consumed by construction vehicles. Data for fuel calorific values and emission factors are available from IPCC and GHG Protocol, but the quantity of fuel normally come from the project documents. This information is not something that is evaluated even during the detailed design phase of the project World Bank (2010). Hence, it was not possible to provide estimates.

iii. Land Clearing

Construction of the project facilities, affects carbon stored in biomass and soil. An obvious example would be clearing forest of the project area, which would result in a one-time release of the carbon stored in the vegetation. Carbon loss from forest clearance is estimated by multiplying above ground biomass in project area and carbon fraction value to convert dry matter to carbon based on emission factors provided in Harmon *et al,* (2001) and summarised in Table 5.4.

$$C_{LB} = B_{AG} \text{ x } A \times CF \text{ x } 44/12$$

C_{LB} =Carbon stocks in living biomass in forest (t-CO_2e/y)

B_{AG} = aboveground biomass, (t-dm/ha)

A = land area of organic soils, (ha)

CF = carbon fraction of dry matter (t-C/t-dm) (default = 0.5, IPCC GPG-LULUCF)

R = root-to-shoot ratio

Table 5.4 GHG Computations for Biomass Clearing

	Description		Value	Unit	Source
A	land area of Forest		Area (A)	ha	
B_{AG}	Aboveground biomass	Evergreen Forest	43.4	t-dm/ha	Page 3.23 Table 3.2.2, *IPCC **GPG-LULUCF
CF	Carbon fraction of dry matter	Default value	0.5	t-C/t-dm	IPCC GPG-LULUCF

* Intergovernmental Panel on Climate Change **Good practice guidance for land use change and forestry

Primary and secondary forests, swampy area, riparian vegetation and plantations are the land covers to be cleared.

Therefore, carbon loss from clearing of vegetation for construction

$$C_{LB} = \text{ 43.4t-dm/ha} \times A \times 0.5 \text{ t-C/t-dm} \times 44/12 = 9{,}094 \text{ t-CO2e.}$$

The total GHG Emission (tCO_2e) from all project activities is summarized in Table 5.5.

Table 5.5 Total GHG Emission from Activities Related to the Project

SITE	AREA (ha)	C_{LB} (t-CO2e/y)
Epe	1.7063	135.7
Neke Uno	1.6904	134.5
Sheda	3.7000	294.4
	TOTAL	**564.6**

* Estimate methods rely of fuel consumption by construction vehicles and materials shipping, which is not available

GHG will be emitted from material production as well as energy use in construction activity. In addition, there will be carbon loss due to the forest clearance. Total 564.6 tons of CO_2 equivalent of GHG emission will be emitted due to site clearing. Since the areas not developed will be revegetated after construction is completed as well as the fact that the GHG emission during construction stage is short and temporally, the impact on climate change is considered to be **minor.**

5.3.2 Operation phase

The operation of the PCB storage and treatment facility will not contribute directly to any atmospheric emissions except movement of the mobile treatment plant between Epe and Neke Uno as well as the operations of a standby electric power generator. Since the frequency of movement is not likely to be more than once in a year, and the generators will only be used when there is power failure, hence the predicted impacts are likely to be **moderate**.

5.4 NOISE GENERATION

5.4.1 Construction Phase

During the construction phase, construction activities, traffic, as well as the use of construction equipment and machinery are likely to lead to a temporary increase in noise levels that may disturb neighbouring communities and local fauna.

The detailed breakdown of activities is not available at this stage, and as the Contractor has not yet been appointed, no construction plant inventory is available at the time of assessment. Therefore, an assumed plant inventory is provided in Table 5.6. Assumptions have made regarding the type of construction plant, based on experience with similar projects. The noise levels present are data provided on standard noise levels of a wide variety of construction equipment (OSHA, 2003). It has been assumed that only one of each type of plant will be on used on each site during any day or night period.

Table 5.6 Assumed Construction Equipment Sound Pressure Level Inventory

Construction Equipment	SPL, dB(A)
Bulldozer	115
Backhoe	96
Impact pile driver	101
Loaders	108
Vibratory roller	102
Fuel truck	104
Welding machine	101
Cranes	106

Dump truck	105
Grader	114
Fork lifts	112
Compressors	104
Generators	93

Source: OSHA (2003)

Noise impacts will be more predominant within 500 m of the activity areas. The closest residential structures to the Epe Site and Neke Uno are 2km and 3km respectively, while at Sheda, SHESTCO quarters is about 800m fom the site. The baseline noise levels around the project sites, range between 50.1 to 67.7 dBA for Epe site, 26.0 – 28.0 dBA for Neke Uno and 53.0 – 57.2 dBA for Sheda respectively. The Epe site is much closer to the a main road (Ikorodu-Epe highway). The baseline noise levels has exceeded the WHO guideline for community noise of 50-55dBA for outdoor living, at some sampling locations at Epe and Sheda. The construction activity will be undertaken during daytime. Construction activities will be concentrated and done sequentially so that no area is prone to extensive duration of noise impacts. There will be some noise generated from the movement of tractors and trucks transporting the materials and equipment but the traffic volumes are expected to be occasional.

Considering the construction activity schedule and nature of construction, overall noise impact on nearby sensitive receptors with embedded controls in place will be of **Moderate** significance, especially at where residential area is close to the construction area.

5.4.2 Operation Phase

Noise during the operation phase, maintenance activities conducted could lead to an increase in noise levels which may disturb neighboring communities. However, these disturbances will be temporary since they will be felt only during maintenance activities, which is infrequent. Management measures proposed to reduce noise impacts during the construction phase will also be helpful in reducing noise impacts through the operation phase as well.

Overall, noise-related impacts during the operation phase are expected to be **minor**, with implementation of mitigation measures.

5.5 GEOLOGY AND SOILS

5.5.1 Construction Phase

Impact on Geology and Soil Structure

During the construction phase, construction of access roads, excavation for foundation and removal of vegetation (for foundation purposes) are the main activities likely to affect soil structure and quality. Foundations will be dug up to variable depths, depending upon the facility type and soil characteristics. At the sites, all vegetation within the footprint of the areas to be developed will be cleared to ground level.

Excavation works and removal of vegetation, especially on steep slopes, would render soils unstable and more vulnerable to erosion. Soil quality may also deteriorate as a result of removal of vegetation.

Considering the fact that only small areas are exposed and impact localised and very few ground water sources, duration short, sensitivity of the receptor medium and its magnitude will be **Moderate**, during the construction period.

Potential contamination of soil from inadvertent release of hazardous or contaminating material

Finally, soils can be contaminated during the construction phase by accidental oil/fuel spills from heavy machinery either at storage yards or work sites. In the event of an accidental spill, the proportion of soil contamination will depend on the magnitude of these accidental events. Avoiding storage of materials within these areas as well as implementation of an Emergency Response Plan will help manage accidental spills properly. Considering the medium magnitude of this activity and medium receptor sensitivity, the impact is **moderate.**

5.5.2 Operation Phase

Impact on Geology and Soil Structure

During maintenance, vehicular movement are likely to be on paved access roads, since the sites are located close to major roads. Therefore, soil compaction that could affect soil structure is very unlikely. Considering the that only small areas are exposed and also the low frequency of such movements, the impact will be **unlikely**.

Potential contamination of soil from inadvertent release of hazardous or contaminating material

Polychlorinated Biphenyls (PCBs) has a very high ability to bioaccumulate, persistence in the environment, toxicity and carcinogenicity. PCBs are also classified as both toxic chemicals and carcinogens for humans as well as other animals, with 12 of the 209 congeners considered dioxin-like. If it finds its way into soil soil due to accidental spill, it can degrade vegetation due to adsorption from contaminated soil onto the outer surface of the plant.

During the operation phase, leakages resulting from equipment breakdown and/or accidental spills from the treatment plant or storage facility could lead to soil contamination.

However, the application of sound management measures listed above will help reducing this risk significantly. In the event of accidental leaks and/or spills, the impact significance will depend on the volume of leaks and/or spills and the duration. Implementation of an Emergency Response Plan will help manage accidental spills/leaks properly. Overall, the potential impact on soil quality during operation is considered **high**

5.6 WATER RESOURCES

5.6.1 Construction Phase

Impact on hydrogeology due to exploitation of water for construction

During construction watercourses can be temporarily or permanently impaired, if construction spoils are not properly managed. However, sound construction management measures such as using non-toxic construction spoils for filling low lying areas, frequent evacuation of wastes to designated disposal sites, ect could allow reducing impacts on water resources. Considering the distance of water courses from the sites (upto 1-2 km), the hydrodynamics of these watercourse are not expected to be affected significantly. Therefore, the impact on hydrogeology is considered to be **minor.**

Potential contamination on water resource

In addition, unsound waste management practices are likely to have an effect on water quality (e.g. improper waste disposal in surface waters). Development and implementation of a waste management plan by the contractor and sub-contractors will allow mitigating that risk.

Finally, the risk of accidental oil spills from heavy machinery is present during the construction phase and could result into both surface water and groundwater contamination. The contamination level resulting from accidental spills will depend on their magnitude. However, implementation of an Emergency Response Plan will help managing them properly.

Moreover, groundwater could be contaminated during digging of foundation, particularly near watercourses or the swampy area around the Epe site. Proper management of excavation work will allow avoiding these potential impacts. Given the fact that the local community uses Lagos Lagoon which is about 2km south of the Epe site for fishing and transport, the water body have high sensitivity. However, considering the distance, coupled with the magnitude of the potential consequences of an uncontrolled spill, impact is rated as **moderate**.

5.6.2 Operation Phase

During operations phase, even a small amount of spill of PCB into water courses could be significant, because of its bioaccumulation ability, persistence in the environment, toxicity and carcinogenicity. PCBs are classified as both toxic chemicals and carcinogens for humans as well as other animals, with 12 of the 209 congeners considered dioxin-like. A further 9 are considered highly toxic, and 25 have been commonly identified bio-accumulated in milk or fish. Contamination of surface or groundwater will render the non usable for fishing and domestic purposes. There is no evidence yet to show PCBs being particularly phytotoxic (except for a slowing of growth at very high concentrations); however, this is an uptake route for aquatic organisam. Aquatic life is especially prone to bioaccumulation, with the PCB concentrations increasing up the food chain.

Therefore, considering the level of toxicity, sensitivity of the receptor and its bioaccumulation ability, the significance of this impact is considered **High.**

5.7 TERRESTRIAL ECOLOGY

5.7.1 Construction Phase

Impact on Terrestrial flora and Fauna

The construction phase of the project will require clearing vegetation from the site. The Sheda and Neke Uno sites consist of forested area and agricultural areas, while the Epe site is predominantly swamp. However terrestrial agricultural dedicated areas still host trees and shrubs species. This habitat which supports woody species, will experience more significant disturbances. Other habitats, which are sparsely vegetated and consist mostly of herbaceous vegetation, will experience fewer losses due to clearing, but remain vulnerable to disturbances that could occur during the construction phase. The flora present on the sites does not include any species identified in the IUCN Red List of threatened species or in a national list (Isichei 2010). There are no known endemic species in the study area as well.

Vegetation clearing will cause habitat disturbances that could create suitable conditions for the establishment of invasive species. The spread of invasive species can have negative impacts on local species, by modifying plant community composition. Alien invasive species have the potential to substantially modify wildlife habitat which can impact associated fauna populations.

Although local in nature, this may have long-term effects, thus the magnitude of the impact is high. Since there are sensitive ecosystem around the swampy Epe area, the receptor sensitivity is high. Therefore, the impact significance is **Moderate**

Impact due to the introduction of Alien species

Vegetation clearing for the construction will cause habitat disturbances that could create suitable conditions for the establishment of invasive species. The spread of invasive species can have negative impacts on local species, by modifying plant community composition. Considering the small area to be cleared and non-observance of invasive species in the area of influence, this impact is **minor.**

5.7.2 Operation Phase

5.1.1.1 Impact on terrestrial flora and fauna

Noise generation during operation of the project is likely to affect avifauna. Two of the three project sites -Epe and Neke Uno are greenfield, while the Sheda site is located within the Sheda technology center. Hence, effects on birds may likely occur particularly at the grrenfield sites. The significance of the potential impact on avifauna is **minor**, considering the low magnitude and localised.

Impact on terrestrial ecology of operations and maintenance is also considered **negligible** as localised and in an already degraded ecosystem.

Impact of introduction of invasive species

This impact is not likely during operation.

5.8 AQUATIC ECOLOGY

5.8.1 Construction Phase

The construction works, particularly at the swampy Epe site may cause wetland and riparian habitat loss. Due to their soft and spongy soils swampy areas cannot support heavy loads. Construction activities can influence water quality or modify flooding patterns and surface water flow over a certain period of time.

Construction activities could also cause an increase in suspended solids in wetlands and aquatic environments, which could result in siltation of feeding sites and breeding grounds of some species, particularly for fish species. Furthermore, an increase of organic matter in aquatic environments could lead to an increase in biochemical oxygen demand (BOD) and a decrease in dissolved oxygen that could be locally harmful for aquatic fauna species. Water could also become contaminated by accidental oil and hydrocarbon spills. In lentic or stagnant aquatic environments, the contamination could exacerbate the impacts of the spills because contaminants could become locally concentrated. Rapid response measures in case of a spill will reduce associated impacts.

Impact on aquatic and semi-aquatic habitats will be limited to the Epe site. Impacts will be local and the magnitude will be low. Since these areas are highly sensitive, the impact significance is **moderate**.

5.8.2 Operational Phase

As mentioned earlier, PCBs are known to have bioaccumulation ability. Hence, it can cause significant health issues along the food chain when it is accidentally spilled into water body. These disturbances could also influence habitat availability and presence of some fauna species. Since the sensitive of these habitats are **Low**, the impact significance is considered **minor**.

5.9 VISUAL AMENITIES

5.9.1 Construction Phase

Site clearance and site development: Aesthetic impacts during the construction phase will be limited to work zones. Deforestation of the sites will change the landscape, particularly in Epe and Neke Uno. The areas already has other developments such as residential estate in Epe and telecommunication towers adorn the skyline, the changes in the landscape is not likely produce significant impacts on the sites, particularly, when the structures to be erected are not very high.

Construction Derived Waste: Since no construction camp will be required, because the three sites are located few kilometres to cities, domestic waste will be limited to waste generated from construction workers. Domestic waste might be disposed within construction area, creating visual impact. Construction waste will be disposed at sites approved by Lagos State Waste Management Authority (LAWMA), the Enugu State Waste Management Agency (EWMA) or Abuja Environmental Protection Board (AEPB), as applicable.

The duration of the construction activity is short term in nature and sensitivity of the area is also low. Overall, the potential impact on Visual and aesthetics is considered to be **minor** significance.

5.9.2 Operation Phase

Visual impact during operation is considered not likely.

5.10 LAND PLANNING AND USE

5.10.1 Construction Phase

Very few agricultural activities will be affected during the construction -a cassava farm at Neke Uno and cowpea at Sheda. The lands for the project sites are already acquired the PCB PMU office, and it allows the people to farm on the land. Hence, compensation for loss of land is not required. Hence, the significance of the impact on land use is considered **negligible** because the sites are located close to other developments and there are no resettlement issues.

5.10.2 Operation Phase

This impact is considered unlikely

5.11 STAKEHOLDER AND COMMUNITY RELATIONS MANAGEMENT

5.11.1 Construction Phase

The construction activities may cause community concerns linked to impacts associated with issues like air and dust emissions, traffic, influx and community safety/security, noise/ vibrations and the adverse impacts and inconveniences experienced from these issues. In addition, community/stakeholder perceptions with respects to the toxicity of PCBs, will also require good management. Community expectations, with respect to available jobs and other benefits from the project are some of the issues, as the project has limited need for unskilled labour that could be sourced from the communities. The potential impact is considered **moderate**.

5.11.2 Operation Phase

The operation and maintenance of the proposed projects may cause community concerns linked to impacts associated with issues like nuisance of noise, accidental spills, etc. Overall, there will be no direct impact on existing structures during operation phase. This is considered a **moderate** impact.

5.12 COMMUNITY HEALTH, SAFETY AND SECURITY

5.12.1 Construction Phase

Safety risk due to transportation

The increase in traffic in the villages and the roads could also be a source of accidents. The contractor will develop appropriate strategies to minimize the need for transportation of supplies and will ensure compliance with all applicable laws, such as maximum load restriction and speed limits. An awareness program for truck drivers to speed limits and other precautionary measures will be implemented. Sign indications (inhabited area, school, pedestrian crossings, etc.) and speed limits will be in place where appropriate. These measures will minimize the risk of accidents that could be caused by the project related traffic. As this is a temporary activity with limited transportation movements, this risk is considered **minor**.

Health risk due to influx of construction workers

During the construction phase, the working population in the project area may increase temporarily, increasing the pressure on local health systems. The influx of foreign workers in local communities can increase the risk of communicable diseases such as the transmission of HIV/AIDS. To avoid this impact, the contractor in charge of work will implement a prevention program for communicable diseases among workers and local communities.

However, this impact remains low since the passage of these workers will be only short duration.

Also, workers' camp(s) can be a source of pollution and various disturbances of the surrounding environment: waste, septage, and wastewater, if not properly managed. The following management measures will be implemented in each set up camp: waste and wastewater management, latrines, containment of machinery in appropriate areas, etc.

Accidents may occur during construction. Construction sites have potential risks for workers and nearby communities because they can generate curiosity, especially among children. To prevent accidents, the contractor will ensure the proper use of equipment and implementation of all appropriate security measures. Employees will be trained properly regarding occupational health and safety (safety equipment port, etc.). The site and the equipment and material storage area will be fenced temporarily, prohibiting access to unauthorized people. In addition, warning signs will be posted for public safety. Finally, educational programs in schools and communities may be implemented to educate people about the dangers and safe practices around the facility.

Moreover, disturbances (noise, dust, air pollution and risk of accidents) may cause stress in generally calm rural areas. Appropriate mitigation and containment of construction activities during normal working hours will reduce these drawbacks for the local population. Proper communication and stakeholder engagement activities and grievance mechanism will be implemented to obtain community concerns. Therefore, the impact is considered **Minor.**

5.12.2 Operational Phase

Exposure to PCBs is associated with an increased risk of certain cancers of the digestive tract, liver and skin. PCB exposure is also associated with reproductive deficiencies, such as reduced growth rates, retarded development, and certain neurological effects which may or may not persist beyond infancy. The immune system can also be affected, leading to increased infection rates, and changes in the skin such as chloracne and pigmentation disturbances (WHO, 2003).

Accidental spill from the treatment plant or the storage facilities could be severely harmful to the neighbouring communities. Workers may also be exposed during handling and other operational activities. However, the effects can reduced by implementing a sound emergency response plan as well as proper PPE for workers. Considering the magnitude and high receptor sensitivity, the health impact during operations is considered **Moderate.**

5.13 RESETTLEMENT

The project is not likely to result in resettlement, because the sites have been acquired and fenced. A notice board indicating the plans for the site is also erected at the three sites.

5.14 LABOUR AND WORKING CONDITIONS

The workforce engaged on the project will vary during the construction program and will be dependent on the specific activities underway. Labour requirements will generally be a maximum of 10 on each site. Working hours will normally be between 8:00 to 17:00 hours. The contractors shall ensure compliance with the following laws and regulations to minimize impacts arising from labour and working conditions.

- The Factories Act, 1987
- Wages Board and Industrial Council Act, 1974
- Workers' Compensation Act, 1987
- IFC Performance Standard 2: Labor and Working Conditions
- International Labour Organisations (ILO) requirements

These were discussed in detailed under section 1.2

5.14.1 Construction Phase

Occupational accident risk

In the construction phase there will be job opportunities for construction workers. At this moment in time the number of workers required has not been assessed yet. Also, the construction period is not known yet. It is expected that the majority of the workers can probably be sourced locally, with the non skilled labour coming from the host communities. The majority of the employees required during construction will be unskilled and semi-skilled labourers. Worker's accommodation camp will not be needed, because there are adequate hotels as well as good houses in the area that could be rented. unskilled workers recruited from the communities can stay with their households. To manage construction traffic and parking needs, transport will be provided. Since there is quite some unemployment among the people, and especially the youth, living in the communities near the proposed sites, there will be quite some eagerness to find temporary employment in the construction of the project. This creates the risk that the EPC Contractor may get tempted to recruit labour force against insufficient labour and working conditions to save costs.

In the construction, occupational accidents may occur particularly among unskilled labour force, ranging between minor incidents such as cuts and major incidents related with working at height. Also there would be possible hazards, like snake bite and scorpion sting in the clearance of the vegetation. In view of the number of construction workers, the use of quite some unskilled labour, albeit internationally managed, the risk of occupational accidents is considered **moderate**

Security risk

With the construction activities, valuable materials and equipment and the presence of a labour force will come to the construction site. Opportunistic people (possibly local youth) or organised crime may be tempted to steal materials from the site, to raid construction workers or force to obtain some benefits from the Project in another way. These security risks may threaten all staff working at the construction site.

The construction yard will be secured by a permanent fence at an early stage of construction. Security guards will be employed to patrol the site and control access 24 hours a day. All vehicles entering and leaving the site will be searched. All personnel will be required to display personal identification and all visitors will be required to sign in. The EPC Contractor will be responsible for site security during construction. Since these works do not take place in a remote area, security guards on site, security forces in the area are in place from the Government, the risk is considered **minor.**

5.14.2 Operation Phase

Operation and maintenance of the project will involve transportation of retrieved PCBs to the centers, loading and off-loading, storage, treatment and disposal of residual wastes. These activities could expose workers to the dangers associated with PCBs as described earlier.

Similar to the construction phase, potentially workers may be exploited and occupational health & safety risks may occur in the regular and emergency maintenance and repair works. The likelihood of these risks is lower, as there will be less labour hired and fewer activities, compared to the construction phase. These coupled with strong adherence to safety rules, this risk of exploitation is considered **minor** and the health and safety risks **moderate**.

5.15 EMPLOYMENT AND ECONOMY

5.15.1 Construction Phase

There will be no significant adverse impacts on local and regional economy during the construction. On the other hand, the project could generate some temporary jobs during construction phase. The impacts to the communities hosting the project will be relatively small due to the limited duration of the project. Overall, the impact on economic activities and livelihood is a **positive** impact.

5.15.2 Operation Phase

The most important benefit generated by the project will certainly be the improved management of PCBs in the country. This will allow the retrieval all PCB contaminated materials from all over the country, which can improve general health and wellbeing and added convenience to people's lives. The project could also generate jobs for the operation and maintenance though very few.

Overall, the project will bring **positive impacts** to the local economy and livelihoods of people both directly (new employment) or indirectly (increased access to reliable electricity).

5.16 CULTURAL HERITAGE

5.16.1 Construction Phase

Consultation with local and regional authorities did not reveal the presence of any form of cultural heritage within the three proposed sites in Epe, Neke Uno and Sheda. In addition, during the construction activities, unknown archaeological sites or objects can be discovered and partially destroyed by the machinery used. If archaeological or historic remains are discovered, the construction works will immediately stop along this section of line, the National Commission for Museums and Monuments (NCMM) and the LGA authorities where the discovery took place and the State Ministry responsible for culture in the FCT, or Lagos or Enugu State shall be informed. Therefore, the impact is considered **minor**, since worship can still continue at the new site.

5.16.2 Operation Phase

Impact of operations on cultural heritage is not likely.

5.17 CUMULATIVE IMPACTS

5.17.1 Defining Cumulative Impacts

In theory, any development such as the proposed Project may be taking place at the same time as other developments, causing impacts affecting the same resources or receptors, such that the impacts on these resources and receptors from all potential development will be cumulative. According to the Performance Standard, cumulative impacts can be defined as impacts that:

> "***result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted.***"

Generally, Cumulative Impacts are considered to be impacts that act with impacts from other projects such that:

- The sum of the impacts is greater than the parts; or
- The sum of the impacts reaches a threshold level such that the impact becomes significant.

The types of cumulative impacts that may be of relevance are detailed as follows:

- ✓ **Accumulative**: the overall effect of different types of impacts at the same location. An example would be fugitive dust emissions, construction noise and construction traffic all impacting the local communities as a nuisance/ disturbance.
- ✓ **Interactive**: where two different types of impacts (which may not singly be important) react with each other to create a new impact (that might be important) (e.g. water abstraction from a watercourse might exacerbate the impacts caused by increased sediment loading).
- ✓ **Additive or In-combination**: where impacts from the primary activity (i.e. the construction and operation of the Project) are added to impacts from third party activities e.g. other major projects in the vicinity of the Project which are already occurring, planned or may happen in the foreseeable future).

- Performance Standard suggests that in identifying cumulative impacts, “cumulative impacts are limited to those impacts generally recognized as important on the basis of scientific concerns and/or concerns from Affected Communities”.

5.17.2 Identification of Relevant Development(s)

The focus of the cumulative impact assessment is on the combination effects of the Project with potential future development in the immediate area around the Project site. Our assessment cumulative impacts regarding the potential project in view, depends on the status of other projects and the level of data available to characterize the magnitude of the impacts.

In view of the paucity of available information regarding such future developments, this assessment follows a generic pattern and focuses on key issues and sensitivities for this project and how these might be influenced by cumulative impacts with a combination of other developments. Consultations with local and state authorities and identification of relevant and significant developments via searches of relevant documents provided invaluable assistant in this assessment. The main developments identified are;

- Cumulative impacts from other projects within 10 km square radius
- Those likely to arise from other projects

The following projects exist within 10 km square radius are expected to exert cumulative impacts. There are no known adjacent future development

EXISTING PROJECTS	DISTANCE FROM PROPOSED PROJECT SITE
Epe Site:	
• Mater Ecclesiae College	2km
• Epe Resort and Spa	5km
• 3LW Farms	2km
• Residential Estate development	2km
Neke Uno:	
• Neke Lake Resort	8km
Sheda Site:	
• Sheda Science and Technology Complex (SHESTCO)	1km

5.17.3 Cumulative Impact

Traffic: The construction phase will require certain amounts of material and equipment to be transported to the Project site. It is expected that the same Ikorodu-Epe highway that are used by the four existing projects in the area will used. And this will exert additional pressure and traffic on the road. Similarly, one the biggest hotels in Enugu, Neke Lake resort located about 8km from the project site, is also like to increase traffic along the Anangu road. However, there may be no significant cumulative traffic effects in Sheda, because the site is located within the facility.

Given the foregoing, there is increased potential for accidents and disruption to the road traffic network for local users associated with the increase in traffic movements from overlapping construction traffic. It is expected that the traffic management plan to be developed for the project will consider other traffic movements associated with the development of the project in view which will help to mitigate this impact. However, in overall consideration, this impact is considered to be ***moderate*** due to the high likelihood of accidents occurring.

Economy, Employment and Skills: The operation of the various considered projects earlier outlined is proposed to occur simultaneously with the project in view. As such, the economic, employment and skills development opportunities will be greater for all the projects combined than a single project.

It should be noted that expectations regarding economic development, employment and skills development will be high amongst stakeholders in the local community and as such, in the event that one project does not meet expectations, there is the potential for all projects within the area to be the target of this negative outcome.

5.18 SUMMARY OF IMPACTS

Tables 5.7 and 5.8 presents the summary of various activities involved in the project development and the significant impacts associated with each of them on the environment and social. The status of significance is in line with international standards in addition to national and state policies.

Table 5.7 Summary of Potential Impacts During Site Preparation and Construction

Indicator	Potential impact	Receptor	Significance
Air quality	Localized impairment of air quality by exhaust emissions from vehicles and equipment engines (SO_2, CO, NOx, CO_2, PM)	Affected communities in area of influence	Minor
	Elevated dust levels in nearby communities as a result of dust raised by vehicle movements, wind, and handling of dusty material	Affected communities in area of influence	Minor
Climate Change	GHG will be emitted from forest clearing	Global warming	Minor
Noise, and vibration	Nuisance noise and vibration from construction activities	Affected communities in area of influence Construction workers	Moderate
Soils, geology and land-use	Change to soil structure (erosion and compaction) as a result of excavation and backfilling and removal of vegetation	Soil around construction sites	Minor
	Potential contamination of soil from inadvertent release of hazardous or contaminating material (liquid fuel, solvents, lubricants, aluminium oxide paint, etc)	Soil on construction site	Moderate
Water resources	Potential surface and groundwater contamination from accidental spills and improper disposal of waste and wastewater	Local groundwater and Rivers around construction sites	Moderate
	Exploitation of water resources (e.g. casting of foundations) sourced from nearby water bodies through tanks	Local surface water resources	Minor
Terrestrial ecology	Disturbance to habitats, fauna and flora arising from dust, air emissions, light, noise and vibration, traffic, accidental spillages and sediment run-off	Flora and fauna and habitat in the area of influence	Moderate
	Vegetation clearing will cause habitat disturbances that could create suitable conditions for invasive species to spread	Flora and fauna within the project sites	Minor
	Loss of vegetation due to site clearing for the construction will cause habitat disturbances.	Project site	Minor
Aquatic ecology	Degradation of aquatic species due to construction activities around surface water bodies	Water bodies around the sites	Moderate
Ecosystem Services	Species that provide services to the communities will be cleared in the project area	Livelihoods	Minor
Visual amenities	Temporary presence of an active construction site with storage of materials and equipment	People living close to the construction sites.	Minor
Land use	Land use changes that converted secondary forest areas to the project site	Communities around the site	Minor
Stakeholder and Community expectation /relations Manageme nt	Management of Community concerns linked to impacts associated with construction phase issues (like air and dust emissions, traffic, influx and community safety/security, noise/vibration, etc) and adverse impact/inconveniencies resulting from it. In addition, dealing with community/stakeholder perceptions around cumulative impacts linked to the project operations. Management	Affected communities in area of influence	Moderate

Indicator	Potential impact	Receptor	Significance
	of legacy issues on account of environmental pollution from the stakeholder concerns.		
Community Health, Safety and Security	Increased risks of traffic safety incidents on public roads	People living close to access roads and road users	Minor
	Temporary influx of outside workers in the communities, risking tensions between outside (partly possibly expatriate) labour and local population, due to differences in wealth and culture.	Affected communities in area of influence	Minor
	Potential for increase in prevalence of sexually transmitted diseases in local communities and other communicable diseases.	Affected communities in area of influence	Minor
	Risk of erosion into Lagos Lagoon, which are used as fishing and transportation	Affected communities in area of influence	Minor
Labour and working conditions	Exploitation of workers	Labour force	Minor
	Activities and staff at site may create security risks	All staff working at the construction site	Minor
	Risk of health & safety incidents amongst labour force, including minor incident's such as cuts and major incidents such as loss of life	Construction labour force	Moderate
Employment and economy	Creation of temporary jobs for locals residents and Nigerian nationals with skilled trades	Local residents of affected communities and Nigerian nationals	Positive
	Supply chain opportunities for Nigerian companies that can provide goods and services needed by the company	Nigerian companies and local SMEs	Positive
Infrastructure	Influx of outside workers may pose additional pressure on social infrastructure, like medical posts, emergency services, water supply, solid waste management	Affected communities in area of influence	Negligible
Cultural heritage	Accidental finds of cultural heritage at construction sites	Affected communities-	Minor
	Potential interactions between construction works and cultural festivals due to traffic, noise and/or vibration impacts	Affected communities	Minor

Table 5.8 Summary of Potential Impacts during Operation and Maintenance

Aspect	Potential impact	Receptor	Significance (pre-mitigation)
Air quality	Exposure to emissions from vehicles (PM, NO_2/NOx) very limited as very little traffic	Workers on site, communities in area of influence	moderate
Noise and vibration	Noise from operation of treatment plant	Workers on sites and affected communities in area of influence	Minor
Soils, geology and land-use	Compaction effects on soil structure due to vehicular movement in swampy areas during line maintenance	Ecologically sensitive areas, particularly around Epe	Minor
	Potential contamination of soil from inadvertent release of hazardous or contaminating material	Soil in the project siites at Epe, Neke Uno and Sheda	Major
Water resources	Quality water resources will be affected due to accidental spill of PCB	Surface water and Local groundwater	Major
Terrestrial ecology	Impact due to alien species	Flora and fauna	Negligible
	Loss of vegetation due to routine clearance of vegetation	Flora and fauna	Negligible
Aquatic ecology	Degradation of aquatic species due to maintenance of the plant	Water bodies close to the site	Moderate
Ecosystem Services	Loss of species that provide ecosystem services	Project site	Negligible
Visual amenities	Structures erected will be visible from far and become an extrinsic element in the landscape.	communities in the area of influence	Negligible
Stakeholder and Community expectation/ relations Management	Management of Community concerns linked to impacts associated with operation phase issues (like air and dust emissions, traffic, and community safety/security, noise/vibration, etc) and adverse impact/inconveniencies resulting from it. Dealing with community/stakeholder perceptions around cumulative impacts linked to the new plant and existing cement plant operations.	Affected communities in the area of influence	Moderate
Community Health, Safety and Security	External safety risks of exposure to PCBs	Affected communities	Moderate
Labour and working conditions	Exploitation of workers	Labour force for maintenance work	Minor
	Occupational H&S risks in operation and maintenance	Labour force	Moderate
Cultural heritage	Potential interactions between maintenance works and cultural festivals due to traffic, noise and/or vibration impacts	Affected communities in the area of influence	Negligible

CHAPTER SIX

6.0 MITIGATION MEASURE

6.1 INTRODUCTION

As presented in Chapter 5, the proposed PCB collection, storage and treatment centers at Sheda, Neke Uno and Epe has the potential to impact the various components of the biophysical, health and social environment of the project area. The identified negative impacts have been ranked variously as minor, moderate and major. To preserve the environment, a number of steps have been taken to mitigate the significant, major and moderate ranking negative impacts, as well as enhance those impacts identified as positive. The mitigation measures proffered for the predicted impacts of the proposed project activities took cognizance of the following requirements.

- Environmental laws and regulations in Nigeria, with emphasis on permissible limits for waste streams (FMEnv (formerly FEPA), 1991);
- World Bank Requirements and other relevant international requirements
- Best available Technology for sustainable Development;
- Feasibility of application of the proposed mitigation measures in Nigeria;
- View and concerns of stakeholders as expressed during extensive consultations carried out during the study.

The residual effects that may remain after the application of the impact mitigation measures have also been discussed for further reduction of residual impacts to as low level as possible.

6.2 MITIGATION METHODOLOGY

6.2.1 Definition of Mitigation Measures

Mitigation measures are developed to avoid, reduce, remedy or compensate for any negative impacts identified, and to create or enhance positive impacts such as environmental and social benefits. In this context, the term "mitigation measures" includes operational controls as well as management actions. These measures are often established through industry standards and may include:

- changes to the design of the project during the design process (eg changing the development approach);
- engineering controls and other physical measures applied (eg waste water treatment facilities);
- operational plans and procedures (eg waste management plans); and
- the provision of like-for-like replacement, restoration or compensation.

For impacts that are assessed to be of **Major** significance, a change in design or layout is usually required to avoid or reduce these. For impacts assessed to be of **Moderate** significance, specific mitigation measures such as engineering controls are usually required to reduce these impacts to ALARP levels. This approach takes into account the technical and financial feasibility of mitigation measures. Impacts assessed to be of **Minor** significance are usually managed through good industry practice, operational plans and procedures. And **Negligible** impacts require no mitigation action, other than those already included in the project design.

In developing mitigation measures, the first focus is on measures that will prevent or minimise impacts through the design and management of the Project rather than on reinstatement and compensation measures.

6.2.2 Assessing Residual Impacts

Impact prediction considers any mitigation, control and operational management measures that are part of the project design and project plan. A residual impact is the impact that is predicted to remain once mitigation measures have been designed into the intended activity. The residual impacts are described in terms of their significance in accordance with the categories identified in Chapter 5.

Social, economic and biophysical impacts are inherently and inextricably interconnected. Change in any of these domains will lead to changes in the other domains. This section looks at how the local way of life might change as a result of the proposed project. Potential changes to local culture, livelihoods, health and well-being, personal and communal property rights are examined.

6.3 AIR QUALITY

6.3.1 Construction Phase

Air Pollutant Emission

Regarding impacts of emissions from vehicles and equipment engines the following mitigation measures are recommended:

- Maintain and operate all vehicles and equipment engines in accordance with manufacturers recommendations;
- Stationary generators to be located to facilitate dispersion;
- Cover properly loose materials and keep top layers moist;
- Use binder material for erosion and dust control for long term exposed surfaces;
- Regular cleaning of equipment, drains and roads to avoid excessive build-up of dirt;

- Spray surfaces prior to excavation;
- Use covered trucks for the transportation of materials that release dust emissions; and
- Speed limits on-site of 25km/hr on unhardened roads and surfaces.
- Contractors would be advised on the specific age of vehicles to be allowed within the project sites
- Timely and schedule completion of construction works

With the implementation of the aforementioned measures, the residual air quality impacts can be expected to be **negligible**.

Green House Gas Emission

In consideration of the Climate Change under the construction phase, the impact of vegetation clearing, resulting to reduction of carbon sink ability of the environment and the use of equipment and vehicles during the construction resulting to the release of GHG gases shall be mitigated through the use of good international practice, including maintaining and operating all vehicles and equipment engines in accordance with manufacturers recommendations, location of stationary generators to facilitate dispersion, restriction of vegetation clearing to only the required area and the use of experienced drivers and fuel efficient equipment, vehicles and machineries during construction activities. Even the implementation of above mitigation measure, GHG emission cannot be avoided. Therefore, the impact on climate change still be maintained as **minor**.

6.3.2 Operation Phase

The impact of construction on air quality as well as climate change arise from vehicular emissions and operations of standby power generator. During the stakeholders meeting in Lagos, it was recommended that the project consider the use of solar to augment power supply from the National Grid. This action will reduce the impact from moderate to a **minor** significance.

6.4 NOISE AND VIBRATION

6.4.1 Construction Phase

The following recommendations for mitigation measures are outlined below:

- Develop a detailed plan that relates to noise control for relevant work practices and discuss this with construction staff during health & safety briefings;
- Select 'low noise' equipment or methods of work;

- Use temporary noise barriers for equipment (e.g. sound proofing walls around stationary power generating sources);
- Avoid dropping materials from height, where practicable;
- Avoid metal-to-metal contact on equipment;
- Maintain and operate all vehicles and equipment in accordance with manufacturers recommendations;
- Avoid mobile plant clustering near residences and other sensitive land uses;
- Ensure periods of respite are provided in the case of unavoidable maximum noise level events;
- Inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as providing the contact details of the PMU Community Relation Officer;
- Noisy activities (activities that can be heard in nearby communities) restricted to day-time working hours.
- Inverters should used where possible as means to minimize noise pollution that could result from power failure.
- Provision of ear muffs to reduce noise on workers
-

With the implementation of the above measures the residual air quality impacts can be expected to be reduced from moderate to **minor**.

6.4.2 Operation Phase

The minor impact of noise emissions during operation can be reduced by conducting noise generating maintenance activities during the day time, when most residents are at work. In addition, the use of PPE by workers shall be enforced. And these measures can reduce the impacts to **negligible.**

6.5 SOIL AND GEOLOGY

6.5.1 Construction Phase

Impact on Geology and Soil Structure

The highly unstable soils around the Epe Site may require construction of access road from the main Ikorodu-Epe highway. The distances of these road may not exceed 200m.

The following mitigation measures to reduce impacts on soil structure from compaction and erosion are recommended:

- Construction of foundations to be undertaken in the dry season;
- Backfill foundation pits by the excavated soils which will resemble the order of the original soil layers;

- Protect excavated soil materials from erosion;
- Ensure that the land is physically restored (include revegetation where possible) before leaving the site

With the implementation of the above measures the residual impacts can be expected to reduce to **negligible.**

Potential Soil Contamination

With regards to soil contamination impacts, the following measures will be implemented:

- Implement effective site drainage on the construction camp to allow for the directed flow of surface water off site. This shall include cut-off drains to divert surface runoff from exposed soils or construction areas;
- Install oil/water separators and silt traps before effluent, leaves the site;
- Minimise bare ground and stockpiles to avoid silt runoff;
- Bounding of areas where hazardous substances are stored (eg fuel, waste areas);
- Remove all water accumulation within bunds using manually controlled positive lift pumps not gravity drains;
- Regular checking and maintenance of all plant and equipment to minimize the risk of fuel or lubricant leakages;
- Training of relevant staff in safe storage and handling practices, and rapid spill response and clean-up techniques;
- Set-up and apply procedure regarding dealing with contaminated soils;
- Development and implementation of a Waste Management Plan (as part of the ESMP) to ensure that waste is disposed of correctly; and
- Spread sheet underneath the structures prior to start any painting activity.

With the implementation of the above measures the residual soil and geology quality impacts can be expected to reduce to **minor**.

6.5.2 Operation Phase

Same measures as for the construction phase, shall be implemented. In addition, concrete bound wall shall be constructed around the PCB storage facility, such that spills can be contained and safely recovered and adequately protected from storm water. This can reduce the impact from major to **Moderate**, considering its effect, when it finds it way into the adjacent soils**.**

6.6 WATER RESOURCES

6.6.1 Construction Phase

Impact on Hydrogeology

The potential contamination of groundwater and surface water from release of hazardous or contaminating material (liquid fuel, solvents, lubricants, paint, etc), can be mitigating by the following actions

- The construction of drainage around the sites fitted with an API gravity separator for oil removal.
- Development of access road within swamp area around Epe area
- Avoiding storage of materials that are likely to leach into soil in the open
- Construction of bund wall around fuel and oil storage areas

With the implementation of these actions, the impact is expected to be reduced to **Negligible.**

Potential contamination on water resource

Same as in section Soil and Geology for on the prevention of spills and leakage of hazardous substances to surface and ground water. The residual impacts on surface and groundwater can be expected to be **negligible**.

6.6.2 Operation Phase

Same measures as for soil during operations shall be implemented, and the impact can be reduced to **moderate.**

6.7 TERRESTRIAL ECOLOGY

6.7.1 Construction Phase

Impact on Terrestrial flora and Fauna

The following recommendations for mitigation measures are outlined below:

- Limit lightening on site;
- Sensitivity training to staff and anti-poaching policy; and
- Site clearance activities to be restricted to the minimum required area for development.

The residual impacts on terrestrial ecology can be expected to be **minor**.

Impact due to the introduction of alien species

The project sites are disturbed zones, with the potential of being colonized by invasive species. Such species could use the cleared sites as a spreading area and consequently reach adjacent habitats. The implementation of the following measures will result in a reduced **Minor** impact with the implementation of the following actions.

- Herbicides should not be used for vegetation clearing
- Revegetation should use species locally native to the site and not use any environmental weeds for erosion control
- Retention of native species where possible along the line route.
- Clearing should be minimised and restricted to the area required for construction purposes.

Impact on Ecosystem Service

Impacts of ecosystem services is expected to be reduced to **minor** after implementing the following actions.

- Preserve species that provide services as much is possible

6.7.2 Operation Phase

Impact on Ecosystem Service

These impacts are negligible during operation phase. No additional measures are identified

Impact on Terrestrial flora and Fauna and Impact due to the introduction of alien species

These impacts are negligible during operation phase, No additional measures are identified

6.8 AQUATIC ECOLOGY

6.8.1 Construction Phase

The following measures shall be implemented during construction in order to minimize impacts on aquatic ecology during construction.

- Natural flow of a River shall not be blocked
- Conduct activities during the dry season to minimize disturbance of sensitive shoreline and wetland areas
- Perform all vegetation clearing work manually along streams/rivers and swamps.
- Avoid vegetation clearing along stream shores and on steep slopes.

- Based on an appropriate project design, select the most optimized site for construction considering human uses and areas of higher ecological integrity.
- Prohibit construction of permanent access roads along river banks, in swamps or in areas where soils are saturated
- Maintain vegetated buffer zones within and around wetlands and along both sides of watercourse crossings. Restore as soon as possible any disturbed areas in the riparian buffer zone.

Implementing these measures is expected to reduce the impact to **minor.**

6.8.2 Operation Phase

The following measures shall be implemented during construction in order to minimize impacts on aquatic ecology during operation and maintenance phase.

- Natural water courses shall not be obstructed.
- Vegetation wastes or other types of wastes shall not be disposed along water courses or sensitive areas.
- Avoid equipment and vehicle movements in rivers, floodplains and wetland areas. If unavoidable, reduce access to a minimum length in wetlands and floodplains and select the most optimized site for the access considering human uses and areas of higher ecological integrity.

These measures is expected to reduce the impacts to **negligible**.

6.9 VISUAL AMENITIES

6.9.1 Construction Phase

The minor impact of the change in visual amenities can be reduced by maintaining the construction site in orderly condition and do not distribute material over many locations before usage. Following mitigation measure will be implemented.

- Provision of enlightenment to construction workers for waste management
- Construction waste will be appropriately managed at the site and treated and disposed in accordance with waste management regulation governing each site

The residual impact will be **negligible**.

6.9.2 Operation Phase

These impacts are negligible during operation phase, No additional measures are identified

6.10 LAND PLANNING AND USE

6.10.1 Construction Phase

The few cropland within the Neke Uno and Sheda sites will be converted to the PCBs management infrastructure, and the impacts will remain as **minor**

6.10.2 Operational Phase

These impacts are negligible during operation phase, No additional measures are identified

6.11 STAKEHOLDER AND COMMUNITY EXPECTATION/RELATIONS MANAGEMENT

6.11.1 Construction Phase

The concerns of the close-by communities of cumulative effects of environmental and safety/security impacts of the project shall need serious attention.

By implementing a package of mitigation and enhancement measures, the concerns can be reduced to a manageable level for the majority of the community members. However, there may be vulnerable people, who need special attention to reduce the effects to an acceptable level.

The following package of measures shall be implemented:

- Follow mitigation for construction phase air quality, noise and traffic;
- Inform communities about details of construction activities (e.g., employment opportunities, schedule, timing of noise activities, traffic including movements of oversized loads) by billboards, posters and community meeting;
- Set-up, manage and effectively manage construction phase grievance mechanism system;
- Sharing of independent monitoring reports of all monitoring actions during construction as mentioned in the ESMP;
- Engage communities in the monitoring activities to enhance transparency and involvement.
- Enhance ongoing consultations with local communities (with good representation) by PMU to create continuous dialogue, trust and planning of community development activities. Coordinate Stakeholder Engagement of all partners of industrial site, implement SEP; and
- Ongoing reporting to stakeholders on the overall environmental performance of the plant and the steps taken to mitigate any adverse environmental impacts.

With a proper, continuous and serious implementation of the above-mentioned measures the experience of cumulative impacts can be reduced to a **minor** level, since there many people affected.

6.11.2 Operation Phase

In the operation phase the same package of mitigation and enhancement measures should be continued from the construction phase as described above. This package, when implemented rigorously, continuously and with participation of the affected communities, can support the project in bringing the community impact to a **minor** from **moderate** level. However, potentially certain community members may not be satisfied with the mitigation and enhancement measures and may still provide resistance, also to negotiate better benefit sharing mechanisms.

The follow measures apply in the operation phase:

- Follow mitigation for operation phase air quality, noise and traffic;
- Inform communities about details of operation activities (e.g., employment opportunities by billboards, posters and plant visit
- Set-up, manage and manage grievance mechanism
- Sharing of independent monitoring reports of all monitoring actions as mentioned in this ESMP;
- Engage communities in the monitoring activities to enhance transparency and involvement;
- Enhance ongoing consultations with local communities (with good representation) by PMU to create continuous dialogue, trust and planning of community development activities. Coordinate Stakeholder Engagement of all partners of industrial site, prepare and implement Stakeholder Engagement Plan. Create Broad Community Support;
- Ongoing reporting to stakeholders on the overall environmental performance of the plant and the steps taken to mitigate any adverse environmental impacts;

6.12 COMMUNITY HEALTH, SAFETY AND SECURITY

6.12.1 Construction Phase

To reduce the potential adverse impacts and risks of the construction works on the community health, safety and security, the following mitigation measures should be implemented.

To reduce traffic accident risks the Contractor should implement a traffic safety plan including design of access point, signalization, speed limits, training of drivers, use of traffic guards, procedures for transport of oversized loads (e.g., engines), maintain log of traffic related incidents, sensitization of road users and people living close to the construction site. If this plan is thoroughly implemented, this residual risk can be **negligible**.

A Local Content Plan should be prepared to facilitate involvement of local labour as much as possible. The implementation of the plan will enhance ability to locate local hires and Nigerian nationals. This plan should include provisions for hiring women and for “equal pay for work of equal value”. A local hiring office (or offices) to be set-up for use by all contractors to advertise positions, receive applications, and provide guidance to applicants. Further a code of behaviours for workers should be developed, which should be trained and periodically refreshed, as needed based on community liaison/grievance mechanism feedback. This will help in reducing the potential for frictions between outside labour and local community members to a **minor** level.

To reduce the risk of an increase in STD prevalence, awareness raising material and condoms should be provided to all workers. Herewith the risk can be mitigated to a **negligible** level.

The construction site should be managed to eliminate potential mosquito breeding sites. This includes the prevention of surface water ponding and an avoidance of outside storage of tires. For unavoidable ponding monitor for mosquito larvae and treat with a US-EPA (or similar) approved mosquito larvicide as needed. These measures can bring this risk to a **negligible** level.

Erosion prevention measures are required to prevent soil entering nearby fields and creeks. Especially in locations close to creeks and cropped fields construction sites should be kept flat, clearing lose soil from the site and covering with geo-textile if needed. These measures can bring this impact to a **negligible** level.

6.12.2 Operation Phase

To reduce the external safety risks for the people living close to the sites, the following measures shall be implemented:

- To prevent as much as possible emergencies and to manage the response to emergencies when they occur in the operation phase of the Project in emergency response plan should be developed and implemented following international best practice including provisions for prevention and response to accidental spills, roles and responsibilities and emergency response. This plan should be coordinated with PMU and the Local Government;
- Annually a safety audit of each site shall be performed to identify potential safety risks in an early stage and keep maintenance at high standards, and
- The affected communities in the area of influence shall be informed about the safety risks related to the facilities, the do’s and don’ts and the response measures in place,

when an incident happens (from the emergency response plan). Sign boards will be placed informing about the inherent risks.

With the serious implementation of the above measures the residual safety risks can be expected to be reduced to a **minor** level.

6.13 LABOUR AND WORKING CONDITIONS

6.13.1 Construction Phase

To prevent the exploitation of the workforce, the Contractor should comply with the provisions in the Labour Act of Nigeria and the international ILO conventions. The following items apply specifically for this Project:

- Develop transparent human resources policies and procedures for recruitment process, working conditions, terms of employment wages, worker-employer relations, non-discrimination policy, monitoring, roles and responsibilities;
- Provide reasonable, and if applicable negotiated, working terms and conditions;
- Establish worker's grievance mechanism, so that potential conflicts can be dealt with in an early and proper way;
- No use of child labour (workers under age 18) or forced labour is allowed;
- Provisions to ensure compliance with labour standards by supply chain and subcontracts, including training if required;
- Provide proper work place facilities for water/sanitation/rest rooms;
- If case of retrenchment needs first viable alternatives are analysed and then adverse impacts of retrenchment on workers are reduced as much as possible. A transparent retrenchment plan will be prepared;
- No hiring of short-term labour to be made at the site gate; and
- A worker’s grievance mechanism will be in place.

If indeed the Contractor implements their human resources procedures in line with the Nigerian Labour Act and ILO Conventions and his held by these through their construction contract, the risk of exploitation of the labour force can be kept to a **negligible** level.

Security risks can be mitigated by preparing and implementing a security and emergency response plan in close cooperation with Lafarge security and local security forces. If security measures are well implemented these risks can be reduced to a **negligible** level.

To prevent and respond effectively to occupational health & safety incidents a project specific health and safety procedures needs to be developed and implemented, based on PMU’s HSE guidelines, including provisions for training and certifications to be followed by all workers including subcontractors, especially slip-trip and fall hazards. Consult with local health facilities to be prepared in case of incidents that need medical help.

To prevent and manage occupational health & safety risks the following measures need to be implemented:

- ensure proper design, construction and installation of the plant and associated facilities;
- train staff regularly and thoroughly in prevention and response of electrocution incidents, monitor and keep record;
- special focus on slip-trip, fall from height and electrocution in maintenance and repair works;
- audit management of electrocution incidents;
- emergency prevention and management;
- provide and maintain first aid facilities at all places where electrocution risks exist and train staff to use these; and
- provide and use personal protection equipment.

When all measures mentioned above are well implemented, the risk of occupational health & safety incidents can be kept to an acceptable level, to a **minor** level. However, these incidents cannot be prevented at all times.

6.13.2 Operation Phase

The same mitigation measures apply for the operation as for the construction phase to reduce the risks of labour force exploitation, to a **negligible** level and the risks of occupational health & safety, to a **minor** level. However, environmentally sound management measures for PCB shall be implementation for the management of these risks.

The following main items apply to reduce risks of labour exploitation to an acceptable level:

- Follow human resources policies and procedures of PMU, following Nigerian Labour Law and ILO conventions;
- Provide reasonable, and if applicable negotiated, working terms and conditions;
- Establish worker's grievance mechanism, so that potential conflicts can be dealt with in an early and proper way;
- No use of child labour (workers under age 18) or forced labour;
- Provisions to ensure compliance with labour standards by supply chain and subcontracts, including training if required; and
- A worker’s grievance mechanism will be in place.

PMU shall follow Nigerian and international requirements:

- train staff regularly and thoroughly in prevention and response of electrocution incidents, monitor and keep record;

- special focus on slip-trip, fall from height and electrocution in maintenance and repair works;
- audit management of electrocution incidents;
- emergency prevention and management;
- provide and maintain first aid facilities at all places where electrocution risks exist and train staff to use these; and
- provide and use personal protection equipment.

6.14 EMPLOYMENT AND INCOME

6.14.1 Construction Phase

To enhance the **positive** impact of employment opportunities for local residents a local content plan needs to be prepared to enhance the ability to locate local hires and Nigerian nationals. This plan should include provisions for hiring women and youth and for “equal pay for work of equal value”. A local hiring office (or offices) to be set-up for use by all contractors to advertise positions, receive applications, and provide guidance to applicants.

To enhance the positive impact of opportunities for local businesses and entrepreneurs the local content plan should also facilitate identification and selection of qualified local and Nigerian companies to provide needed supplies and services. This plan should include provisions for advance notice to local companies, along with selection criteria including health and safety, to allow them to prepare for upcoming opportunities.

6.14.2 Operation Phase

The **positive** impact of an important contribution to the national safety, enhancing PCBs free country, can only be reached when all PCB containing materials are collected and treated.

6.15 INFRASTRUCTURE

6.15.1 Construction Phase

In the preparation and execution of the construction works the Contractor shall coordinate with medical posts and emergency services about the potential of an increase demand of these services. Preparedness can be raised for temporary water supply to the communities, additional waste management and an increase in demand for medical services.

Proper and independent facilities for water supply, sanitation, solid and liquid waste need to be installed at the construction site, so that pressure on community infrastructure in limited.

By implementing both measures the impact of construction activities of the Project can be managed to a reduced **negligible** level.

6.15.2 Operation Phase

The effect of the operation phase of the project on infrastructure is **negligible** and no additional measure has been identified.

6.16 CULTURAL HERITAGE

6.16.1 Construction Phase

There are no cultural heritage sites or materials within the three sites shrines, but accidental find may happen during construction, particularly excavation of foundation. When this happens, work shall stop and National Commission for Museums and Monuments shall be contacted. As the agency responsible for cultural properties, they will implement procedure on accidental find of physical cultural properties. And this will result in reducing the impact to **negligible**.

6.16.2 Operation Phase

These impacts are negligible during operation phase, No additional measures are identified.

6.17 SUMMARY OF MITIGATION MEASURES

Tables 6.1 and 6.2 presents the summary of mitigation measures on various activities involved in the project development and the significant impacts associated with each of them on the environment and social.

Table 6.1 Summary of Mitigation Measures During Construction

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
Air quality	Localized impairment of air quality by exhaust emissions from vehicles and equipment engines ($SO2$, CO, NOx, CO_2, PM)	Affected communities in area of influence	Minor	Use good international practice: • Maintain and operate all vehicles and equipment engines in accordance with manufacturers recommendations • Stationary generators to be located to facilitate dispersion	Negligible
	Elevated dusted levels in nearby communities as a result of dust raised by vehicle movements, wind, and handling of dusty material	Affected communities in area of influence	minor	Use good international practice: • Cover properly loose materials and keep top layers moist • Use binder material for erosion and dust control for long term exposed surfaces • Regular cleaning of equipment, drains and roads to avoid excessive buildup of dirt • Spray surfaces prior to excavation • Use covered trucks for the transportation of materials that release dust emissions • Speed limits on-site of 15kph on unhardened roads and surfaces	Negligible
Climate change	GHG emissions that could add to climate change effects	Global warming	Minor	Maintain and operate all vehicles and equipment engines in accordance with manufacturers specifications, location of stationary generators to facilitate dispersion, restriction of vegetation clearing to only the required area	Minor
Noise and vibration	Nuisance noise from construction activities	Affected communities in area of influence	Moderate	Use good international practice: • Develop a detailed plan that relates to noise control for relevant work practices and discuss this	Minor

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
		Construction workers		with construction staff during health & safety briefings • Select 'low noise' equipment or methods of work • Use temporary noise barriers for equipment (e.g. sound proofing walls around stationary power generating sources). • Avoid dropping materials from height, where practicable • Avoid metal-to-metal contact on equipment • Maintain and operate all vehicles and equipment's in accordance with manufacturers recommendations • Avoid mobile plant clustering near residences and other sensitive land uses • Ensure periods of respite are provided in the case of unavoidable maximum noise level events • Inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as providing the contact details of the CLO. • Noisy activities (activities that can be heard in nearby communities) restricted to day-time working hours	
Soils, geology and land-use	-Change to soil structure (erosion and compaction) as a result of excavation and backfilling and removal of vegetation	Soil on construction site	Minor	• Construction of foundations to be undertaken in the dry season. • Backfill foundation pits by the excavated soils which will resemble the order of the original soil layers.	Negligible

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
				• Protect excavated soil materials from erosion. • Ensure that the land is physically restored (include revegetation where possible). • Use of existing track for transport of man and material to the extent possible. • The metallic structures should be protected against corrosion. Also, where the subsoil is clayey and incompetent, foundation should be anchored on friction piles to prevent settlement.	
	Potential contamination of soil from inadvertent release of hazardous or contaminating material (liquid fuel, solvents, lubricants, aluminium oxide paint, etc)	Soil on construction site	Moderate	Use good international practice: • Implement effective site drainage on the construction yard to allow for the directed flow of surface water off site. This shall include cut-off drains to divert surface runoff from exposed soils or construction areas. • Install oil/water separators and silt traps before effluent, leaves the site. • Minimise bare ground and stockpiles to avoid silt runoff. • Bunding of areas where hazardous substances are stored (eg fuel, waste areas). • Remove all water accumulation within bunds using manually controlled positive lift pumps not gravity drains. • Regular checking and maintenance of all plant and equipment to minimize the risk of fuel or lubricant leakages.	Negligible

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
				• Training of relevant staff in safe storage and handling practices, and rapid spill response and clean-up techniques. • Set-up and apply procedure regarding dealing with contaminated soils. • Development and implementation of a Waste Management Plan (as part of the ESMP) to ensure that waste is disposed of correctly. • Spread sheet underneath the structures prior to start any painting activity.	
Water resources	Potential surface and groundwater contamination from accidental spills and improper disposal of waste and wastewater	Local groundwater-well and bore hole	Moderate	See above measures to mitigate 'Potential contamination of soil' impact	Negligible
	Exploitation of water resources (e.g. casting of foundations) sourced from nearby water bodies through tanks	Rivers and streams	Minor	Rivers and streams shall not be dammed for the purpose of water abstraction	Negligible
Terrestrial ecology	Vegetation loss and disturbance to habitats, fauna and flora by construction activities	Flora and fauna and habitat in the area of influence	**moderate**	• Restrict construction activities, including vehicle movements and material storage on bare soil • Minimize the construction of new access roads. Promote the use of existing access roads for machinery and vehicle movements. • Promote the use of existing roads for transporting material to the construction sites in order to reduce the project's footprint and minimize the need for new access roads	Minor
	Vegetation clearing will cause habitat disturbances that could create suitable conditions for invasive species to spread		minor		Negligible

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
				• Herbicides should not be used for vegetation clearing • Revegetation should use species locally native to the site and not use any environmental weeds for erosion control • Retention of native species where possible along the line route. • Clearing should be minimised and restricted to the area required for construction purposes only and disturbance to adjacent vegetation communities and/or remnant trees within the corridor should be strictly controlled.	
	Loss of species that offer Provisioning Services		minor	• Site clearance activities to be restricted to the minimum required area.	negligible
Aquatic ecology	Loss/disturbance of aquatic species	Rivers/streams crossed	moderate	• Natural flow of a River shall not be blocked • Conduct activities during the dry season to minimize disturbance of sensitive shoreline and wetland areas • Perform all vegetation clearing work manually along streams/rivers and swamps. • Avoid vegetation clearing along stream shores and on steep slopes. • Prohibit construction of permanent access roads along river banks, in swamps or in areas where soils are saturated • Maintain vegetated buffer zones within and around wetlands and along both sides of watercourse crossings. Restore as soon as possible any disturbed	minor

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
				areas in the riparian buffer zone. • Avoid equipment and vehicle movements in rivers, floodplains and wetland areas. If unavoidable, reduce access to a minimum length in wetlands and floodplains and select the most optimized site for the access considering human uses and areas of higher ecological integrity	
Visual amenities	Temporary presence of an active construction site with storage of materials and equipment within the sites	People living close to the construction sites.	Minor	Maintain construction site in orderly condition and do not distribute material over many sites before usage.	Negligible
Land planning and use	Change in land use cause by land take for the project, vegetation clearance, and access restriction	Land on the sites	minor	• Site clearance activities to be restricted to the minimum required area. • Provision of predefined route, barriers or boundary markings to prevent incursion of machinery and workers into neighbouring areas.	Minor
Stakeholder and Community expectation/ relations Management	Management of Community concerns linked to impacts associated with construction phase issues (like air and dust emissions, traffic, influx and community safety/security, noise/vibration, etc) and adverse impact/inconveniencies resulting from it. In addition, dealing with community/stakeholder perceptions around	Affected communities in area of influence	Moderate	Follow mitigation for construction phase air quality, noise and traffic. Inform communities about details of construction activities (e.g., employment opportunities, schedule, timing of noise activities, traffic including movements of oversized loads) by billboards, posters and community meeting Set-up and effectively monitor construction grievance mechanism Sharing of independent monitoring reports of all monitoring actions during	minor

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
	cumulative impacts linked to the new plant operations. Management of legacy issues on account of environmental pollution from stakeholder concerns around existing similar projects.			construction as mentioned in this ESMP.	
				Engage communities in the monitoring activities to enhance transparency and involvement.	
				Enhance ongoing consultations with local communities (with good representation) by PMU to create continuous dialogue, trust and planning of community development activities. Coordinate Stakeholder Engagement of all partners of industrial site, prepare and implement Stakeholder Engagement Plan	
				Ongoing reporting to stakeholders on the overall environmental performance of the plant and the steps taken to mitigate any adverse environmental impacts.	
Community Health, Safety and Security	Increased risks of traffic safety incidents on public roads	People living close to access roads and road users	Minor	Implement a traffic safety plan including design of access point, signalization, speed limits, training of drivers, use of traffic guards, procedures for transport of oversized loads (e.g., engines), maintain log of traffic related incidents, sensitization of road users and people living close to the construction site.	Negligible
	Temporary influx of outside workers in the communities, risking tensions between outside (partly possibly	Affected communities in area of influence	Minor	A Local Content Plan should be prepared to facilitate involvement of local labour. See HR policies and procedures below.	Negligible

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
	expatriate) labour and local population, due to differences in wealth and culture.			No hiring of short-term labour to be made at the site gate. Develop a code of behaviours for workers. All workers to receive training on community relations and code of behaviour. Periodic refreshing as needed based on community liaison/grievance mechanism feedback.	
	Potential for increase in prevalence of sexually transmitted diseases in local communities and other diseases	Affected communities in area of influence	Minor	Provide STD awareness material to all workers. Provide condoms to workers.	Negligible
Labour and working conditions	Exploitation of workers	Labour force	Minor	Develop transparent human resources policies and procedures for recruitment process, working conditions and Terms of Employment wages, worker-employer relations, Grievance Mechanism, non-discrimination, monitoring, roles and responsibilities following Nigerian Labour Law and ILO conventions. • Provide reasonable, and if applicable negotiated, working terms and conditions. • Establish worker's grievance mechanism, so that potential conflicts can be dealt with in an early and proper way. • No use of child labour (workers under age 18) or forced labour. • Provisions to ensure compliance with labour standards by supply chain and subcontracts,	Negligible

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
				including training if required. • Provide proper work place facilities for water/sanitation/rest rooms. • If case of retrenchment needs first viable alternatives are analysed and then adverse impacts of retrenchment on workers are reduced as much as possible. A transparent retrenchment plan will be prepared. • A worker's grievance mechanism will be in place.	
	Activities and staff at site may create security risks	All staff working at the construction site	Minor	Make security plan and emergency response and contacts with security forces.	Negligible
	Risk of health & safety incidents amongst labour force, including minor incident's such as cuts and major incidents such as loss of life	Construction labour force	Moderate	Develop project specific health and safety procedures based on Wärtsilä's standard health and safety procedures, including provisions for training and certifications to be followed by all workers including subcontractors. Especially slip-trip and fall hazards with installation of plant.	Minor
Employment and economy	Creation of temporary jobs for locals residents and Nigerian nationals with skilled trades	Local residents of affected communities and Nigerian nationals	Positive	Prepare a local content plan to enhance ability to locate local hires and Nigerian nationals. Include provisions for hiring women and youth and for "equal pay for work of equal value". A local hiring office (or offices) to be set-up for use by all contractors to advertise positions, receive applications, and provide guidance to applicants.	Positive

Indicator	**Potential impact**	**Receptor**	**Significance (pre-mitigation)**	**Mitigation or enhancement measures**	**Significance (post-mitigation)**
	Supply chain opportunities for Nigerian companies that can provide goods and services needed by the company	Nigerian companies and local SMEs	Positive	Prepare a local content plan to facilitate identification and selection of qualified local and Nigerian companies to provide needed supplies and services. Include provisions for advance notice to local companies, along with selection criteria including health and safety, to allow them to prepare for upcoming opportunities.	Positive
Infrastructure	Influx of outside workers may pose additional pressure on social infrastructure, like medical posts, emergency services, water supply, solid waste management	Affected communities in area of influence	Minor	Coordinate with medical posts and emergency services to prepare for water supply, waste management and incidents. Install proper and independent facilities at construction site for water supply, sanitation, solid and liquid waste, so that pressure on community infrastructure is limited.	Negligible
Cultural heritage	Accidental finds of cultural properties during excavation	Affected communities-	Minor	Inform NCMM and implement physical cultural property management plan	Negligible
	Potential interactions between construction works and cultural festivals due to traffic, noise and/or vibration impacts	Affected communities along the RoW	Minor	Consult with local communities on festivals and potentials for interaction with construction works. If required cease works on the specific dates.	Negligible

Table 6.*2* Summary of Mitigation Measures During Operation and Maintenance

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
Air quality	Exposure to emissions from vehicles (PM10, NO2/NOx, SOx) very limited as very little traffic	Workers on site, communities in area of influence	Moderate	• Maintain and operate all vehicles and equipment engines in accordance with manufacturers recommendations; • Stationary generators to be located to facilitate dispersion; • Cover properly loose materials and keep top layers moist; • Use binder material for erosion and dust control for long term exposed surfaces; • Regular cleaning of equipment, drains and roads to avoid excessive build-up of dirt; • Spray surfaces prior to excavation; • Use covered trucks for the transportation of materials that release dust emissions; and • Speed limits on-site of 25km/hr on unhardened roads and surfaces.	Negligible
	Elevated dusted levels in nearby communities as a result of dust raised by vehicle movements, wind, and handling of dusty material	Affected communities in area of influence	Minor		Negligible
Noise and vibration	Noise generation from operation and manintenance of the facilities	Affected communities	Minor	• Noise generation is unavoidable. • Conduct maintenance activities that generate noise only day time • Provide PPE to workers	Negligible
Soils, geology and land-use	Potential contamination of soil from inadvertent release of hazardous or contaminating material	Soil around the sites	Major	• Implement effective site drainage on the construction camp to allow for the directed flow of surface water off site. This shall include cut-off drains to divert surface runoff from exposed soils or construction areas; • Install oil/water separators and silt traps before effluent, leaves the site; • Minimise bare ground and stockpiles to avoid silt runoff; • Bounding of areas where hazardous substances are stored (eg fuel, waste areas); • Remove all water accumulation within bunds using manually controlled	Moderate

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
				positive lift pumps not gravity drains; • Regular checking and maintenance of all plant and equipment to minimize the risk of fuel or lubricant leakages; • Training of relevant staff in safe storage and handling practices, and rapid spill response and clean-up techniques; • Set-up and apply procedure regarding dealing with contaminated soils; • Development and implementation of a Waste Management Plan (as part of the ESMP) to ensure that waste is disposed of correctly; and • concrete bound wall shall be constructed around the PCB storage facility, such that spills can be contained and safely recovered and adequately protected from storm water	
Water resources	Contamination of surface water due to accidental spill of PCB	Nearby rivers and streams	Major	• Implement effective site drainage on the construction camp to allow for the directed flow of surface water off site. This shall include cut-off drains to divert surface runoff from exposed soils or construction areas; • Install oil/water separators and silt traps before effluent, leaves the site; • Minimise bare ground and stockpiles to avoid silt runoff; • Bounding of areas where hazardous substances are stored (eg fuel, waste areas); • Remove all water accumulation within bunds using manually controlled positive lift pumps not gravity drains; • Regular checking and maintenance of all plant and equipment to minimize the risk of fuel or lubricant leakages;	Moderate

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
				• Training of relevant staff in safe storage and handling practices, and rapid spill response and clean-up techniques; • Set-up and apply procedure regarding dealing with contaminated soils; • Development and implementation of a Waste Management Plan (as part of the ESMP) to ensure that waste is disposed of correctly; and • concrete bound wall shall be constructed around the PCB storage facility, such that spills can be contained and safely recovered and adequately protected from storm water	
Terrestrial ecology	Impacts due to alien species	Birds in the area of influence	Negligible	• N/A	Negligible
	Loss of vegetation due to routine clearance of vegetation	Flora and fauna within the sites	Negligible	NA	Negligible
Aquatic ecology	Degradation of aquatic species due to construction activities around surface water bodies	Rivers and streams	**Moderate**	• Natural water courses shall not be obstructed. • Wastes shall not be disposed along water courses or sensitive areas. • Avoid equipment and vehicle movements in rivers, floodplains and wetland areas. • construct containment for chemical storage • train staff on safe handling of chemicals	Minor
Visual amenities	Structures erected will be visible	Community	Negligible	N/A	Negligible
Stakeholder and Community expectation/relations Management	Management of Community concerns linked to impacts associated with operation phase issues (like air and dust emissions, traffic, and community safety/security, noise/vibration, etc) and adverse impact/inconveniencies resulting from it.	Affected communities in the area of influence	Moderate	Follow mitigation for operation phase air quality, noise and traffic. Inform communities about details of operation	Minor

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
	Dealing with community/stakeholder perceptions around cumulative impacts linked to the new plant and existing cement plant operations.			activities (e.g., employment opportunities) by by billboards, posters and plant visit Set-up, manage and manage grievance mechanism Sharing of independent monitoring reports of all monitoring actions during construction as mentioned in this ESMP. Engage communities in the monitoring activities to enhance transparency and involvement. Enhance ongoing consultations with local communities to create continuous dialogue, trust and planning of community development activities. Coordinate Stakeholder Engagement of all partners of industrial site, prepare and implement Stakeholder Engagement Plan	
Community Health, Safety and Security	External safety risks of of exposure to PCBs	Affected communities in the area of influence	Moderate	Develop an emergency response plan following international best practice including provisions for prevention and response to PCB spill. Coordinate with emergency services of States and LGAs Annual safety audit of the facilities. Communicate to communities the safety risks of the project and put sign boards about the risks.	Minor
Labour and working conditions	Exploitation of workers	Labour force for maintenance work	Minor	• Follow Nigerian Labour Law and ILO conventions. • Provide reasonable, and if applicable negotiated, working terms and conditions. • Establish worker's grievance mechanism, so that potential conflicts can be dealt with in an early and proper way. • No use of child labour (workers under age 18) or forced labour.	Negligible

Indicator	Potential impact	Receptor	Significance (pre-mitigation)	Mitigation or enhancement measures	Significance (post-mitigation)
				• Provisions to ensure compliance with labour standards by supply chain and subcontracts, including training if required. • A worker's grievance mechanism will be in place.	
	Occupational H&S risks in operation and maintenance	Labour force	Moderate	Develop and implement occupational HSE plan following Nigerian and international requirements: train staff, monitor and keep record. Special focus on slip-trip, fall from height and electrocution in maintenance and repair works, emergency prevention and management. Use personal protection equipment. Have medical emergency equipment at hand.	Minor
Employment and Economy	Employment opportunities for operational staff	National and local levels	Positive	Respect labour laws and ILO conventions	Positive
Cultural heritage	Potential interactions between maintenance works and cultural festivals due to traffic, noise and/or vibration impacts	Affected communities	Negligible	N/A	Negligible

CHAPTER SEVEN

7.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

7.1 INTRODUCTION

This chapter provides the ESMP for the Project. Elements of this plan will be taken forward and incorporated into a comprehensive project. Environmental and Social Management System (ESMS) that will be used to deliver the Project's HSE regulatory compliance objectives and other related commitments.

This ESMP is a delivery mechanism for environmental and social mitigation and enhancement measures made in the EIA Report. The purpose of the ESMP is to ensure that these recommendations are translated into practical management actions which can be adequately resourced and integrated into the Project phases. The ESMP is, therefore, a management tool used to ensure that undue or reasonably avoidable adverse impacts of construction and operation are prevented or reduced and that the positive benefits of the Projects are enhanced (Lochner, 2005).

The ESMP has been developed to meet international standards on environmental and social management performance, specifically those set out by the World Bank, ESS 1. The ESMP is intended to cover those activities described in Chapter 3 of this EIA report. It covers project activities during construction and operation and will be subject to thorough reviews prior to the commencement of activities to ensure completeness. The ESMP does not include measures for activities related to equipment and facility fabrication being done offsite. It should be noted that this provides the outline requirements for environmental management. Provision will be made for updating the outline ESMP once the detailed project design is completed and for adapting the ESMP to relevant project stages as part of the overall ESMS.

The plan details the mitigation and enhancement measures that the project proponents committed to implement through the life of the Project and includes desired outcomes; performance indicators; targets or acceptance criteria; monitoring and timing for actions and responsibilities. The PCB PMU Office will have principal responsibility for all measures outlined in the ESMP. PCB PMU Office may delegate responsibility to its contractors, where appropriate. In cases where other individuals or organisations have responsibility for mitigation or enhancement measures, this is clearly indicated in Tables 7.2. Capacity building and training requirements are also described, where these relate to specific skills required to deliver the ESMP action in question.

7.2 OBJECTIVES OF THE ESMP

The ESMP is needed to successfully manage the project's environmental and social performance throughout its lifecycle. It provides integration of environmental and social management with overall project engineering, procurement, construction, and operations. The ESMP is prepared to achieve the following objectives.

i. promote environmental and social management in the project implementation in all phases;
ii. ensure that all relevant stakeholders are aware of their respective responsibility - promoter, contractors, regulators and other relevant agencies;
iii. incorporate environmental and social management into project design and operating procedures and activities;
iv. serve as an action plan for environmental and social management for the project;
v. provide a framework for implementing environmental and social commitments described in chapter seven;
vi. prepare and maintain records of project environmental performance for monitoring and evaluating performance.

7.3 INSTITUTIONAL FRAMEWORK FOR IMPLEMENTATION

7.3.1 Responsibility

Responsibilities in the implementation and monitoring of the Environmental and Social Management Plan (ESMP) during pre-construction and construction stages are shared between multiple stakeholders, including the PMU, the EPC contractors and regulators.

In the office of the PMU for Environmental and Sound Management (ESM) of PCB designated in the Federal Ministry of Environment will be a responsible administrator to manage environmental and social aspect including the implementation of ESMP. Figure 7.1 illustrates the structure of the institutional arrangements.

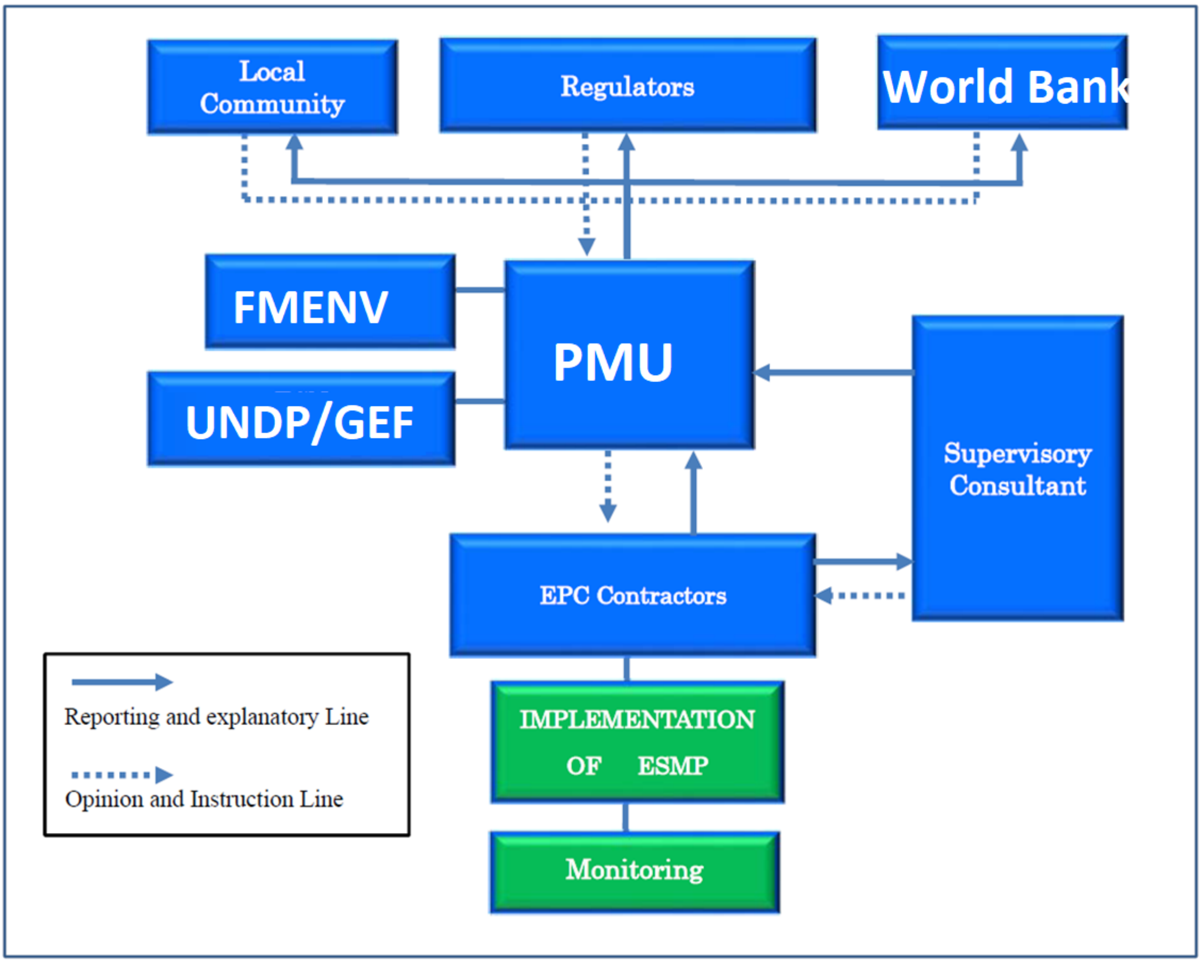


Figure 7.1 Institutional Arrangements for ESMP Implementation

The Federal Government of Nigeria

Section 20 of the constitution of Nigeria makes it an objective of the Nigerian State to improve and protect the air, land, water, forest and wildlife of Nigeria. Sections 33 and 34 which guarantee fundamental human rights to life and human dignity, respectively, can also be linked to the need for a healthy and safe environment to give these rights effect. The executive council of the federation approves all national policies including the National Policy on Environment.

The Global Environment Facility (GEF)

GEF is the interim financial mechanism for the Stockholm Convention. GEF provides the funds for the project.

The United Nations Development Programme (UNDP)

UNDP is the international Implementing Agency for the project, and is responsible for supervising implementation of all project activities specified in the project document.

Federal Ministry of Environment

The Federal Ministry of Environment (FMEnv, is the designated focal agency for the implementation of the Stockholm Convention in Nigeria, as the Lead Executing Agency. The FMENV established a Project Management Unit (PMU) in the Ministry for environmentally sound management of PCB in Nigeria.

The Federal Ministry of Environment is also responsible for the overall environmental policy of the Country. It has the responsibility for ESIA implementation and approval, in accordance with the EIA Act. The responsibility for implementation of EIA Act is handled by the Environmental Assessment Department.

Responsibilities for the ESIA and its implementation are shared between multiple stakeholders, including concerned ministries, competent authorities, the PMU and the contractors. These include the following;

- The Federal Government of Nigeria (FGN)
- Federal Ministry of Environment
- Lagos State Ministry of Environment
- Lagos Waste Management Authority ("LAWMA")
- Enugu State Ministry of Environment
- Enugu Waste Management Authority ("ENWMA")
- Abuja Environmental Protection Board
- Local Government Authority (LGA):
    - ✓ Epe Local Government Area
    - ✓ Enugu East Government Area
    - ✓ Kwali Area Council
- The Customary District Councils headed by Obas of each Kingdom affected
- Village Chiefs (Baale) of Affected Communities

The responsibilities and roles of each of the institutions are discussed below.

Project Management Unit (PMU)

The PMU for environmentally sound management of PCB in Nigeria has been set up for the project implementation. The PMU consist of the Project Coordinator, the Technical officer, the Monitoring and Evaluation Officer, Admin/Finance Assistant, and two support staff (Secretary and Office Assistant). Figure 7.2 illustrate the organizational structure of PMU.

The PMU is charged with the day-to-day activities under the project, in particular monitoring and evaluation and project implementation, including environmental safeguards management; Coordination with the other entities responsible for project implementation and Preparation of annual work plans. The overall responsibility for the implementation of the ESMP resides with the PMU, including the following.

- Oversee the proper application of mitigation and enhancement measures presented in the ESMP that are the responsibility of the Contractor
- Implement management measure of the ESMP
- Coordinate with UND, FMEnv and GEF for the necessary support for the preparation and implementation of ESMP.
- Monitor the environmental and social performance of the project in accordance with the programs presented in the ESMP
- Do internal coordination within PMU for supervising the contractor in charge of the project construction.
- Establish mechanism for handling complaints and distributes with the communities and relevant authorities.

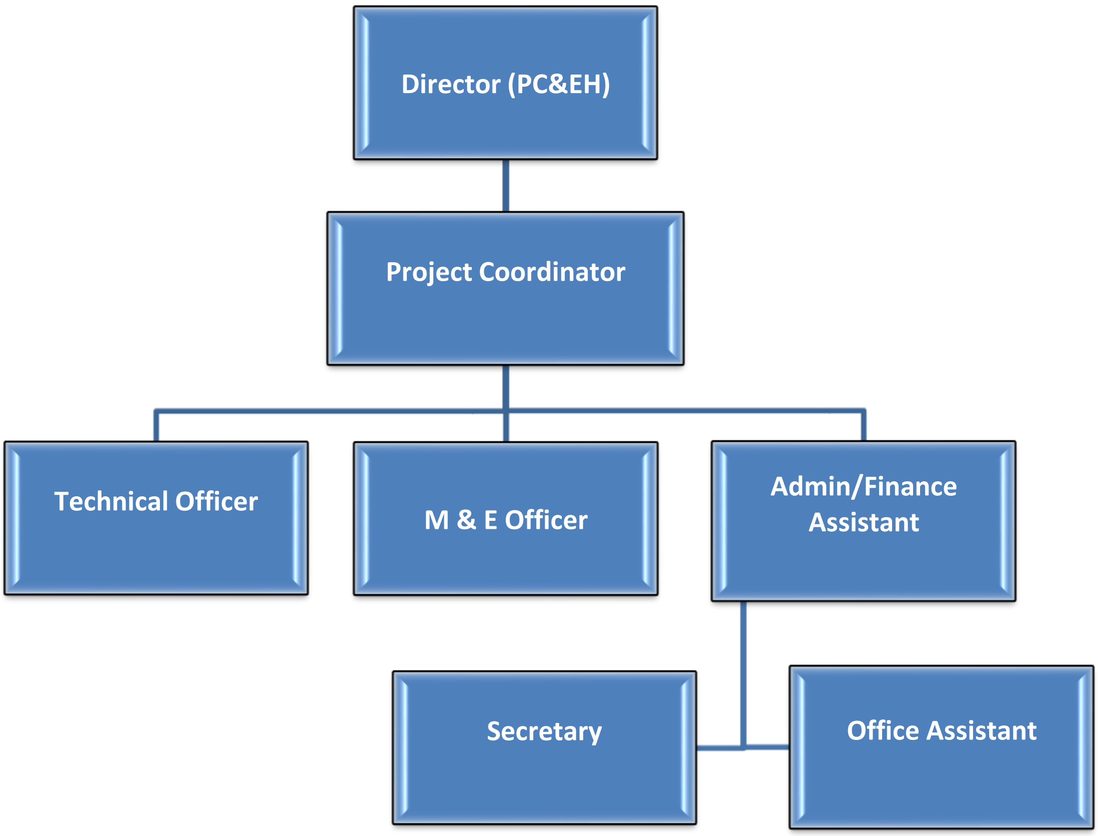


Figure 7.2 PMU Organisation Chart

Federal Ministry of Environment (Environmental Assessment Department)

The Environmental Assessment Department of the Federal Ministry of Environment (FMEnv) has the responsibility for the implementation of the EIA Act 86 of 1992. Furthermore, State Ministries for Environment (Lagos and Enugu States as well as the FCT) and affected LGAs of Epe, Enugu East and Kwali Area Council have certain oversight roles, which they perform under coordination of the FMEnv. Other agencies concerned about the project, which shall be involved in the implementation include;

Enugu State Ministry of Environment

The Ministry of Environment was established with the aim of creating better living and conducive environment for the entire people of Enugu State. It has statutory responsibility in the EIA Act to part of decisions for the approval of EIAs conducted for projects in the State.

Lagos State Ministry of Environment

The Ministry of Environment coordinates the environmental activities in the State through the agencies created under the Environmental Management Protection Law, 2017 ("EMPL 2017"). These include LASEPA and LAWMA.

LASEPA is responsible for regulations, establishing discharge limits, and issuance of permits among others, while LAWMA is responsible for waste management.

Local Government Areas (LGAs)

The project is located on three sites, Epe in Epe LGA of Lagos State, Neke Uno in Enugu East LGA of Enugu State and Sheda in Kwali Area Council of the FCT. These LGAs are involved in the EIA approval process. According to the EIA act, the LGAs will have representatives in the panel that will review the report and advise the Minister to make decisions on the project. The LGAs also have roles in the administration of lands in rural areas.

The Customary District Councils

The customary chiefs and community/village chiefs have important role to play in the project with respect to mobilization of the community members to support the project, grievance redress, peace and security of personnel, equipment and facilities to be installed. Close contact and regular consultation shall be maintained with customary chiefs throughout the life of the project

Contractors

Each contractor shall appoint a qualified environmental manager who, after approval by the PMU, will be responsible for daily management on-site and for the respect of management measures from the ESMP. This manager will report regularly to the environment and social expert of the PMU during the entire construction period.

Contractors must hold all necessary licenses and permits before the work begins. It will befall on them to provide to the PMU all of the required legal documents, among which the signed agreements with owners, authorizations for borrow pits and for temporary storage sites, etc.

7.3.2 Training and Awareness

PMU shall identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact upon the environment or social conditions. The Project recognises that it is important that employees at each relevant function and level are aware of the Project's environmental and social policy; potential impacts of their activities; and roles and responsibilities in achieving conformance with the policy and procedures.

This will be achieved through a formal training process. Employee training will include awareness and competency with respect to:

- environmental and social impacts that could potentially arise from their activities (including dust, biodiversity and soil/water contamination);
- necessity of conforming to the requirements of the ESIA and ESMP, in order to avoid or reduce those impacts; and
- roles and responsibilities to achieve that conformity, including those in respect of change management and emergency response.

The HSE Coordinator is responsible for coordinating training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The HSE Coordinator will also periodically verify that staff are performing competently through discussion and observation.

Employees responsible for performing site inspections will receive training by drawing on external resources as necessary. Training will be coordinated by the HSE coordinator prior to commissioning of the facilities. Upon completion of training and once deemed competent by management, staff will be ready to train other people.

Similarly, the Project will require that each of the sub-contractors institute training programmes for its personnel. Each subcontractor is responsible for site HSE awareness training for personnel working on the job sites. The subcontractors are also responsible for identification of any additional training requirements to maintain required competency levels.

The subcontractor training program will be subject to approval by PMU and it will be audited to ensure that:

- training programs are adequate;
- all personnel requiring training have been trained; and
- competency is being verified.

PMU's training programme will be followed to make permanent staff, contractor staff and temporarily hired staff aware of the ESIA and ESMP contents, their roles and responsibilities in the implementation of the ESMP and the additional requirements related to international standards.

7.4 OPERATIONAL CONTROL PROCEDURES

Each potentially significant impact identified in the ESIA will have an operational control associated with it that specifies appropriate procedures, work instructions, best management practices, roles, responsibilities, authorities, monitoring, measurement and record keeping for avoiding or reducing impacts. Operational controls are monitored for compliance and effectiveness on a regular basis through a monitoring and auditing procedure described in the ESMP.

Operational control procedures will be reviewed and, where appropriate, amended to include instructions for planning and minimising impacts, or to at least reference relevant documents that address impact avoidance and mitigation.

7.4.1 Managing Changes to Project Activities

Changes in the Project may occur due to unanticipated situations. Adaptive changes may also occur during the course of final design, commissioning or even operations. The Project will implement a formal procedure to manage changes in the Project that will apply to all project activities.

The objective of the procedure is to ensure that the impact of changes on the health and safety of personnel, the environment, plant and equipment are identified and assessed prior to changes being implemented.

The management of change procedure will ensure that:

- proposed changes have a sound technical, safety, environmental, and commercial justification;
- changes are reviewed by competent personnel and the impact of changes is reflected in documentation, including operating procedures and drawings;
- hazards resulting from changes that alter the conditions assessed in the ESIA have been identified and assessed and the impact(s) of changes do not adversely affect the management of health, safety or the environment;
- changes are communicated to personnel who are provided with the necessary skills, via training, to effectively implement changes; and
- the appropriate PMU person accepts the responsibility for the change.

As information regarding the uncertainties becomes available, the Project ESMP will be updated to include that information in subsequent revisions. Environmental and social, as well as engineering feasibility and cost considerations will be taken into account when choosing between possible alternatives.

7.4.2 Emergency Preparedness and Response

PMU will prepare plans and procedures to identify the potential for, and response to, environmental accidents and health and safety emergency situations and for preventing and mitigating potentially adverse environmental and social impacts that may be associated with them.

Emergency preparedness and response will be reviewed by PMU on at least an annual basis and after the occurrence of any accidents or emergency situations to ensure that lessons learnt, inform an advanced continuous improvement.

Emergency exercises will be undertaken on a regular basis to confirm adequacy of response strategies. Investigations of accidents or incidents will follow formal documented procedures.

7.4.3 Checking and Corrective Actions

Checking includes inspections and monitoring as well as audit activities to confirm proper implementation of checking systems as well as effectiveness of mitigations. Corrective actions include response to out-of-control situations, non-compliances, and non-conformances. Actions also include those intended to improve performance.

7.4.4 Monitoring

Monitoring will be conducted to ensure compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. Monitoring parameters are included in the ESMP table provided in Tables 7.1 and 7.2.

Monitoring methodologies or processes must be put in place in order to ensure the efficacy of the mitigation measures identified in the ESIA. Monitoring methodologies should be established to address the following:

- Alteration to the biological, chemical, physical, social and health characteristics of the recipient environment;
- Alterations in the interactions between project activities and environmental and social sensitivities, and interactions among the various sensitivities;
- Monitor the effectiveness of the mitigation and enhancement measures;
- Determination of long term and residual effects;
- Identification of Project specific cumulative environmental and social effects, if applicable;
- Social monitoring is focused on following the community relations of PMU. The quarterly FMEnv monitoring shall be performed with involvement of the communities. This joint monitoring will support good community relations, by creating trust and involvement;

- At the construction site inspections should be performed on human resources procedures, occupational health, safety and security risks management, emergency planning and the open water on malaria larvae; and
- The recruitment, human resources procedures, HSE training and awareness of the labour force in the construction as well as the operation phase should be monitored to know their origin in line with the local content plant and the level of knowledge and awareness on the code of conduct, STD prevention and occupational H&S measures.

The FMEnv guidelines require an environmental monitoring plan as part of an ESIA. The aim of the monitoring programme is to ensure that the negative environmental and social impacts identified in this ESIA are effectively mitigated in the construction and operation stages of the proposed Project.

7.4.5 Auditing

Beyond the routine inspection and monitoring activities conducted, audits will be carried out by PMU to ensure compliance with regulatory requirements as well as their own HSE standards and policies. Audits to be conducted will also cover the subcontractor self-reported monitoring and inspection activities. The audit shall be performed by qualified staff and the results shall be reported to PMU to be addressed.

The audit will include a review of compliance with the requirements of the ESIA and ESMP and include, at a minimum, the following:

- completeness of HSE documentation, including planning documents and inspection records;
- conformance with monitoring requirements;
- efficacy of activities to address any non-conformance with monitoring requirements; and
- training activities and record keeping.

There will be a cycle of audits into specific areas of the Project. The frequency of audits will be risk based and will vary with the stage of the Project and will depend on the results of previous audits.

Regulatory compliance audit is a mandatory requirement to be carried out by independent accredited consultant every three years during operation phase and the reports submitted to Federal Ministry of Environment.

7.4.6 Corrective action

Investigating a ‘near-miss’ or actual incident after it occurs can be used to obtain valuable lessons and information that can be used to prevent similar or more serious occurrences in the future.

PMU shall implement a formal non-compliance and corrective action tracking procedure for investigating the causes of, and identifying corrective actions to, accidents or environmental or social non-compliances. This will ensure coordinated action by EPC Contractor and its subcontractors. The HSE coordinator will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programs to avoid repetition of non- conformances and non-compliances.

7.4.7 Reporting

Throughout the Project, PMU will keep the regulatory authorities informed of the Project performance with respect to HSE matters by way of written status reports and face-to-face meetings. PMU will prepare a report on environmental and social performance and submit it to FMEnv. The frequency of this reporting will be determined by FMEnv, in a letter of approval of the project. These reports are prepared as part of requirements for impact mitigation monitoring to be carried by FMENV, Lagos Ministry of Environment, Enugus State Ministry of Environment and Abuja Environmental Protection Board and other relevant agencies.

If required, PMU will provide appropriate documentation of HSE related activities, including internal inspection records, training records, and reports to the relevant authorities. Subcontractors are also required to provide HSE performance reporting to PMU on a regular basis through weekly and monthly reports. These will be used as inputs to the above.

7.5 GRIEVANCE MECHANISMS

During implementation of the ESMP, it is possible that disputes/disagreements between the project developer and the community or among community member will occur, which could affect the project. A grievance procedure based on community grievance resolution channels, regulatory agencies and finally the law courts for resolution of the disputes and complaints.

7.5.1 Customary Mediation

All the communities affected by this project have internal mechanisms for resolution of disputes through the customary chiefdoms. Such customary avenues should provide a first culturally and amicable grievance procedure that will facilitate formal and/or informal grievance resolution.

A Customary Grievance Redress mechanism shall be responsible or involved for to addressing complaints or grievances associated with their members . affected persons' complaints should first be lodged verbally or in writing through the customary chief, who in turn will invite the PMU, if he could resolve it directly. The PMU and the customary chiefs and other council in chief will try to resolve the issue amicably. If the complaint cannot be resolved at this level, or if the plaintiff is not satisfied with the settlement proposed, the matter should be reported to the regulatory agencies.

7.5.2 Regulatory Agencies

The Miistries of agencies responsible for environment in Lagos and Enugu States and the FCT as well as the Federal Ministry of Environment have the statutory responsibility for an oversight and monitoring the implementation of the ESMP. The agencies shall pronounce judgement on any environmental complaint or dispute reported to them based on regulatory requirements. At this stage if the plaintiff is still not satisfied with the settlement he/she can then proceed to the official legal procedures.

7.5.3 Courts of Law

The judicial process in accordance with applicable laws will be followed and the law courts will pass binding judgment on the matter.

Figure 7.3 illustrates the procedure for grievance resolution.

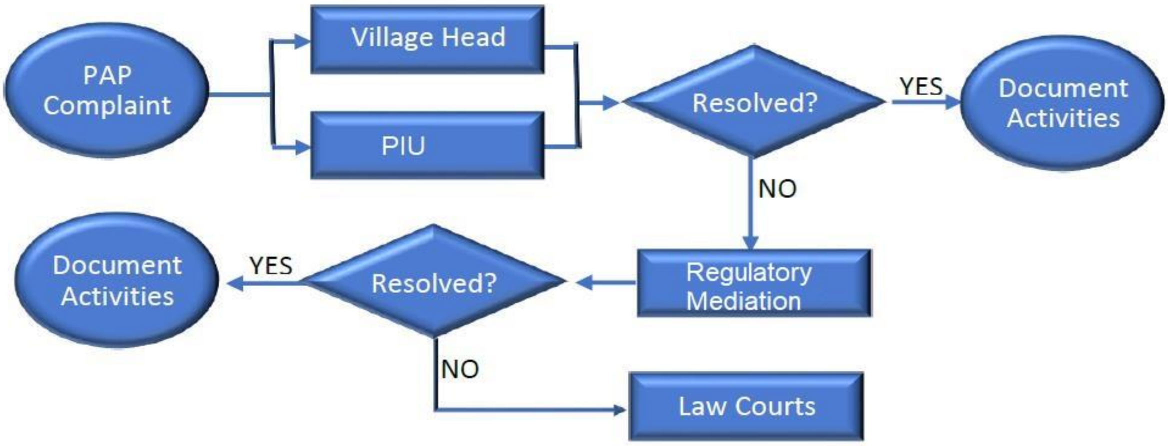


Figure 7.3 Grievance Resolution Procedure

7.6 PROPOSED MANAGEMENT PLAN

7.6.1 General

The Environmental and Social mitigation/enhancement measures, and the responsibilities for implementation are in Tables 7.1 and 7.2 respectively. The EPC contractor has responsibility for implementing the mitigation actions during construction phase. The budget for implementation shall be included in the EPC contract as part of the overall construction cost.

The monitoring plan in Tables 7.3 and 7.4 contain details of responsibilities, parameters to be monitored. Monitoring methods and standards/targets as well as locations and monitoring frequency. The cost estimates cover costs of analyses of samples (where required), travelling expenses and regulatory costs. The budget for environmental and social monitoring during construction (Table 7.3) shall be added to the EPC contract budget, and the EPC Contractor shall be required to disburse when needed, as may be directed by the Project Manager.

The budget for the monitoring during operations shall be provided by the PMU in its annual budgeting process and administered directly by the GM HSE, who has responsibility for ensuring mitigation actions are implemented effectively. These measures shall be adopted by PMU and imposed as conditions of contract on the sub-contractors hired for the Project.

7.6.2 Specific Management Plans

As a result of the final design not being available at this stage. The following specific plans shall be prepared and submitted to the EIA Division of the Federal Ministry of Environment, before commencement of implementation and after the national inventory and the final design have been completed.

- Emergency Response Plan
- Waste Management Plan
- Security Management Plan
- Local Content Plan
- Traffic Management Plan;
- Occupational Health and Safety Management Plan.

Table 7.1 Site Specific Environmental and Social Management Plan (Construction Phase)

Indicator	Potential impact	Receptor	Project Site			Mitigation or Enhancement Measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
Air quality	Localized impairment of air quality by exhaust emissions from vehicles and equipment engines (SO_2, CO, NOx, CO_2, PM)	Affected communities in area of influence	×	x	×	▪ Maintain and operate all vehicles and equipment engines in accordance with manufacturers recommendations ▪ Stationary generators to be located to facilitate dispersion	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
	Elevated dust levels due to vehicle movements, wind, and handling of dusty material	Affected communities in area of influence	×	x	×	▪ Cover properly loose materials and keep top layers moist ▪ Regular cleaning of equipment, drains and roads to avoid excessive buildup of dirt ▪ Spray surfaces prior to excavation ▪ Use covered trucks for the transportation of materials that release dust emissions ▪ Speed limits on-site of 25kph on unhardened roads and surfaces	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
Climate change	GHG emissions that could add to climate change effects	Global warming	×	x	×	▪ Maintain and operate all vehicles and equipment engines in accordance with manufacturers specifications, location of stationary generators to facilitate dispersion, restriction of vegetation clearing to only the required area	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
Noise, vibration	Nuisance noise from construction activities	Affected communities in area of influence Construction workers	×	x	×	▪ Select 'low noise' equipment or methods of work ▪ Use temporary noise barriers for equipment (e.g. sound proofing walls around stationary power generating sources). ▪ Maintain and operate all vehicles and equipment's in accordance with manufacturers recommendations ▪ Ensure periods of respite are provided in the case of unavoidable maximum noise level events ▪ Inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as providing the contact details of the responsible person. ▪ Noisy activities (activities that can be heard in nearby communities) restricted to day-time	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB

Indicator	Potential impact	Receptor	Project Site			Mitigation or Enhancement Measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
						working hours ▪ Provide appropriate PPE to construction workers and visitors			
Soils, geology and land-use	Change to soil structure (erosion and compaction) as a result of excavation and backfilling and removal of vegetation	Soil on construction site	×	x	×	▪ Construction of foundations to be undertaken in the dry period as reasonable as possible. ▪ Protect excavated soil materials from erosion (e.g. ▪ Ensure that the land is physically restored (include revegetation where possible) before the next rainy season. ▪ Use of existing road for transport of man and material to the extent possible.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
	Potential contamination of soil from inadvertent release of hazardous or contaminating material (liquid fuel, solvents, lubricants, paint, etc)	Soil on construction site,	×	x	×	▪ Implement effective site drainage on the construction yard to allow for the directed flow of surface water off site. This shall include cut-off drains to divert surface runoff from exposed soils or construction areas. ▪ Install oil/water separators and silt traps before effluent, leaves the site. ▪ Minimise bare ground and stockpiles to avoid silt runoff. ▪ Bunding of areas where hazardous substances are stored (eg fuel, waste areas). ▪ Regular checking and maintenance of all plant and equipment to minimize the risk of fuel or lubricant leakages. ▪ Training of relevant staff in safe storage and handling practices, and rapid spill response and clean-up techniques. ▪ Set-up and apply procedure regarding dealing with contaminated soils. ▪ Development and implementation of a Waste Management Plan to ensure that waste is disposed of correctly.	EPC Contractor EPC Contractor	PMU Supervision Consultant PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB FMENV, LMENV, ENMENV and AEPB
Water resources	Potential surface and groundwater contamination from accidental spills and improper disposal of waste and wastewater	Local groundwater-well and bore hole	×	x	×	▪ See above measures to mitigate 'Potential contamination of soil' impact	EPC Contractor	PMU Supervision Consultant	FMENV, LAMENV, ENMENV, AEPB

Indicator	Potential impact	Receptor	Project Site			Mitigation or Enhancement Measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
	Potential impact on hydrological condition due to the construction activities including the construction of foundation as well as the access road within the swampy area.	Rivers and streams	x	x		▪ Natural flow of a River shall not be blocked ▪ Based on an appropriate project design, select the most optimized layout considering human uses and areas of higher ecological integrity. ▪ Prohibit construction of permanent access roads along river banks, in swamps or in areas where soils are saturated ▪ Consider and Select the engineering design for construction work, including construction of foundation as well as access road, which would minimize the impact on hydrological condition.	EPC Contractor	PMU Supervision Consultant	FMENV, LAMENV, ENMENV, AEPB
Terrestrial ecology	Vegetation loss and disturbance to habitats, fauna and flora by construction activities	Flora and fauna and habitat in the area of influence Flora and fauna and habitat in the area of influence	x	x	x	▪ Minimize the construction of new access roads. Promote the use of existing access roads for machinery and vehicle movements. ▪ Promote the use of existing roads for transporting material to the construction sites in order to reduce the project's footprint and minimize the need for new access roads ▪ Herbicides should not be used for vegetation clearing ▪ Clearing should be minimised and restricted to the area required for construction purposes only and disturbance to adjacent vegetation communities and/or remnant trees within the corridor should be strictly controlled.	EPC Contractor	PMU Supervision Consultant	FMENV, LAMENV, ENMENV, AEPB
						▪ Revegetation will be carried out, as necessary. Revegetation will use species locally native to the site. The site of revegetation shall be identified and provided by the relevant government agency.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
	Vegetation clearing will cause habitat disturbances that could create suitable conditions for invasive species to spread	Flora and fauna and habitat in the area of influence	x	x		▪ Implementation of the invasive species management plan as part of the Vegetation Management Plan.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
	Loss of species that offer Provisioning Services	Local communities who rely on provisioning service, especially around swampy area.	x			▪ Site clearance activities to be restricted to the minimum required area	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB

Indicator	Potential impact	Receptor	Project Site			Mitigation or Enhancement Measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
						▪ Provide a training/education for the sustainable livelihood practice to local communities, as necessary, with cooperation of relevant agency.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
Aquatic ecology	Loss/disturbance of aquatic species	Rivers/streams/Swampy area crossed	×	x	x	▪ Natural flow of a River shall not be blocked ▪ Conduct activities during the dry period to minimize disturbance of sensitive shoreline and wetland areas ▪ Perform all vegetation clearing work manually along streams/rivers and swamps. ▪ Avoid vegetation clearing along stream shores and on steep slopes. ▪ Avoid equipment and vehicle movements in rivers, floodplains and wetland areas. If unavoidable, reduce access to a minimum length in wetlands and floodplains and select the most optimized site for the access considering human uses and areas of higher ecological integrity	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
Waste management	Potential contamination of soil from inadvertent release of hazardous or contaminating material (liquid fuel, solvents, lubricants, aluminium oxide paint, etc)	Surrounding environment and communities	×	x	×	▪ Prepare and implement the waste management plan	EPC Contractor	PMU Supervision Consultant	FMENV, LAMENV, ENMENV, AEPB
Visual amenities	Temporary presence of an active construction site with storage of materials and equipment within the sites	People living close to the construction sites.	×	x	×	▪ Maintain construction site in orderly condition and do not distribute material over many sites before usage.	EPC Contractor	PMU Supervision Consultant	FMENV, LAMENV, ENMENV, AEPB
Land planning and use	Change in land use cause by land take for the project, vegetation clearance, and access restriction	Land on the sites	×	x		▪ Site clearance activities to be restricted to the minimum required area. ▪ Provision of predefined route, barriers or boundary markings to prevent incursion of machinery and workers into neighboring areas ▪ See below measures under 'Resettlement'	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
Stakeholder and Community expectation/ relations Management	Community concerns linked to impacts associated with construction phase issues (like air and dust emissions, traffic, influx and community safety/security,	Affected communities in area of influence	×	x	×	▪ Follow mitigation for construction phase air quality, water quality, noise and traffic. ▪ Inform communities about details of construction activities (e.g., employment opportunities, schedule, timing of noise	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB

Indicator	Potential impact	Receptor	Project Site			Mitigation or Enhancement Measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
	noise/vibration, etc) and adverse impact/inconveniencies resulting from it.					activities, traffic including movements of oversized loads) by billboards, posters and community meeting ▪ Set-up and effectively monitor construction grievance redress mechanism ▪ Engage communities in the monitoring activities to enhance transparency and involvement.			
Community Health, Safety and Security	Increased risks of traffic safety incidents on public roads Risk of erosion into creeks, which are used as source of domestic water for the communities	People living close to access roads and road users People who use the river water as source of domestic water	×		×	▪ Implement a traffic management plan including design of access point, signalization, speed limits, training of drivers, use of traffic guards, procedures for transport of oversized loads (e.g., engines), maintain log of traffic related incidents, sensitization of road users and people living close to the construction site. ▪ Follow mitigation for construction phase water quality.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
	Temporary influx of outside workers in the communities, risking tensions between outside (partly possibly expatriate) labour and local population, due to differences in wealth and culture.	Affected communities in area of influence	×		×	▪ Priority of employment shall be given to locals. ▪ A Local Content Plan should be prepared to facilitate involvement of local labour. ▪ Develop a code of behaviours for workers. All workers to receive training on community relations and code of behaviour. ▪ Periodic refreshing as needed based on community liaison/grievance mechanism feedback.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
	Potential for increase in prevalence of sexually transmitted diseases in local communities and other diseases	Affected communities in area of influence	×	X	×	▪ Do sensitization and awareness to all EPC workers regarding sexually transmitted diseases ▪ Provide Sexually transmitted disease awareness material to all EPC workers and host communities	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
Labour and working conditions	Exploitation of workers	Labour force	×	X	×	▪ Develop transparent human resources policies and procedures for recruitment process, working conditions and Terms of Employment wages, worker-employer relations, Grievance Redress Mechanism, non-discrimination, monitoring, roles and responsibilities following Nigerian Labour Law and ILO conventions. ▪ Provide reasonable, and if applicable negotiated, working terms and conditions.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB

Indicator	Potential impact	Receptor	Project Site			Mitigation or Enhancement Measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
						▪ Establish worker's grievance redress mechanism, so that potential conflicts can be dealt with in an early and proper way. ▪ No use of child labour (workers under age 18) or forced labour ▪ Provisions to ensure compliance with labour standards by supply chain and subcontracts, including training if required. ▪ Provide proper work place facilities for water/sanitation/rest rooms etc. ▪ A worker's grievance redress mechanism			
	Activities and staff at site may create security risk (e.g. infiltration of criminal)	Workers and local communities	×	X	×	▪ Liaise with community security structure ▪ Provision of security during the construction work ▪ Make security plan and emergency response and contacts with security forces. ▪ Provide the identification tag for all workers and visitors.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
	Creation of tension between security personel and local communities	Local communities	×	X	×	▪ Provide the training and awareness to security personnel ▪ Establish the communication with local communities and awareness	EPC Contractor	PMU Supervision Consultant Nigerian Security and Civil Defense (NSCDC)	Nigerian Police Force
	Risk of health & safety incidents amongst labour force, including minor incident's such as cuts and major incidents such as loss of life	Construction labour force	×		×	▪ Develop project specific health and safety procedure, including provisions for training and certifications to be followed by all workers including subcontractors.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
Employment and economy	Creation of temporary jobs for locals residents and Nigerian nationals with skilled trades	Local residents of affected communities and Nigerian nationals	×		×	▪ Prepare a local content plan to enhance ability to locate local hires and Nigerian nationals. Include provisions for hiring women and youth and for "equal pay for work of equal value". ▪ A local hiring office (or offices) to be set-up for use by all contractors to advertise positions, receive applications, and provide guidance to applicants.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB

Indicator	Potential impact	Receptor	Project Site			Mitigation or Enhancement Measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
	Supply chain opportunities for Nigerian companies that can provide goods and services needed by the company	Nigerian companies and local shops	×		×	▪ Prepare a local content plan to facilitate identification and sel ection of qualified local and Nigerian companies to provide needed supplies and services. Include provisions for advance notice to local companies, along with selection criteria including health and safety, to allow them to prepare for upcoming opportunities.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
Infrastructure	Influx of outside workers may pose additional pressure on social infrastructure, like medical posts, emergency services, water supply, solid waste management	Affected communities in area of influence	×		×	▪ Coordinate with medical posts and emergency services to prepare for water supply and waste management. ▪ Install proper and independent facilities at construction site for water supply, sanitation, solid and liquid waste, so that pressure on community infrastructure is limited.	EPC Contractor	PMU Supervision Consultant	FMENV, LMENV, ENMENV and AEPB
Cultural heritage	Accidental finding of cultural property	Affected cultural heritage	×			▪ Implement cultural property management plan	NCMM	PMU	Witness NGO
	Potential interactions between construction works and cultural festivals due to traffic, noise and/or vibration impacts	Affected communities	×		×	▪ Consult with local communities on festivals and potentials for interaction with construction works. If required cease works on the specific dates.	NCMM	PMU	Witness NGO

Table 7.2 Site Specific Environmental and Social Management Plan (Operations Phase)

Indicator	Potential impact	Receptor	Project Site			Mitigation or enhancement measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
Air pollution / Climate Change:	Vehicular emissions from mobile treatment plant and other vehicles	Air quality	×	x	×	▪ Regular maintenance of vehicles maintenance techniques.	Plant Manager	PMU	FMENV, LMENV, ENMENV ,AEPB
Noise, vibration &	Noise from treatment plant	Affected communities	×	x	×	▪ Avoiding high noise generating activities at night ▪ Ensure use of PPEs by staff and visitors.	Plant Manager	PMU	FMENV, LMENV, ENMENV, AEPB
Terrestrial ecology	Impairments of natural habitats and associated flora communities	Flora and fauna	×	x	x	▪ Maintain all maintenance work inside the footprint of the sites to reduce encroachment on natural habitats ▪ Clearly mark the extent of vegetation control. Identify and mark the	Plant Manager	PMU	FMENV, LMENV, ENMENV and AEPB

Indicator	Potential impact	Receptor	Project Site			Mitigation or enhancement measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
						vegetation to be preserved			
Aquatic ecology	Degradation of aquatic species	Rivers and streams	×	x	x	▪ Wastes shall not be disposed along water courses or sensitive areas. ▪ Existing access roads shall be utilized during maintenance. ▪ Avoid equipment and vehicle movements in rivers, floodplains and wetland areas as reasonable as practicable. ▪ Forbid use of chemical pesticides to control vegetation	Plant Manager	PMU	FMENV, LMENV, ENMENV and AEPB
Waste management	Wastes such as waste oil, general waste will be generated from maintenance activities	Surrounding environment and communities	×		×	▪ Prepare and implement the waste management plan	Plant Manager	PMU	FMENV, LMENV, ENMENV and AEPB
Stakeholder and Community expectation/ relations Management	Management of Community concerns linked to impacts associated with operation phase issues	Affected communities in the area of influence	×		×	▪ Set-up, manage and manage grievance redress mechanism ▪ Engage communities in the monitoring activities to enhance transparency and involvement. ▪ Prepare and implement Stakeholder Engagement Plan (SEP). ▪ Enhance ongoing consultations with local communities to create continuous dialogue, trust and planning of community development activities according to SEP.	Plant Manager	PMU	FMENV, LMENV, ENMENV and AEPB
Community Health, Safety and Security	External safety risks of exposure to PCBs	Affected communities	×		×	▪ Develop an emergency response plan following international best practice including provisions for prevention of/and response to spill, roles and responsibilities. Coordinate with emergency services of LGAs ▪ Communicate to communities the safety risks of the project and provide response measures. Put sign boards about PCB risks.	Plant Manager	PMU	FMENV, LMENV, ENMENV and AEPB
Labour and working conditions	Exploitation of workers	Labour force for maintenance work	×		×	▪ Develop transparent human resources policies and procedures for recruitment process, working conditions and Terms of Employment wages, worker-employer relations, Grievance Redress Mechanism, non-discrimination, monitoring, roles and responsibilities following Nigerian Labour Law and ILO conventions. ▪ Provide reasonable, and if applicable negotiated, working terms and conditions. ▪ Establish worker's grievance mechanism, so that potential conflicts can be dealt with in an early and proper way. ▪ No use of child labour (workers under age 18) or forced labour. ▪ Provisions to ensure compliance with labour standards by supply chain and subcontracts, including training if required. ▪ A worker's grievance mechanism will be in place.	Plant Manager	PMU	FMENV, LMENV, ENMENV and AEPB
	Occupational H&S risks in operation and maintenance	Labour force	×		×	▪ Develop and implement Occupational HSE plan following Nigerian and international requirements: train staff, monitor and keep record. Special focus on slip-trip, fall from height and electrocution in maintenance and repair works, emergency prevention and management. Use personal	Plant Manager	PMU	FMENV, LMENV, ENMENV and AEPB

Indicator	Potential impact	Receptor	Project Site			Mitigation or enhancement measures	Responsibilities		
			Sheda	Epe	Neke Uno		Implementation	Supervision	Monitoring
						protection equipment. ▪ Have medical emergency equipment at hand.			
Employment and Economy	Improved PCB free country.	National and Local levels Nigeria	×		×	▪ Ensure sound employment policies and transparent criteria to avoid conflicts	Plant Manager	PMU	FMENV, LMENV, ENMENV and AEPB
Cultural heritage	Potential interactions between maintenance works and cultural festivals due to traffic, noise and/or vibration impacts	Affected communities	×			▪ Consult with local communities on festivals and potentials for interaction with maintenance works. I f required cease works on the specific dates.	Plant Manager	PMU	FMENV, LMENV, ENMENV and AEPB

Table 7.3 Environmental and Social Monitoring Plan (Construction Phase)

Component	Parameters to be Monitored	Method	Standards/Targets	Location	Frequency	Responsibility	Cost Estimates (NGN)
Air quality	SO2, NOx, CO, VOC, PM	Visual inspection of sites and access roads; verification of equipment and machinery records Ambient air quality measurements	Avoid significant degradation of baseline conditions. WHO and National ambient air quality standards (FMENV)	Project sites	Daily Weekly monthly	PMU	1,500,000
Noise	Noise Levels,	Noise level measurements	Avoid significant degradation of baseline conditions. WHO and FMENV noise standards	Project sites	Daily	PMU	6,000,000
Soils integrity	Visual signs of contamination Status of drainages, bundwalls, stockpiles, etc	Visual inspection of sites	Avoid the use of erosive processes or control them Reduce soil compaction Avoid soil profile structure destruction Avoid any soil contaminations	Project sites	weekly	PMU	Included in PMU`s administrative cost
	Soil biological, physical and chemical properties	Sampling and analyses of soils	Compare with baseline condition	Project sites	weekly	PMU	6,500,000
Terrestrial ecology	Introduction of Alien species	Visual inspection of alien species	Avoid the introduction of alien species	Project sites	weekly	PMU	Included in PMU`s administrative cost
	Natural resource exploitation	Visual inspection and interview with communities	Increase awareness on natural resource protection	Project sites	Continuous	PMU	Included in PMU`s administrative cost
Vegetation integrity and Fauna protection	Vegetation cover Pictorial comparison (before and after the maintenance)	Visual inspection of areas	Avoid significant degradation outside the site and undeveloped areas. Protection of flora species with conservation status Avoid habitat loss and disturbances for local fauna	Project sites	weekly	PMU	Included in PMU`s administrative cost
Waste management	Type and amount of waste generated Disposal of wastes	Keep the record	All waste are appropriately treated and disposed according with applicable regulation	Project sites	weekly	PMU	Included in PMU`s administrative cost
Visual amenities Land planning and use	Orderliness and cleanliness of sites disturbance outside acquired sites	Visual inspection of project areas	Good housekeeping practice Site clearance activities to be restricted to the minimum required area.	Project sites	weekly	PMU	Included in PMU`s administrative cost

Component	Parameters to be Monitored	Method	Standards/Targets	Location	Frequency	Responsibility	Cost Estimates (NGN)
Stakeholder relations Management	No of complaints/ concerns received Status of grievance resolutions	Interview neighboring communities Stakeholder meetings Inspection of complaints/grievance log book	Grievances are resolved effectively Complaints and issues are addressed timely	Neighboring communities	monthly	PMU	Included in PMU`s administrative cost
Health, Safety and Security	Incidences	Inspection and review of incidence log	ILO requirements and Factories Act minimum labour standards	Project sites	Daily	PMU	Included in PMU`s administrative cost
Employment and economy	Proportion of employees from local community materials procured from local community made in Nigeria materials used	Inspect employee records Random interview with workers Inspection of procurement records Interview with suppliers and vendors	Semi-skilled and non-skilled labour employed from local community if requierd Made in Nigeria products are utilized, except where not available	Project sites	As required	PMU	Included in PMU`s administrative cost

Table 7.4 Environmental and Social Monitoring Plan (Operational Phase)

Component	Parameters to be Monitored	Method	Standards/Targets	Location	Frequency	Responsibility	Cost Estimates (NGN)
Air quality	Dust	Visual inspection of construction sites, access roads; verification of equipment and machinery	Avoid significant degradation of baseline conditions.	Project sites	daily	EPC Contractor	Included in EPC Contractor Fee
	SO_2, NO_x, CO, PM10, PM2.5, TSP	Ambient air quality measurements	IFC and National ambient air quality standards (FMENV)	Project sites	quarterly	PMU	8,000,000/ year
Noise, vibration	Noise Levels,	Noise level measurements	IFC and FMENV noise standards	Project sites	quarterly	PMU	19,200,000/ year
Soils integrity	Visual signs of contamination Status of drainages, bundwalls, stockpiles, etc	Visual inspection of construction sites and access roads	Avoid the use of erosive processes or control them Reduce soil compaction Avoid soil prof ile structure destruction Avoid any soil contaminations	Project sites	daily	EPC Contractor	Included in EPC Contractor Fee
	Soil biological, physical and chemical properties	Sampling and analyses of soils	Compare with Baseline condition	Project sites	Once the construction completed	PMU	10,800,000/ year
Water quality	Water physico-chemical and microbiological -pH, temperature, TSS, turbidity, phosphorus, metals, sulphate, BOD, COD, coliform, fungi, etc.	Analysis of surface and ground water samples Visual detection of pollution signs (presence of oil, waste, etc.)	Avoid significant degradation of baseline conditions WHO and FMENV water quality standards	Groundwater: Around project sites Surface water: Rivers and streams	Twice a year	PMU	50,400,000/year
Aquatic ecology	Degradation of aquatic ecology	Visual inspection of rivers and streams	Avoid equipment and vehicle movements in rivers and swamps.	The construction area around rivers and swamps	Daily	EPC Contractor	Included in EPC Contractor Fee
Vegetation integrity and Fauna protection	Vegetation cover Pictorial comparison (before and after)	Visual inspection of construction sites	Avoid significant degradation outside the sites. Protection of flora species with conservation status	Project sites	Once during vegetation removal	EPC Contractor	Included in EPC Contractor Fee

Component	Parameters to be Monitored	Method	Standards/Targets	Location	Frequency	Responsibility	Cost Estimates (NGN)
Waste management	Type and amount of waste generated Disposal of wastes	Keep the record	All waste are appropriately treated and disposed according with applicable regulation	Project sites	Daily	EPC Contractor	Included in EPC Contractor Fee
Visual amenities Land planning and use	Orderliness and cleanliness of sites disturbance outside the sites	Visual inspection of construction sites and access roads	Good housekeeping practice Site clearance activities to be restricted to the minimum required area. Provision of predefined route, barriers or boundary markings to prevent incursion of machinery and workers into neighboring areas	Project sites	Daily	EPC Contractor	Included in EPC Contractor Fee
Stakeholder relations Management	No of complaints/ concerns received Status of grievance resolutions	Interview neighboring communities Stakeholder meetings Inspection of complaints/grievance log book	As per stakeholder engagement Plan	Neighboring communities	Continuous	PMU	1,500,000
Health, Safety and Security	Incidences	Inspection and review of incidence log	ILO requirements, Labour Law and Factories Act minimum labour standards	Project sites	Daily	EPC Contractor	Included in EPC Contractor Fee
Employment and economy	Proportion of employees from local community materials procured from local community made in Nigeria materials used	Inspect employee records Random interview with workers on site Inspection of procurement records Interview with suppliers and vendors	Semi-skilled and non-skilled labour employed from local community Materials available in the communities are used Made in Nigeria products are utilized, except where not available	Project sites	Daily	EPC Contractor	Included in EPC Contractor Fee

CHAPTER EIGHT

8.0 DECOMMISSIONING AND CLOSURE

8.1 INTRODUCTION

The proposed project with the facilities and their ancillary installations have a life span of 20 years after which the performance of the project scales to diminishing returns or the project is no more viable and then will be decommissioned. A decommissioning plan will be prepared at end of the project life and submitted to EA Department of FMEnv and other relevant regulators for approval before it is implemented. This plan shall contain procedures, outcome of consultations, impacts and mitigation.

Nevertheless, as required in the Guidelines for the ESIA study, the decommissioning Plan for the proposed project is presented herewith. The incorporation of remediation plans into the overall project planning is essential because it allows proponents to understand the need for restoring the environment into its original, or near its original status when abandonment plans are being conceptualized. Operating projects beyond the designed lifespan makes it economically unproductive as returns from such investment become unattractive.

8.2 STAKEHOLDERS CONSULTATION FOR DECOMMISSIONING

The project-decommissioning plan will include consultation with various stakeholders including host communities, nearby facility owners, regulatory bodies and experts.

As the Project approaches the end of its economic viability, plans will be put in place to wind down operations and maintenance. This will allow for a carefully planned redeployment and, where necessary, disengagement of personnel as appropriate.

8.3 PRE-DECOMMISSIONING ACTIVITIES

Prior to engaging in decommissioning works, the Proponent will develop a decommissioning plan in accordance with regulatory requirements at the time of decommissioning. Decommissioning and restoration activities will be performed in accordance with all relevant statutes in place at the time of decommissioning.

8.4 DECOMMISSIONING ACTIVITIES

At the end of the facilities utility, all equipment will be decommissioned. In general, the activities to be carried out during the decommissioning phase shall include the following:

- Dismantling of facilities including excavation
- Dismantling of all surface equipment
- Removal and disposal of concrete works

- Removal and disposal of conductors, etc

8.5 IMPACTS AND MITIGATION MEASURES

8.5.1Impacts

The potential impacts that might result from the decommissioning phase of the proposed project include:

- physical disturbance of the environment arising from the removal of the plant and ancillary equipment,
- potential hazards/accidents associated with decommissioning activities, and
- waste management problems

The strategy to be adopted for site remediation shall depend on the prevailing biophysical and social environmental attributes and the attendant impacts that may result from such an action as discussed in Chapter 6. The following measures need to be planned for implementation after decommissioning:

- Facilities and ancillary equipment shall be dismantled completely
- All equipment and debris shall be removed from the environment
- Good waste management plan shall be implemented.

- **Acoustics (Noise)**: Sources of noise during decommissioning would be similar to those during construction and would be caused primarily by construction equipment and vehicular traffic
- **Air Quality:** Emissions generated by activities during the decommissioning include vehicle emissions; diesel emissions from large construction equipment and generators; and fugitive dust from many sources such as structure removal, backfilling, dumping, reclamation of disturbed areas (grading, seeding, planting), and truck and equipment traffic.
- **Ecological Resources:** Removal of aboveground structures would eliminate the impacts to wildlife that occur during operation.
- **Environmental Justice:** Issues that could be of concern during decommissioning and site reclamation are noise, dust, and visual impacts, as well as possible restoration of fish and wildlife populations for subsistence users.
- **Hazardous Materials and Waste Management:** Impacts could result if these wastes were not properly handled and were released to the environment.
- **Human Health and Safety:** Potential impacts to worker and public health and safety during decommissioning and site reclamation would be similar to those during construction; and relate to earthmoving, use of large equipment, dismantling of industrial components, and transportation of overweight and oversized materials.

- **Land Use**: Upon decommissioning, land use impacts resulting from construction and operation of the project, could be largely reversed depending on the end use selected for the site. No permanent land use impacts would occur during this phase.
- **Socioeconomics:** Direct impacts would include the creation of new jobs for workers during decommissioning.
- **Soils and Geologic Resources:** Activities during decommissioning that would result in impacts to soils include removal of access roads, project components, and other ancillary structures. Surface disturbance, heavy equipment traffic, and changes to surface runoff patterns could cause soil erosion. Soil erosion impacts include soil nutrient loss and reduced water quality in nearby surface water bodies.
- **Transportation:** Short-term increases in the use of local roadways would occur during decommissioning and site reclamation. Overweight and oversized loads could cause temporary disruptions to local traffic.
- **Water Resources**: Water would be used for dust control for road traffic, dismantling of the plant, pipelines, structures, and other buildings, and for consumptive use by the construction crew. It might be trucked in from off-site or obtained from local groundwater wells or nearby surface water bodies, depending on availability.

8.5.2 Mitigation Measures

The strategy to be adopted for site remediation shall depend on the prevailing biophysical and social environmental attributes and the attendant impacts that may result from such an action as discussed in Chapter 6. The following measures need to be planned for implementation after decommissioning:

- Facilities and ancillary equipment shall be dismantled completely
- All equipment and debris shall be removed from the environment
- Good waste management plan shall be implemented.

For abandonment, strict adherence to facilities abandonment policy of World Bank, which includes restoring the project environment to its original status as much as possible, shall be encouraged. The procedure shall be in accordance with approved Environmental and Social Management Plan (ESMP) and international industry standards. It is expected that if these measures are implemented, an environmentally friendly site restoration after decommissioning will be achieved.

Decommissioning of the plant and the ancillary installations will result in potential for work-related injuries and fatality from the dismantling process. Decommissioning process which entails the restoration of land to its original situation as much as possible, will increase land available for agriculture and other uses. The reclaimed land will eventually be handed over to the original community and landowners

All facility components that can be used or recycled will be identified and quantified. Vehicles for the operation and other facilities will be scrapped and / or moved to other locations. Cleared locations will be re- vegetated using fast growing native plant species.

8.6 REPORTING

As required by regulations, a post-decommissioning report will be prepared and submitted to the Nigerian Regulators. The report will provide the following details:

- Overview of decommissioning facilities
- Details of methods used for decommissioning
- Nature of decommissioning (partial or whole)
- Record of consultation meetings
- Details of recyclable/reusable materials/facility components
- Decontaminated facilities
- Decommissioning schedule
- State of the surrounding environment
- Waste management plan
- Plans for restoration/remediation where necessary

CHAPTER NINE

9.0 CONCLUSIONS

The Environmental and Social Impact Assessment (ESIA) of the proposed project has been carried out in line with statutory requirements for environmental management in Nigeria and as such ensures that potential environmental, social and health impacts of the project are fully appraised. This ESIA report has documented the existing environment of the area, potential and associated impacts of the proposed project, proffered cost effective mitigation/ ameliorative measures for impacts and enhancement measures for the beneficial impacts. A management plan that would be effective throughout the projects life cycle has also been put in place to assure environmental sustainability of the project.

The environmental baseline condition of the project area showed that the physical, chemical and biological characteristics as well as meteorological, climatic and hydrological characteristics were generally consistent with previous studies carried out within the environment with some few exceptions. Also documented were unique assemblages of wild flora and fauna species with abundances that relate to the nutrients and chemical composition of the ecosystems.

The identified adverse impacts of the proposed project include; air pollution, soil, sediment, groundwater and surface water contamination from accidental/ routine discharges of effluent, workplace accidents, improper waste management has been identified. Consequently, cost-effective mitigation/ amelioration measures have been designed to ensure that these impacts are prevented, reduced or controlled to as low as reasonably practicable, in order to ensure conservation of biodiversity in the area and enhance continual compliance with environmental standards and requirements in Nigeria. It is understood that the project will result in substantial social and economic benefit for Nigeria. The EMP developed would ensure that the plans/ procedures for managing the significant impacts of the project are maintained throughout the project implementation.

Socio economic consultations with the project host communities and other relevant stake holders were also carried out and shall continue throughout the life cycle of the project

It is therefore hoped that all data/evidence contained in this report is sufficient in the development of an environmental impact statement (EIS), and afterward in the acquiring of necessary permits for commencement of project.

In consideration of the above therefore, all the environmental issues identified can be mitigated and managed through the ESMP.

Therefore, we recommend that the *EIA of the PCB Collection, Storage and Treatment Centers Project* be approved and issued EIA permit. The mitigation measures that have been proffered shall be adequately implemented in accordance with the ESMP and in compliance with the ESIA Act and the world bank environmental and social standard (ESS1).

BIBLIOGRAPHY

Ababo W. T., Gereslassie, T., X.Yan, and Wang, Y.,(2018). Determination of Heavy Metal Concentrations and Their Potential Sources in Selected Plants: *Xanthium strumarium* L. (Asteraceae), *Ficus exasperata* Vahl (Moraceae), *Persicaria attenuata* (R.Br) Sojak (Polygonaceae), and *Kanahia laniflora* (Forssk.) R.Br. (Asclepiadaceae) from Awash River Basin, Ethiopia. Biological Trace Element Research. pp 1–12

Abdulsalam N.N, Ologe O. (2013). The use Of Resistivity Profiling Method In Grounwater Investigaton of a typical Basement Complex: A Case Study Of L.E. A Primary School-Dagiri In Gwagwalada Area Northcentral Nigeria. *Rep Opinion* 2013;5(5) :48-53]. (ISSN: 1553-9873). http://www.sciencepub.net/report. 7

Adeigbe, O.C. and Salufu, A.E. (2010): Geology and petroleum potential of Campano-Maastrichtian sediments in the Anambra Basin, southeastern Nigeria, NAPE Bulletin, 22(1): 13-19.

Adelana, S. M. A., Olasehinde, P. I., Vrbka, P.; Edet, A. G. & Goni, I. B. (2008). An overview of the Geology and Hydrogeology of Nigeria. In: S. M. A. Adelana and A. M. Mc Donald (Eds.), *Applied groundwater studies in Africa*. IAH Selected papers in Hydrogeology, Vol. 13. Leiden, Netherlands. CRC Press/Balkema.

Agagu, O.K, Fayose EA, Paters SW (1991). Stratigraphy and Sedimentation in the senonian Anambra basin of Eastern Nigeria. J. Min. Geol. 2:25-35.

Ajao E. A (1989): The influence of domestic and industrial effluent on population of sessile and benthic organisms in Lagos Lagoon. –Ph. D Thesis, Univ. Ibadan, 411pp.

Akande, S.O, Ojo OJ, Adekeye OA, Egenhoff SO, Obaje NG, Erdtmann BD. (2011). Stratigraphic evolution and petroleum potential of middle cretaceous sediments in the lower and middle Benue trough, Nigeria: Insights from new source rock facies evaluation. Petroleum Technology Development Journal. 2011; 1:74-106.

Alloway, B.J. (1995). Bioavailability of elements in soil. In Alloway, B.J. (ed.). *Heavy metals in soils*. 2nd Edition. Blackie Academic Professional, London. 347 – 372.

Amadi, U.M.P and Amadi, P.A (1990). Saltwater migration in the coastal aquifers of Southern Nigeria. J. Mining Geol. 26(1), pp35-44 .

Anonymous, (2018). Copper and Soil – How Copper Affects Plants https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/copper-for-the-garden.htm

APHA, AWWA, WEF. (2012). Standard Methods for exa-mination of water and wastewater. 22nd ed. Washington: American Public Health Association; 2012, 1360 pp. ISBN 978-087553-013-0

APHA. (1992). Compendium of Methods for the Microbiological Examination of Foods, 3rded. American Public Health Association, Washington, DC.

APHA/AWWA/WEF (2012). Standard method 2130: turbidity. Standard methods for the examination of water and wastewater, 22nd edition. Washington, DC: American Public

Health Association, American Water Works Association and Water Environment Federation.

Babafemi E.M, Bamidele O.E,Sangodiji E.E (2016). Mapping Of Structural Features in Basement Complex Part of Southwestern Nigeria Using Integrated Geophysical Methods. International Journal of Science and Technology Volume 5 No. 5,May, 2016, pp 218-227

Balogun. B (2000) Monitoring and Assessing Drinking water quality In: Lagos State Water Corporation In- House Training for Chemist 19th – 21st Dec. 2000 p. 1-32.

Barbour, M.G., J.H. Burk, and W.D. Pitts. (1987). Terrestrial Plant Ecology. Chapter 9: Method of sampling the plant community. Menlo Park, CA: Benjamin/Cummings Publishing Co.

Barnett, H.L. and Hunter, B.B. (1987) Illustrated Genera of Imperfect Fungi. Macmillan Publishing Co., New York, and Collier Macmillan, London.

Bellinger, E. G. and Sigee, D. C. (2010). Freshwater Algae: Identification and Use as Bioindicators. John Wiley and Sons, Ltd. Pp.140-250.

Bellinger, V. and D. C. Sigee (2010). Freshwater Algae: Identification and Use as Bioindicators. Article *in* Journal of Applied Phycology 25(4).DOI: 10.1007/s10811-012-9926-x

Billman, H. G. (1992). Offshore stratigraphy and paleontology of Dahomey (Benin) Embayment. Nigerian Association of Petroleum Explorationists Bulletin, v. 70, no. 02, p. 121- 130.

Bonnie, L. G. (2019). Certified Urban Agriculturist https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/sodium-in-plants.htm

Botes, L. (2003). Phytoplankton Identification Catalogue ñ Saldanha Bay, South Africa, April 2001. GloBallast Monograph Series No. 7. IMO London

Breivik, K.; Sweetman, A.; Pacyna, J.; Jones, K. (2002). "Towards a global historical emission inventory for selected PCB congeners — a mass balance approach: 1. Global production and consumption". The Science of the Total Environment. ***290*** *(1–3): 181–98. Bibcode:2002ScTEn.290..181B. doi:10.1016/S0048-9697(01)01075-0. PMID 12083709.*

Burke, K.; MaCgregor, D. S. and Cameron, N. R. (2003). In Arthur, T.J., MaCgregor, D. S. and Cameron, N. R. (Edited), Petroleum Geology of Africa: New Themes and Developing Technologies. Geological Society, London, Special Publications, v. 207, p. 21-60

Canter, L.W and Hill, L.G (1977): Handbook of Variables for Environmental Impact Assessment. Ann Arboor Science Publishers Inc, ANN ARBOUR. Mich. 48106

Caughley, G. (1977). Analysis of Vertebrate Populations. Wiley, London.

Chindo, I. Y., Karu, K., Ziyok, I. and Amanki, E. D. (2013). Physicochemical Analysis of Ground Water of Selected Areas of Dass and Ganjuwa Local Government Areas, Bauchi State, Nigeria. World Journal of Analytical Chemistry, 1(4):73-79.

Choudhory, R., Rawrani, P. and Vishwakarma M. (2011). Comparative study of Drinking Water Quality Parameters of three Manmade Reservoirs i.e. Kolar, Kaliasote and Kerwa Dam. Curr. World Environ., 6(1), 145-149.

Colborn, Theo; Dumanoski, Dianne; and Myers, John Peterson. (1996). *Our Stolen Future.* New York: Dutton

Community Conservation and Development Initiatives (CCDI), (2001). Air Pollution and Industrialization in Nigeria. Ecology and Development Series Number 01

Consumer Factsheet on Polychlorinated Biphenyls (PDF). National Primary Drinking Water Regulations. U.S. Environmental Protection Agency. May 14, 2009

Cox, G. (1990). Laboratory manual. of general ecology 6th Ed. Dubuque, Iowa: WIlliam C. Brown;.

Cruickshank, R., Duguid, J. P., Mamion, R. P., Swain, R. S. (1976). Medical Microbiology. Vol II, London: Churchill, Livngstone, pp. 46

Dada, S. S. (2006). Proterozoic evolution of Nigeria. In: Oshin, O. (ed.). *The Basement Complex of Nigeria and its mineral resources*. Ibadan, Nigeria, Akin Jinad & Co.

Daily, G. C.; Söderqvist, T; A. Sara; Kenneth, A., D, Partha; Ehrlich, P. R.; F, Carl; Jansson, A; J, Bengt-Owe (2000). "The Value of Nature and the Nature of Value". *Science*. 289 (5478): 395–396.

Domsch, K.H.; Gams, W.; Anderson, T.-H. (1980). Compendium of soil fungi. Academic Press, London 1:1-860

Eka, O. U., Fogathy, M. N. (1972). Descriptive studies on a Streptomyces Species part 1. Description and some properties of the microorganisms. West African Journal Biology Applied Chemistry, 3(5), 11-17

El-Shahawi, M.S., Hamza, A., Bashammakhb, A.S., Al-Saggaf, W.T. (2010). An overview on the accumulation, distribution, transformations, toxicity and analytical methods for the monitoring of persistent organic pollutants. Talanta. 80, 1587–1597. doi:10.1016/j.talanta.2009.09.055.

Ene, A., Bosneaga, A. and Georgescu, L. (2010). Determination of heavy metal in soil using XRF techniques. *Rommania Journal of Physics* (7-8):815-820.

Enwezor, W. O., Udo, E.J., Usoroh, N.J., Ayotade, K.A., Adepetu, J.A., Chude, V.O. and Udegbe, C.E. (1989). *Fertilizer use and management practices for crops in Nigeria*. Series No 2 Federal Ministry of Agric.Water Resources and Rural Development. Lagos. 163 PP.

EPA (2002). "*Method 1106.1: Enterococci in Water by Membrane Filtration Using membrane-Enterococcus-Esculin Iron Agar* (mE-EIA)." Document no. EPA 821-R-02-021.

EPA (2003). Guidelines on the Management of Lead Contamination in Home Maintenance, Renovation and Demolition Practices: A Guide for Councils. NSW Environment Protection Authority, Sydney 59–61.

Erickson, M. D. and R.G Kaley (2010). "Applications of polychlorinated biphenyls". Environmental Science and Pollution Research. ***18*** *(2): 135–151. doi:10.1007/s11356-010-0392-1*

Eze, S. and Hilary, M. (2008). Evaluation of Heavy Metals Pollution of Soils Around the Derelict Enyigba Mines and Their Sources. *International Journal of Applied Environmental Science*13(3):4.

Ezeigbo, H.I, Ozioko DC (1997). Towards efficient rural-water supply to Nsukka area and environs. Proc., 2nd NISWASA-Symposium Lagos

Ezekiel, A.K., Samuel, A.O., Asaolu, S.S. and Irenosen, O.G. (2013). Determination of Heavy Metals in Soil Sample of Selected Sawmills in Ekiti State, Nigeria.

Fakayode, S. O. (2005). Impact Assessment of Industrial Effluent on Water Quality of the Receiving Alaro River in Ibadan, Nigeria. AjeamRagee, 10:1-13.

FAO (2006). *Guidelines for soil description*. Fourth edition. Food and Agriculture Organization of the United Nations, Rome, Italy. 97 pp.

FAO (2009). Fisheries and Aquaculture in our Changing Climate Policy brief of the FAO for the UNFCCC COP-15 in Copenhagen, December 2009.

Fatoki, O.S. (2003). Lead, Calcium and Zinc Accumulation in Soil and Vegetation among some Selected Major Roads of Eastern Cape. *International Journal of Environmental Studies* 6(2):199-204.

Federal Office for the Environment (FOEN), 2011, Indicator Water temperature of surface waters, Department of the Environment, Transport, Energy and Communications, www.bafu.admin.ch

GF (2019) Ground Water, The Groundwater Foundation is operated by the National Ground Water Association. https://www.groundwater.org/get-informed/basics/whatis.html

Govil, P.K., Sorlie, J.E., Murthy,N.N., Sujatha,D., Reddy,G.L.N., Rudolph-Lund,K., Krishna,A.K. and Rama-Mohau,K. (2008). Soil Contamination of Heavy Metals in the Katedan Industrial Development Area, Hyderabad, India. *Environmental Monitoring and Assessment* 140:313-323.

Goyer, R.A. (1990). Transplacental transport of lead. Conference on Advances in Lead Research: Implications for Environmental Health. Environmental Health Perspective 89:101–106.

Gray J. R. (2005). Conductivity Analyzers and Their Application, In Environmental Instrumentation and Analysis Handbook. John Wiley and Sons, Inc., Hoboken, NJ, USA, 491-510.

Greig-Smith, P. (1964). Quantitative Plant Ecology. London: Butterworths; 1964.

Haack, R.C.; Sundararaman, P.; Diedjomahor, J.O.; Xiao, H.; Gant, N.J.; May, E.D. and Kelsch, K. 2000. Niger Delta petroleum systems, Nigeria, in Mello, M.R., and Katz, B.J., (Edited), Petroleum systems of South Atlantic margins. American Association of Petroleum Geologists, Memoir 73, p. 213–231.

Hanaa, E., A. Eweida, and Azza, F. (2000). Heavy Metals in Drinking Water and Their Environmental Impact of Human Health.

Hardalo, C. and Edberg, S. C. (1997). "Pseudomonas aeruginosa: Assessment of risk from drinking water. *Critical Reviews in Microbiology.* 23:47-75

Hlavay,J and G. G. Guilbault (1978). Detection of hydrogen chloride gas in ambient air with a coated piezoelectric quartz crystal. *Anal. Chem.*, 1978, 50 (7), pp 965–967

Holt, J.G., N.R. Krieg, P.H.A. Sneath, J.T. Stanley and S.T. Williams (1994). Bergey's Manual of Determinative Bacteriology (9th ed.), Williams & Wilkins, Co., Baltimore

Hötzel G and R. Croome (1999). **A Phytoplankton Methods Manual for Australian Freshwaters**, LWRRDC Occasional Paper 22/99. ISSN 1320-0992 ISBN 0642 267715. Editing and layout: Green Words & Images, Canberra Printing: October 1999

https;//weather-nga.com/en/Nigeria accessed on 17th January 2019

Husain, K.Z. (1992). Wildlife preservation in Bangladesh. Wildlife Newsletter, Pp. 5-10. Wildlife Society of Bangladesh No. 4.

Hutzinger, Otto; Safe, Stephen; and Zitko, V. (1983). *The Chemistry of PCBs.* Melbourne, FL: Krieger

IFC, (2017). Environmental, Health, and Safety (EHS) Guidelines General Ehs Guidelines: Environmental Energy Conservation.

Intergovernmental Panel on Climate Change Good Practice Guidance for Land Use Change and Forestry (2003) by J Penman

International Finance Corporation (IFC)/World Bank Environmental, Health, and Safety (EHS) Guidelines for Construction and Decommissioning (2007 http://en.wikipedia.org/wiki/Geology <viewed: 09/11/2010>).

IUCN (2015). G*uidelines for the application of IUCN Red List of Ecosystems Categories and Criteria*, Version 1.0. Bland, L.M., Keith, D.A., Murray, N.J., and Rodríguez, J.P. (eds.). Gland, Switzerland: IUCN. ix + 93 Pp.

Janse van Vuuren, S., Taylor, J., Gerber, A. and Van Ginkel, C. (2006). *Easy identification of the Most common freshwater algae*. A guide for the identification of microscopic algae in South African freshwaters. ISBN 0-621-35471-6

Jha D K, Sharma G D and Mishra R.R. (1992). *Soil microbial population numbers and enzyme activities in relation to altitude and forest degradation; Soil Biol. Biochem. 24 761–767*

Jiang, Y., Zhuang, Q. L. and Liang, W. J. (2007) “Soil Organic Carbon Pool and Its Affecting Factors in Farm Land Ecosystem,” Chinese Journal of Ecology, Vol. 26, No. 2, pp. 278-285.

Joan G. Ehrenfeld (2010). "Ecosystem Consequences of Biological Invasions", Annual Review of Ecology, *Evolution, and Systematics,* 41: 59–80.

John, A. W 1987: PCB’s and the environment. Boca Raton; Fl: CRC press

Kabata-Pendias, A. (2011). *Trace elements in soils and plants.* Taylor and Francis Group LLC. Fourth Edition. CRV. Press, Boca Raton, Florida. 505pp.

Keke, U. N., Arimoro, F. O., Ayanwale, A. V. and Aliyu, S. M. (2015). Physicochemical parameters and Heavy metals content of surface water in downstream Kaduna River, Zungeru, Niger State, Nigeria. Applied Science Research Journal, 3(2): 46-57.

Khuhawari M. Y., Mirza, M. A., Leghari, S. M., and Arain, R. (2009). Limnological study of Baghsar Lake District Bhimber, Azad Kashmir. Pak J Bot 41(4):1903–1915.

Kodavanti, P.R.S (2017). Polychlorinated biphenyls. Encyclopedia of the Neurological Sciences. Reference Module in Neuroscience and Biobehavioral Psychology. http://doi.org/10.1016/B978-0-12-809324-5.03955-9

Kodavanti, P.R.S and Loganathan, B.G (2014). Chapter 25-Polychlorinated biphenyls, polybrominated biphenyls and brominated flame retardants. Biomarkers in Toxicology, 433-450. http://doi.org/10.1016/B978-0-12-404630-.00025-7

Kogbe, C. A. (1989). The cretaceous and Paleogene sediments of southern Nigeria. In Kogbe, C.A. (ed). Geology of Nigeria. 2nd Edition. Rockview Nigeria Limited, Jos. 1989;273-286.

Konijnendijk, C. C., R.M. Ricard, A. Kenney, and T. B. Randrup (2006). "Defining urban forestry—a comparative perspective of North America and Europe," Urban Forestry & Urban Greening, vol. 4, no. 3-4, pp. 93–103.

Krebs, C. J. (1989). Ecological Methodology. Harper and Collins, New York.

Kumar, B., V. K. Verma, Singh, S. K., S. Kumar, C.S. Sharma, and A. B. Akolkar (2014). Polychlorinated Biphenyls in Residential Soils and their Health Risk and Hazard in an Industrial City in India. J Public Health Res.3(2): 252. doi: 10.4081/jphr.2014.252. PMCID: PMC4207023

Liang, J., Chen, C., Song, Z., Han, Y. and Liang, Z. (2011). Assessment of Heavy Metal Pollution in Soil and Plants from Dunhua Sewage Irrigation Area. *International Journal of Electrochemical Science* 6:5314-5324.

Longe, E.O; Malomo, S and Olorunniwo, M.A (1987). Hydrogeology of Lagos metropolis. Journal of African Earth Sciences, Vol. 6, pp 163 – 174.

MA (2005). Ecosystems and Human Well-Being: Synthesis. Millennium Ecosystem Assessment (MA) Island Press, Washington. 155pp.

Mausbach M J and Seybold C A (1998). *Assessment of soil quality; in Soil quality and agricultural sustainability* (ed.) R Lal (Chelsea: Ann Arbor Press) Pp 33–43

Mezgebe, k. and Gebrekidan, A., Hadera, A. and Weldegebriel, Y. (2015). Assessment of Physico-Chemical Parameters of Tsaeda Agam River n Mekelle City, Tigray, Ethiopia. Bull. Chem. Soc. Ethiop., 29(3), 377-385.

Murat, R.C. (1970). Stratigraphy and paleogeography of the cretaceous and lower tertiary in Southern Nigeria. In Dessauvagie, T.T.J. and Whiteman, A.J.(eds.) African Geology. University of Ibadan

National Resources Board (NRB) minutes (2001) - Wisconsin Department of Natural Resources https://dnr.wi.gov/about/nrb/2005/08-05-NRB-minutes.pdf

NESREA. (2007). *Environmental Affairs Law Revised 2007*. National Environmental Standards and Regulations Enforcement Agency. 23(4):885 – 919.

NGSA (2004). *Geological map of Nigeria*. The Nigeria Geological Survey Agency (NGSA). Published by the Authority of the Federal Republic of Nigeria.

NIMET (2009), Nigerian Meteorological Agency

NOM-127-SSA1-1994. Water quality. Official Mexican Standard for processes of purifying drinking water for human consumption. Amendment to the Official Mexican Standard NOM- 127- SSA1 - 1994, Environmental Health. Water for human use and consumption.

NRB (2001). Biodiversity of Nigeria. First National Biodiversity Report July 2001. Pp.12-20

Nwachukwu, S.O. (1972). The tectonic evolution of the southern portion of the Benue trough. Geological Magazine. 1972;109(5):411- 419Press, Ibadan, Nigeria. 1970;251-256.

Nwajide C. S, (1990) Cretaceous sedimentation and paleogeography of the central Benue trough. In: The Benue Trough structure and evolution (Ed. C. O. Ofoegbu), Braunschweig and Wiesbaden, Germany, Virweg and Sohne Verlag. 1990;19-38.

Nwajide, C. S. (2005) Anambra Basin of Nigeria: Synoptic Basin Analysis as a Basis for Evaluating its Hydrocarbon Prospectivity, In C. O. Okogbue, Ed., *Hydrocarbon Potentials of the Anambra Basin*: *Geology*, *Geochemistry and Geohistory Perspectives*, Great AP Express Publisher Limited, Nsukka, 2005, pp. 83-110.

Nwajide, C.S. and Reijers, T.J.A. (1996). Geology of the southern Benue trough, sedimentary geology and sequence stratigraphy of the Afikpo Basin, SPDC Publication pp133- 148.

Obaje, N. G. (2009). Geology and mineral resources of Nigeria. In S., Brooklyn, H. S. N., Neugebauer, H. J., Bonn, J. R., & Gottingen, K. S. (Eds.), *lecture notes in Earth sciences*. Bhattacharji. http://dx.doi.org/10.1007/978-3-540-92685-6

Obaje, N.G (2009). Geology and Mineral Resources of Nigeria, London: Springe Dordrecht Heidelberg. Pg 5

Obi, G.C., Okogbue, C.O., Nwajide, C.S. Evolution of the Enugu Cuesta: A tectonically driven erosional process. Global Journal of Pure Applied Sciences. 2001; 7:321–330.

Occupational Safety and Health Administration, 1988a. US Department of Labor, Code of Federal Regulations. 29 CFR 1910.1000

Ofomata, G.E.K (1980). Landforms on the Nsukka Plateau of Eastern Nigeria. Nig. Geol. 1(10):3-9

Oguntoyinbo, J.S. and Derek, H.F. (1987). *The Climatology of West Africa*. London: Hutchinson Education

Ojanuga, A.G. (2006). *Agroecological zones of Nigeria Manual.* Berding, F. And Chude, V.O. National Special Programme for Food Security (NSPFS) and FAO. 124 pp.

Ojea, E. (2010). Classifying Ecosystem Services for Economic Valuation: the case of forest water services. BIOECON Conference, Venice 27–28 September 2010

Ojoh, K.A., (1990). Southern part of the Benue Trough (Nigeria) Cretaceous stratigraphy, Basin Analysis, Paleo-oecanography and Geodynamic Evolution in the Equatorial domain of the South Atlantic: NAPE Bulletin Vol, 7. P. 131-152.

Okunola,O.J., Uzairu, A. and Ndukwe, G. (2007). Levels of Trace Metals in Soils and Vegetation Along Major Roads in Metropolitan City of Kaduna, Nigeria. 6:1703-1709.

Olade, M.A., (1975). Evolution of Nigeria Benue trough (Aulacogen) a tectonic model. Geol. Mag. 112(6), 572-582

Olorunfemi, M. O., and Fasuyi, S. A., (1993). Aquifer types and the geoelectic/ hydrogeological characteristics of part of the central basement terrain of Nigeria. Journal African Earth Science, 16, 309– 317.

Omatsola, M.E and Adegoke, O.S (1981). Tectonic Evolution and Cretaceous Stratigraphy of the Dahomey basin. Journal Min. & Geology, 18 (1), 130 -137.

Onuoha, K.O. (1999). Structural features of Nigeria's coastal margin: an assessment based on age data from wells. Journal of African Earth Sciences, v. 29/ 03, p. 485-499.

Pankhurst, C. E, Doube B M and Gupta V V S R (1997). Biological indicators of soil health Wallingford, UK: CAB International

Papafilippaki, A. K., Kotti, M. E. and Stavroulakis, G. G. (2008). Seasonal Variations in Dissolved Heavy Metals in the Keritis River, Chania, Greece. GlobalNEST Int. J., 10:320.

Perry, R (2003). A Guide to the Marine Plankton of southern California, 3rd Edition. © 2003 Robert Perry. - UCLA Ocean Globe & Malibu High School

Phogat, V. K., Tomar, V. S. and Dahiya, R. (2015). Soil Physical Properties. In book: Soil Science: An Introduction. Edition: First Publisher: Indian Society of Soil Science. Editors: Rattan R.K., Katyal J.C., Dwivedi B.S., Sarkar A.K., Bhattachatyya Tapan, Tarafdar J.C., Kukal S.S. Available from: https://www.researchgate.net/publication/297737054_Soil_Physical_Properties[accessed Jan 13 2019].

*Pivnenko, K.; Olsson, M. E.; Götze, R.; Eriksson, E.; Astrup, T. F. (2016). "Quantification of chemical contaminants in the paper and board fractions of municipal solid waste". Waste Management. **51**: 43–54. doi:10.1016/j.wasman.2016.03.008*

PMID: 25343135

*Porta, M.; Zumeta, E. (2002). "Implementing the Stockholm Treaty on Persistent Organic Pollutants". Occupational and Environmental Medicine. **59**: 651–2. doi:10.1136/oem.59.10.651. PMC 1740221. PMID 12356922*

Rahaman, M. A. & Lancelot, J. R. (1984). Continental crustal evolution in S.W.Nigeria: constraints from U-Pb dating of Pre Pan African gneisses. *Report de Centre geophysique de Montepellier*.

Rattray, J.E and Jones, M (2007). Essential Elements of Questionnaire Design and Development. Literature Review *in* Journal of Clinical Nursing 16(2):234-43. DOI: 10.1111/j.1365-2702.2006.01573.x

Richard, A. (2017). The Thomson Ecology Handbook: A practical guide to wildlife legislation for project managers. Kindle Edition, Publisher: Harriman House Pp.2-20

Ritter L; Solomon KR; Forget J; Stemeroff M; O'Leary C.(2007). "Persistent organic pollutants" (PDF). United Nations Environment Programme. Archived from the original (PDF) on 2007-09-26). Retrieved 2018-11-18).

Robert, I. (2004). "A neutral terminology to define 'invasive species'", *Diversity and Distributions*, 10, 135–141.

Robertson, Larry W., and Hansen, Larry G., eds. (2001). *PCBs: Recent Advances in Environmental Toxicology and Health Effects.* Lexington: The University Press of Kentucky.

Sampathkumar P, and Ananthan G (2007) Phytoplankton. In: Coastal Biodiversity in Mangrove Ecosystems, UNU-INWEH-UNESCO- International Training Course Manual. 205-212

Sampathkumar, P. and Ananthan, G. (1990). Phytoplankton Centre of Advanced Study in Marine Biology Annamalai University. Pp.310

Schorr, U., Distler, A. and Sharma, A. M.. ()1996). Effect of sodium chloride- and sodium bicarbonate-rich mineral water on blood pressure and metabolic parameters in elderly normotensive individuals: a randomized double-blind crossover trial. J. Hyperten, 14(1):131-5

Shell International Exploration and Production (SIEP), (1995). Environmental Quality Standards – Air (Doc. EP 95 – 0375).

Shrinivasa Rao B and Venkateswaralu P, (2000). Physicochemical Analysis of Selected Groundwater Samples, Indian J Environ Prot., 20 (3):161.

Soil Science Division Staff. (2017). *Soil Survey Manual.* Agric. Handbook. No 18. U.S. Gov. Print. Office. Washington, DC. 639 pp.

Strahan, R. (1995). Mammals of Australia. Australian Museum/Reed Books, Sydney.

Stuti, K. (2001), Fiscal Federalism and Service Delivery in Nigeria: The Role of States and Local Governments, prepared for the Nigerian PER Steering Committee, July 2001, page 4.

Swanson, T. (1997). Global Action for Biodiversity. Earthscan, London

Tang, X., C. Shen and D. Shi (2010). “Heavy metal and persistent organic compound contamination in soil from Wenling: an emerging e-waste recycling city in Taizhou area, China,” Journal of Hazardous Materials, vol. 173, no. 1–3, pp. 653–660.

Tennessee Valley Authority (TVA). (1995). Clean Water Initiative: Volunteer Stream Monitoring Methods Manual, Field Test Draft, TVA: Chattanooga, USA. Trough, Nigeria. Journal of African Earth Sciences, Elsevier. 2014; 100:179-190.

Todd, D.K., 1959. Ground Water Hydrology. Willey, London, pp: 185.

Ukaegbu, V.U. and I.O. Akpabio. 2009. “Geology and Stratigraphy Northeast of Afikpo Basin, Lower Benue Trough, Nigeria”. *Pacific Journal of Science and Technology.* 10(1):518-527

UNEP Chemicals (1999). Guidelines for the Identification of PCBs and Materials Containing PCBs (PDF). United Nations Environment Programme. p. 40. Archived from the original (PDF) on 2008-04-14. Retrieved 2018-11-07

UNICEF (2008). Water, Sanitation and Hygiene Annual Report 2008. 52pages

USEPA (2008). Analytical methods approved for compliance monitoring under the long term 2 enhanced surface water treatment rule. Washington, DC: US Environmental Protection Agency.

Waid, John. (1987). *PCBs and the Environment.* Boca Raton, FL: CRC Press.

Wanga, J., Li, A., Wanga, Q., Zhoua, Y., Fua, L. and Li, Y. (2010). Assessment of the manganese content of the drinking water source in Yancheng, China. J. Hazard. Mater. 182:259–265.

Whiteman, A. 1982. Nigeria: Its Petroleum Geology, Resources and *Potentials*. Vol. 1 & 2.

WHO 1993 Guidelines for Drinking-Water Quality, Volume 1, Recommendations. Second edition. World Health Organization, Geneva, 130.

WHO, (2008). Drinking-water Quality 3rd edition.

WHO, (2008). Turbidity measurement: the importance of measuring turbidity: Fact sheet 2.33. Geneva: World Health.

World Health Organization. (1998). "Report on waterborne disease cases." Geneva. 1:55.

World Health Organization. (2003). "Guidelines for drinking water quality." 3rd edition. Geneva, Switzerland.

World Health Organization. (2004). "International standards for drinking water."Geneva.

world resources Institute (WRI) (1992-93). Guide to global environment by world resources institute in collaboration with the united nations environment programme and the united nations development programme - march 1992

WRI (1992). Global Biodiversity Strategy: Guidelines for action to save, study, and use earth's biotic wealth sustainably and equitably. WRI (World Resources Institute)., IUCN, and UNEP.

Yamaguchi, E. and Gould, A. (2007). *Phytoplankton Identification Guide.* The University of Georgia Marine Education Center and Aquarium. Http://www.marex.uga.edu/aquarium.Dateretrieved 23/11/2018.

Yusuf, A.A., Abdu, N. and Tanimu, B. (2011). Assessment of lead contamination of farmlands in Abare village, Zamfara State. Proceedings of the 45th Annual Conference of the Agricultural Society of Nigeria. pp. 487-491.

Zhang, X., Li, F., Liu, T, Peng, C., D., Duan, Xu, C., Zhu, S and J. Shi (2013). The influence of Polychlorinated Biphenyls contamination on Soil Protein Expression. ISRN Soil Science, vol. 2013, Article ID 126391, Hindawi Publishing Corporation. http://dx.doi.org/10.1155/2013/126391

APPENDICES

Appendix 1 Socio-Economics Data

Appendix 1.1 Sample Questionnaires

Appendix 1.2 Socio-Economics Data

Appendix 2 Consultations

Appendix 2.1 First Round Consultations

Appendix 2.2 Second Round Consultations

Appendix 3 Facility Layout Design