IMPACT ASSESSMENT REPORT

FOR

PROPOSED MM PORT FZE PROJECT

AT

FEDERAL OCEAN TERMINAL, ONNE PORT COMPLEX, ONNE, ELEME LGA, RIVERS STATE

BY

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1.0 INTRODUCTION

This document present preliminary Environmental and Social Impact of the proposed MM Port FZE Project to be located at Federal Ocean Terminal (FOT), Onne Port Complex, Oil & Gas Free Zone, Onne in Eleme Government Area, Rivers State. This preliminary impact assessment is in line with the provisions of the Environmental Impact Assessment (EIA) Act CAP E12 LFN 2004, which makes it mandatory for proponents of all new developmental projects to carryout Environmental and Social Impact Assessment of their proposed Projects in compliance with the EIA Act. Besides the Act mentioned above, the ESIA shall be developed in accordance with the Equator Principles 4 (2020), The International Finance Corporation (IFC) Performance Standards (PSs) on Environmental and Social Sustainability (2012), The World Bank Group General and relevant industry-sector Environmental, Health and Safety (EHS) guidelines, and IFC Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets (2007).

1.1 Background Information

Indorama operates a Petrochemical and Fertilizer manufacturing facilities within the Indorama Complex in Eleme, Port Harcourt, Rivers State, Nigeria having manufacturing capacity of 2.8 MMTA of Urea & 400 KTA of Polymers (Polyethylene & Polypropylene) utilizing Natural Gas & Natural Gas Liquids as feedstock. The Petrochemical manufacturing facilities comprising of the Cracker, Polyethylene and Polypropylene plants have been in operation since 2006. The Fertilizer manufacturing facilities consists of two trains of 2,300 TPD & 4000 TPD each of Ammonia and Urea, respectively. While the first line of Fertilizer was commissioned in 2016, the second line was commissioned in May 2021.

As a part of expansion plan, Indorama intends to set up a greenfield Ammonia & Urea manufacturing Project (IEFCL-Train3) of same capacity as IEFCL-Train1 & IEFCL-Train2, on newly acquired 250 hacters of land adjacent to existing facilities at Eleme in Port Harcourt.

Based on the design capacities of Ammonia and Urea plant, Post IEFCL-Train3 Project commissioning, there will be a surplus ammonia of 375 MTPD over and above the requirement of Urea plants. Indorama is planning to export this surplus liquid ammonia and 1.4 million tons of Urea produced by IEFCL-Train3 project, through MM Port Terminal.

For exporting Ammonia and Urea, Indorama is planning to set-up a liquid Ammonia and Urea handling Port Terminal with all requisite facilities at Federal Ocean Terminal (FOT), Onne Port Complex, Oil & Gas Free Zone, Onne in Eleme Government Area, located around 20 km away from the existing/proposed Production facility. The proposed Port Terminal shall be developed for storage, handling, and exporting surplus Ammonia & Urea produced from operating both trains and proposed third train of Indorama Eleme Fertilizer & Chemicals Limited.

The Federal Government of Nigerian developed an Environmental Impact Assessment Procedural Guidelines as blueprint to protect the environment from accelerated growth in the country. The aspirations of the Guideline are to ensure that possible and potential effects (positive and negative) of any development project /programme are determined prior to the commencement of the development project/ programme/policy.

In compliance with FMEnv letter reference number FMEnv/EA/EIA/6791/Vol.1/86 dated 30th January 2023, the scoping workshop with relevant stakeholders was conducted on 12th & 13th April 2023 in presence of FMEnv and RSMEnv representatives. The inputs from stakeholders have been incorporated in this revised TOR/SOW.

1.2 Project Proponent

The proponent of the proposed Project is Meliora Methanol FZE, Federal Ocean Terminal (FOT), Onne Port Complex, Oil & Gas Free Zone, Onne, Eleme LGA, Rivers State. It is the proponent's intent to establish Port Terminal facility from concept to design and to engineering, construction in line with the Nations Guidelines for Infrastructure sector.

1.3 Applicable Regulatory Framework

Several regulations exist to control developmental activities (oil and gas, chemicals, mining, infrastructure, etc). These regulations are derived from International, National and State sources. The regulations from International and National sources are general in nature and applicable all over Nigeria, whilst the state regulations are specific and only applicable to project/activities within the state. Law and Regulations which control and regulate this project will be reviewed and documented.

1.4 Legal Basis for Environmental Permitting

Environmental planning and permitting in Nigeria as are related to this project is carried out through the provisions of environmental legislation.

Federal Regulations/Guidelines

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

- S.I. 109, Environmental Impact Assessment Procedure and Charges Regulations 2021
- Federal Ministry of Environment (FMEnv) National Guidelines for Environmental Audit in Nigeria 1999.
- S.I.8 - National Environmental Protection (Effluent Limitations) Regulations of 1991
- S.I.9 – National Environmental Protection (Pollution Abatement in Industries and Facilities Generation Wastes) of 1991
- S.I.15 – National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations of 1991
- National Environmental Standards and Regulation Enforcement Agency (NESREA) Act 25 of 2007
- Nigerian Ports Authority Act 1999, CAP. 126 LFN
- The National Building Code (NBC) 2006
- National Inland Waterway Authority Act 2016
- Oil and Gas Export Free Zone Act, 2010
- Nigerian Maritime Administration and Safety Agency (NIMASA) Regulations 2014.
- Land Use Act CAP L5 LFN 2004
- Factories Act CAP F1 LFN 2004
- Land use Act CAP L5 LFN 2004
- NSITF Employee’s Compensation Act 2010
- Nigeria Export Processing Zones Act No 63 of 1992
- Investment Procedures, Regulations and Operational Guidelines for Free Zones in Nigeria, 2004

State Regulations

- Rivers State Noise (Control) Edict, No. 20, 1985
- Rivers State Environment and Development Planning Authority Edict, 1998
- Rivers State Forestry Law, 1998
- Rivers State Land Use (Environmental Degradation/Protection) Charge Law, 2005

- Rivers State Waste Management Law, 2012

- Rivers State Interim Guidelines and Standards on Environmental Pollution Control and management, 2013

- Rivers State Environmental Protection & Management Law, 2019, 15 Vol 55.

Relevant International Conventions, Guidelines and Standards

- The Equator Principles 4 (2020)

- The International Finance Corporation (IFC) Performance Standards (PSs) on Environmental and Social Sustainability (2012)

- The World Bank Group General and relevant industry-sector Environmental, Health and Safety (EHS) guidelines

- IFC Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets (2007)

- International Labour Organisation (ILO) conventions signed and ratified by Nigeria, covering core labour standards and basic terms and conditions of employment.

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

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

- Convention on Biological Diversity (Rio Summit) 1992

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

- Ramsar Convention on Wetlands (Ramsar, Iran, 1971)

2.0 PROJECT DESCRIPTION

The Project entails construction and operation of a Port terminal facility to be located in the existing Onne Port Complex, Onne, Eleme LGA, Rivers State. The Project location is depicted in figure 2.1 to 2.5 below.

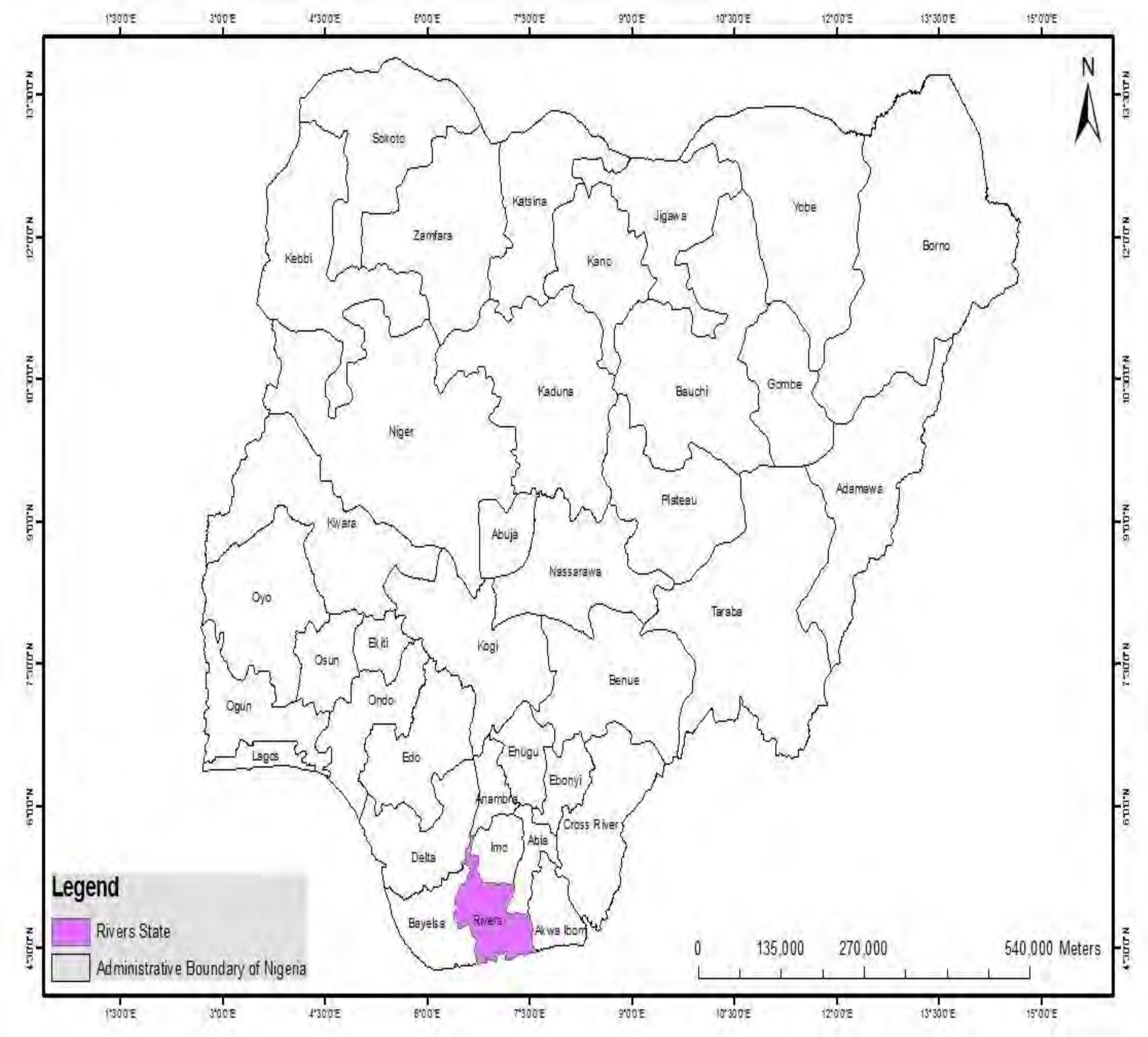


Figure 2.1: Administrative map of Nigeria showing Rivers State

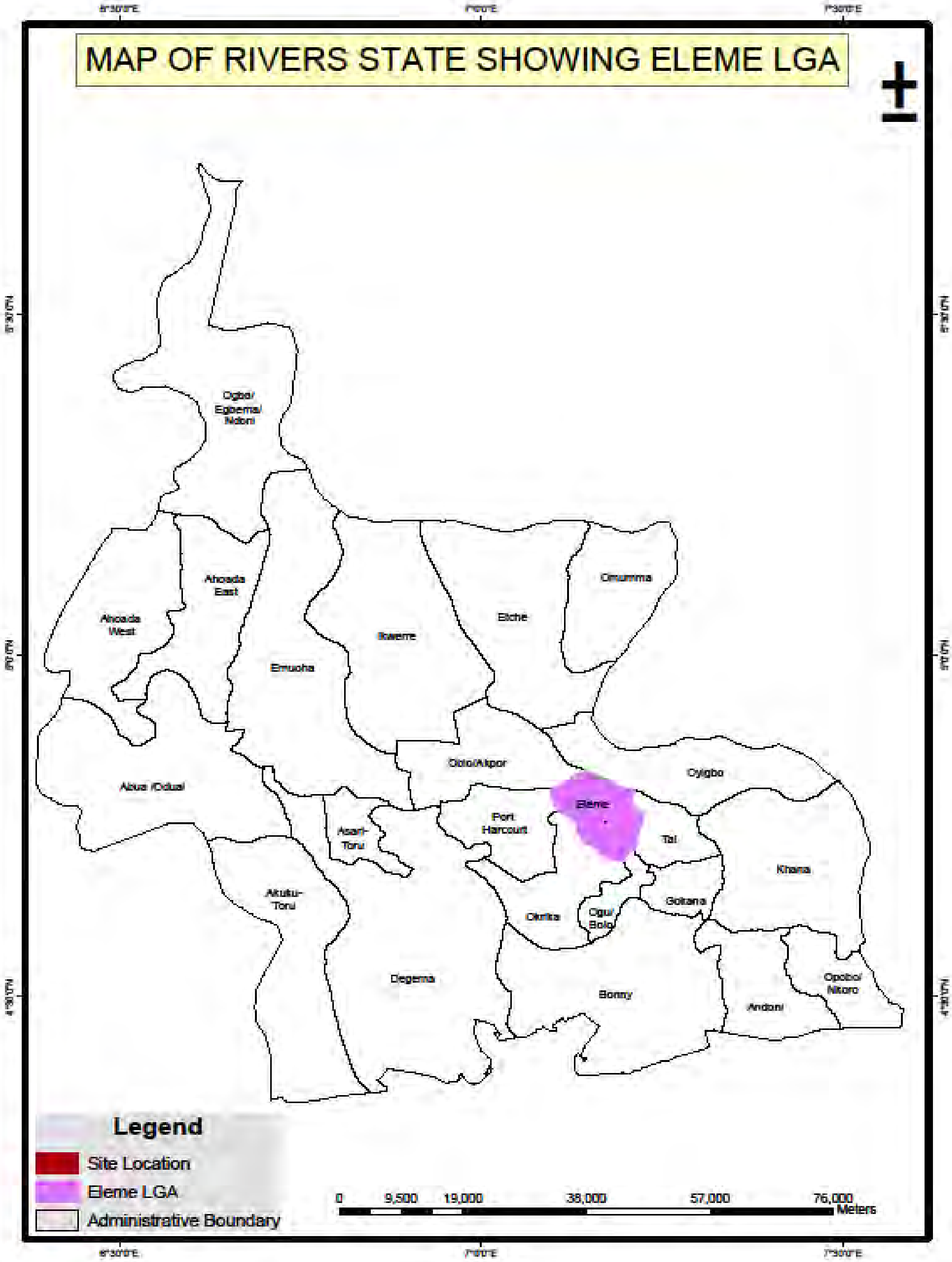


Figure 2.2: Administrative map of Rivers State showing Eleme LGA

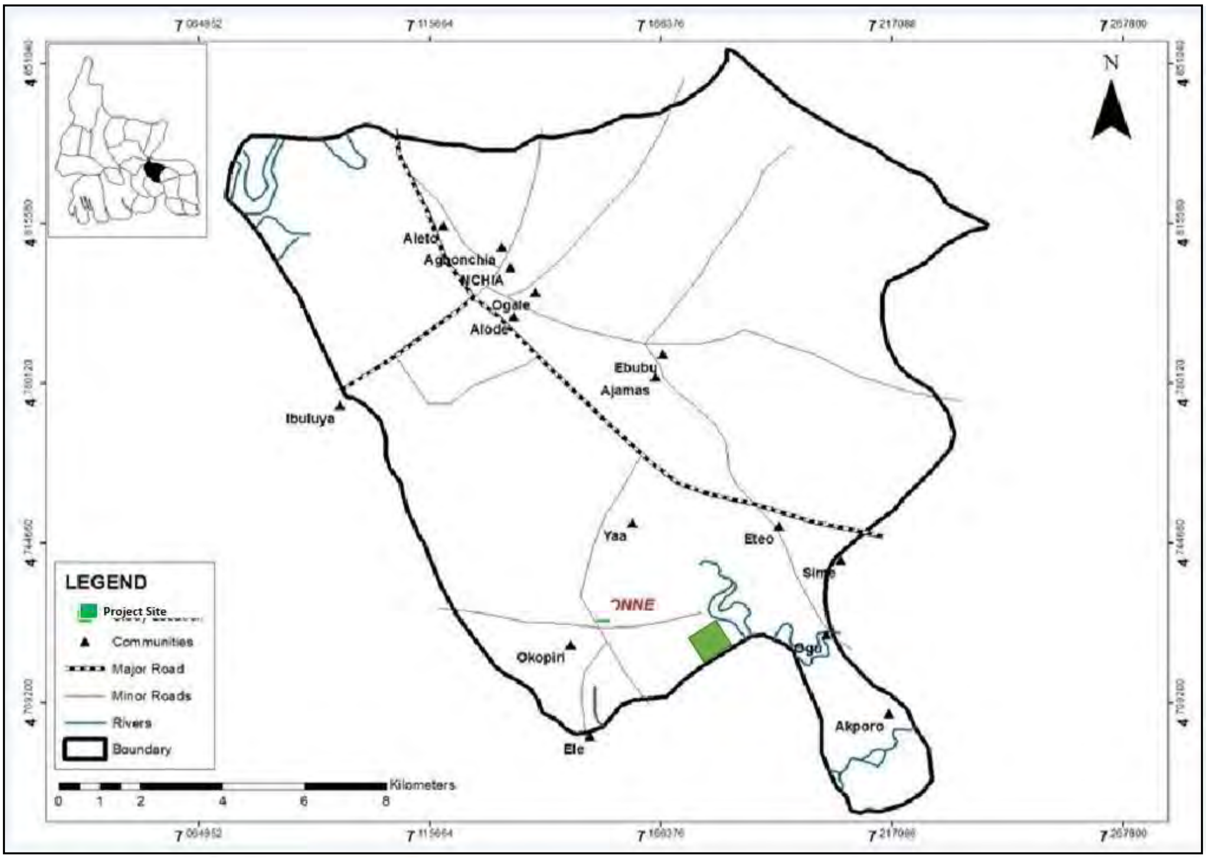


Figure 2.3: Administrative map of Eleme LGA showing Onne the project Location.

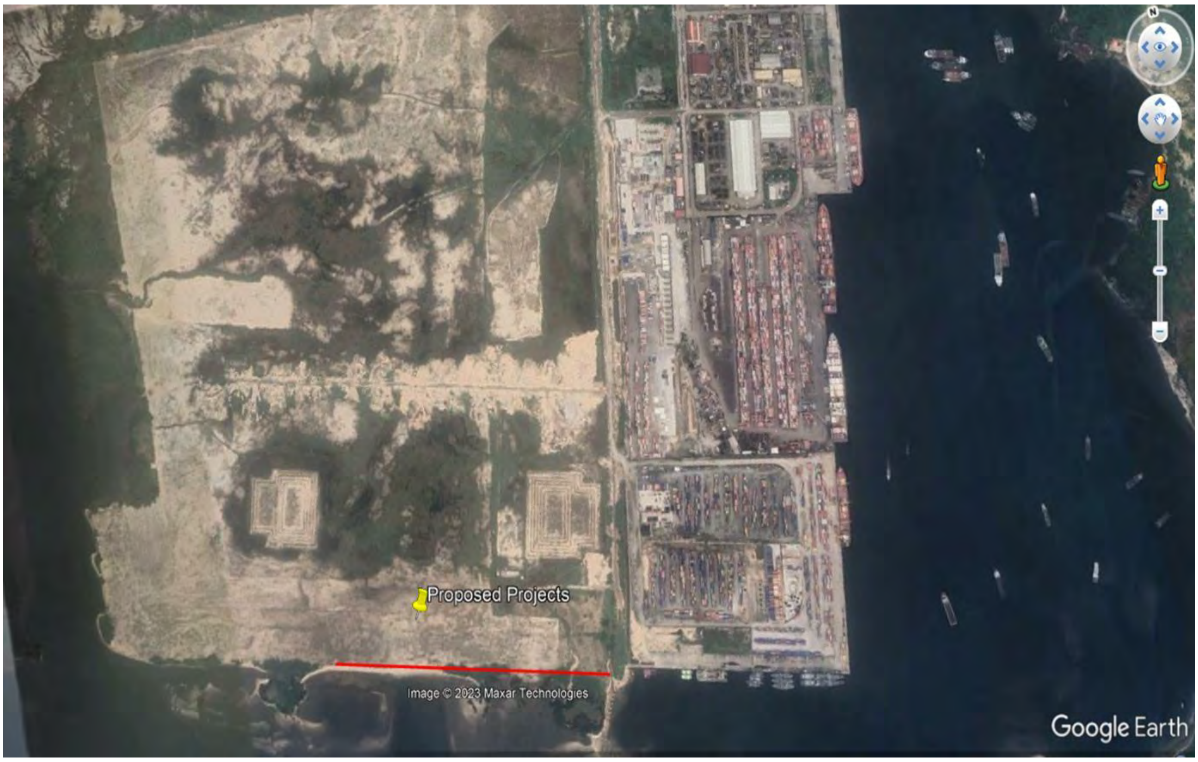
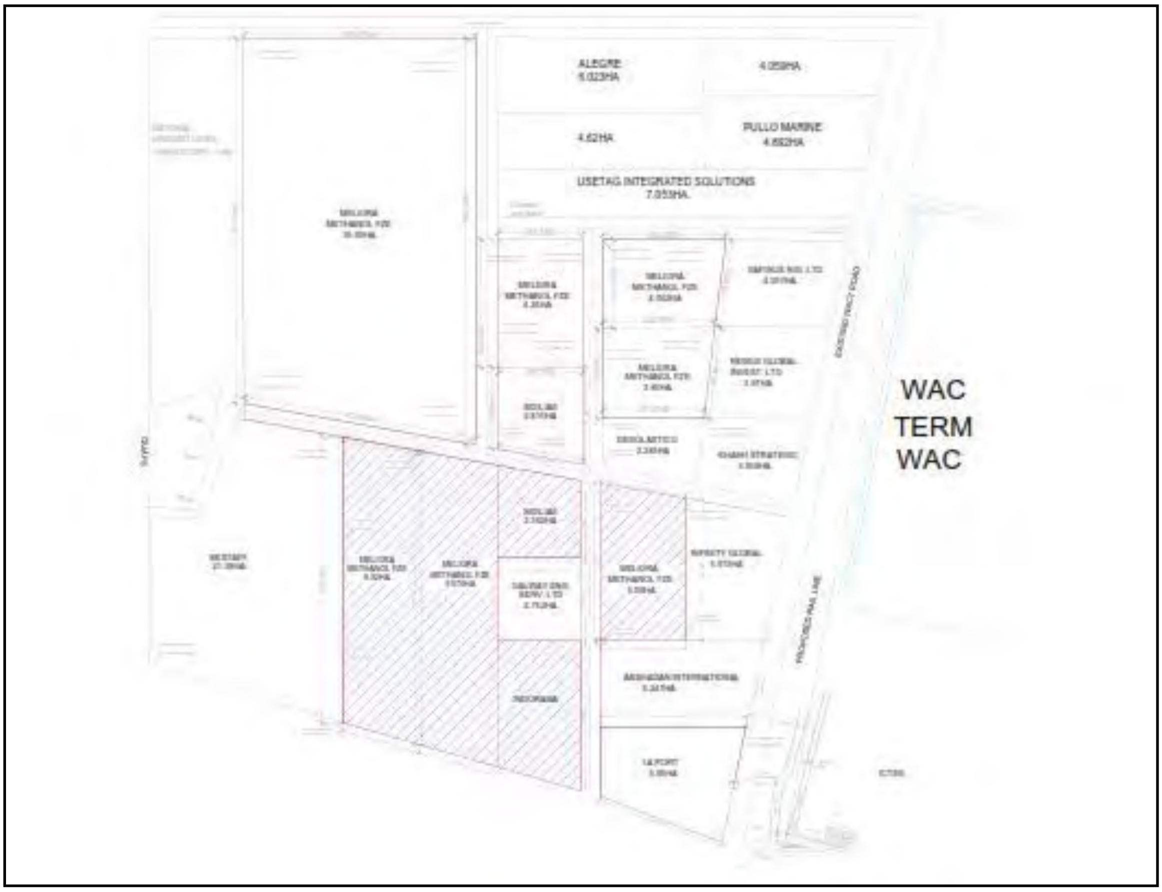


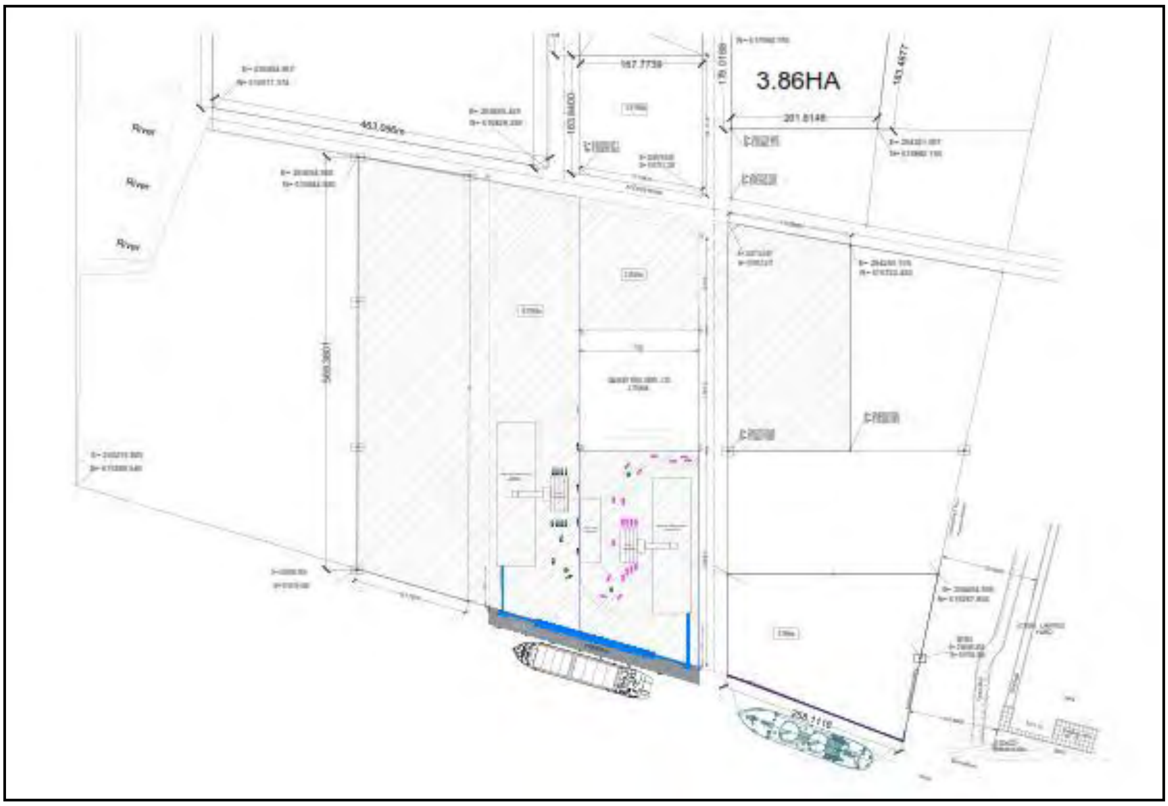
Figure 2.4: Google map showing Project Site

The precise location of the Port Terminal is within the premises of the Federal Ocean terminal (FOT) at Onne, situated on the Bonny River Estuary along Ogu Creek where Nigerian Port Authority has set up the Onne Port Complex.

Strategically located, the Port is an Oil and Gas Free Zone, primarily supporting exploration and production activities. Port is operated on the Landlord Port Model devised to encourage private sector participation in the Port Industry.

The map below shows the plot areas allocated for the development of Methanol, Ammonia & Urea export facilities.





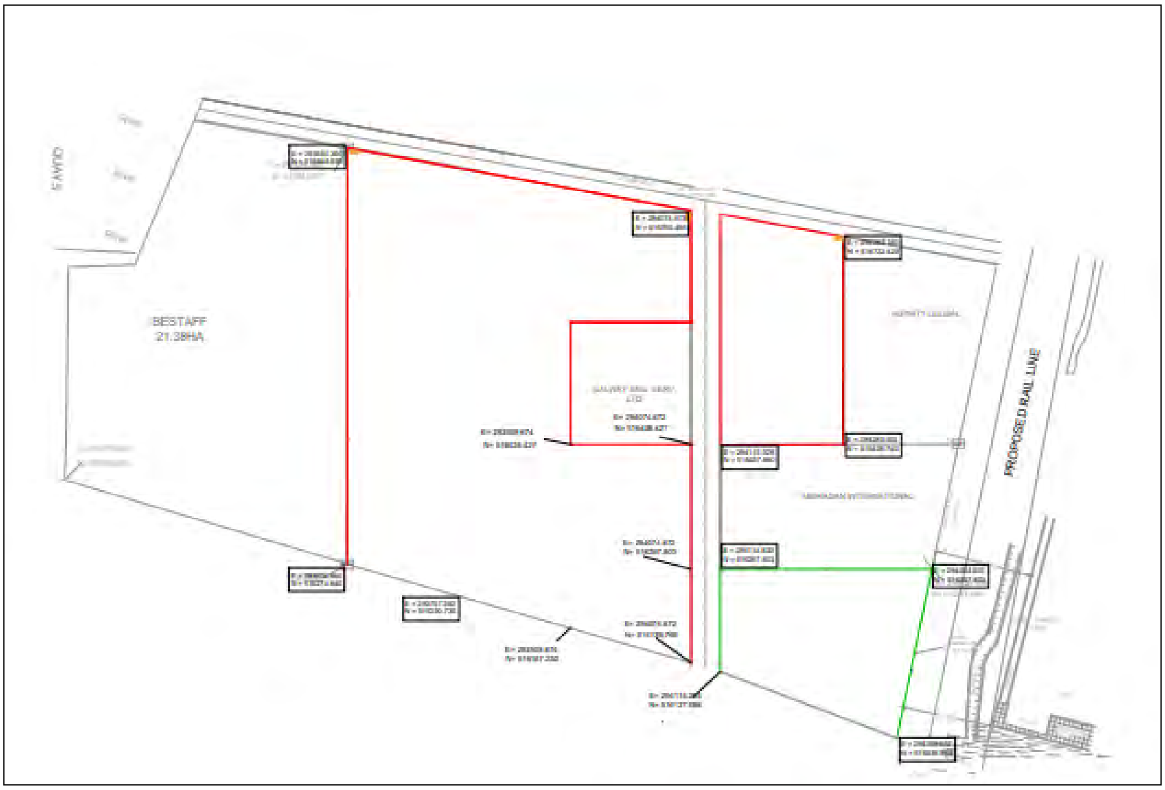


Figure 2.5: General Plan view and Plot area Coordinates

2.1 Proposed Development

The proposed Port Terminal will have below mentioned facilities,

- Quay for Mooring and Loading of Vessels
    - Quay of 300 meters long with concrete deck on piles
    - Sheet piled Combi wall or Diaphragm wall.
- Urea Storage & Handling
    - Weighbridges for Incoming Outgoing trucks
    - Truck Unloading Station
    - Intake System consisting of Bucket Elevator & Belt Conveyors to transfer urea from Truck Unloading Station to Urea Warehouse
    - Urea Warehouse with Air Handling Unit
    - Outtake System consisting of Belt Conveyors, Portal Scrapper Reclaimer & Ship loader to transfer urea from Urea Warehouse to Vessels.
    - Dedusting unit at Truck Unloading station & Outtake System
- Ammonia Storage & Handling
    - Ammonia Storage Tank
    - Flare stack for Ammonia Storage Tank and associated systems
    - BOG Reliquefication Unit
    - Ammonia Tanker Unloading System
    - Ammonia Ship Loading Pumps
- Jetty top side facilities
    - Ammonia Loading Arms
    - Urea Loading System
- Utilities & Other Facilities
    - Cooling Water System for BOG Unit/Others
    - Plant air, Instrument Air Unit and Nitrogen storage
    - Power Generators with CNG storage modules
    - Substation & Control Room
    - Firefighting System Fire water pumps (sea water) and fire water network
    - Fire & Gas Detection and Protection System
    - Fresh Water Tank and Borewell (include package water treatment)
    - Slop tank / oil water separator

- The jetty will also have below mentioned buildings,
    - Workshop / Maintenance Building
    - Storage area for Oil & chemicals
    - Security Building
    - Administration Building
    - Amenities Building

2.2 Project Execution Strategy

The Engineering contractor (Contractor) will do basic engineering, detailed engineering, procurement assistance and co-ordination with package vendor for facilitating detailed engineering. The proponent will procure the equipment / packages based on the procurement documents prepared by the Contractor. Indorama will engage an experienced Construction company for construction. Construction & commissioning of the Port Terminal will be done by Proponent based on the relevant documents prepared by Contractor. The civil design and construction of loading platform, diaphragm wall along the shoreline, mooring/dolphin facility and other marine facilities will be done by Proponent. However, Contractor will provide the design inputs (layout, load, foundation details, etc.) of the facilities / equipment / racks / skids / piping, etc. to be installed on Jetty top side facilities.

2.3 Technical Details

The block process flow of Ammonia and Urea handling is shown in figure 2.6.

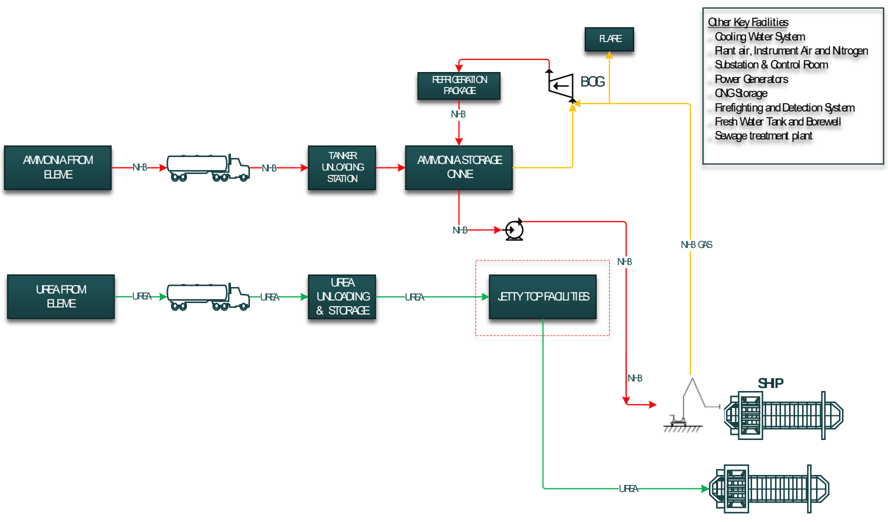


Figure 2.6: Block Process flow of Ammonia and Urea handling

Operating modes for Liquid Ammonia

The below-mentioned operating modes for Ammonia loading will be considered during the design of Port terminal facilities.

- Mode-1: Unloading from ISO-Tanker to Storage Tank
- Mode-2: Loading from Storage to Ship
- Mode-3: Simultaneous ISO-tankers (2 nos.) unloading and ship loading.
- Mode-4: Idle mode (No ISO-Tanker unloading and No ship loading)

Operating modes for Urea

The below mentioned operating modes for Urea loading will be considered during design of Port terminal facilities.

- Mode-1: Unloading from Customized trucks and storage in warehouse.
- Mode-2: Loading from warehouse to Ship.
- Mode-3: Simultaneous unloading and ship loading
- Mode-4: Idle mode (No trucks unloading and No ship loading)

2.3.1 Description of Facilities at Port Terminal

Ammonia Storage Tank and Flare

Two (2) liquid ammonia storage tanks of 15000 MT (working volume) capacity will be constructed at Port Terminal. The design of the tank will be of atmospheric pressure, double wall, double containment having inner insulation on outer wall, suspended deck type tank with construction complying with latest edition of applicable standards.

The liquid ammonia from existing Eleme Complex is received through ISO tankers at a rate of minimum 375MTPD. The storage tank will have all the necessary instrumentation and controls, over pressure and vacuum protection systems. The liquid ammonia will be stored at -33 °C. Ammonia storage flare stack of suitable size will be constructed near the storage tank for flaring ammonia vapours from the tank and other systems. Natural gas will be supplied to the flare stack as fuel and LPG manifold will be provided for alternate source of assist gas.

Boil of Gas (BOG) Unit

The ammonia vapours generated in the storage tank will be reliquefied and sent back to tank. The BOG unit will be installed near the Ammonia storage tank. The BOG Unit will have BOG compressor along with associated equipment. Compressor units and associated equipment will be designed accordingly to meet all the operation requirements as mentioned in operating modes. The number and capacity of compressor will be selected considering the minimum and maximum BOG generation case.

Ammonia Tanker Unloading Station

A tanker unloading station will be constructed near the storage tank. The unloading station will have all the facilities required to unload two tankers of ~20 MT capacity each.

Ammonia Pumping Station from Storage tank to ship

The liquid Ammonia from the storage tank will be transferred to the ship. A pumping station with interconnecting piping, requisite instrumentation and safety systems will be designed, considering all the operating modes. The pumping station will have liquid ammonia transfer pumps of capacity 250 T/H each, considering 36 hours of loading period for each ship.

Urea Storage and Handling

Truck unloading station.

The truck unloading / urea intake station will have 4 dump pits for offloading of urea. Urea from this station will be conveyed to the Urea warehouse by means of a bucket elevator & Belt Conveyors of capacity 400 tons/hour. The dedusting unit will be installed at Truck Unloading station.

Urea Warehouse

The storage capacity of urea warehouse will be 43,000 MT and will have air handling unit to regulate the relative humidity and temperature. This will be designed based on automated belt conveyor (Shuttle or tripper) for intake and tunnels with conveyors for outtake. A scraper reclaimer will run along rails in the bulk flat store and reclaim the material into a conveying system to load the urea from warehouse to the ship. Two Permanent Magnetic Separators & one Belt Weighing Scale will be installed at designated locations in the conveying system.

2.3.2 Jetty top side facilities

Ammonia Loading Arm

The ammonia loading arm will have the capacity of 250 T/H to transfer liquid ammonia to ship. The type of loading arm along with all safety and control systems will be as per international standards. The loading arm will be designed with Quick Release Coupling. During ship loading, generated ammonia vapor will be sent to the Ammonia Storage BOG Unit via Ammonia Vapor Return arm and return header. The capacity of the return arm will be designed accordingly. Provision will be considered for cooling of loading line up to the arm. In addition, provision will be considered for depressurizing, draining, recovery and purging of loading line up to the arm. Requirement of flow measurement and sampling point for liquid ammonia will be evaluated and incorporated accordingly.

Urea Loading System

The urea loading system will have Belt Conveyors and Ship loaders. The ship loader will be the Rail-mounted Ship loader with telescoping boom. To minimize dust emissions, it will be outfitted with a loading chute. The urea outtake design capacity will be 900 tons/hour. The Quay will be constructed for Mooring & Loading of Vessels

Quay

The quay structure will be of either steel combi pile or Rain Forced Cement Concrete (RCC) wall of length 300 meters. The key structure will be equipped with fenders, bollards, and safety ladders. The birth pocket in-front of the key wall will be dredged up to -13.5meters Chart Datum so that the vessels can be loaded up to draft of -12.5 meters CD with one meter keel clearance.

2.3.3 Utilities & Other Facilities

Cooling Water System (Package Unit)

Cooling water is needed for the BOG unit and any other systems in Jetty. A modular construction, FRP material, induced draft, evaporative type (package unit) cooling tower will be constructed near the BOG Unit. The capacity of cooling tower and circulating pumps will be decided based on the heat load of BOG and other consumption points. Suitable size circulating water supply and return piping to be designed up to the individual equipment requiring cooling water. The requirement of cooling water treatment and filtration will be evaluated during design.

Plant Air, Instrument Air Unit (Package Unit), and Nitrogen Storage

Based on the overall requirement of Plant & Instrument air, compressors of suitable capacity will be considered. A PSA (package unit) type instrument air drier unit to be considered for generating instrument air as per the requirement. Plant air and instrument air will be routed through individual buffer vessels having adequate hold-up volume to provide back-up during any disturbance in plant air / instrument air generation facility. A liquid nitrogen storage of adequate capacity, equipped with vaporizer and turbocharger to be considered for supplying gaseous nitrogen. The liquid nitrogen storage will be filled by ISO containers; therefore, storage will have liquid filling arrangement. Interconnecting piping of suitable sizes to be considered up to the individual equipment requiring these utilities.

Power Generation

The power required by facilities / equipment at Port Terminal will be generated in-house. A power generation unit with associated sub-systems will be considered to meet the power requirement. The unit will comprise of Natural gas driven power generating engines with all the relevant auxiliaries. The generating voltage will be 3.3 kV, frequency. 50 Hz. The number of generators and capacity will be designed considering peak and minimum power requirement of Port Terminal.

Substation & Control Room

Substation

The generated power will be stepped down to required voltage levels (415/230V) and further distribution to electric drives. The Substation will be designed for two (02) voltage levels, i.e., 3.3 kV and 415 V AC and to cater to the power requirement of entire facilities / equipment of the Port Terminal. The sizing of transformers, bus bars, circuit breakers, power distribution board, etc. will be done in consideration of power requirements.

Control Room

All utility units / facilities of the jetty will be integrated with a control room for monitoring and control. The control room will have a PLC based system with consoles for HMI. Consideration will be given to adequate data storage capacity for long-term trending. Utility systems, mostly being packaged units, will be controlled locally through package PLC. However, certain critical parameters, alarms, operating status, ESD systems of all units will be made available in the control room. ESD and control systems for all operating modes will be designed as per international standards. The base station of the PA system, CCTVs control and monitoring, F&G panel with annunciator will be in the control room. The substation, control room and UPS room will be in the same building along with space for other offices.

CNG Storage Module

Natural gas will be the fuel for power generation. The natural gas required for power generation will be stored under high pressure in a stationary cascade at Port Terminal. The refilling of the stationary cascade will be done by truck mounted mobile cascades which will transport the CNG from the existing Eleme plant to Port Terminal. From these stationary cascades, the natural gas will be supplied to power generators and flare, after pressure reduction through de-compression station. The capacity of the CNG storage module and de-compression station will be decided based on the consumption by power generating units and flare stack with adequate margins considering different possible operating scenarios, disruptions in re-filling, buffer quantity, etc. Also, a back-up of 3 days of storage cascades at maximum load to be considered for design.

Bore-well and Water Storage, Treatment, and distribution.

The water requirement of Port Terminal will be fulfilled by underground water. Borewells of suitable capacity will be developed at the Port Terminal. The groundwater extracted by bore-well pumps will be stored in storage tank of suitable capacity. The water will be supplied to the point of use based on the requirement.

The water will be mainly required for following purposes,

- Cooling tower make-up
- Potable water (including eye wash shower)
- Service water (general purpose)

The water storage and distribution facility will be constructed considering the consumption and specific usage requirement. Potable water treatment like disinfection, filtration, etc. may be evaluated based on the water quality.

Firefighting System, Foam storage, Fire water pumps network

Sea water will be used for the fire water requirement of Port Terminal. Fire water pump houses will be constructed near the shoreline. Sea water will be pumped from the fire water pumping station and distributed within the Port Terminal area through an underground / above ground fire water piping network. The configuration, capacities and operating philosophy of the fire water pumping system will be decided on the fire scenario studies of the Port Terminal facilities/ equipment. However, for preliminary configuration, electric motor operated jockey pumps and diesel engine operated main pumps will be considered.

Fire & Gas Detection and Protection System

Fire and Gas (including Ammonia) detection and protection systems will be considered for all facilities as per applicable codes and standards. The indication / control of the system will be provided in the control room.

Sewage Treatment Unit (Package Unit)

The sewage generated in the Port Terminal will be appropriately treated before discharging it outside of premises. A sewage treatment unit (package type) of suitable size and technology will be considered for treatment and disposal of sewage within jetty area.

Oil Water Separator (Package Unit)

An oil separator (package unit) of suitable size and technology will be evaluated and designed for collection, separation, and disposal of Oily water from all sources.

2.3.4 Common facilities at Port Terminal

The following buildings are considered at Port Terminal. The Civil design (civil outline drawing including foundation) of these buildings will be as per national building code and applicable international codes.

- Administrative offices
- Workshop / Maintenance area
- Security office
- Oil and Chemical Storage

2.4. Project Construction

Details on the construction methods are not available at present. The Engineering contractor for the Project is yet to be selected. As per the Project plan, the Engineering contractor will be engaged during 2023 and the construction contractor will be mobilized to site during 2023, subjected to all necessary permits and approvals. Project specific details on construction will be available after contract signing and mobilization to site. In the ESIA report, construction-related information that is as similar as possible to a project of this nature will be presented. These will be based on Proponent and Consultant experience on similar projects.

Dredging

The birth pocket in- front of the key wall will be dredged to a depth of -13.5-meter CD and the dredged spoils will be disposed at designated locations identified by the Nigerian Ports Authority (NPA). The turning circles and the navigation channel is done by Nigerian Port Authority n regular basis as a part of their maintenance practice.

2.5 Manpower

Manpower plan requirement during peak time of construction will be approximately 500 personnel and during operation phase it will be approximately 50. Meliora Methanol FZE is committed to follow National Regulations while employing manpower and will attempt to maximize the number of locals employed.

2.6 Resources for the Project

Potential Project resources and energy requirements during construction and operation phases are presented in the tables below.

Table 2.1: Construction Phase Resources and Energy Requirements

Utilities	Source
Construction Power Supply	Will be sourced from Gas engine generators (GEG) installed at Project site
Potable Water	Will be sourced from deep borewell and shall be used after suitable treatment
Construction Materials	Like cement, steel, etc.; will be sourced from local suppliers.
Construction Water	The source of industrial water will be deep borewells
Waste Disposal Facilities	Wastes will be temporarily stored onsite before offsite disposal by government approved waste management contractors.
Wastewater Treatment/Disposal	Onsite sewage treatment plant(s) will be established, and treated sewage water will be used for site application like dust suppression, irrigation etc.
Fuel	Diesel fuel shall be brought from local retailers to the site by road and will be used for refueling construction vehicles and machinery. For GEG, the CNG shall be sourced from existing CNG station located within Indorama Complex, Eleme.

Table 2.2: Operation Phase Resources and Energy Requirements

Utilities	Source
Electricity Supply	Will be generated by a Project using Gas Engine Generators (GEG). Decompressed CNG will be used as fuel.
Potable Water	Will be sourced from deep borewell and shall be used after suitable treatment
Industrial water	The source of industrial water will be deep borewells and shall be used after appropriate treatment
Cooling Water	The source of cooling water make-up will be deep borewells and shall be used after appropriate treatment
Fire Water	The sea water will be used as fire water
Waste Disposal	Wastes will be temporarily stored onsite before offsite disposal by government approved waste management contractors.
Wastewater Treatment/ Disposal	Domestic wastewater will be treated onsite in sewage treatment plant before disposal

3.0 ENVIRONMENTAL AND SOCIAL BASELINE STUDIES

3.1 Overview

The baseline study for the Project is a combination of secondary reviews and primary surveys. Secondary reviews included review of published information and reports, consultation with concerned agencies and referring to archives, as available. Secondary reviews proposed for the Project ESIA study are discussed in subsequent section. Primary surveys include physically visiting the Project site and carrying out monitoring and sampling activities.

3.2 Purpose of the ESIA

The purpose of the ESIA study is to determine the current environmental conditions of the area where the project will be sited prior to the commencement of the project activities. This is to:

- Identify the Physical, Biological and Socio-economic indicators that would enable effective monitoring of change in the quality of the project area environment and
- Provide a document that can be used in predicting and evaluating impacts of proposed development on the environment.

3.3 Scope of Work

The scope of work shall include the following:

- Determination of the physical, biological, and socio-economic baseline conditions of the study area.
- Conducting an assessment and identifying the effect of the project activities on the existing environment.
- Advise on the mitigation of significant adverse effects of the development projects and their operations.
- Propose an Environmental and Social Management Plan (ESMP) for continued monitoring of the environmental conditions during the life span of the project.
- Preparing an acceptable report & its approval by the appropriate regulatory agencies.

3.4 Literature Review

The desktop review will cover the study of existing literature particularly, from reports of previous FMEnv approved ESIA/EA studies, reports, survey maps, aerial photographs, articles, and national/internal research journals etc. Outline of secondary reviews proposed to be carried out for Project ESIA study is presented in Table 3.1 below.

Table 3.1: Secondary data survey

Element	Method
Climate and Meteorology	Data on meteorological parameters will be obtained from sources like NiMET (National Metrological Agency) or Civil Aviation Authority or Satellite data
Topography and Landscape	Review of satellite imageries (as available) of the Project area Review of the topographic survey results for the Project area
Groundwater Quality	Information of groundwater will be sourced from available secondary data (published information)
Geology and Hydrogeology	Data on study area geology and hydrogeology will be sourced from Project geotechnical investigation interpretative report and available published geological and hydrogeological.
Hydrology	Data will be sourced from available published hydrological information about Project area
Socio-Economic	Review of census data and any recent study reports for developments in area.
Archaeological and Heritage Resources	The archaeological baseline will be established through desktop research.

3.5 Primary Survey

3.5.1 Reconnaissance Survey

A reconnaissance survey was undertaken to familiarize the ESIA Team with the proposed project site and its environs. This helped the team in concept design of field work execution plan.

3.5.2 ESIA Study Consultation Program

Consultations shall be carried out throughout the project lifecycle with relevant stakeholders to ensure that their views and opinions concerning the proposed project are integrated into the ESIA process. The regulatory agencies, project affected communities, Non-Governmental Organizations, and financial institutions are the key stakeholders for the project. A detailed stakeholder mapping was performed duing ESIA process to chart Stakeholder Engagement Plan.

3.5.3 Baseline Data Collection

Field data gathering exercise shall be performed to assess current physical, biological, and socio-economic condition to the project environment and secondary information gathered from desktop studies shall be used to support the study outcomes. Specifically, the survey shall cover the following environmental and social components:

- Physical environment – surface water and sediments, groundwater, air quality, noise, soil, and land use.
- Biological environment – plankton, benthos, flora, fauna, and various aspects to cover Biodiversity of project environment.
- Socio-economic environment – Socio-economic including health, cultural heritage, traffic, and transport.

3.5.4 Fieldwork Activities

The work scope for field activities performed in the project site and environs is summarized in Table 3.2 below. The field data gathering exercise covers the study of three environmental components - physical, biophysical, and socio-economic environments.

Table 3.2: Field Activities

S/N	Environmental Components	No. of Sampling Stations	Description of Sampling Equipment / Instrument
1	Ambient Air	12+2 control	Digital In-situ measurement meters were used
2	Noise	12+2 control	Digital In-situ measurement meters were used
3	Meteorology	1	A weather station was set up at Project Site
4	Soil / Geology	6+1 control	Samples collected at two depths namely Top-soil (0 – 15cm) and Sub-oil (15 – 30cm) 3 borings on site for soil profile
5	Ground water	5+1 control	3 borings on site, 3 on existing boreholes in communities
6	Surface Water	10+2 control	Sampling done using grab sampler, omogenized, and collected in plastic bottles for physiochemical parameters, glass bottle for heavy metals fixed with HNO_3, glass bottles for O&G/ hydrocarbons fixed with H_2SO_4 and in-situ measurements
7	Sediment	10+2 control	Use of Eckman grab sampler
8	Aquatic Biology	10+2 control	Water filtering, sediment sieving fisheries,
9	Vegetation	Transect	2 points each of 2km & 4km radius & 4 transects
10	Riverine & Estuarine	Transect	2 points each of 2km & 4km radius & 4 transects
11	Wildlife	Transect	Hunters' interviews, animal droppings & others
12	Socio-economic including health, cultural heritage, traffic, and transport	Ogu and Onne community	Structured questionnaire, discussion / Interview etc. Survey for portable water, waste disposal, health care system etc. Cultural Heritage, Ecosystem services etc.

3.6 Meteorology / Climate Report

Executive summary

Overview: Measurement of micro-meteorological parameters within the proposed project area forms an essential part of the baseline meteorological and climatic assessment of the area. Both measured primary data recorded at the proposed project site and collected historical secondary meteorological data were used to provide an understanding of the short-term and long-term meteorological scenario and weather conditions of the proposed project area.

Methodology: Field monitoring of diurnal meteorological parameters at the proposed project site was carried out from the 3rd of July to 20th of July 2023. The methodology adopted and employed for meteorological assessment and monitoring was in compliance with standard norms laid down by the Nigerian Meteorological Agency (NiMet). Hourly meteorological data were collected at the proposed project site using a Davis Vantage Pro2™ Plus Automated Weather Station (AWS) mounted in an open space at the proposed project site. In addition, a five year (January 2018 to Dec 2022) historical meteorological data were obtained from National Aeronautics and Space Administration (NASA) and the 30years average data from NiMet, Port Harcourt Station.

Results and discussion: The environmental baseline describing the pre-construction meteorology of the proposed project area has been conducted through intensive measurements and analysis of field data (primary data) and historical meteorological parameters (secondary data) of the area. The micro-meteorological parameters assessed in the study were wind speed, wind direction, ambient temperature, relative humidity, barometric air pressure, rainfall, and cloud cover.

Wind speed and direction: The mean wind speed measured at the proposed project area was 1.84±0.4m/s; while the mean value of the historical data was 1.81±0.25m/s. Both the field data and the historical data indicated no period of calmness in the proposed project environment. The absence of calm conditions indicates the dominance of unstable atmosphere, which will favour the dispersion of air pollutants during the construction and operation of the proposed project. The study reveals the prevalence northeast (NE) wind in the dry season months (January, February, March and December), and southwest (SW) wind in the rainy season months. The dominance of South-Westerly (SW) wind in the area was due to the long period of rainy season that characterized the area. This suggests that air pollutants would be dispersed towards the northern direction in the rainy season and towards the southern direction in the dry season.

Temperature: The mean temperature measured at the proposed project area was 25.81±1.22^{0}C; while the mean value of the secondary data was 28.76±0.96^{0}C. The project area exhibits the characteristics of an unstable atmospheric condition, which prevents temperature inversion and favours air pollutants dispersion. The moderate levels of temperature observed in the area may result in the formation of photochemical oxidants such as ground-level ozone. The project area exhibits the characteristics of an unstable atmospheric condition, which prevents temperature inversion and favours air pollutants dispersion.

Relative humidity: The mean relative humidity measured at the proposed project area was 92.69±6.17; while the mean value of the historical data was 88.92±4.98%. Relative humidity was high in the rainy season months and low in the dry season months. Relative humidity was observed to be high when there was overcast cloud and low when it was sunny during field monitoring. High relative humidity will tend to wash dissolved air pollutants (SO_2 and NO_2 and suspended particles) out of the atmosphere.

Barometric air pressure: The mean wind speed measured at the proposed project area was 101.21±0.14kPa; while the mean value of the five-year secondary data was 101.02±0.16kPa. Both the measured field data and the secondary data indicated the barometric air pressure in the project area was relatively constant. The project area frequently experiences low pressure in the rainy season, which is associated with clouds, high winds, warm air, precipitation, and tropical storms. The area also experiences high pressure in the dry season, which is associated with clear sky and high long wave solar radiation or insolation.

Cloud covers: A cloudy weather condition was observed in the proposed project area during the period of field monitoring during day hours. Cloud covers ranging between 5 and 8 Oktas, with average values between 6 and 7.5Oktas were observed in the project area. A lofty cloudy weather of this nature is a common characteristic of the proposed project area during the months of rainy season. Sunny days are observed during dry season and hence minimal cloud cover, this may tend to encourage unstable atmospheric conditions that promotes atmospheric emission dispersions.

Rainfall: The daily rainfall values measured at the proposed project area ranged from 8.2mm to 68.4mm; while the monthly mean values of the secondary data ranged from 21.44mm to 431.34mm. The secondary data indicated that monthly maximum amount of average rainfall occurs in the months of June, July, August, and September indicating the periods of peak rainfall in the Onne, Eleme area, while monthly minimum average rainfall occurs in the months of December (mean = 21.44mm), followed by January (mean = 23.57mm). The 30 years (1990-2020) secondary data of the proposed project area shows that monthly rainfall between May and October averages over 300 mm, while the monthly averages for the months of dry season are below 40 mm. Rainfall in the project area begins in late March and ends in early-December due to closeness of the area to tropical wet maritime air mass of the Atlantic Ocean. Rainfall in the area is expected to play a significant role in atmospheric wash-out of dissolved air pollutants.

3.6.1. Introduction

3.6.1.1 Meteorology and Climatic Conditions of the project area

The Niger Delta region, where the proposed project is to be sited is a tropical, warm, and humid/wet region. The area experiences a tropical climate that consists of lengthy wet/rainy season (mid-March to November) and short dry season (December to March). The climate of Onne, Eleme in the Niger Delta region can be classified into two seasons. The rainy season starts in late March and can continue through November. During this period mean temperatures range from a minimum of 21.8°C to a maximum of 32.0°C. Nights are much cooler, and the average humidity is around 80.0%. July and September experience increased rainfall from the Southwest monsoon. During this time, daytime temperatures average around 28.7°C. The dry season starts in December and lasts through March. During this time, temperatures range from a minimum of 20.5°C to a maximum of 36.0°C. Moderate temperatures, wind speed and high relative humidity are common characteristics of the proposed project area (Adejuwon, 2012; Igweze et al., 2014; Yorkor et al., 2017).

The rainy season is characterized by cloudy skies and heavy precipitation/rainfall of about 230 days, with a temporary cessation of rain (a period of short sunshine usually in the month of August) within the raining season commonly referred to as *'August break'* (Ofomata 1975). The August break may last for a period of two weeks. The heaviest precipitation is usually observed in the months of July and September every year (double Maxima) with an average of 367 mm of rainfall. During the rainy season period, winds are mainly southerly, the sea breeze blows steadily, and sea and river levels usually rise above normal. The complex coastline and low-lying flat topology of the area results in composite surface wind speed patterns, especially during low wind activity when land and sea breezes dominate the surface wind of the area (Yorkor et al., 2017).

December and January are the driest months of the proposed project area (Ofomata, 1975). The dry season harmattan, which climatically influences many regions in West Africa, is also pronounced in the proposed project area. December on average is the driest month of the year, with an average rainfall of 20 mm. Temperatures throughout the year in the area are relatively constant, showing little variation throughout the course of the year. Average temperatures are typically between 23°C and 32°C in the area. The relative humidity in the area is often high (80 – 90%) during the raining season and reduced to about 50 – 60% during the dry season because of the drier tropical continental air mass referred to as *harmattan* (Wali, 2017).

3.6.2. Methodology

Measured meteorological variables during the field monitoring period provided a useful information for interpretation of the baseline condition of the proposed project area. Measurement of micro-meteorological parameters within the proposed project area during the air quality monitoring exercise forms an essential part of the baseline air quality assessment of the area. Both measured primary data recorded at the proposed project site and collected historical secondary meteorological data were used to provide an understanding of the short-term and long-term meteorological scenario and weather conditions of the proposed project area. These data were also used in the explanation of the variations of meteorological vectors including wind variation scenarios that influence the air quality of the area.

3.6.2.1 Primary Data

Field monitoring of diurnal meteorological parameters at the proposed project site was carried out from the 3rd of July to 20th of July 2023. The methodology adopted and employed for meteorological assessment and monitoring was in compliance with standard norms laid down by the Nigerian Meteorological Agency (NiMet). On-site monitoring was conducted for various meteorological variables in order to obtain site specific data. Hourly meteorological data were collected at the proposed project site using a Davis Vantage Pro2™ Plus Automated Weather Station (AWS). Meteorological parameters recorded were wind speed, wind direction, temperature, humidity and rainfall and cloud cover.

The Automated Weather Station (AWS) was set up at N4^{0}40'02.71" and E7^{0}08'44.65" coordinates in an open space at the proposed project site. The AWS has an Integrated Sensor Suite (ISS), connected with console through WeatherLink software. The weather station is equipped with a solid-state magnetic sensor for wind speed, Wind vane, potentiometer for wind direction, PN Junction Silicon Diode for temperature, Film capacitor element for relative humidity, barometric pressure sensors and Tipping bucket type rain collector. The Davis weather station complies with World Meteorological Organization (WMO) specifications as shown in Table 1. Cloud cover was measured through visibility in Oktas.

Table 3.2: Weather Station Specifications

Variables	Unit	Range	Accuracy	Resolution	Averaging time
Air temperature	°C	-40 to 60	±0.1°C	0.1°C	1 minute
Relative humidity	%	0 to 100	±5%	1%	
Wind speed	m/s	0 to 67.0	±0.5m/s for ≤5m/s 10% for ≥5m/s	0.5	2 minutes
Wind direction	^{0}	0 to 360	±5%	10°	2 minutes
Rainfall	mm	0 to 999	3%	0.25mm	
Atmospheric pressure	mbar	610 to 1134	±0.1mbar	0.1mbar	1 minute

3.6.2.2 Secondary Data

Historical data on meteorology also play an important role in identifying the general meteorological status of the proposed project area. Site specific data were compared with historical data in order to identify changes which may have taken place due to the various developments in the area. A five year (January 2018 to December 2022) historical data was obtained from National Aeronautics and Space Administration (NASA). Also, a 30-year meteorological data was obtained from the Nigerian Meteorological Agency (NiMet). The collected historical data include temperature, humidity, rainfall, wind speed, and wind direction recorded on daily basis.

3.6.3 Results and discussion

3.6.3.1 Field Result

The statistical summary result of the daily (24 hours) averages of meteorological variables obtained in the proposed project site is shown in Table 2. The plots of the trends in daily average diurnal of the meteorological parameters measured at the project site are presented in Figures 2 to 5.

Table 3.2: Statistical summary meteorological variables measured at proposed project Site.

Date		Wind Speed (M/s)	Temp. (0C)	Rel. hum. (%)	Air Pressure (kPa)	Rainfall (mm)	Cloud cover (Oktas)
03-Jul	Min.	1.49	24.55	75.56	101.15	0.0	5
	Max.	2.40	29.17	97.31	101.44	5.0	8
	Mean	1.91	26.18	90.74	101.28	1.5	
	Stdev.	0.25	1.6	7.88	0.09	1.8	
04-Jul	Min.	1.41	24.65	86.38	101.19	0.0	7
	Max.	2.58	26.98	97.75	101.44	5.9	8
	Mean	1.84	25.55	94.52	101.32	1.4	
	Stdev.	0.31	0.86	4.04	0.08	1.6	
05-Jul	Min.	0.75	24.30	77.62	101.19	0.0	6
	Max.	1.83	27.62	97.88	101.50	15.8	8
	Mean	1.28	25.76	90.73	101.32	2.1	
	Stdev.	0.32	1.14	7.17	0.1	3.4	
06-Jul	Min.	1.40	24.10	72.81	100.89	0.0	6
	Max.	2.53	29.32	97.19	101.20	5.8	8
	Mean	1.88	26.18	88.65	101.07	1.1	
	Stdev.	0.4	1.83	8.9	0.1	1.3	
07-Jul	Min.	1.51	24.36	85.00	101.02	0.0	5
	Max.	2.34	27.11	97.88	101.34	7.9	7
	Mean	1.92	25.46	94.38	101.17	1.2	
	Stdev.	0.22	0.9	4.33	0.09	2.0	
08-Jul	Min.	1.12	24.19	86.75	101.11	0.0	7
	Max.	2.68	26.65	97.12	101.48	3.4	8
	Mean	1.99	25.23	94.15	101.3	0.9	
	Stdev.	0.5	0.84	3.39	0.13	1.1	
09-Jul	Min.	1.20	23.89	77.19	101.20	0.0	7
	Max.	2.07	28.03	97.50	101.56	3.8	7
	Mean	1.62	25.56	91.02	101.37	1.0	
	Stdev.	0.28	1.4	7	0.1	1.1	
10-Jul	Min.	1.10	23.60	70.00	101.07	0.0	6
	Max.	2.09	29.06	97.88	101.46	1.8	7
	Mean	1.65	25.79	89.33	101.24	0.5	
	Stdev.	0.31	1.8	10.16	0.1	0.6	
11-Jul	Min.	1.50	24.16	76.00	100.91	0.0	6
	Max.	2.71	28.69	97.81	101.25	3.7	7
	Mean	2.12	25.96	90.69	101.09	0.7	
	Stdev.	0.43	1.54	7.95	0.1	1.0	
12-Jul	Min.	1.67	24.65	88.00	100.93	0.0	6
	Max.	2.76	26.50	97.25	101.25	5.7	8
	Mean	2.24	25.34	94.61	101.06	1.1	
	Stdev.	0.34	0.66	3.08	0.1	1.4	
13-Jul	Min.	1.38	24.57	80.94	100.90	0.0	6
	Max.	1.90	27.69	97.19	101.27	3.1	8

Date		Wind Speed (M/s)	Temp. (0C)	Rel. hum. (%)	Air Pressure (kPa)	Rainfall (mm)	Cloud cover (Oktas)
	Mean	1.58	25.82	92.16	101.1	0.9	
	Stdev.	0.15	1.13	5.62	0.11	1.0	
14-Jul	Min.	1.42	24.74	81.81	100.95	0.0	6
	Max.	1.91	28.15	97.19	101.31	6.4	7
	Mean	1.67	26.05	92.65	101.11	0.5	
	Stdev.	0.14	1.2	5.52	0.1	1.3	
15-Jul	Min.	1.41	24.80	84.62	100.98	0.0	6
	Max.	1.81	28.02	97.69	101.27	3.6	8
	Mean	1.62	26.11	93.48	101.14	0.7	
	Stdev.	0.11	1.2	4.97	0.09	1.0	
	Min.	1.49	24.53	86.62	100.96	0.0	5
	Max.	2.17	27.19	97.75	101.28	3.1	8
16-Jul	Mean	1.84	25.73	93.86	101.1	0.7	
	Stdev.	0.17	0.94	4.34	0.09	1.0	
17-Jul	Min.	0.98	24.90	83.94	101.04	0.0	5
	Max.	2.68	28.17	97.81	101.37	1.8	7
	Mean	1.88	26.11	94	101.2	0.3	
	Stdev.	0.49	1.13	4.87	0.11	0.6	
18-Jul	Min.	1.19	24.92	90.00	101.14	0.0	5
	Max.	2.98	26.70	97.81	101.44	2.1	6
	Mean	1.99	25.69	95.31	101.3	0.4	
	Stdev.	0.42	0.65	2.89	0.09	0.6	
19-Jul	Min.	1.44	24.75	85.19	101.14	0.0	5
	Max.	2.55	27.97	98.12	101.39	3.1	7
	Mean	1.94	26.1	94.53	101.28	0.8	
	Stdev.	0.32	1.08	4.48	0.07	0.8	
20-Jul	Min.	1.61	24.85	86.19	101.09	0.0	5
	Max.	2.89	27.44	97.81	101.41	13.4	6
	Mean	2.2	25.93	93.59	101.26	3.2	
	Stdev.	0.41	0.95	4.38	0.09	3.4	

3.6.3.2 Secondary Result

Statistical summaries of monthly and yearly meteorological variables of the five years data (2018 to 2022) around the project area obtained from National Aeronautics and Space Administration (NASA) are presented in Tables 3 and 4 respectively. The 30 year monthly average meteorological data obtained from NiMet is shown in Table 5.

Table3.3: Statistical summary of monthly meteorological variables around project area (2018-2022)

Parameter	Month/ Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp (0C)	Min.	26.97	26.56	26.26	26.73	26.69	25.85	25.73	24.40	25.50	26.22	26.09	26.32
	Max.	32.45	33.54	32.62	31.65	31.14	31.12	28.05	29.96	30.40	31.24	31.55	31.56
	Mean	29.82	30.42	29.56	29.30	28.75	27.93	27.68	27.71	27.68	28.10	28.78	29.51
	Stdev.	1.12	1.31	1.07	1.02	0.89	1.06	0.92	0.97	0.90	1.11	1.22	1.20
Rel.hum. (%)	Min.	63.56	60.12	62.69	66.19	66.50	69.12	70.12	71.75	73.56	72.31	67.44	66.50
	Max.	63.50	91.56	94.06	94.75	95.62	96.12	97.12	95.19	95.44	95.56	96.06	94.12
	Mean	82.97	83.98	88.92	89.34	90.93	91.53	91.34	90.36	91.58	91.04	90.20	84.70
	Stdev.	6.84	6.31	3.01	3.24	2.83	3.00	2.84	2.75	2.36	2.19	3.34	6.51
wind speed (m/s)	Min.	0.05	0.01	0.04	0.20	0.03	0.80	0.74	0.97	0.24	0.12	0.08	0.09
	Max.	4.17	3.00	3.23	3.15	3.28	3.41	3.81	4.46	4.12	2.95	3.56	2.80
	Mean	1.64	1.74	1.79	1.69	1.61	1.76	2.12	2.46	1.91	1.66	1.70	1.63
	Stdev.	0.78	0.70	0.59	0.58	0.52	0.47	0.65	0.74	0.70	0.45	0.56	0.61
Air pres (kPa)	Min.	100.70	100.67	100.58	100.62	100.79	100.80	100.97	100.87	100.89	100.80	100.66	100.68
	Max.	101.18	101.18	101.16	101.18	101.38	101.43	101.47	101.48	101.38	101.30	101.23	101.22
	Mean	100.96	100.88	100.88	100.89	101.03	101.16	101.22	101.22	101.13	101.04	100.94	100.95
	Stdev.	0.10	0.11	0.11	0.12	0.11	0.11	0.10	0.14	0.10	0.09	0.10	0.11
Rainfall (mm)	Min.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Max.	52.48	64.43	173.51	317.93	363.18	419.74	506.23	486.42	521.69	402.58	154.44	33.29
	Mean	23.57	58.53	141.82	206.7	239.84	337.69	428.73	407.5	431.34	281.37	98.62	21.44
	Stdev.	12.64	29.28	47.69	52.15	78.21	103.47	98.64	69.43	110.41	83.46	97.82	27.39
Prominent wind dir.		NE	NE	SE	SW	SW	SW	SW	SW	SW	SW	SW	NE

Source: NASA

Table 3.4: Statistical summary of yearly meteorological variables around project area (2018-2022)

Parameter	**Year/ Statistics**	**2018**	**2019**	**2020**	**2021**	**2022**
Temp (0C)	Min.	24.40	25.25	25.49	26.23	25.45
	Max.	33.54	31.81	33.38	32.39	31.93
	Mean	28.70	28.80	28.90	28.68	28.70
	Stdev.	1.49	1.40	1.59	1.28	1.32
Rel.hum. (%)	Min.	63.56	68.06	60.12	62.69	66.50
	Max.	95.49	95.62	96.06	95.75	95.38
	Mean	89.10	88.90	88.50	89.60	88.72
	Stdev.	5.09	5.03	5.52	4.05	4.66
wind speed (m/s)	Min.	0.01	0.04	0.05	0.02	0.03

Parameter	Year/ Statistics	2018	2019	2020	2021	2022
	Max.	4.06	3.86	4.39	3.81	4.46
	Mean	1.10	1.15	1.20	1.08	1.10
	Stdev.	0.48	0.45	0.44	0.46	0.50
Air pres (kPa)	Min.	100.64	100.68	100.69	100.66	100.58
	Max.	101.43	101.40	101.48	101.47	101.38
	Mean	101.00	101.05	101.10	101.01	101.00
	Stdev.	0.17	0.16	0.14	0.17	0.17
Rainfall (mm)	Min.	0.01	0.01	0.01	0.01	0.01
	Max.	371.35	549.17	418.26	420.15	341.63
	Total	3501.68	3706.17	4053.66	4005.21	2723.46
	Mean	286.71	293.58	278.38	282.57	225.51

Table3.5: Average Weather Trend for Port Harcourt (1990-2020)

S/No	Month	Average Temp (^{0}C)	Rainfall (mm)	Cloud Cover (oktas)	Pressure (mbar)	R/H (%)	Wind Speed (m/s)	Prominent Wind Dir.
1	January	33.5	17.2	6.5	1007	74	2.9	NE
2	February	34.2	76.5	6.6	1007	79	2.8	SW
3	March	33.8	95.2	6.8	1006	83	3.6	SW
4	April	31.7	144.1	6.8	1007	83	3.7	SW
5	May	31.9	248.4	7	1007	87	3.8	SW
6	June	30.3	312.2	7	1009	91	3.9	SW
7	July	28.1	368.0	7	1010	92	4.3	SW
8	August	28.6	325.2	7	1010	92	4.3	SW
9	September	28.3	374.5	7	1009	92	4.4	SW
10	October	30.8	241.9	7	1009	89	3.8	SW
11	November	32.4	74.0	6.6	1007	84	2.9	SW
12	December	33.4	20.4	6.5	1007	73	2.6	NE

Source: NIMET, Port Harcourt

3.6.4. Discussion

3.6.4.1 Wind speed and Wind direction

The result obtained during field monitoring (Table 2) indicated temperate wind speeds around the proposed project area ranging from 0.75m/s to 2.98m/s with a mean deviation of 1.84±0.4m/s. Similarly, analysis of the five years secondary data (Table 3) also indicated temperate wind speeds ranging from 0.01m/s to 4.46m/s with a mean deviation of 1.81±0.25m/s. Monthly analysis of historical data (Table 3) indicates that mean wind speed was minimum (1.61m/s) in May and maximum (2.46m/s) in August. Similarly, Yearly analysis of secondary data (Table 4) indicates that mean wind speed was minimum (1.08m/s) in 2021 and maximum (1.2m/s) in 2020s. Diurnal trend in field data (Figure 2) indicates steady increase in mean wind speed at the proposed project site.

The field data wind speed frequency distribution (Figure 3) indicates three main prevailing wind class of the project area in the range of 0.5 - 2.0m/s, 2.0 – 2.5 and 2.5 - 3.5 m/s, constituting about 37.5%, 25.0% and 33.3% frequencies of occurrences respectively for the wet season. Similarly, analysis of the secondary data (Figure 4) indicated three prevailing wind classes in the range of 0.5 - 2.0m/s, 2.0 - 2.5m/s and 2.5 - 3.5m/s, constituting about 50%, 41.7% and 4.2% frequencies of occurrences respectively for both the wet and dry seasons. Both the field data and the secondary data indicated no period of calmness in the proposed project environment. The absence of calm situation around the project site can be attributed to the sea breeze blows steadily across the area.

A calm weather occurs in a stable atmosphere and is very important to air pollution studies because it is often associated with *temperature inversion*. Inversion refers to a very *stable atmosphere* with vertical temperature increasing with height. This vertical temperature gradient traps pollutant emissions at ground level leading to a condition known as *fumigation*. The absence of calm conditions indicates the dominance of unstable atmosphere, which will favour the dispersion of air pollutants during the construction and operation of the proposed project.

The wind rose plots for the field data and the secondary data are shown in Figures 5 and 6 respectively. The wind roses show the general wind direction and wind speed for each sampling period. It is evident from Figures 5 and 6 that both the field data and secondary data show similar wind rose pattern. The field data wind rose (Figure 5) shows that during this particular sampling period the wind blew from the southwest 29.7% of the time, while the secondary data wind rose (Figure 6) shows that the wind blew from southwest 21.3%, from the south 8.5% and the northeast 4.25% of the time. The statistical analysis of the secondary data (Table 3) indicates the prevalence northeast (NE) wind in the dry season months (January, February, and December); while southwest (SW) wind prevails in the rainy season months. The analysis of both the field and the secondary data shows the dominance of south-westerly (SW) wind in the area, which can be attributed to the long period of rainy season that characterized the area.

Study has shown that wind speed and direction are the parameters that mostly influence pollutants concentrations in the ambient air of the proposed project area and determined the transport and dispersion of air pollutants along prevailing wind of direction Yorkor et al. (2017). It is clear from the wind roses (Figures 5 and 6) that air pollutants would be dispersed towards the northern direction in the rainy season and towards the southern direction in the dry season. These factors will influence pollutant dispersion in the project area during construction and operation of the proposed project. The coastal area where this study was carried out is dominated by the tropical maritime (mT) air-mass from the Atlantic Ocean most time of the year. The influence of this moisture laden wind depends on the position of the counter tropical continental air mass, separated by the inter-tropical discontinuity (ITD) (Adejuwon, 2012).

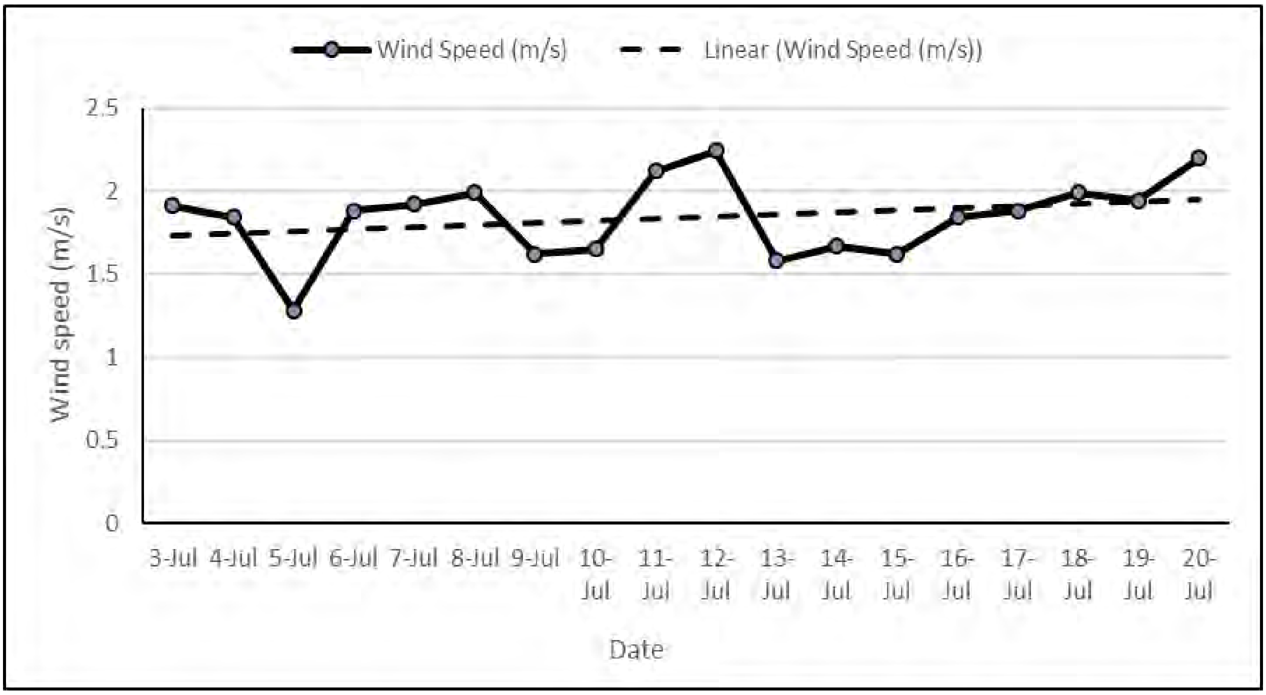


Figure 3.1: Trend in daily average diurnal wind speed (July 3 – July 20, 2023)

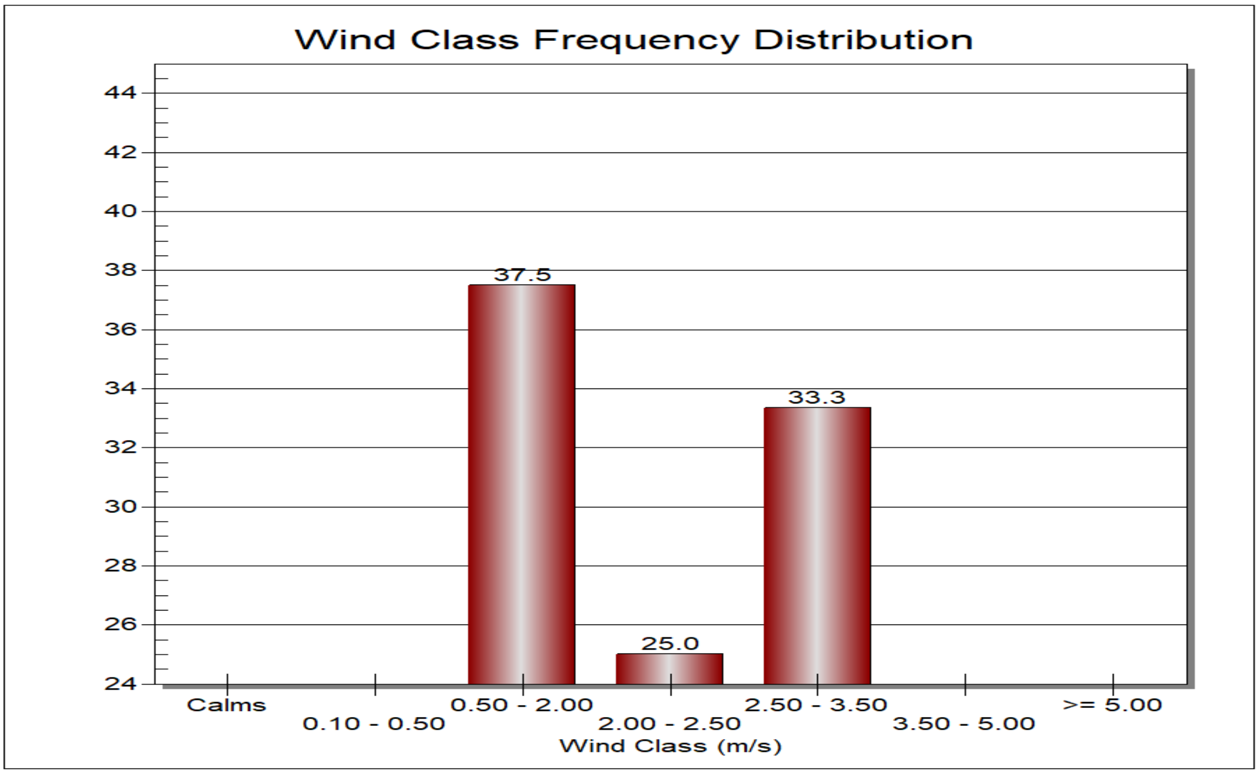


Figure 3.2 Wind class of field meteorological data (July 3 – July 20, 2023)

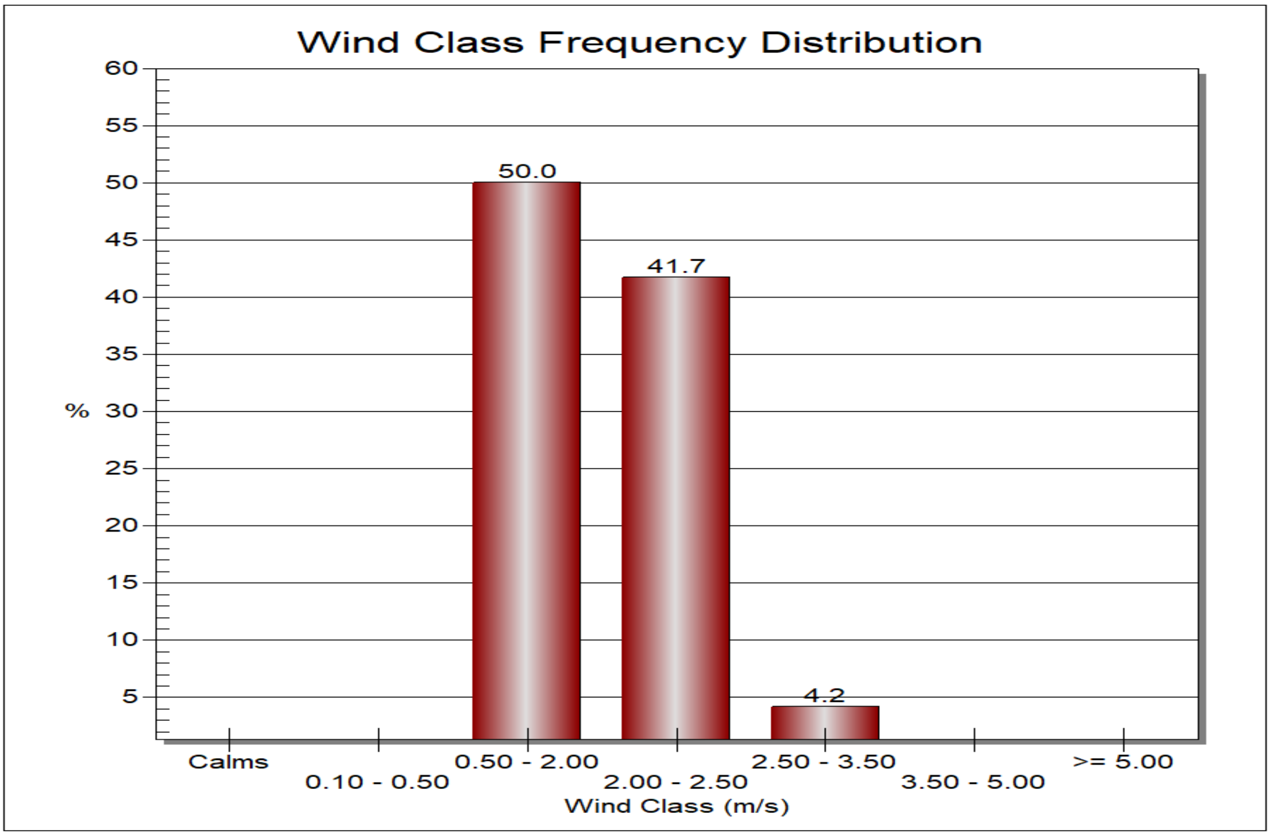


Figure 3.3: Wind class of secondary meteorological data (2018 – 2022)

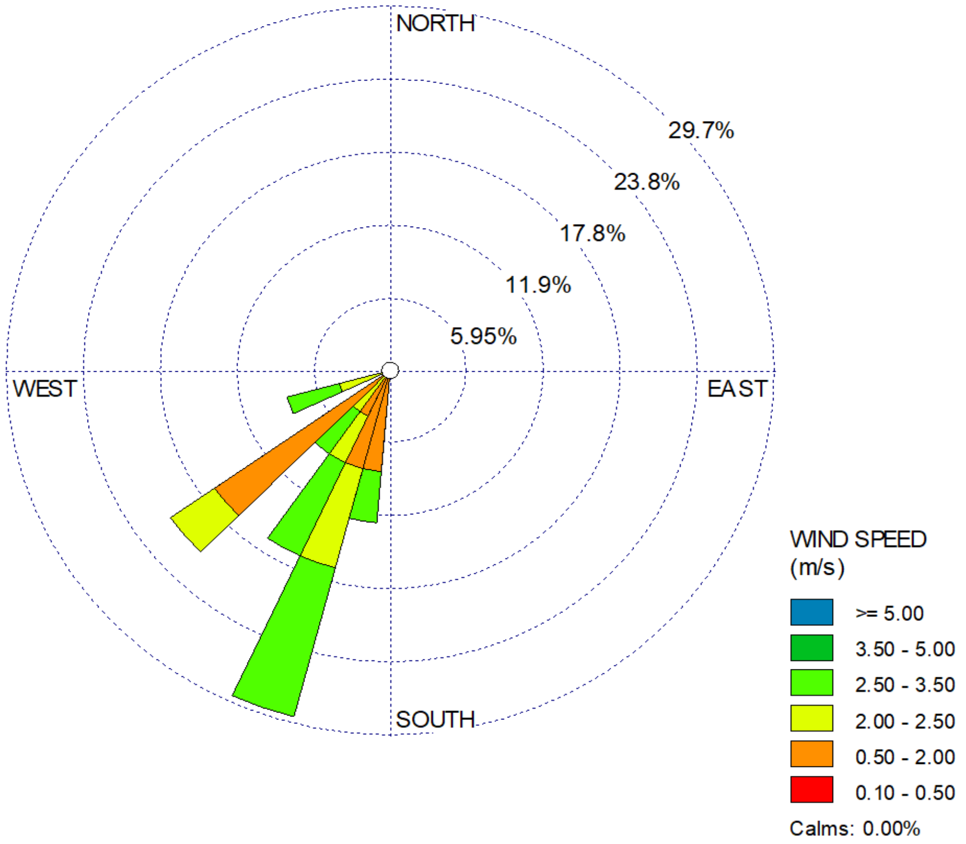


Figure 3.4: Wind Rose of field meteorological data (July 3 – July 20, 2023)

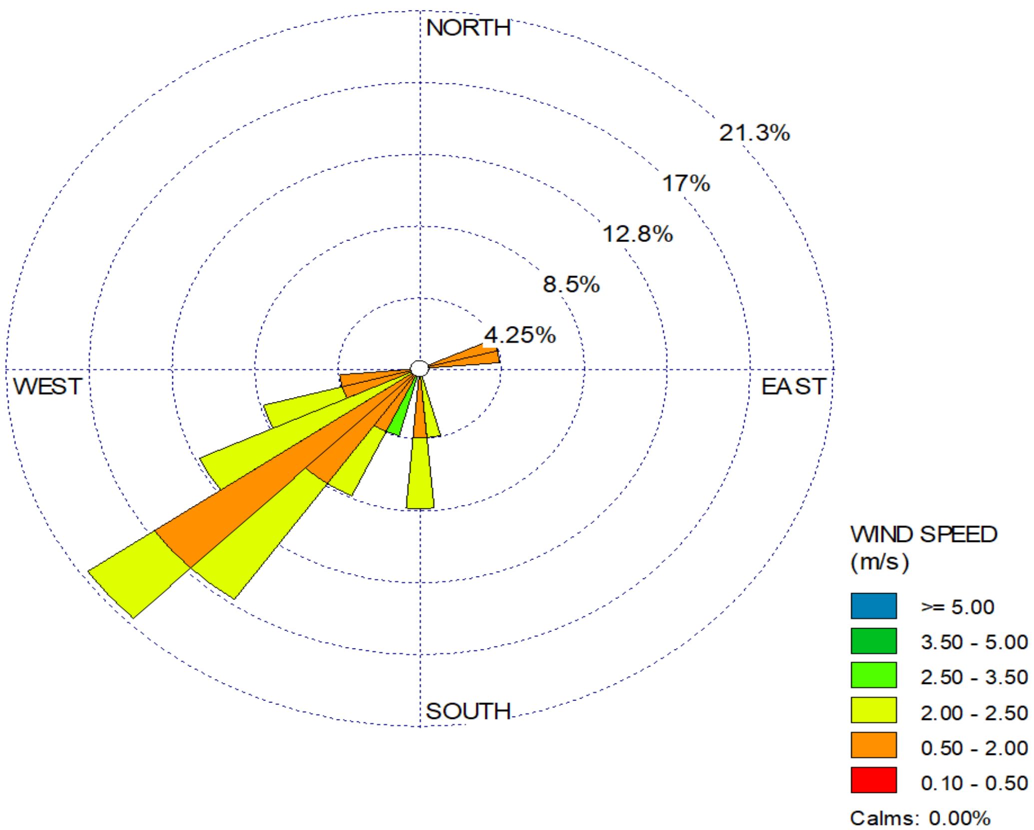


Figure 3.5: Wind rose of secondary meteorological data (2018 – 2022)

3.6.4.2 Temperature

The field result obtained during site monitoring (Table 2) indicates that temperature levels around the project site vary from $23.60^{0}C$ to $29.32^{0}C$ with a mean deviation of $25.81\pm1.22^{0}C$. Similarly, analysis of the five years secondary data (Table 3) also indicates that temperature levels ranged from $22.55^{0}C$ to $33.54^{0}C$ with a mean deviation of $28.76\pm0.96^{0}C$. Monthly analysis of five years secondary data (Table 3) indicates that mean temperature was minimum ($27.71^{0}C$) in August and maximum ($30.42^{0}C$) in February. Similarly, Yearly analysis of secondary data (Table 4) indicates that mean temperature was minimum ($28.68^{0}C$) in 2021 and maximum ($28.9^{0}C$) in 2020. The monthly average climate trend for 30 years as shown in Table 5 indicates that the months of July-September recorded lower temperatures ($28^{o}C$) due to rainy periods while the months of November to March recorded higher temperatures ($32\text{-}34^{o}C$) due to increased solar radiation with low cloud cover dominant during the dry season.

Temperature is an important weather variable because it determines the movement of water vapour, which brings precipitation. The time variations of diurnal mean temperature levels at the project site are shown in Figure 7. Temperature affects the chemistry of air pollutants as well as their emissions. The moderate levels of temperature observed in the area may result in the formation of small amount of photochemical oxidants such as ground-level ozone. However, the formation of ground-level ozone may increase during periods of high sunshine (high sun intensity) which often take place in the dry season due to thermal convection of solar radiation.

The ambient temperature is depending on the number of solar radiations reaching the surface of the earth and this affects the boundary layer stability condition of micro-meteorological atmospheric environment. Factors such as cloud cover and humidity also affect atmospheric temperature levels. The project area exhibits the characteristics of an unstable atmospheric condition, which prevents temperature inversion and favours air pollutants dispersion. The field data, secondary (NASA and NiMet) data show similar temperature levels in the proposed project area.

3.6.4.3 Relative humidity

The diurnal relative humidity measured during field monitoring of the proposed project site (Table 2) ranged from 70.0% to 98.12% with a mean deviation of 92.69±6.17. Similarly, analysis of the secondary data (Table 3) also indicates that relative humidity ranged from 60.12% to 96.12% with a mean deviation of 88.92±4.98%. Monthly analysis of secondary data (Table 3) indicates that mean relative humidity was minimum (82.97%) in January and maximum (91.58%) in September. Similarly, Yearly analysis of secondary data (Table 4) indicates that mean relative humidity was minimum (88.50%) in 2020 and maximum (89.6%) in 2021. In a similar study in Eleme where the proposed project is to be sited, Yorkor et al. (2017) reported an annual mean relative humidity of 80%.

Relative humidity plays important roles in pollutants' wash-out and acid rain formation. When relative humidity (the percentage value of water vapour in the air) rises above some critical point during rainy season, atmospheric SO_2 and NO_2 including suspended particles become soluble and are wash out from the atmosphere (Yorkor et al., 2017). Relative humidity was high in the rainy season months and low in the dry season months. Relative humidity was high when there was overcast cloud and low when it was sunny. Humidity values oscillate in tandem with air temperature, but as opposite fluxes as shown in Figure 7 (Yorkor et al., 2017). High relative humidity of this nature is expected in the project environment due to continuous complete cloud cover and prolong heavy precipitation in the rainy season (Yorkor et al., 2017). The variation of mean relative humidity in project area during field measurement is shown in Figure 7.

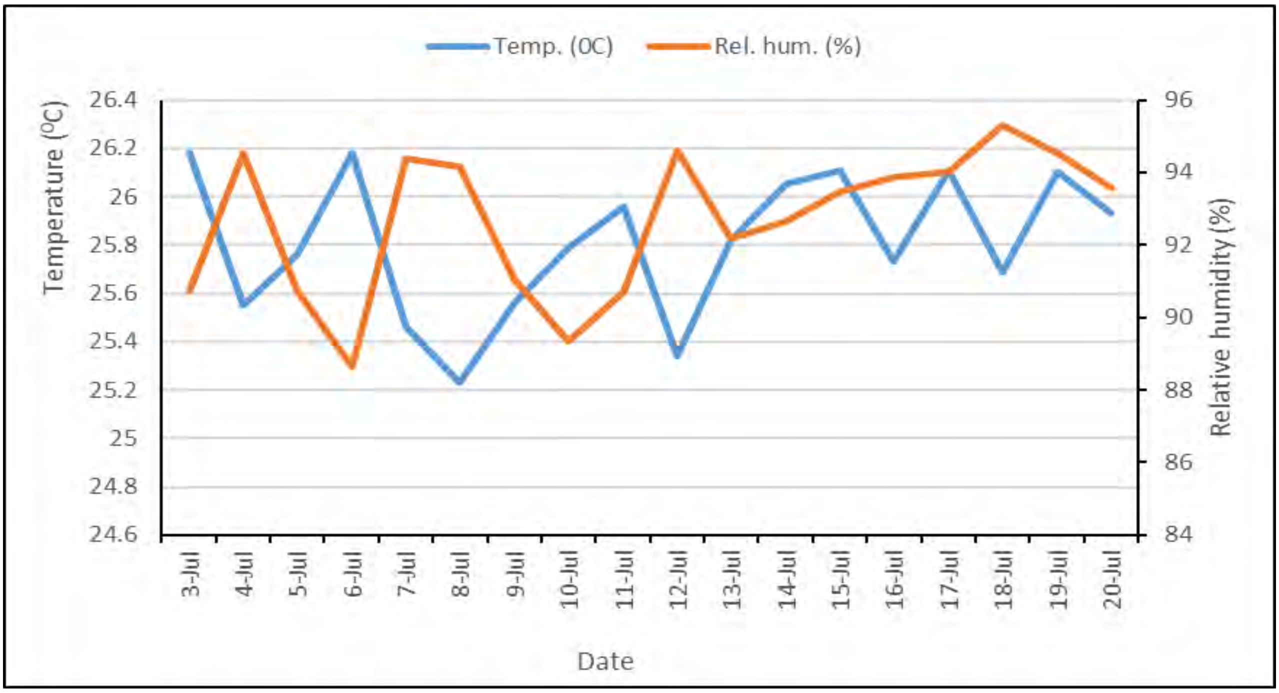


Figure 3.6: Trend in daily average diurnal temperature and relative humidity (July 3 – July 20, 2023)

3.6.4.4 Barometric air pressure

The diurnal barometric air pressure measured at the proposed project site (Table 2) ranged from 100.89kPa to 101.56kPa with a mean deviation of 101.21±0.14kPa. Similarly, analysis of the secondary data (Table 3) also indicates that barometric air pressure ranged from 100.58kPa to 101.48kPa with a mean deviation of 101.02±0.16kPa. Monthly analysis of secondary data (Table 3) indicates that mean barometric air pressure was minimum (100.88kPa) in January and March, and maximum (101.22kPa) in July and August. Similarly, Yearly analysis of secondary data (Table 4) indicates that mean barometric air pressure was minimum (1001.00kPa) in 2018 and 2022, and maximum (101.1kPa) in 2019 and 2020. These results fall within the normal range of the barometric air pressure of the earth (97.0kPa to 105.0kPa). Figure 8 shows the variation of diurnal mean barometric air pressure in project area during field measurement.

Barometric air pressure was lower in the dry season months compared to the rainy season months. The atmospheric pressure an area usually determines its wind and weather pattern across the area. The atmosphere exerts more pressure at the earth's surface than it does at higher elevations. Wind speed is in part a function of the steepness of the atmospheric pressure. The winds flow from the higher-pressure areas to the lower pressure areas resulting in unequal heating across the earth's surfaces. The wind speed is zero at the ground surface and rises with elevation to near the speed imposed by the atmospheric pressure gradient (Davis and Masten, 2004). The project area frequently experiences low pressure in the rainy season, which is associated with clouds, high winds, warm air, precipitation, and tropical storms. Contrarily, the project area experiences high pressure in the dry season, which is associated with clear sky and high long wave solar radiation or insolation.

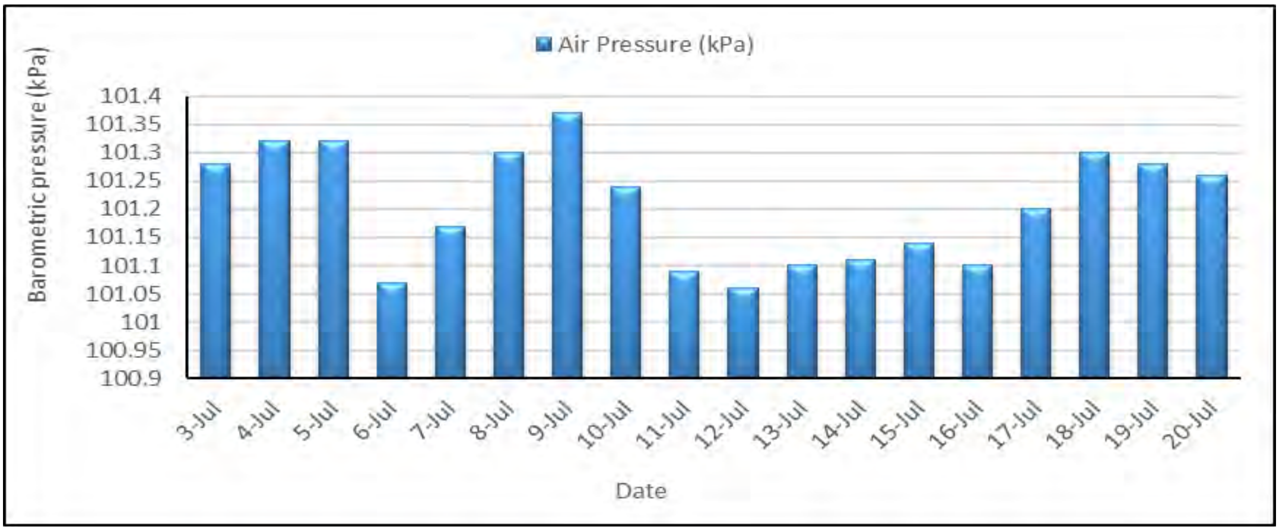


Figure 3.7: Trend in daily average diurnal barometric air pressure (July 3 – July 20, 2023)

3.6.4.5 Cloud Cover

A cloudy weather condition was observed in the proposed project area during the period of field monitoring in day hours. The observed cloud covers ranged between 5 and 8 Oktas, with average values between 6 and 7.5Oktas. A lofty cloudy weather of this nature is a common characteristic of the proposed project area during the months of rainy season. Elevated cloud cover causes the temperature of the atmosphere to fall at a rate greater than adiabatic lapse rate. This tends to suppress unstable atmosphere which enhances air emission dispersions. Sunny days are observed during the dry season and hence minimal cloud cover. Lower cloud cover in the dry season encourages unstable atmospheric conditions that promotes atmospheric emission dispersions.

3.6.4.6 Rainfall

Some rainfalls were observed during the period of field monitoring. The daily mean values of rainfall measured at the proposed project area ranged from 0.3mm to 3.2mm with an overall daily mean value of 1.0±1.7mm. Similarly, analysis of the secondary data (Table 3) also indicates that the monthly mean values of the secondary data ranged from 21.44mm to 431.34mm with an overall monthly mean of 223.10±155.62mm. Monthly analysis of the five years secondary data (Table 3) indicates that mean rainfall was minimum (21.44mm) in December and maximum (431.34mm) in September. Similarly, Yearly analysis of secondary data (Table 4) indicates that total rainfall was minimum (2723.46mm) in 2022 and maximum (4053.66mm) in 2020. The next highest rainfall was obtained in 2021 with a total rainfall of 4005.21mm. The monthly, mean rainfall distribution of 30 years (1990-2020) for the area is shown in Table 5. Average highest rainfall peaks were attained in September (374mm), July (368mm) and August (325mm). The lowest rainfall values were attained in January (17.2mm) and December (20.4mm). The 30 years (1990-2020) secondary data of the proposed project area shows that monthly rainfall between May and October averages over 300 mm, while the monthly averages for the months of dry season are below 40 mm.

The average amount of rainfall recorded in the project area during field measurement and the average amount of rainfall obtained in December corroborated the study by Ofomata (1975). This study indicates that the Niger delta region where the proposed project will be sited is a very wet region, with monthly mean rainfall ranging between 218.28mm and 408.25mm. The maximum amount of average rainfall occurs in the months of June, July, August and September indicating the periods of peak rainfall in the Onne, Eleme area, while the minimum average rainfall occurs in the months of December and January.

Rainfall in the project area begins in late March and ends in November due to the environment's closeness of the area to tropical wet maritime air mass of the Atlantic Ocean. The field data, secondary (NASA and NiMet) data show similar rainfall pattern in the proposed project area. The amount and distribution of rainfall in the area is such that it plays a vital role in atmospheric wash-out of air pollutants from the atmosphere to other areas of the environment. Rainfall plays a very significant role in environmental and air pollution studies because of its ability to cause wet deposition resulting in pollutants' wash-out from the atmosphere onto land and water. Rainfall has the ability to dissolve pollutants such as NO_2, CO and SO_2 to form acidic compounds resulting in the formation of acid rain, which could be hazardous to humans, plants, animals and the environment in general.

3.6.5. Identification of likely Climate Impacts

Analysis of micro-meteorological data showed that the proposed project area exhibits the characteristics of very unstable to slightly unstable atmospheric condition according to Pasquill-Gifford Stability Classes (Davis and Masten, 2004). Atmospheric stability is important as it influences the rate of dispersion of pollutants. Increased amounts of turbulence atmospheric conditions will cause air pollutants to be dispersed more rapidly than with more stable atmospheric conditions. Both the field data and the secondary data indicated three main wind class of the project area ranging from 0.5 to 3.5 m/s (Classes A, B and C), suggesting unstable atmosphere. The climatic condition indicates that the atmosphere will be unstable throughout the year. However, July and August would experience slightly unstable atmosphere.

The project area is dominated by the tropical maritime air-mass from the Atlantic Ocean most time of the year. Air pollutants would be dispersed towards the northern direction in the rainy season and towards the southern direction in the dry season. Temperature levels observed in the area may result in the formation of photochemical oxidants. Rainfall and relative humidity may dissolve pollutants such as NO_2, CO and SO_2 to form acidic compounds resulting in the formation of acid rain. Generally, the proposed project is expected to have negligible impacts on the local climate.

3.6.6. Conclusion

Moderate mean wind speed and mean temperature and high mean relative humidity are common characteristics of the proposed project area. Wind speed showed no period of clam atmosphere. Prevailing wind directions were north-easterly in the dry season and south-westerly in the rainy season. Air pollutants would be dispersed towards the northern direction in the rainy season and towards the southern direction in the dry season. The moderate levels of temperature observed in the area may cause the formation of small number of photochemical oxidants such as ground-level ozone. The project area exhibits the characteristics of an unstable atmospheric condition, which prevents temperature inversion and favours air pollutants dispersion. High levels of relative humidity and rainfall in the project area may result in atmospheric wash-out of dissolved air pollutants during construction and operations. The proposed project is expected to have negligible impacts on the local climate.

3.7 NOISE ASSESSMENT REPORT

EXECUTIVE SUMMARY

Overview: The noise study of the proposed project area was conducted from July 4^{th} to July 17^{th}, 2023. The exercise was carried out in compliance with statutory requirements. A total of fourteen (14) sampling stations were monitored for the assessment of existing baseline ambient noise status of the project environs. Twelve (12) stations were established within and around the project site, while two (2) stations were established outside the project site as control stations.

Methodology: existing baseline noise levels of the proposed project area were measured using a Type 1 digital Cygnet integrated data logging sound level data logger (model 2001), which logged data continuously over the period of time. The instrument was programed to log or record data at every one (1) minute) interval. The noise monitoring was conducted for both daytime and nighttime.

Result: Baseline result obtained during daytime monitoring indicated that the daytime noise levels varied from 41.1dBA (minimum) at station N3 to 55.7 (maximum) at station NC1. L_{10} was minimum (48.4dBA) at station N1 and maximum (52.9dBA) at station N7; L_{50} was minimum (47.0dBA) at station N10 and maximum (50.8dBA) at station NC1; L_{90} was minimum (45.6dBA) at station N11 and maximum (48.2dBA) at station NC. Daytime L_{eq} was minimum (47.1dBA) at station N10 and maximum (51.1dBA) at station NC1; while nighttime L_{eq} was minimum (38.6dBA) at station N12 and maximum (39.9 dBA) at station N2, N9 & NC1. These values are below both NESREA and IFC permissible limits and represent the baseline noise environment of the proposed project area before construction and operation activities.

Identified existing potential sources of noise around the project site is operation of construction equipment and, vehicular movement.

3.7.1. Introduction

Field monitoring exercise of noise levels for the proposed project was conducted from July 4^{th} to July 17^{th}, 2023, in compliance with statutory requirements. Ambient noise monitoring was required to determine the existing noise environment of the proposed project area. Prolonged exposure to noise of value higher than specified limits can result in temporary hearing loss (temporary threshold shift) or permanent hearing loss (permanent threshold shift). (Sheela, 2000).

3.7.2. Methodology

3.7.2.1 Sampling Strategy

The noise survey was carried out at fourteen (14) sampling stations (shown in Table 1) within the proposed project geographical zone. Ten (10) out of the fourteen (14) stations were located within the proposed site, two (2) located around the project site, while two (2) control stations were located about 2 to 3kilometers away from the project site.

A brief description of the sampling stations relative to the project site, sampling station codes, and coordinates are presented in Table 1 and on Google earth map shown in Figure 1. The first controls station (ANC1) was monitored at Owo gono community, located approximately 1.8km from the project site; while the second control station (ANC2) was monitored at Ele community, located about 2.7km from the project site.

Table 3.6: Sampling stations and Coordinates

Station	**Description**	**Latitude**	**Longitude**
N1	Within the project site boundary in South, Southeast directions	4°40'00.60"N	7°8'47.40"E
N2	Within the project site boundary in South, Southwest directions	4°40'02.30"N	7°8'37.88"E
N3	Within the project site boundary in South, Southwest directions	4°40'05.95"N	7°8'28.79"E
N4	Within the project site boundary in West, South directions	4°40'07.01"N	7°8'20.89"E
N5	Within the project site boundary in West, Northwest directions	4°40'22.98"N	7°8'21.48"E
N6	Within the project site boundary in North, Northwest directions	4°40'22.62"N	7°8'30.84"E
N7	Within the project site boundary in North, Northeast, Southeast directions	4°40'19.76"N	7°8'42.39"E
N8	Inside the project site	4°40'10.79"N	7°8'41.83"E
N9	Middle of project site	4°40'09.97"N	7°8'29.96"E
N10	Inside the project site	4°40'07.56"N	7°8'45.88"E
N11	Within the project site boundary in South, Southeast directions	4°40'05.08"N	7°8'51.93"E
N12	Within the project site boundary in East, North, Southeast, directions	4°40'17.68"N	7°8'52.74"E
NC1	Outside the project site boundary in South, Southeast directions (After river) – Owo gono cummunity	4°39'33.39"N	7°9'21.92"E
NC2	Outside the project site boundary in Northeast, Southeast directions (After river) – Ele community	4°41'23.76"N	7°9'39.04"E

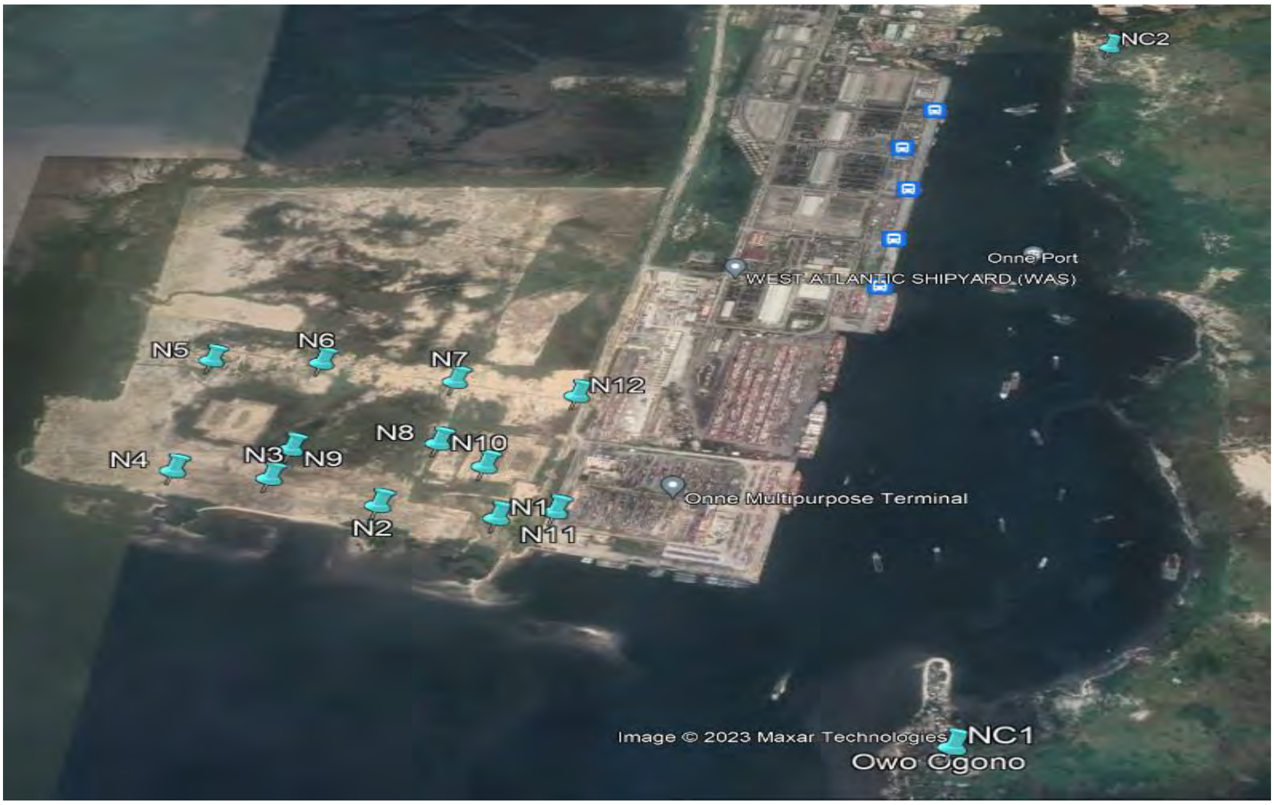


Figure 3.8: map showing ambient noise monitoring stations.

3.7.2.2 Instrumentation and Sampling Techniques

Noise monitoring was undertaken using the CYGNET Integrating Datalogging Sound Level Meter 2001. This datalogging Sound Level Meter is Type 1 accuracy (Precision grade) instrument conforming to IS 9779:1981 and Class 1 IEC 61672:2013 with built-in smart integrating algorithms. The equipment has a measuring range of 34-134 dB in three scales, each with a dynamic range of 50 dB. The scales are 34-84 dB, 54-104 dB, 84-134. It also measures noise with A, C and Lin weightings. A slow, fast, and impulse time response is provided on the equipment, it can store up to 128K readings in its memory and the time interval between readings may be set between 0.025 seconds and 9999 seconds. It was calibrated with a digital Multi- Range Sound Acoustic Calibrator. The instrument measure noise levels via a microphone probe that generates signals appropriately proportional to sound waves. The sensor of the noise meter was directed up wards and the reading were recorded by instrument in one-minute intervals. In day hours monitoring period was for five to seven hours whereas in night hours monitoring period was one hour. In day hours monitoring was performed in between 8 AM to 6PM and in night hours in between 11:00PM to 6AM when there was no rain, and the wind speed is less than 5m/s. The instrument was placed approximately 1.5m above the ground level in open terrain and no closer than 3m to any reflecting surface. The recorded noise data were downloaded and processed by using DL03 software to get the various noise indices.

Table 3.7 Monitoring station details

Station Code	Sampling Location	Monitoring Date	Monitoring duration min.)		Remark or Field Observation, if any
			Day	Night	
N1	Within the project site boundary in South, Southeast directions	04/07/23	367	60	Sound from singing birds, Nigerian Navy Ship base, port activities
N2	Within the project site boundary in South, Southwest directions	05/07/23	330	60	Sound from singing birds, Nigerian Navy Ship base, port activities
N3	Within the project site boundary in South, Southwest directions	06/07/23	367	60	Sound from singing birds, Nigerian Navy Ship base, port activities
N4	Within the project site boundary in West, South directions	07/07/23	367	60	Sound from singing birds, Nigerian Navy Ship base, port activities
N5	Within the project site boundary in West, Northwest directions	08/07/23	420	60	Singing birds, earth moving equipment working on the northern side of the project site
N6	Within the project site boundary in North, Northwest directions	09/07/23	304	60	Singing birds, earth moving equipment working on the northern side of the project site
N7	Within the project site boundary in North, Northeast, Southeast directions	10/07/23	367	60	Singing birds, earth moving equipment working on the northern side of the project site
N8	Inside the project site	11/07/23	367	60	Sound from singing birds, Nigerian Navy Ship base, port activities
N9	Middle of project site	12/07/23	367	60	Sound from singing birds, Nigerian Navy Ship base, port activities
N10	Inside the project site	13/7/2023	367	60	Sound from singing birds, Nigerian Navy Ship base, port activities
N11	Within the project site boundary in South, Southeast directions	14/7/2023	360	60	Sound from singing birds, Nigerian Navy Ship base, port activities
N12	Within the project site boundary in East, North, Southeast, directions	15/7/2023	429	60	Sound from Singing birds, earth moving equipment working on the northern side of the project site
NC1	Outside the project site boundary in South, Southeast directions (After river) – Owo gono cummunity	16/7/2023	300	60	Sound from domestic animals and singing birds
NC2	Outside the project site boundary in Northeast, Southeast directions (After river) – Ele community	17/7/2023	300	60	Sound from domestic animals and singing birds

3.7.3. Baseline Noise Results

The summary result of the noise levels measurement during field survey is presented in Table 4.

Table 3.8: Summary statistic of **Baseline** noise levels **of the proposed project area**

	Daytime (dBA)							Night-Time (dBA)					
Station	**Min.**	**Max.**	**L_{10}**	**L_{50}**	**L_{90}**	**L_{eq}**		**Min.**	**Max.**	**L_{10}**	**L_{50}**	**L_{90}**	**L_{eq}**
N1	41.9	53.9	48.4	47.3	45.8	47.4		35.9	40.3	39.3	38.6	36.8	38.7
N2	42.1	55.1	51.0	48.4	47.5	48.6		35.9	41.6	40.8	39.8	38.5	39.9
N3	41.1	52.6	49.3	48.1	47.1	48.2		41.1	52.6	40.9	38.3	37.5	38.5
N4	42.1	55.3	50.2	48.2	44.6	48.7		36.2	41.9	38.9	38.5	37.2	38.6
N5	42.1	53.7	49.5	47.9	45.6	48.1		36.1	41.8	40.2	38.5	36.9	38.7
N6	41.6	55.1	50.1	48.5	47.4	48.6		36.2	40.8	40.2	38.8	37.4	38.9
N7	41.9	55.4	52.9	48.8	47.9	49.2		36.6	41.9	41.1	39.7	38.1	39.4
N8	42.3	55.2	51.3	49.5	47.8	49.8		36.2	41.9	41.3	39.3	37.4	39.5
N9	41.7	55.6	50.0	49.0	48.1	49.1		36.1	41.9	40.9	39.8	38.7	39.9
N10	41.8	54.7	49.4	47.0	46.8	47.1		36.2	42.6	40.7	38.7	37.1	38.9
N11	41.8	54.5	50.3	48.5	45.6	48.9		36.1	41.8	39.1	38.7	37.2	38.8
N12	41.9	55.1	50.7	47.3	46.8	47.5		35.8	41.7	40.1	38.5	37.5	38.6
NC1	42.1	55.7	52.3	50.8	48.2	51.1		36.1	42.1	40.1	39.3	37.2	39.9
NC2	42.1	52.9	51.3	48.5	45.9	49.0		36.2	41.3	40.8	39.5	37.0	39.7

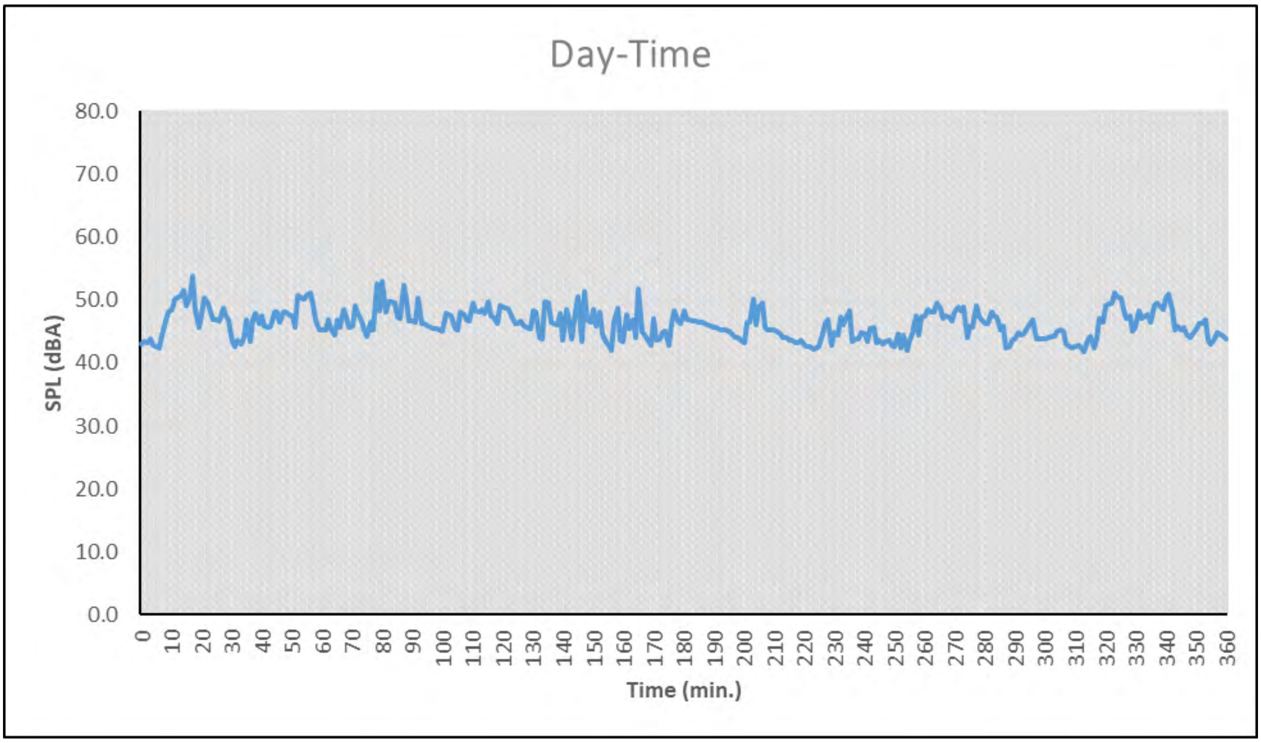
3.7.4. Discussion of results and findings

Baseline results obtained during daytime monitoring indicated that daytime noise levels varied from 41.1dBA (minimum) at station N3 to 55.7 (maximum) at station NC1. L_{10} was minimum (48.4dBA) at station N1 and maximum (52.9dBA) at station N7; L_{50} was minimum (47.0dBA) at station N10 and maximum (50.8dBA) at station NC1; L_{90} was minimum (45.6dBA) at station N11 and maximum (48.2dBA) at station NC1. Daytime L_{eq} was minimum (47.1dBA) at station N10 and maximum (51.1dBA) at station NC1; while nighttime L_{eq} was minimum (38.6dBA) at station N12 and maximum (39.9 dBA) at station N2, N9 & NC1. These values are below both NESREA (day 70dB(A), Night 60dB(A) and IFC permissible limits (Residential 55 (day) & 45 (night) and Commercial 70db(A)) represent the baseline condition of existing noise environment of the proposed project area before construction and operation activities.

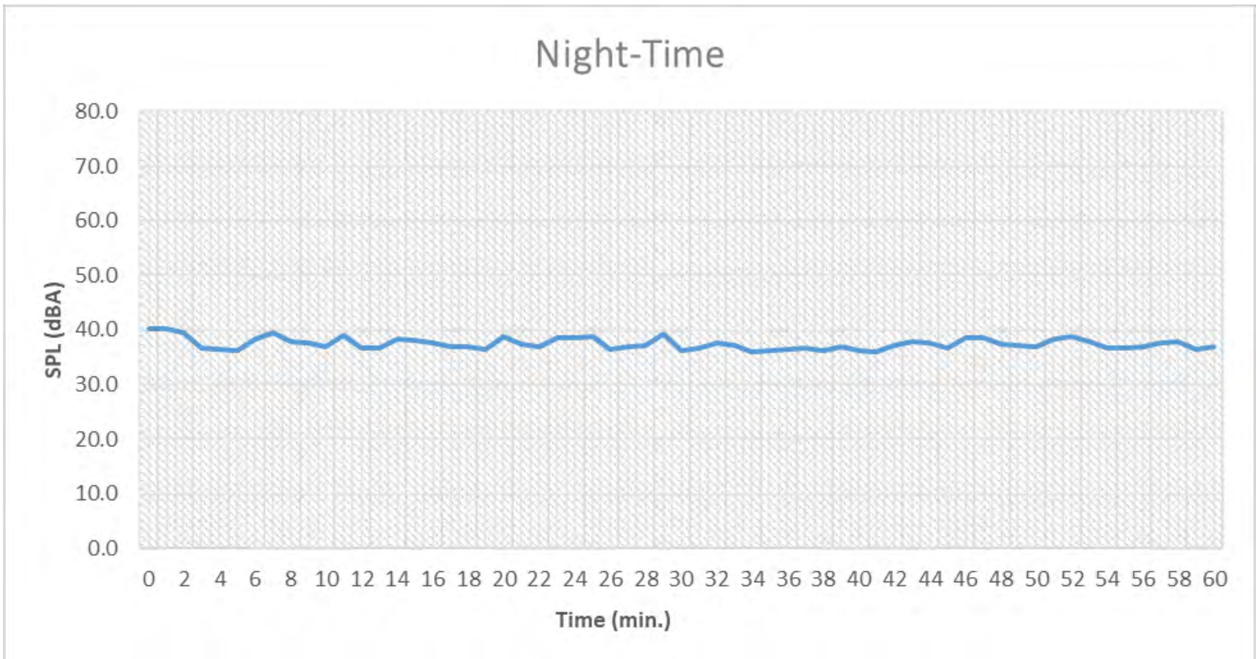
3.7.5 Conclusion

Baseline noise levels around the project area are generally low, below prescribed permissible limits. With appropriate noise control measures in place during construction and operation, noise levels shall be adequately controlled, and impacts shall be minimized.

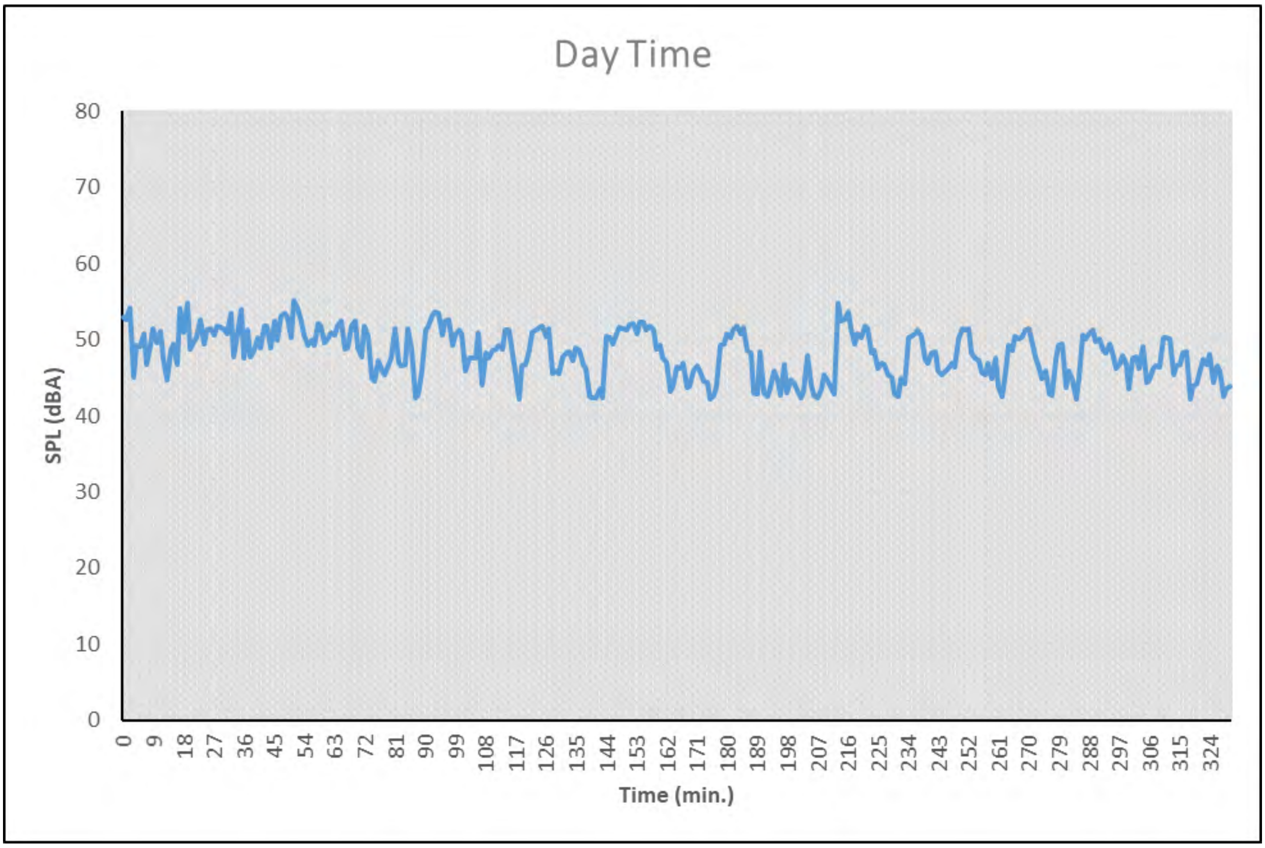
Figure 3.9 Time series Noise Graphs



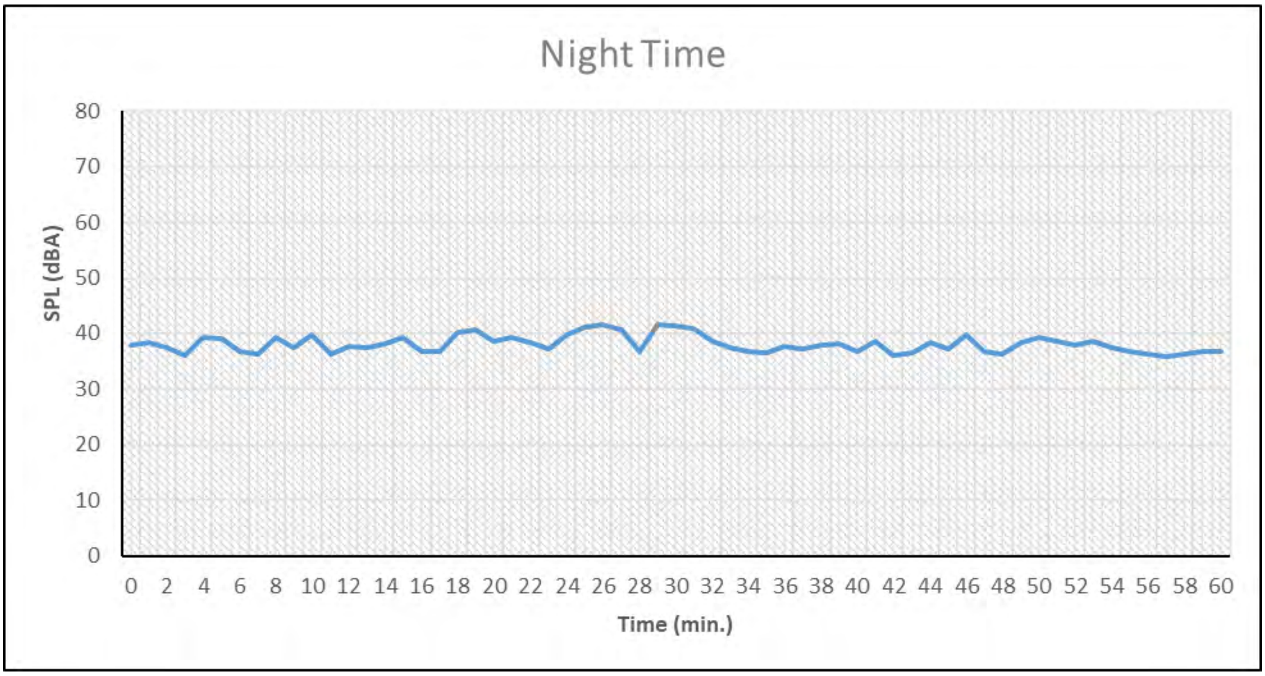
N1 – Day Hours



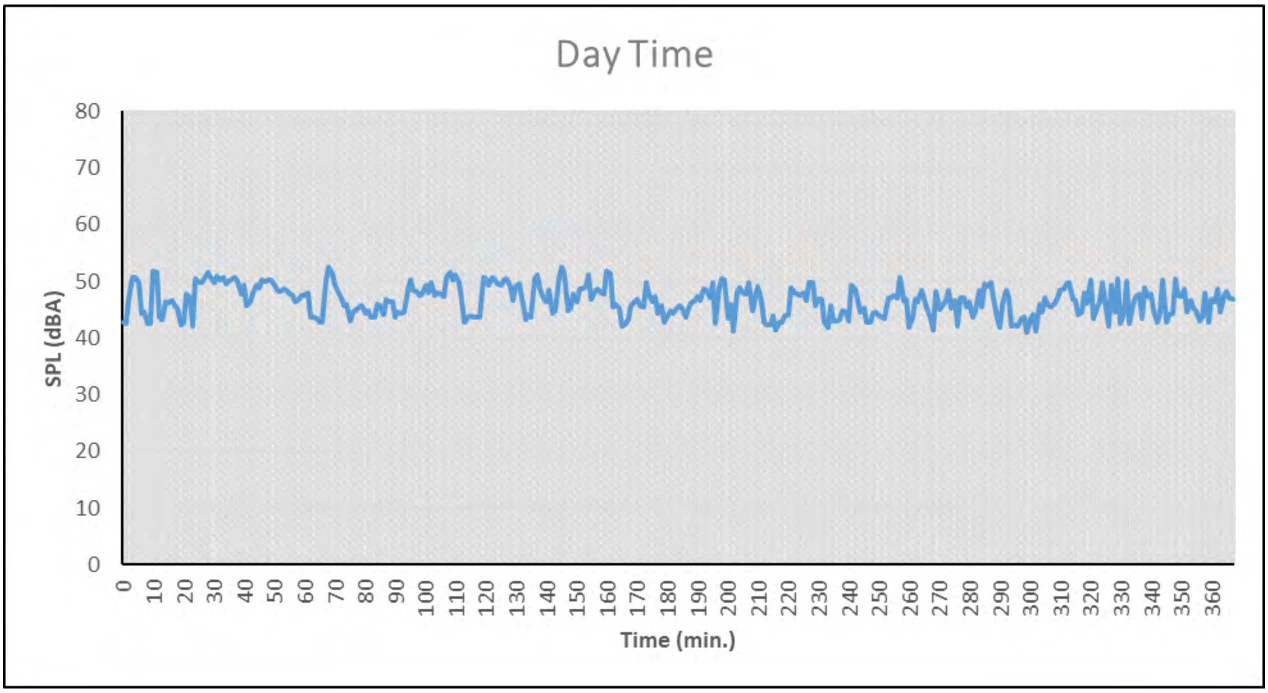
N1 – Night Hours



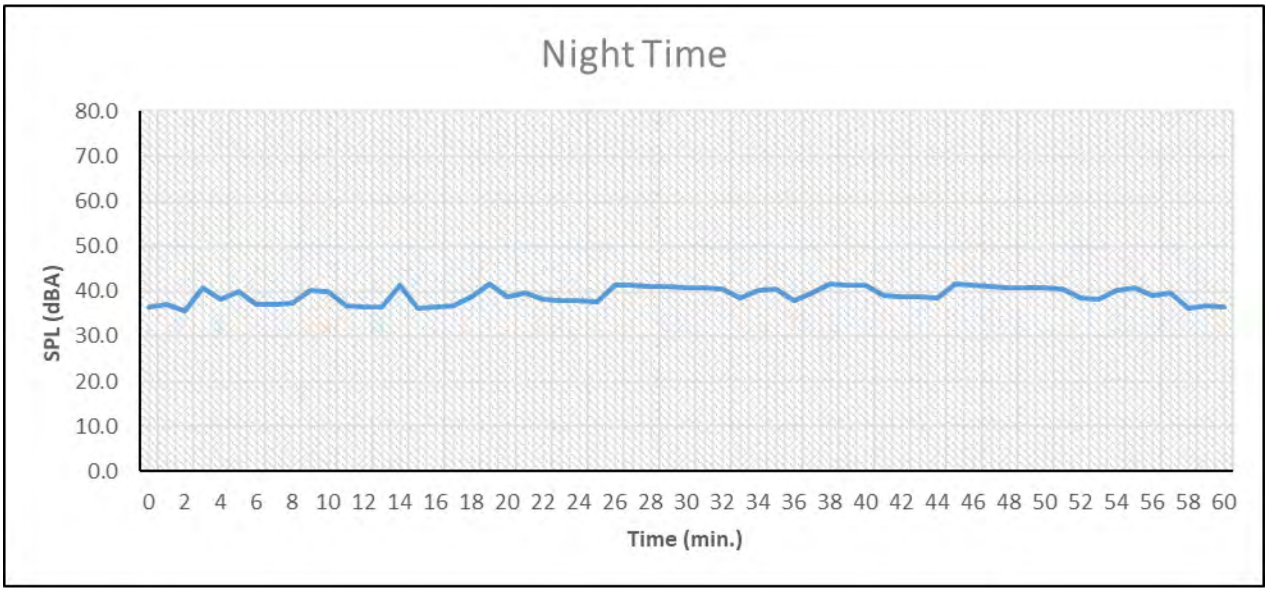
N2 – Day Hours



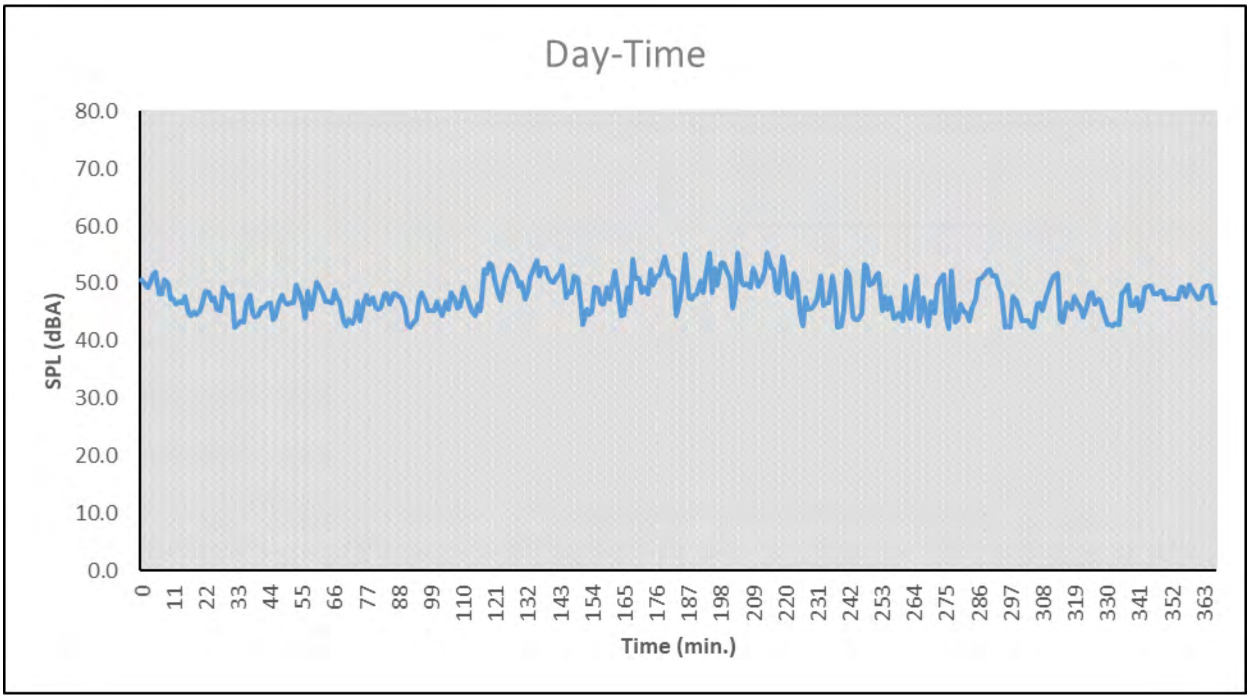
N2 – Night Hours



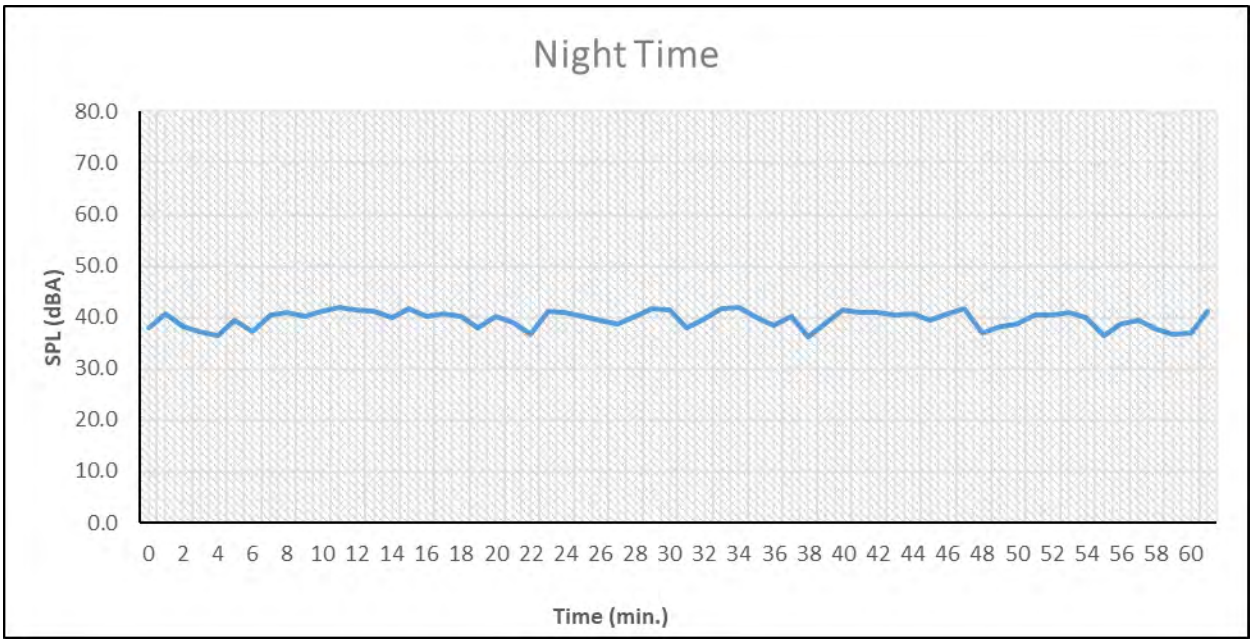
N3 – Day Hours



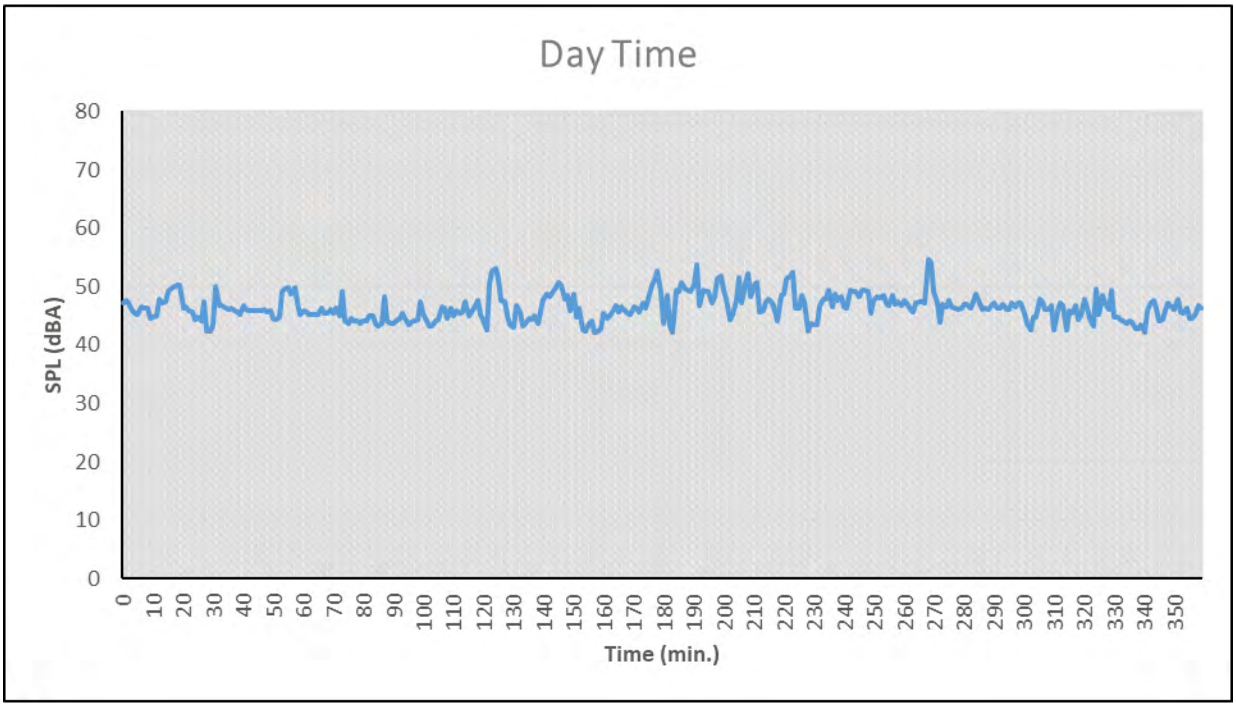
N3 – Night Hours



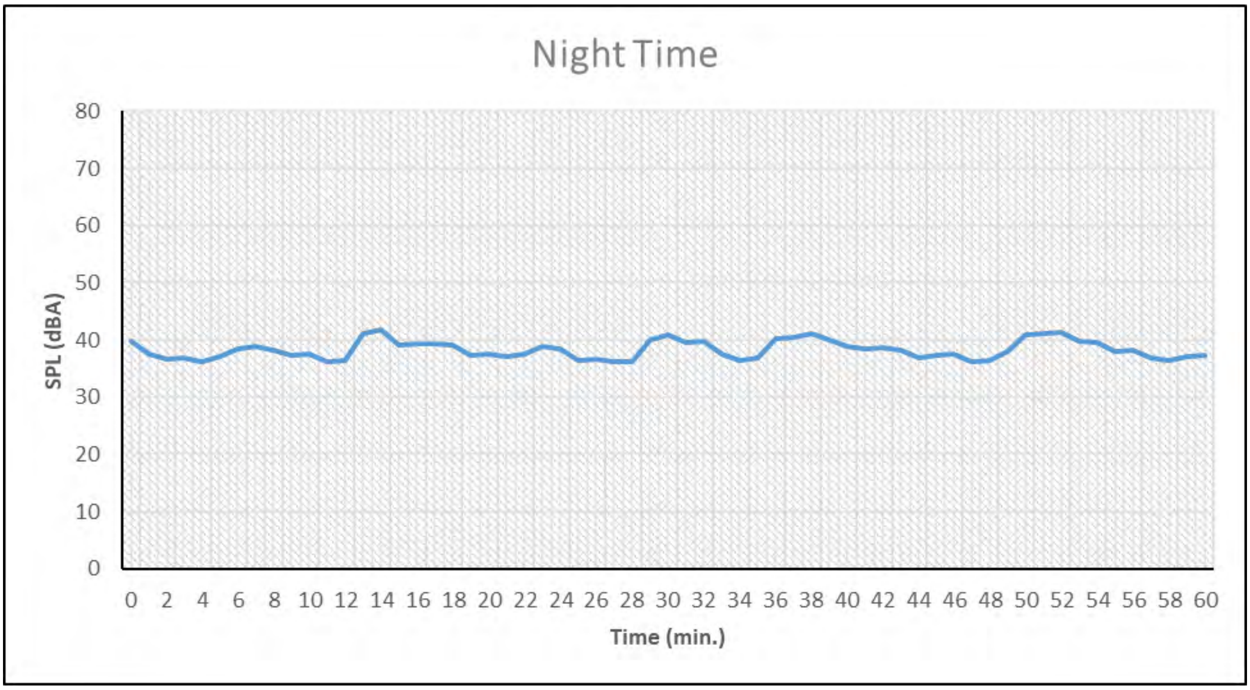
N4 – Day Hours



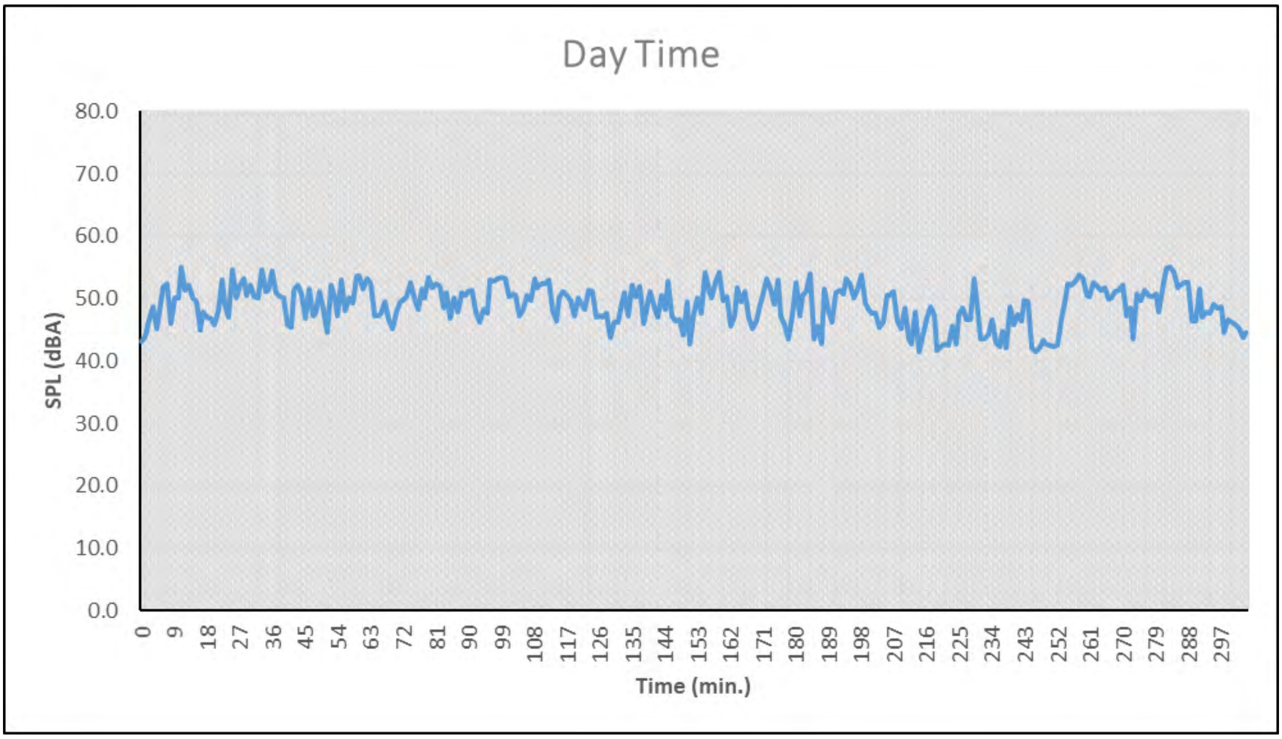
N4 – Night Hours



N5 – Day Hours



N5 – Night Hours



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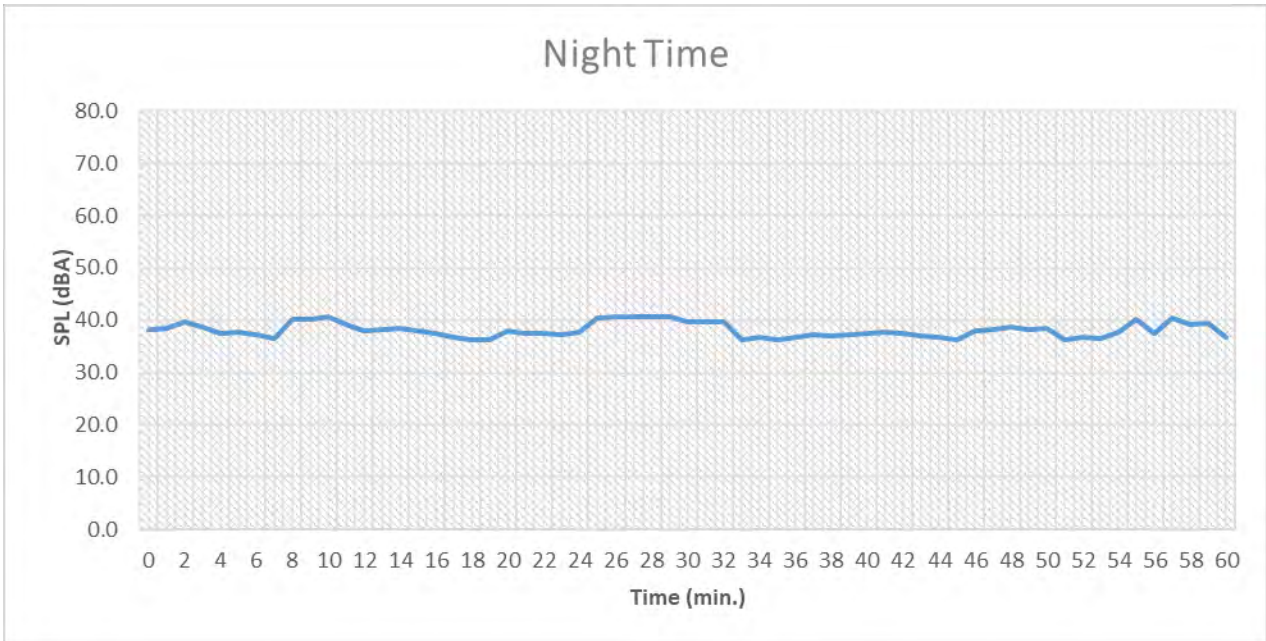

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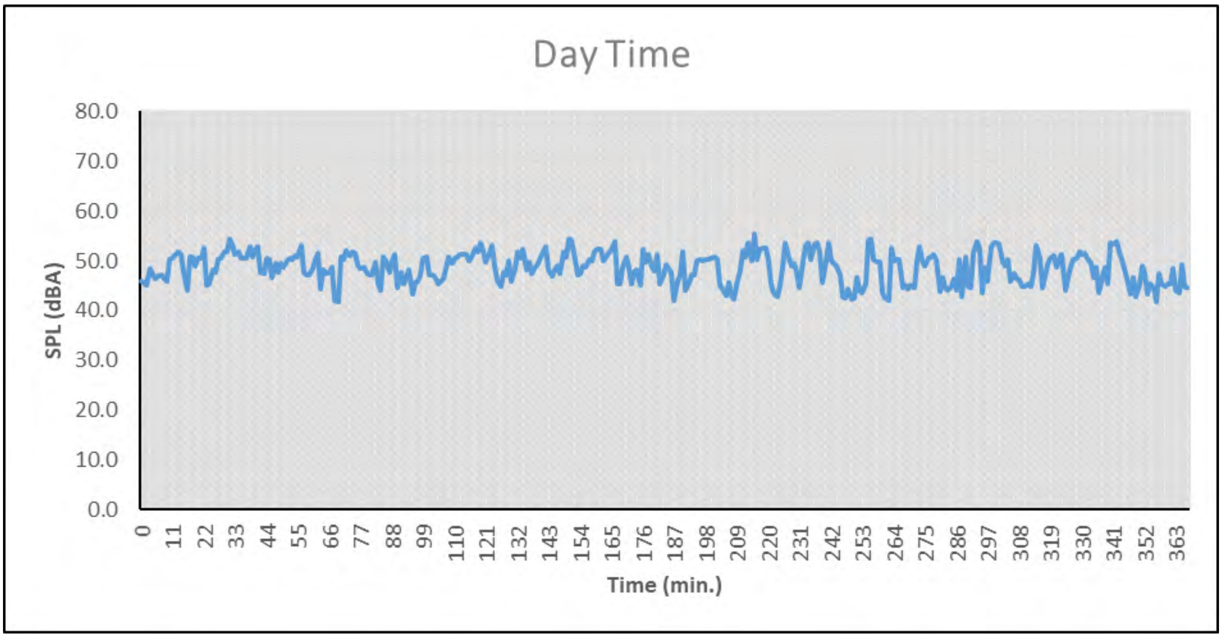

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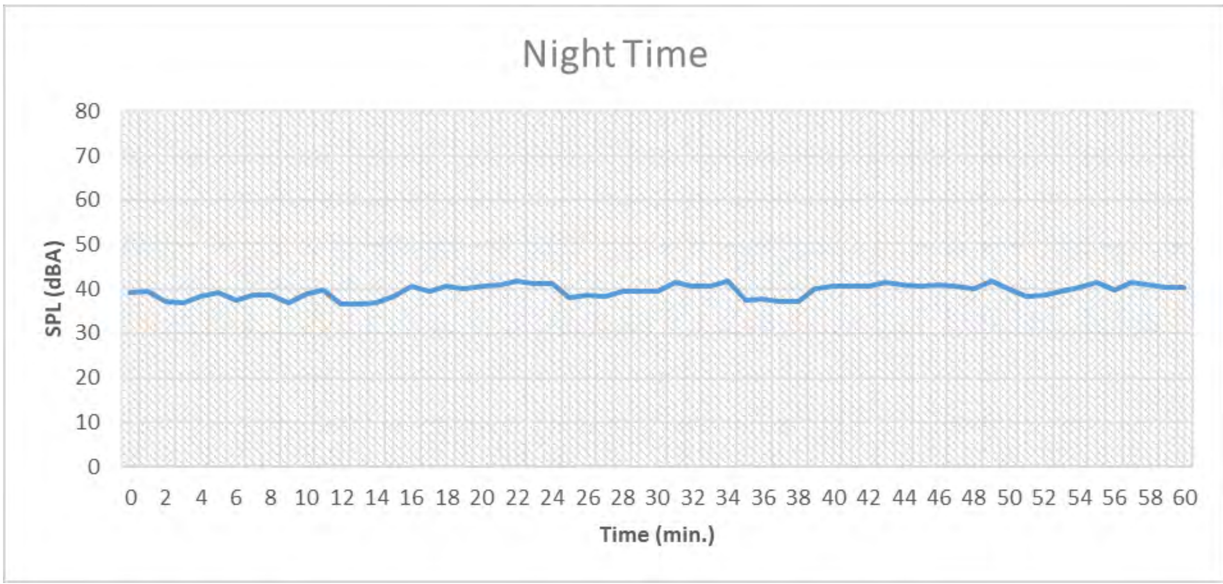

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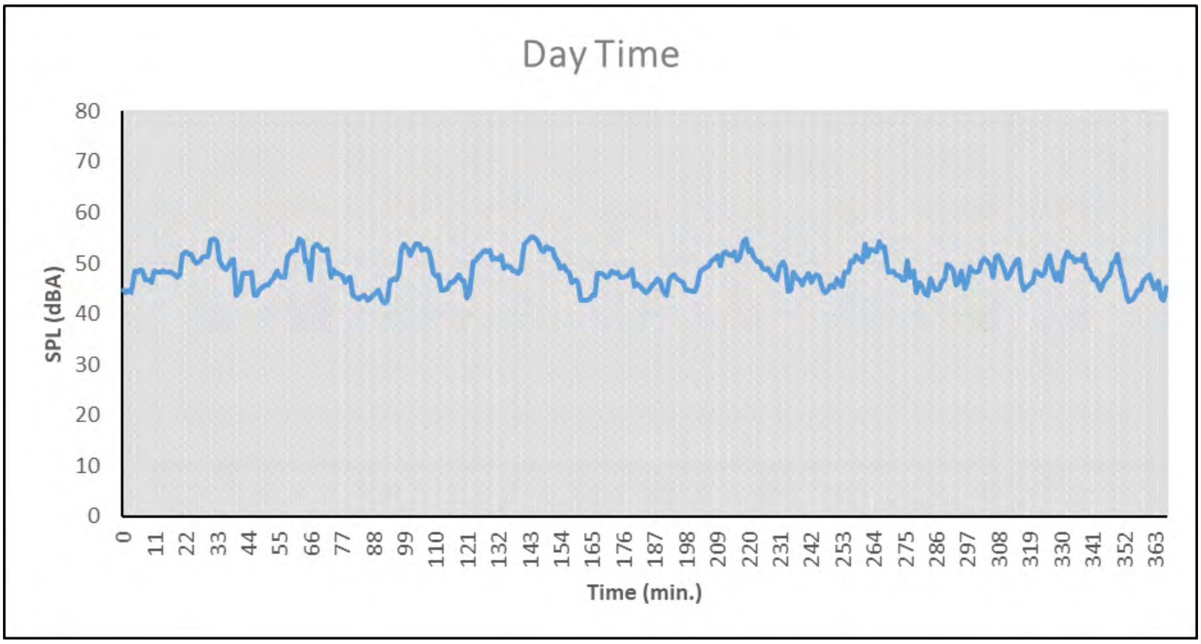

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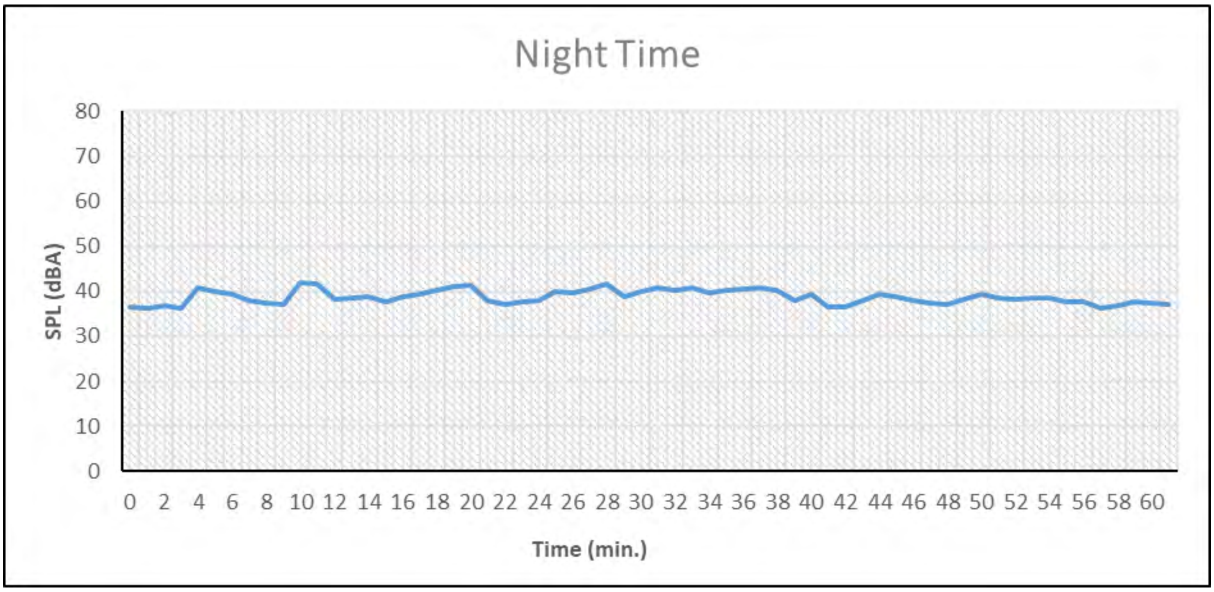

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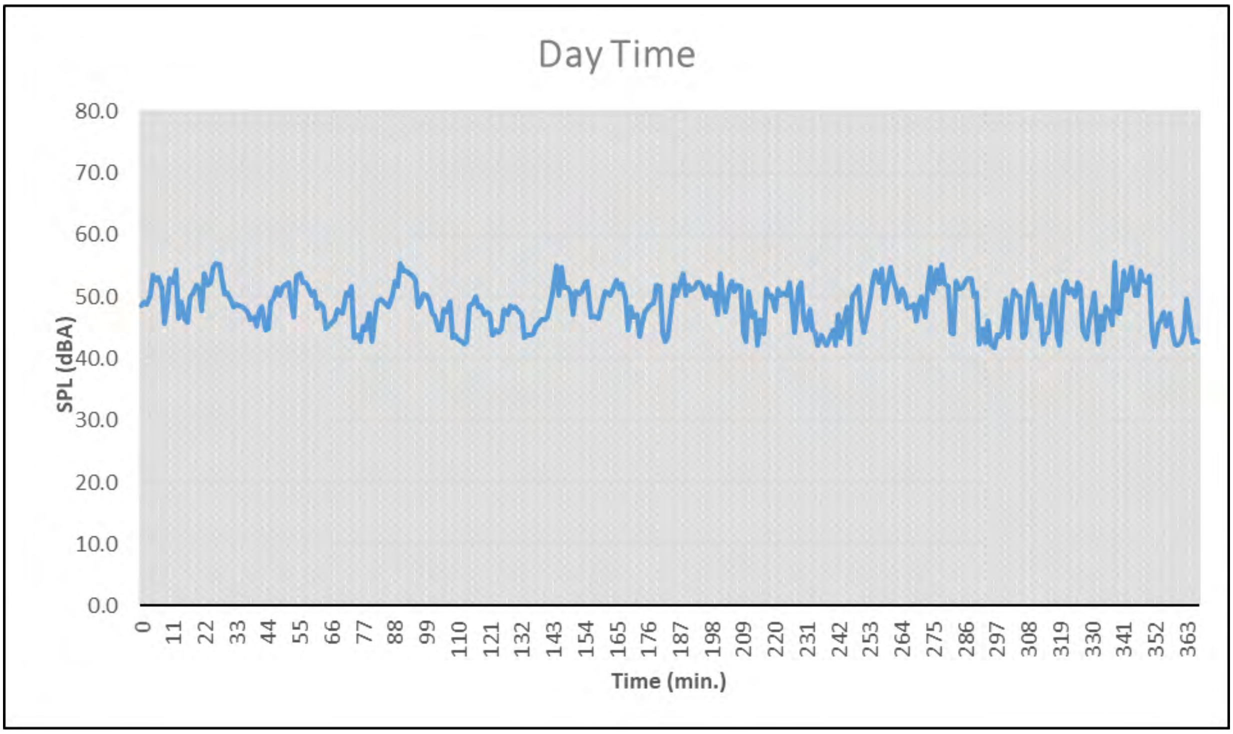

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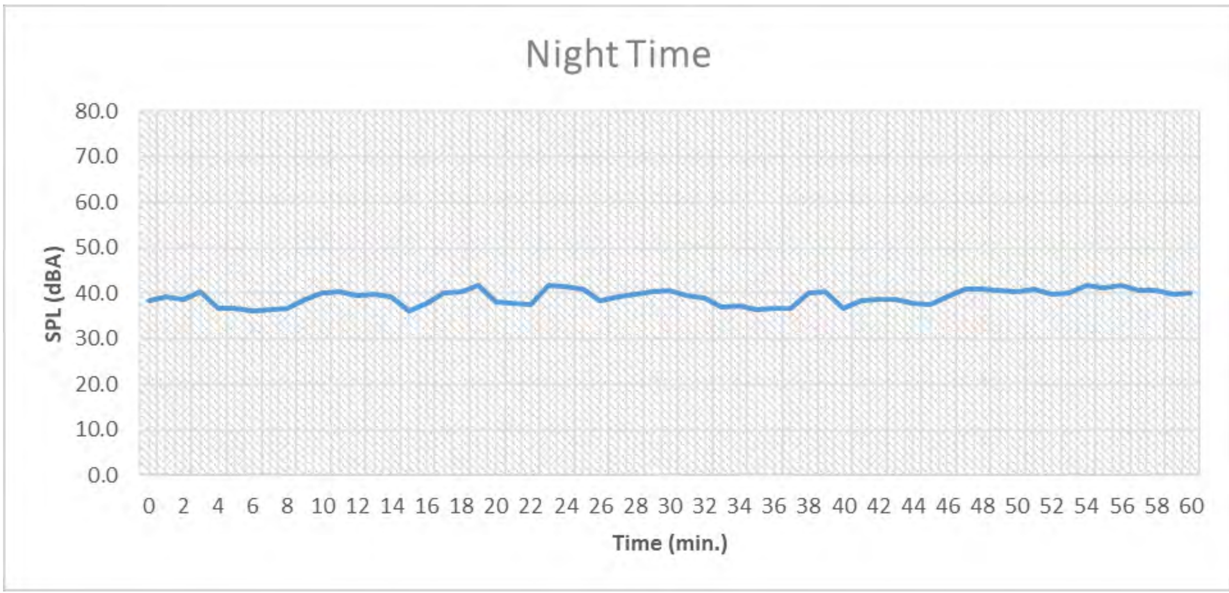

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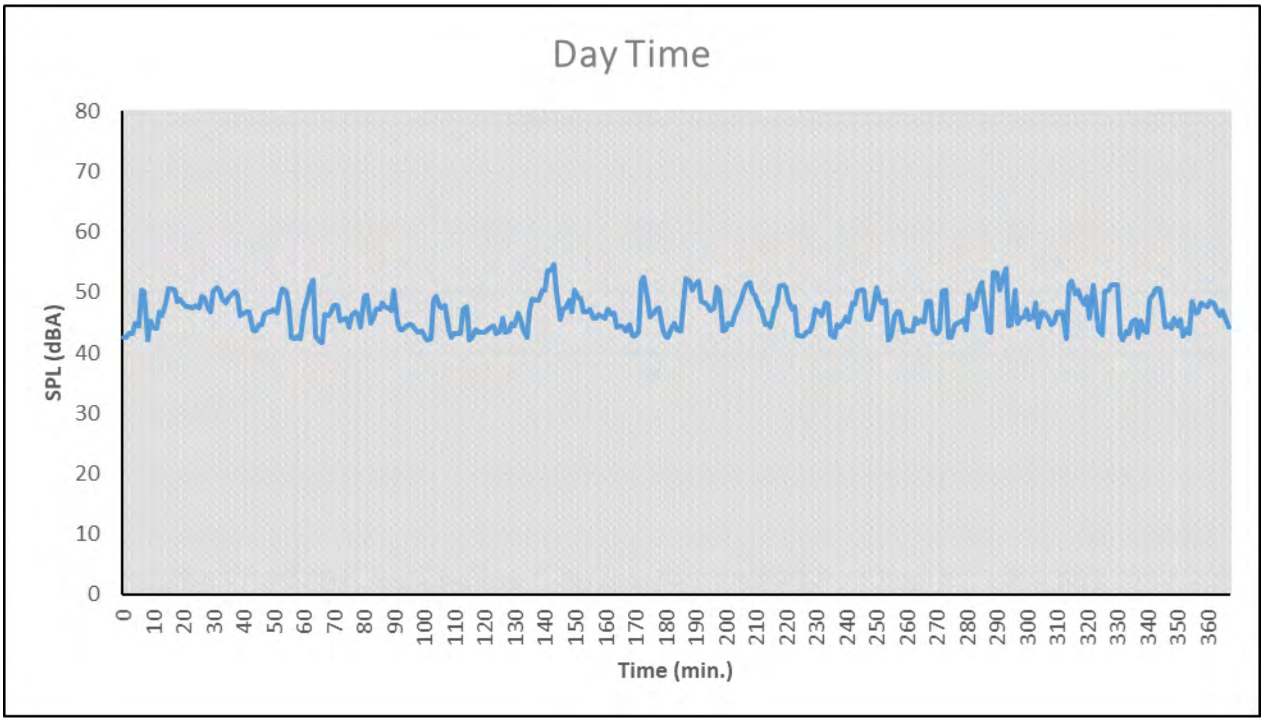

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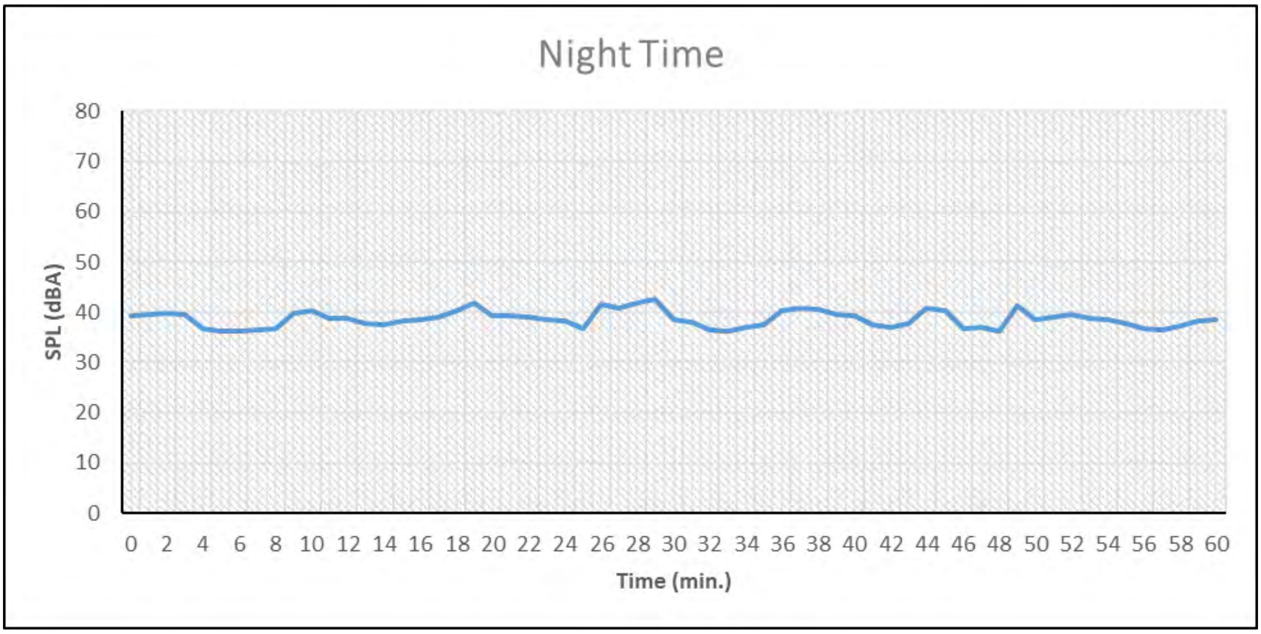

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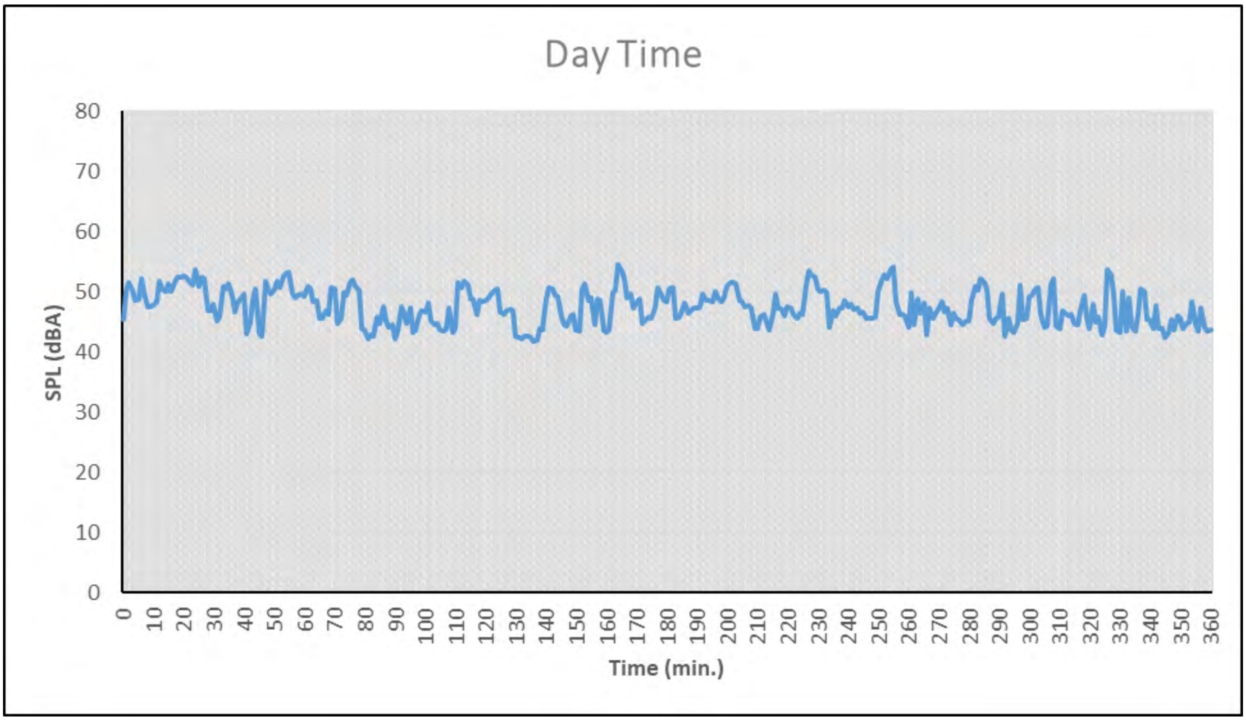

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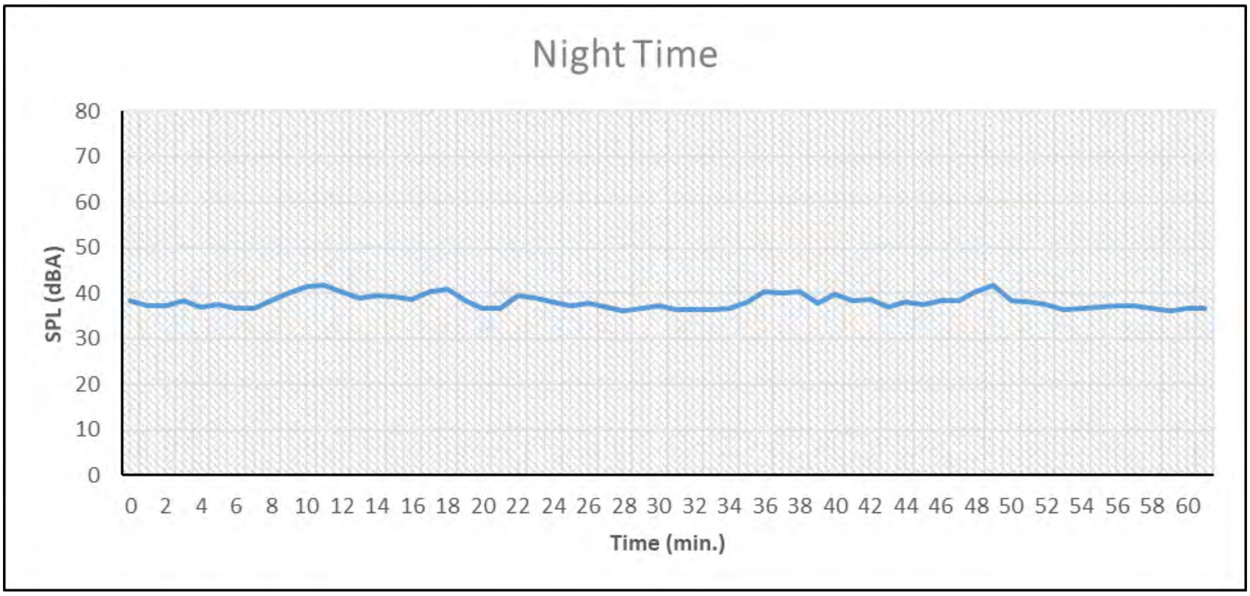

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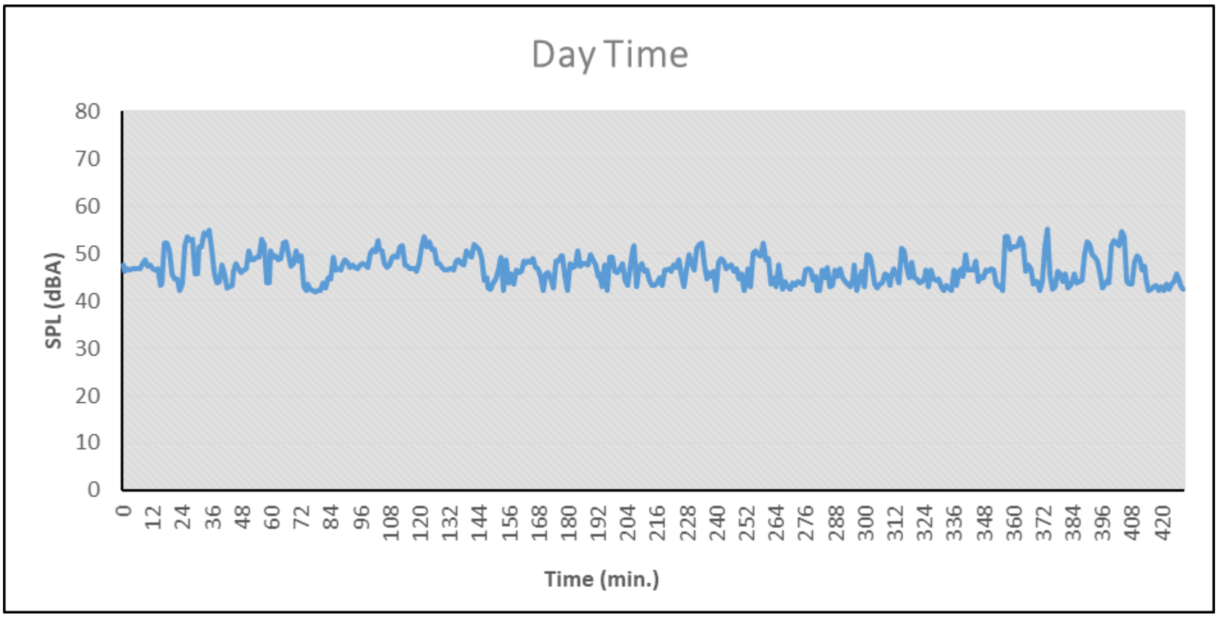

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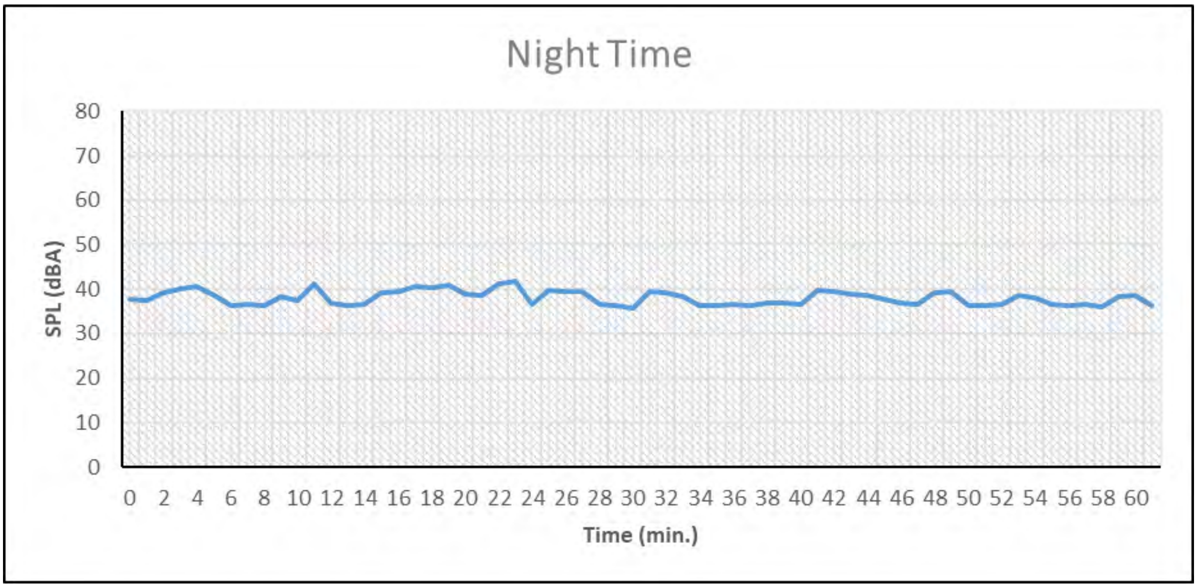

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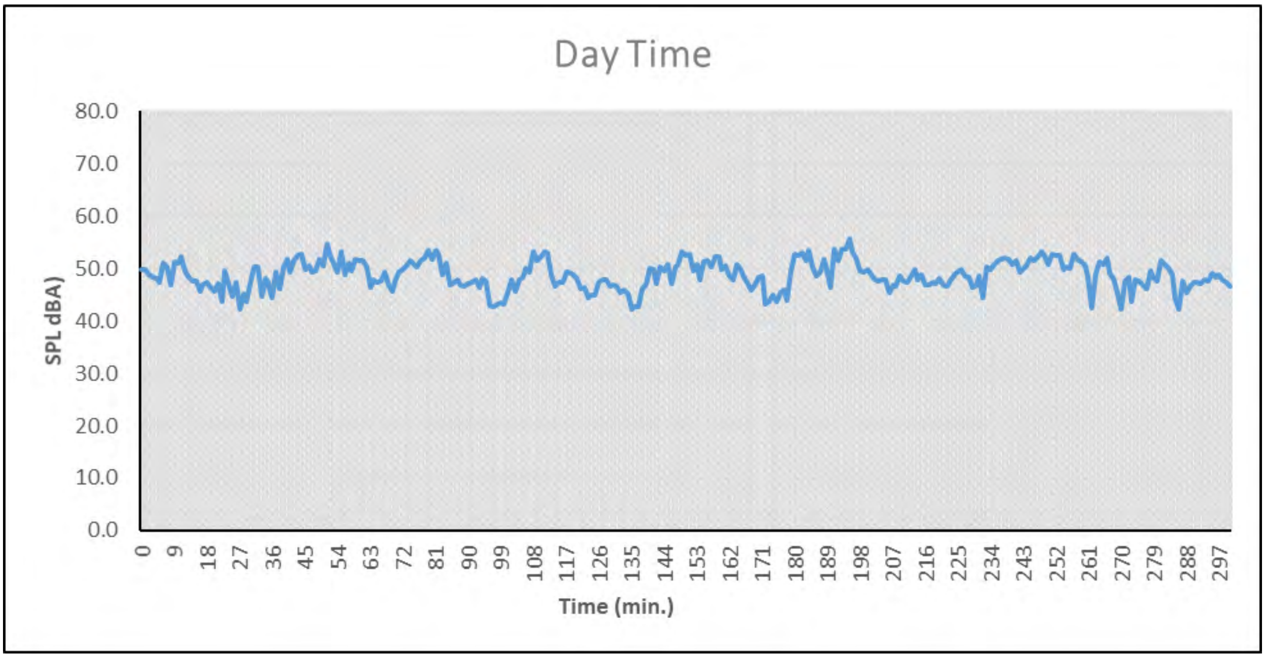
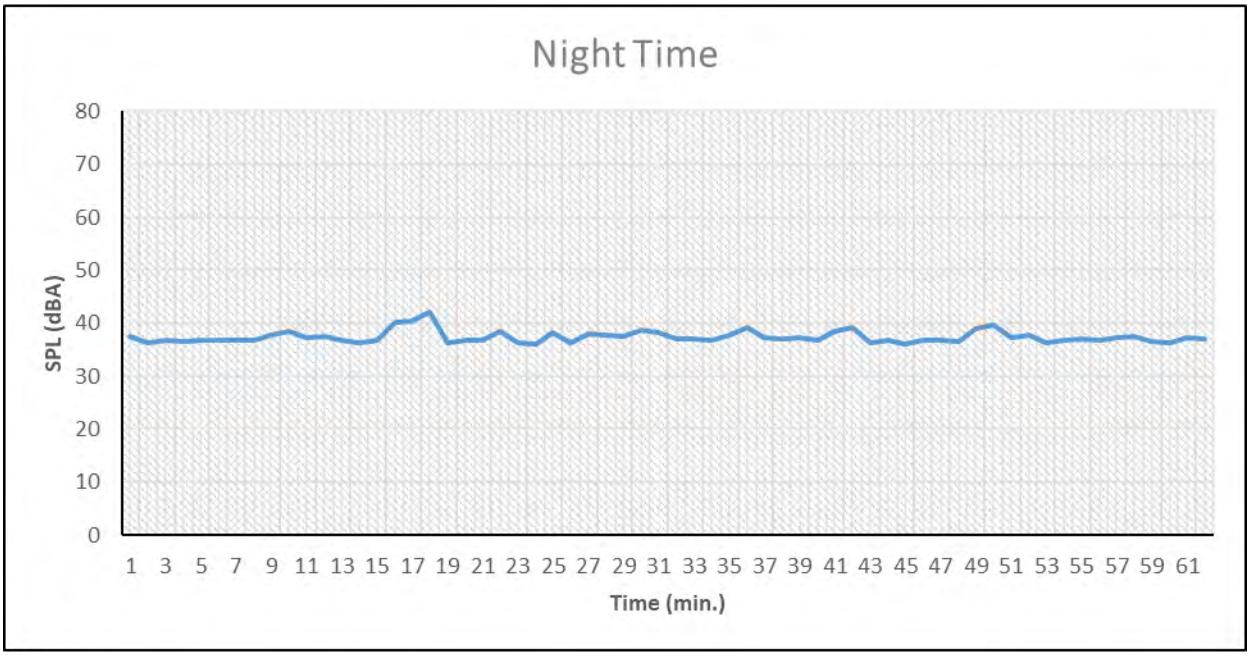


NC1 – Day Hours



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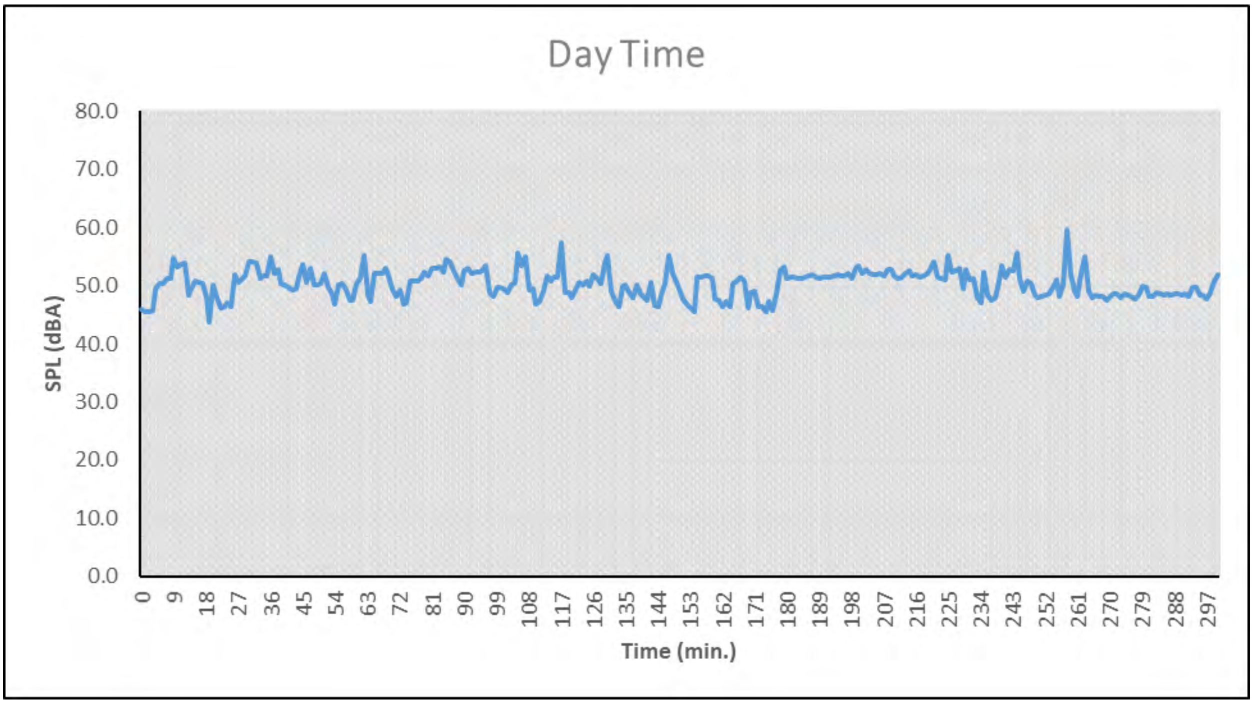
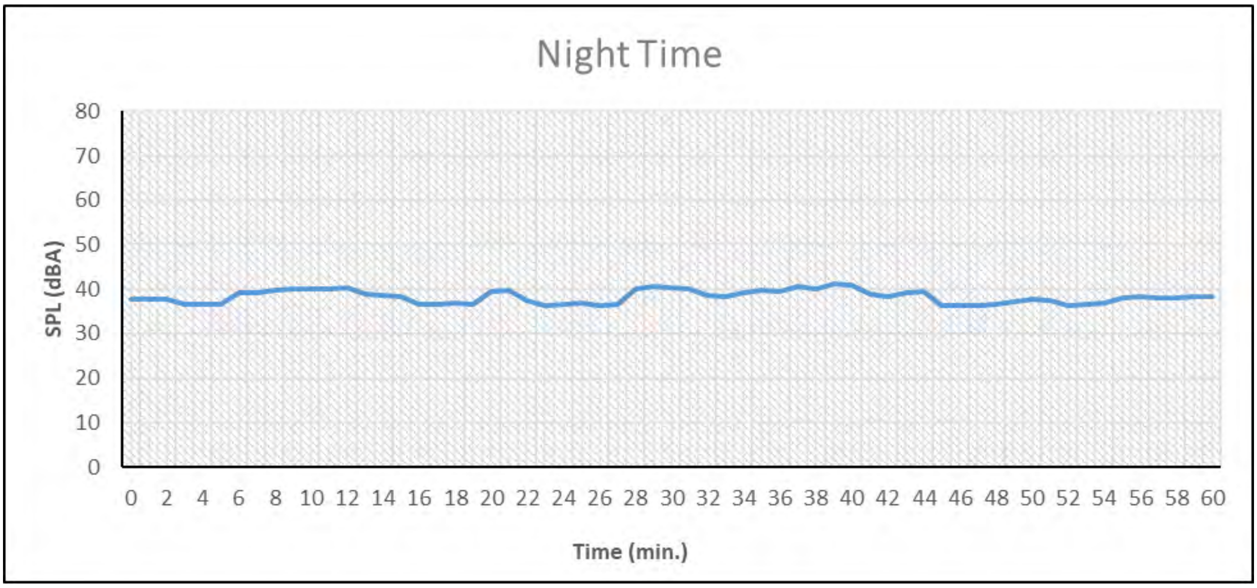


NC2 – Day Hours



NC2 – Night Hours

3.8 AIR QUALITY MONITORING REPORT

EXECUTIVE SUMMARY

Overview: The Ambient Air Quality study of the proposed project area was conducted from July 4th to July 17th, 2023. The exercise was carried out in compliance with statutory requirements as per approved ToR by FMEnv. Monitoring locations within and outside the project area were chosen for the air quality study, an hourly mean monitoring was carried out for 14 to 23 hours.

Methodology: The air quality study exercise was conducted using digital gas detector instruments. The parameters measured were sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), hydrocarbon (CxHy) as CH_4, volatile organic compounds (VOCs), ammonia (NH_3), total suspended particulate matter (TSPM), particulate matter PM_{10}, and particulate matter $PM_{2.5}$). A total of fourteen (14) sampling stations were monitored for the assessment of existing baseline ambient air quality status of the project area. Twelve (12) stations were established within and around the project site, while two (2) stations were established outside the project area as control stations. Secondary data from previous studies conducted in the area was used for the dry season analysis.

Result: Baseline results obtained from field monitoring indicated that mean values of sulphur dioxide ranged from 2.19µg/m^3 to 3.13µg/m^3; nitrogen dioxide from 8.18µg/m^3 to 10.54µg/m^3; carbon monoxide from 4.29µg/m^3 to 6.71µg/m^3; ground-level ozone from 5.93µg/m^3 to 8.88µg/m^3; hydrocarbon (as methane) from 1.57µg/m^3 to 2.65µg/m^3; volatile organic compounds from 1.57µg/m^3 to 2.91µg/m^3; ammonia from 1.23µg/m^3 to 2.70µg/m^3; total suspended particulate matter from 21.68µg/m^3 to 26.45µg/m^3; PM_{10} particulate matter from 11.55µg/m^3 to 13.40µg/m^3; and $PM_{2.5}$ particulate matter from 6.18µg/m^3 to 7.63µg/m^3. These values are below both FMEnv and IFC permissible limits. Seasonal variation showed significant change in pollutant concentrations in both dry and rainy seasons. The concentrations of NO_2 and particulate matter were higher in the dry season than in the wet season.

Identified existing potential sources of air pollution around the project site were exhaust emissions from trucks, heavy duty equipment/ machinery, and power generating facilities around the proposed project site. The domestic burning of firewood for smoking of fish and cooking; and burning of biomass as well as the use of electric generators (DG sets) were observed in the communities (ANC1 and ANC2), which are considered as control stations in this study.

Conclusively, baseline results showed that concentrations of air pollutants in the area are generally low and air shed can be categorized as un-degraded. This represents the baseline condition of existing air environment of the proposed project area before construction and operation activities.

3.8.1. Introduction

Field monitoring exercise of ambient air quality for the proposed project was conducted from July 4^{th} to July 17^{th}, 2023. The ambient air quality survey was carried out in compliance with statutory requirements, as per approved ToR by FMEnv. Ambient air quality monitoring was required to determine the quality of the existing air environment in the proposed project area. The ambient air quality objectives/standards are pre-requisite for developing management programme for effective management of ambient air quality and to reduce the impact. The results of baseline ambient air quality obtained from field monitoring were compared with the maximum stipulated permissible limits by the Federal Ministry of Environment (FMEnv.) of Nigeria and World Bank Ambient Air Quality Guidelines (International Finance Corporation (IFC, 2007).

3.8.2 Aim and Objectives of the study

The specific objectives of the air quality study are to:

i. Assess the existing baseline conditions of air quality of the proposed project area.
ii. Identify potential impacts of the proposed project on air quality environment during construction and operation.
iii. Proffer control and mitigation measures to minimize impacts during construction and operation.
iv. Develop air quality management and monitoring plans during construction and operation.

3.8.3 Methodology

3.8.3.1 Sampling Strategy

The ambient air quality monitoring survey was carried out at fourteen (14) sampling stations (shown in Table 1) within the proposed project geographical zone. Ten (10) out of the fourteen (14) stations were located within the proposed site, two (2) located at nearby to the project site, while two (2) control stations were located about 2 to 3 kilometres away from the project site. Sampling stations were established during the preliminary survey of the project area.

A brief description of the locations of the sampling stations relative to the project site, the sampling station codes, and tentative coordinates are presented in Table 1 and Google earth map is shown in Figure 1. The first controls station (ANC1) was monitored at Owo ogono, located approximately 1.8km from the project site; while the second control station (ANC2) was monitored at Ele, located about 2.7km from the project site.

Table 3.9: Sampling stations and Coordinates

Station	Description	Latitude	Longitude
AN1	Within the project site boundary in South, Southeast directions	4°40'00.60"N	7°8'47.40"E
AN2	Within the project site boundary in South, Southwest directions	4°40'02.30"N	7°8'37.88"E
AN3	Within the project site boundary in South, Southwest directions	4°40'05.95"N	7°8'28.79"E
AN4	Within the project site boundary in West, South directions	4°40'07.01"N	7°8'20.89"E
AN5	Within the project site boundary in West, Northwest directions	4°40'22.98"N	7°8'21.48"E
AN6	Within the project site boundary in North, Northwest directions	4°40'22.62"N	7°8'30.84"E
AN7	Within the project site boundary in North, Northeast, Southeast directions	4°40'19.76"N	7°8'42.39"E
AN8	Inside the project site	4°40'10.79"N	7°8'41.83"E
AN9	Middle of project site	4°40'09.97"N	7°8'29.96"E
AN10	Inside the project site	4°40'07.56"N	7°8'45.88"E
AN11	Nearby the project site boundary in South, Southeast directions	4°40'05.08"N	7°8'51.93"E
AN12	Nearby the project site boundary in East, North, Southeast, directions	4°40'17.68"N	7°8'52.74"E
ANC1	Outside the project site boundary in South, Southeast directions – Owo-ogono	4°39'33.39"N	7°9'21.92"E
ANC2	Outside the project site boundary in Northeast, Southeast directions - Ele	4°41'23.76"N	7°9'39.04"E

Figure 3.10: map showing ambient air quality monitoring stations.

3.8.3.2 Instrumentation and Sampling Techniques

The digital AEROQUAL 500 series monitor with sensor heads were used to monitor and record the priority parameters of ambient air quality. The different and calibrated sensor heads were used for the specific gases and particulate matter monitored. The battery-operated monitor has on-board diagnostics, which will inform the user about the functionality of sensor head. The monitor can log up to 8188 data points. The data can be downloaded to a personal computer or can also be logged directly to a personal computer via a serial connection while displaying real time data on the monitor screen. The data logging interval was set in one-minute increments. A mini-volume portable air sampler (Airmetrics ®) with a pre-weighed membrane filter (45µm) was used to collect total suspended particulate matter. After sampling, the membrane filter was dried in a desiccator and weighed in the laboratory to determine concentrations. PM_{10}, $PM_{2.5}$ and gases were monitored by using Aeroqual 500 series monitors fixed with sensor heads. The details of sensors heads used are shown in below table 2.

Table 3.10: Sensor details

Sensor	Sensor type	Range	Minimum detection limit	Accuracy	Resolution
Nitrogen dioxide (NO_2)	GSE (Gas Sensitive Electrochemical)	0-1ppm	0.005ppm	<±0.02ppm 0-0.2ppm <±10% 0.2-1ppm	0.001ppm
Sulphur dioxide (SO_2)	GSE (Gas Sensitive Electrochemical)	0-10ppm	0.04ppm	<±0.05ppm 0-0.5ppm <±10% 0.5-10 ppm	0.01ppm
Carbon Monoxide (CO)	GSE (Gas Sensitive Electrochemical)	0-25ppm	0.05ppm	<±0.5ppm 0-5ppm <±10% 5-25 ppm	0.01ppm
Ozone (O_3)	GSE (Gas Sensitive Electrochemical)	0-10ppm	0.01ppm	<±0.01ppm + 7.5%	0.01ppm
Ammonia (NH_3)	GSE (Gas Sensitive Electrochemical)	0-25ppm	0.05ppm	<±0.5ppm 0-5ppm <±10% 5-25 ppm	0.01ppm
Hydrocarbons (C_xH_y)	GSS (Gas Sensitive Semiconductor)	0-25ppm	0.1ppm	<±0.1ppm +10%	0.1ppm
Volatile organic compounds (VOCs)	PID (Photo Ionization Detector)	0-20ppm	0.01ppm	<±0.02ppm +10%	0.01ppm
Particulate Matter (PM2.5 & PM10)	LPC (Laser Particle Counter)	0.001-1000 mg/m3	0.001mg/m3	±0.005 mg/m3 +15%	0.001 mg/m3

3.8.3.3 Air Quality Sampling Procedure

The sampling period for ambient air quality within the project area and its environs was varied from minimum fourteen hours to twenty-three hours depending on the location of sampling station and security of equipment and personnel. At each locations the readings of all the parameters were taken on hourly basis. The monitoring period was carried out from day to day so that reading could be taken from early morning to late at night over the monitoring period. All precautions taken when setting up the instruments. The instruments were positioned away from obstacles like buildings and tall vegetation. The series of monitors with specific sensors head are fixed in a stand about 2-3m above the ground level in open space and allowed to run for an hour to determine the values. After recording the values, the instrument was allowed to run for suitable period with recording values every hour. Table 3 shows the monitoring dates and hours for each sampling station including field observation.

Secondary data from a previous study conducted around the proposed project area (ICTS, 2022) was used for the dry season analysis. The data were aggregated, processed, and analysed to determined trends.

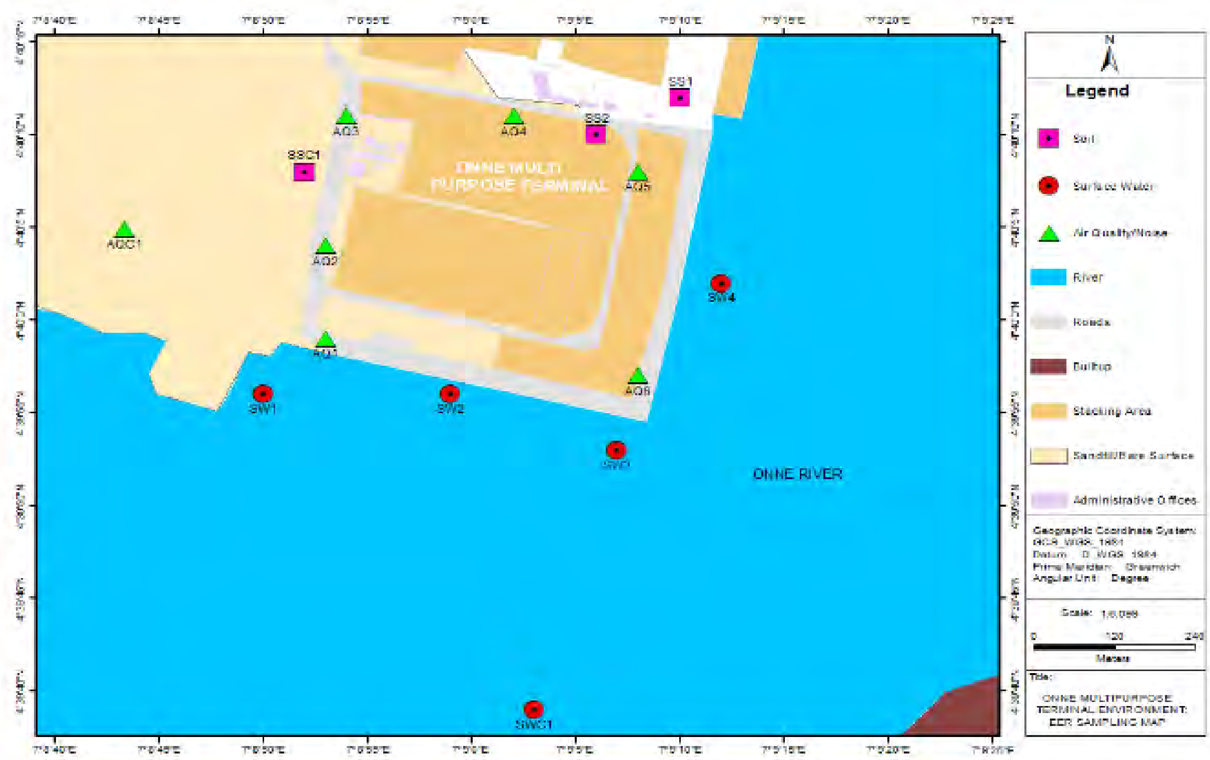
Table 3.11: Monitoring station details

Station Code	Sampling Location	Monitoring Date	Monitoring Duration	Remark or Field Observation, if any
AN1	Within the project site boundary in South, Southeast directions	04/07/23	20	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN2	Within the project site boundary in South, Southwest directions	05/07/23	22	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN3	Within the project site boundary in South, Southwest directions	06/07/23	21	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN4	Within the project site boundary in West, South directions	07/07/23	21	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN5	Within the project site boundary in West, Northwest directions	08/07/23	22	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN6	Within the project site boundary in North, Northwest directions	09/07/23	21	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN7	Within the project site boundary in North, Northeast, Southeast directions	10/07/23	20	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN8	Inside the project site	11/07/23	23	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN9	Middle of project site	12/07/23	22	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN10	Inside the project site	13/7/2023	21	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN11	Within the project site boundary in South, Southeast directions	14/7/2023	19	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
AN12	Within the project site boundary in East, North, Southeast, directions	15/7/2023	18	A dense fume emission from a Nigerian Navy Ship (NNS) power generating and earth moving equipment.
ANC1	Outside the project site boundary in South, Southeast directions-Owo-ogono	16/7/2023	14	Domestic burning of biomass and use of petrol generators.
ANC2	Outside the project site boundary in Northeast, Southeast directions-Ele	17/7/2023	18	Domestic burning of biomass and use of petrol generators.

3.8.4 Results of Baseline Air Quality

This section provides information on the existing baseline air quality environment of the proposed project area, which shall be used as benchmarks for future monitoring during project construction and operation. The summary results, showing average values of air pollutants measured in the wet season during field survey is presented in Table 4.

Table 5 shows the summary results, showing mean values of air pollutants in the dry season obtained from a previous study conducted around proposed project environment as and used as secondary data in this study (EIA-ICTS, 2022). Figure 2 shows the sampling stations including coordinates, monitored during this dry season study.



Stn.	Longitude	Latitude	Stn.	Longitude	Latitude
AQ1	7° 08' 53" E	4° 39' 59" N	AQ5	7° 09' 08" E	4° 40' 08" N
AQ2	7° 08' 53" E	4° 40' 04" N	AQ6	7° 09' 08" E	4° 39' 57" N
AQ3	7° 08' 54" E	4° 40' 11" N	AQC1	7° 09' 00" E	4° 40' 03" N
AQ4	7° 09' 02" E	4° 40' 11" N			

Figure 3.11: Dry season sampling stations including coordinates (Janu-2022)

Table 3.12: Summary of Wet Season Baseline Air Quality of the proposed project area

Parameter	AN1	AN2	AN3	AN4	AN5	AN6	AN7	AN8	AN9	AN10	AN11	AN12	ANC1	ANC2	FMEnv limit	IFC limit
SO_2 (µg/m^3)	2.71	3.00	2.79	2.98	2.51	2.27	2.30	2.2	2.29	2.19	2.66	2.43	3.05	3.13	26	20
NO_2 (µg/m^3)	9.85	9.65	9.84	9.48	9.24	9.91	8.35	9.05	9.02	8.18	9.04	8.74	10.54	9.55	75-113	40*
CO (µg/m$^{3)}$	4.29	5.61	6.27	4.92	5.41	6.06	5.63	4.90	5.31	5.66	5.82	6.14	6.71	6.37	22.8	
O_3 (µg/m^3)	6.26	7.10	7.33	6.24	6.75	7.23	6.98	5.93	6.58	6.74	7.35	7.89	8.88	8.25	117	100
CxHy (µg/m^3)	1.57	2.13	1.77	1.89	2.08	2.15	2.18	2.04	2.31	2.02	2.01	2.30	2.65	1.97		
VOC (µg/m^3)	2.57	1.57	2.70	2.70	2.73	2.43	2.27	2.46	2.32	2.54	2.33	2.64	2.91	2.52		
NH_3 (µg/m^3)	1.33	1.45	2.13	1.33	1.23	1.75	1.63	2.07	1.76	1.73	1.92	1.81	2.70	2.33		
TSPM (µg/m^3)	22.58	22.17	23.04	21.68	22.26	24.12	24.45	23.28	22.00	22.71	23.26	24.93	26.45	25.28		
PM_{10} (µg/m^3)	12.61	15.51	12.47	11.55	11.96	12.20	11.76	12.36	12.60	13.13	12.75	12.44	13.40	12.76		75
$PM_{2.5}$ (µg/m^3)	7.28	7.12	7.10	6.24	6.76	6.85	6.72	6.18	6.62	6.71	6.45	6.93	7.63	7.34		35
WIND SPD (m/s)	1.40	1.55	1.61	1.64	2.05	1.84	2.09	2.17	1.93	1.97	1.99	2.26	1.64	1.84		
TEMP (°C)	27.36	26.21	28.79	28.28	28.50	29.38	29.08	28.44	29.55	28.60	26.36	29.04	28.39	29.20		
REL. HU (%)	86.91	86.38	83.12	87.65	86.23	86.36	84.00	88.40	83.99	86.14	87.99	85.06	86.14	86.74		

*Annual Average (1Hour max - 200µg/m^3)

Table 3.12b: Summary of Dry Season Air Quality

Parameter/ Station	SO_2 (µg/m^3)	NO_2 (µg/m^3)	CO (µg/m^3)	O_3 (µg/m^3)	CxHy (µg/m^3)	VOC (µg/m^3)	NH_3 (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
AQ1	0.00	22.57	0.00	0.00	0.00	0.00	0.00	52.00	19.00
AQ2	0.00	24.45	0.00	0.00	0.00	0.00	0.00	48.00	21.00
AQ3	0.00	30.10	0.00	0.00	0.00	0.00	0.00	33.00	17.00
AQ4	0.00	18.81	0.00	0.00	0.00	0.00	0.00	54.00	22.00
AQ5	0.00	22.57	0.00	0.00	0.00	0.00	0.00	47.00	16.00
AQ6	0.00	30.10	0.00	0.00	0.00	0.00	0.00	35.00	26.00
AQ7	0.00	22.57	0.04	0.00	0.00	0.00	0.00	39.00	18.00

Note: 0.00 indicates below instrument's detection limit.

The dry season air quality data retrieved from previous study (EIA-ICTS, 2022) indicates that the study followed spot monitoring procedure in which the pollutants were measured for maximum of 10 minutes and values were recorded and presented.

3.8.5 Discussion of results and findings

3.8.5.1 Sulphur dioxide (SO_2)

Result (shown in Table 4) indicates that the wet season mean concentration of sulphur dioxide ranged from 2.19µg/m^3 to 3.13µg/m^3; whereas, the dry season mean SO_2 from secondary data (Table 5) was below instrument's detection limit of 1.75µg/m^3.The minimum wet season mean value (2.19µg/m^3) of SO_2 was observed at station AN10, located inside the project site; while the maximum mean value of 3.13µg/m^3 was obtained at station ANC2 (Ele community), located outside the project site boundary. The reason for sulphur dioxide can be attributed to the use of petrol or diesel power generators, vehicles exhaust emissions and operation activities of earth moving and other heavy equipment. The level of SO_2 observed at the control can be attributed to human activities. Table 4 and Figure 3 show that the mean values of SO_2 both at the project site and the control are below both FMEnv and IFC permissible limits. This result represents the baseline concentration of sulphur dioxide in the air environment of the proposed project area before construction and operation activities.

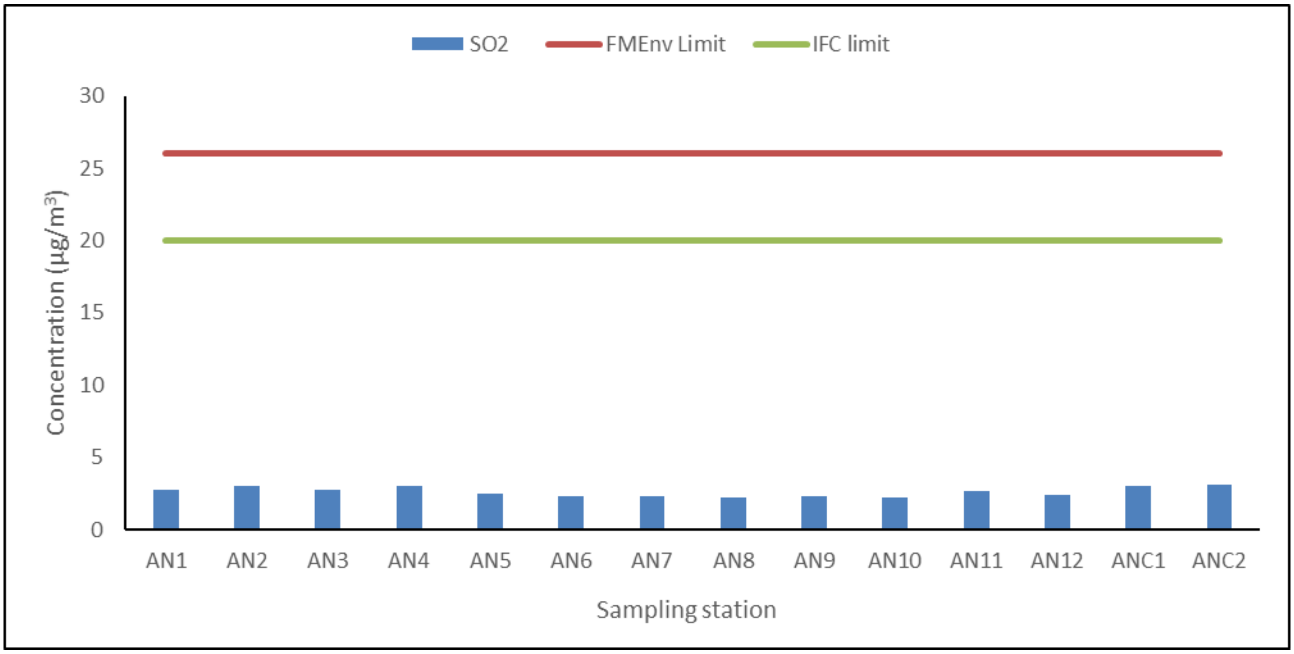


Figure 3.12 Trend in mean concentration of sulphur dioxide

3.8.5.2 Nitrogen dioxide (NO_2)

The field measurement (Table 4) in the wet season shows that the mean concentration of nitrogen dioxide ranged from 8.18µg/m^3 to 10.54µg/m^3; while the dry season secondary data (Table 5) shows that mean NO_2 ranged from 18.81µg/m^3 to 30.10µg/m^3. The mean values of NO_2 are higher in the dry season than in the wet season. Figure 4 shows the trend in the diurnal variations of mean concentration of nitrogen dioxide in comparison with regulatory standards. The minimum value (8.18µg/m^3) of NO_2 was observed at station AN10, located inside the project site; while the maximum value of 10.54µg/m^3 was obtained at station ANC1 (Owo gono community), outside the project site. The level of nitrogen dioxide observed in the project area may be caused by emissions from trucks, heavy duty equipment, power plants emissions as well as operation activities of earth moving equipment. The level of NO_2 observed at the control may be caused by domestic activities such as combustion of fossil fuels and burning of biomass. Table 4 and Figure 3 show that the values of NO_2 are below both FMEnv and IFC permissible limits. This result represents the baseline concentration of nitrogen dioxide in the air environment of the proposed project area before construction and operation activities.

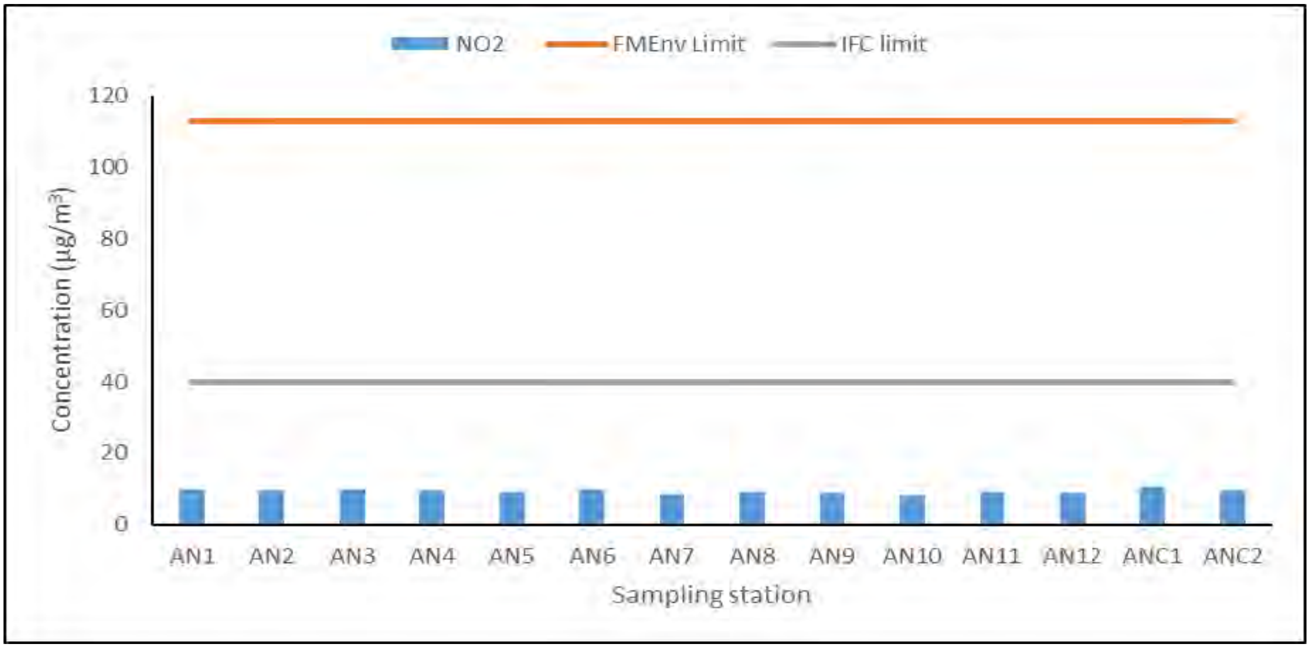


Figure 3.13: Trend in mean concentration of Nitrogen dioxide

3.8.5.3 Carbon Monoxide (CO)

The mean concentration levels of carbon monoxide obtained during field monitoring ranged from 4.29µg/m^3 to 6.71µg/m^3 as shown in Table 4. However, dry season secondary data (Table 5) indicates that CO was below instrument's detection limit of 0.95µg/m^3. Figure 4 shows the trend in the diurnal variations of mean concentration of carbon monoxide in comparison with regulatory standards. The minimum value (4.29µg/m^3) of CO was recorded at station AN1, located within the project site boundary; while maximum value of 6.71µg/m^3 was obtained at station ANC1 (Owo ogono), located outside the project site boundary. The level of carbon monoxide observed in the project area may be caused by emissions from trucks, heavy duty equipment/machinery, power plants as well as operation activities of earth moving equipment. Similarly, the level of CO obtained at ANC1 (Owo ogono) could be attributed to domestic burning of firewood for smoking of fish and cooking; and burning of biomass as well as the use of electric generators. As indicated in Table 4 and Figure 5, CO values obtained during field monitoring are below both FMEnv permissible limits. This result represents the baseline concentration of carbon monoxide in the air environment of the proposed project area before construction and operation activities.

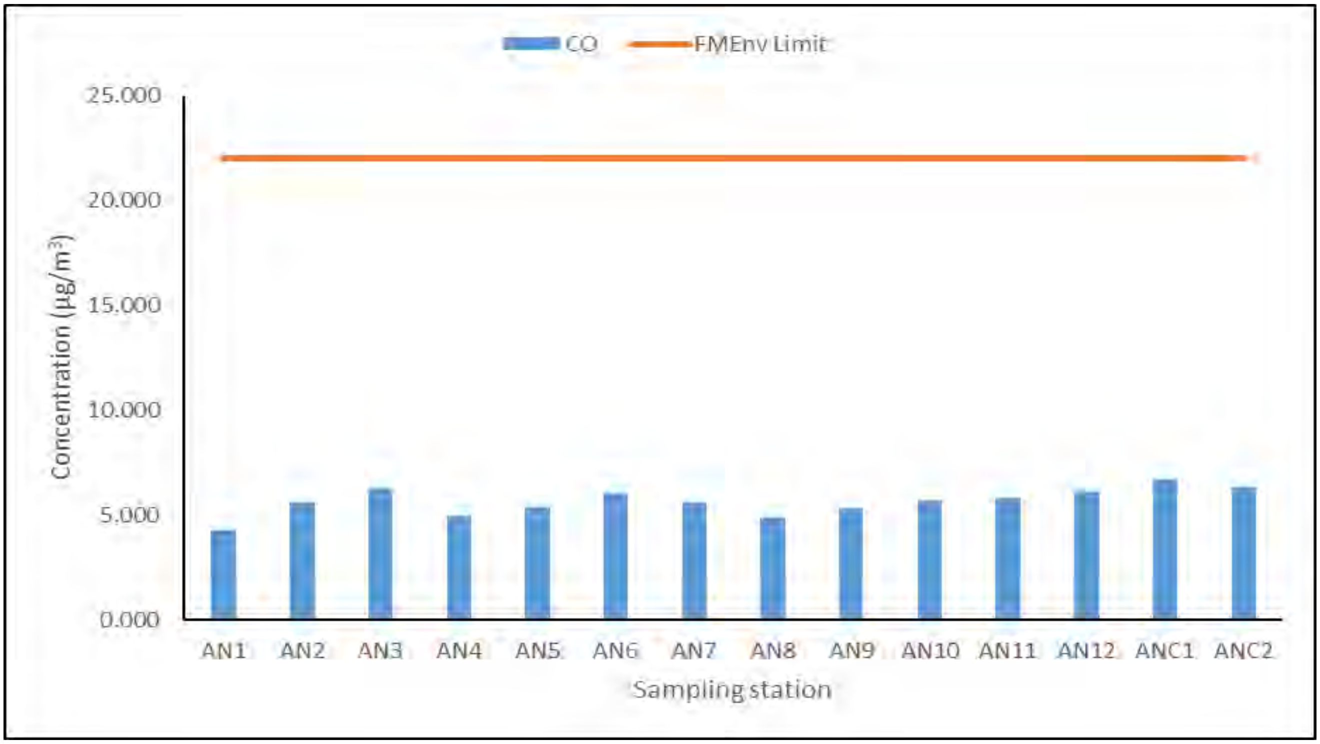


Figure 3.14: Trend in mean concentration of carbon monoxide

3.8.5.4 Ground-level ozone (O_3)

The mean concentrations of ground-level ozone monitored in the area during field sampling ranged from 5.93µg/m^3 to 8.88µg/m^3 as shown in Table 4; while the dry season values of O_3 from secondary data (Table 5) was below instrument's detection limit of 0.33µg/m^3. The trend in the diurnal variations of mean concentration of ground-level ozone in comparison with regulatory standards is shown in Figure 5. The minimum value (5.93µg/m^3) of ground-level was recorded at station AN8, located inside the project site; while maximum value of 8.88µg/m^3 was obtained at station ANC1 (Owo gono community), located outside the project site boundary. The presence of ground-level ozone in ambient air is a common characteristic of the Niger Delta region where the proposed project is to be sited due to hydrocarbon activities. It is evident from Table 4 and Figure 6 that O_3 values obtained during field monitoring are below both FMEnv and IFC permissible limits. This result represents the baseline concentration of ground-level in air environment of the proposed project area before construction and operation activities.

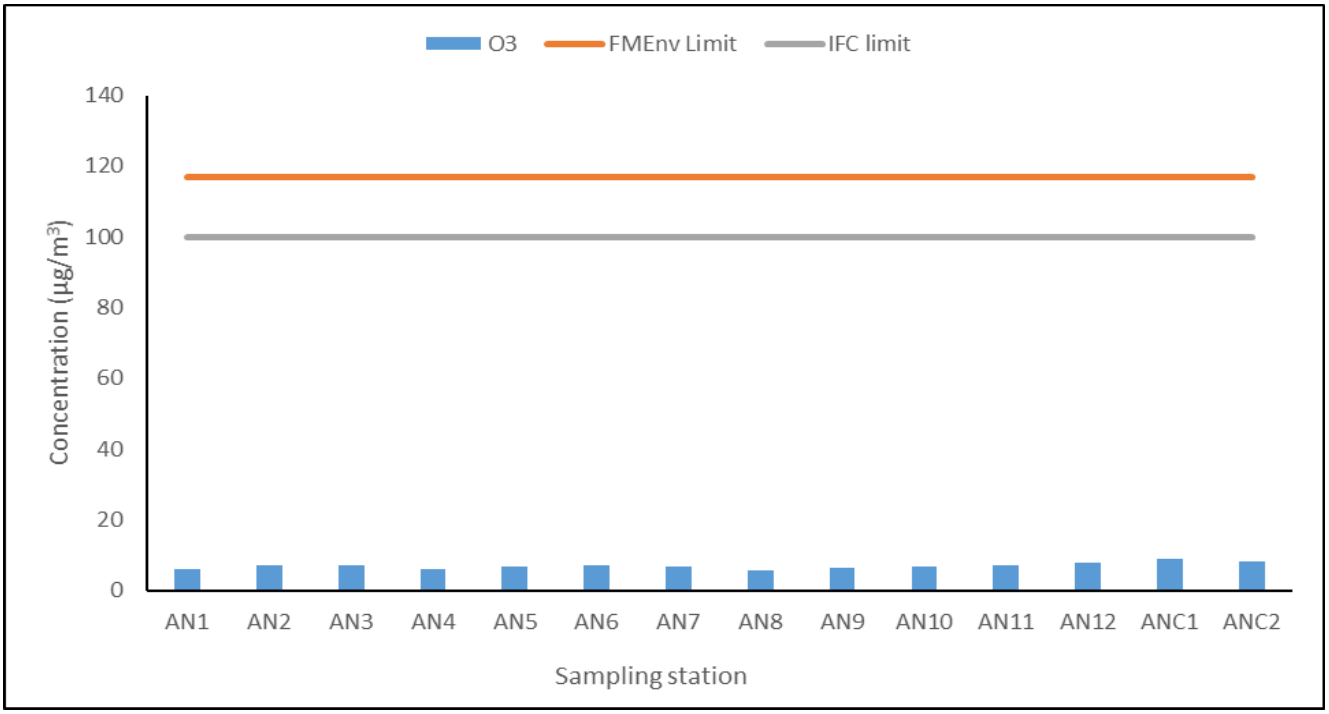


Figure 3.15: Trend in mean concentration of ground-level ozone

3.8.5.5 Hydrocarbon (as methane, CH_4)

The mean concentration of hydrocarbon (as methane) obtained during field monitoring ranged from 1.57µg/m^3 to 2.65µg/m^3 as shown in Table 4; however, the dry season methane hydrocarbon from secondary data (Table 5) was below instrument's detection limit of 1.23µg/m^3. The trend in the diurnal variations of mean concentration of hydrocarbon is shown in Figure 7. The minimum value (1.57µg/m^3) of methane hydrocarbon was recorded at station AN1, located within the project site boundary; while maximum value of 2.65µg/m^3 was obtained at station ANC1 (Owo ogono), located outside the project site boundary. Also, the presence of hydrocarbon in ambient air is a common characteristic of the Niger Delta region where the proposed project is to be sited due to hydrocarbon activities. This result represents the baseline concentration of methane hydrocarbon in the air environment of the proposed project area before construction and operation activities.

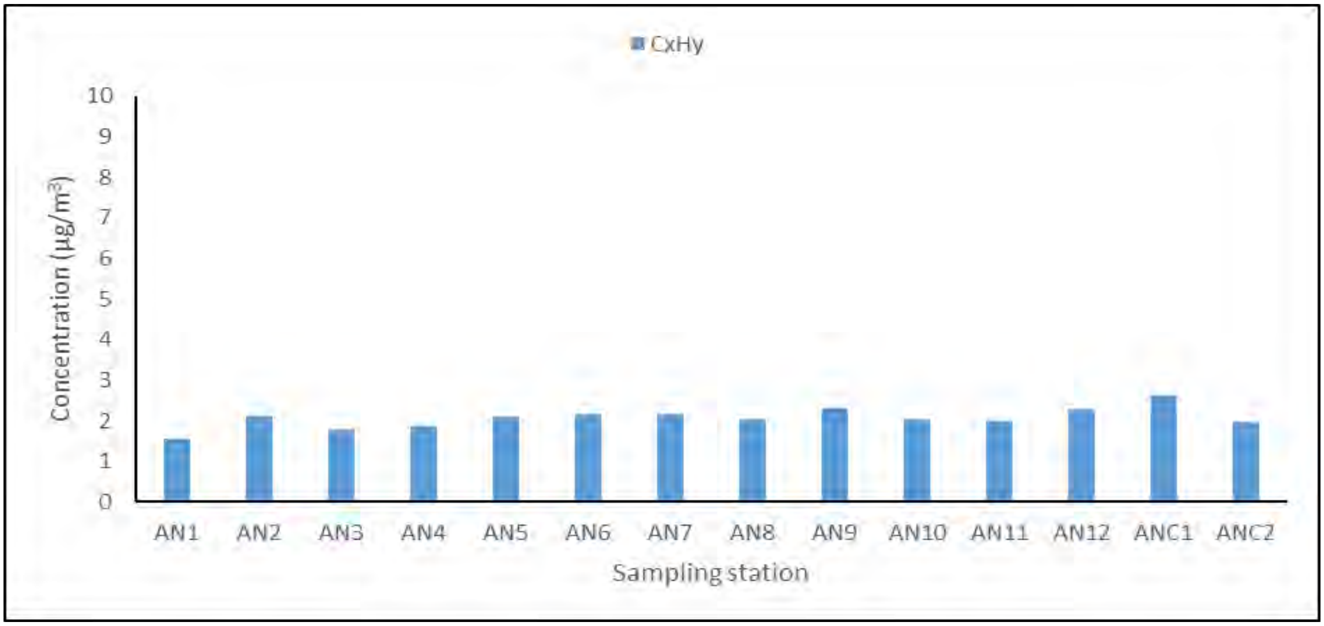


Figure 3.16: Trend in mean concentration of hydrocarbon as methane

3.8.5.6 Volatile Organic Compounds (VOC)

The result of field measurement (Table 4) indicates that the mean concentration of volatile organic compounds in the area ranged from 1.57µg/m^3 to 2.91µg/m^3, while the dry season VOCs from secondary data (Table 5) was below instrument's detection limit of 1.12µg/m^3. The trend in the diurnal variations of mean concentration of volatile organic compounds is shown in Figure 7. The minimum value (1.57µg/m^3) of volatile organic compounds was recorded at station AN2, located within the project site boundary; while maximum value of 2.91µg/m^3 was obtained at station ANC1 (Owo ogono), located outside the project site boundary. The presence of volatile organic compounds in ambient air may be due to human activities around the Onne port area. This result represents the baseline concentration of volatile organic compounds in the air environment of the proposed project area before construction and operation activities.

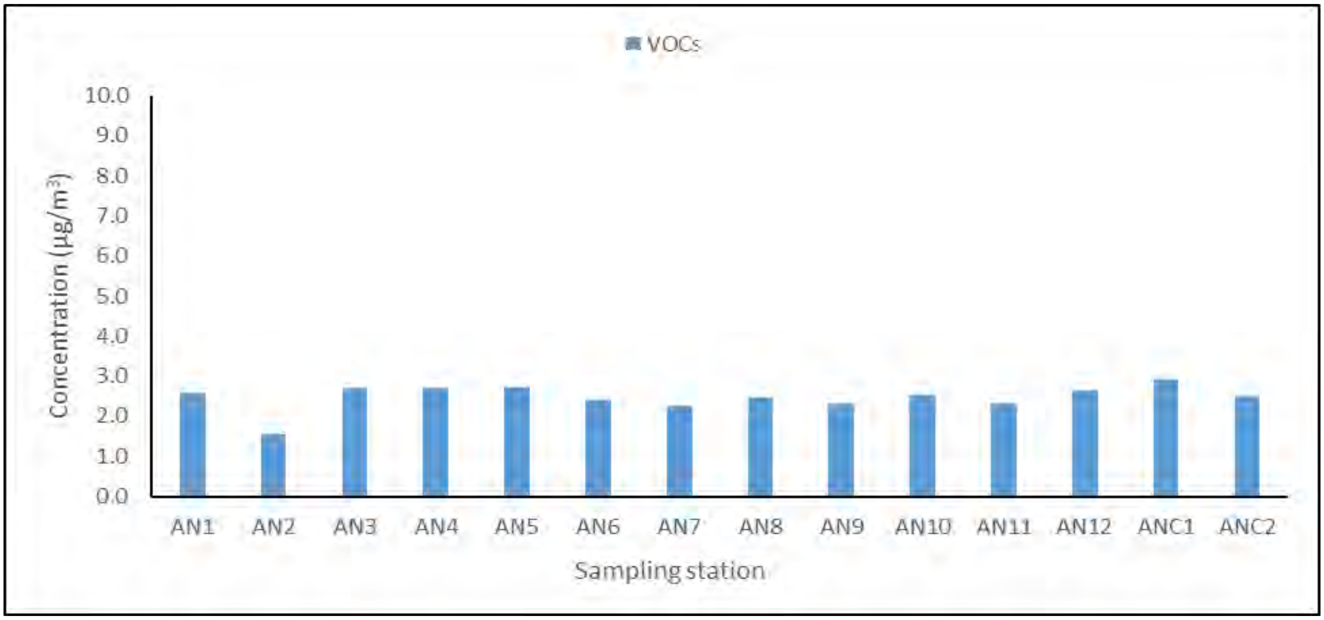


Figure 3.17: Trend in mean concentration of volatile organic compounds

3.8.5.7. Ammonia (NH_3)

The mean concentration of ammonia (Table 4) measured during field monitoring of the project area ranged from 1.23µg/m^3 to 2.70µg/m^3; while the dry season results secondary data (Table 5) indicates that NH_3 was below instrument's detection limit of 0.58µg/m^3. The trend in the diurnal variations of mean concentration level of ammonia in the proposed project area is shown in Figure 9. The minimum value (1.23µg/m^3) of NH_3 was recorded at station AN5, located within the project site boundary; while maximum value of 2.70µg/m^3 was obtained at station ANC1 (Owo ogono), located outside the project site boundary. The presence of traces of ammonia in ambient air may be due to anthropogenic activities. This result represents the baseline concentration of ammonia in the air environment of the proposed project area before construction and operation activities.

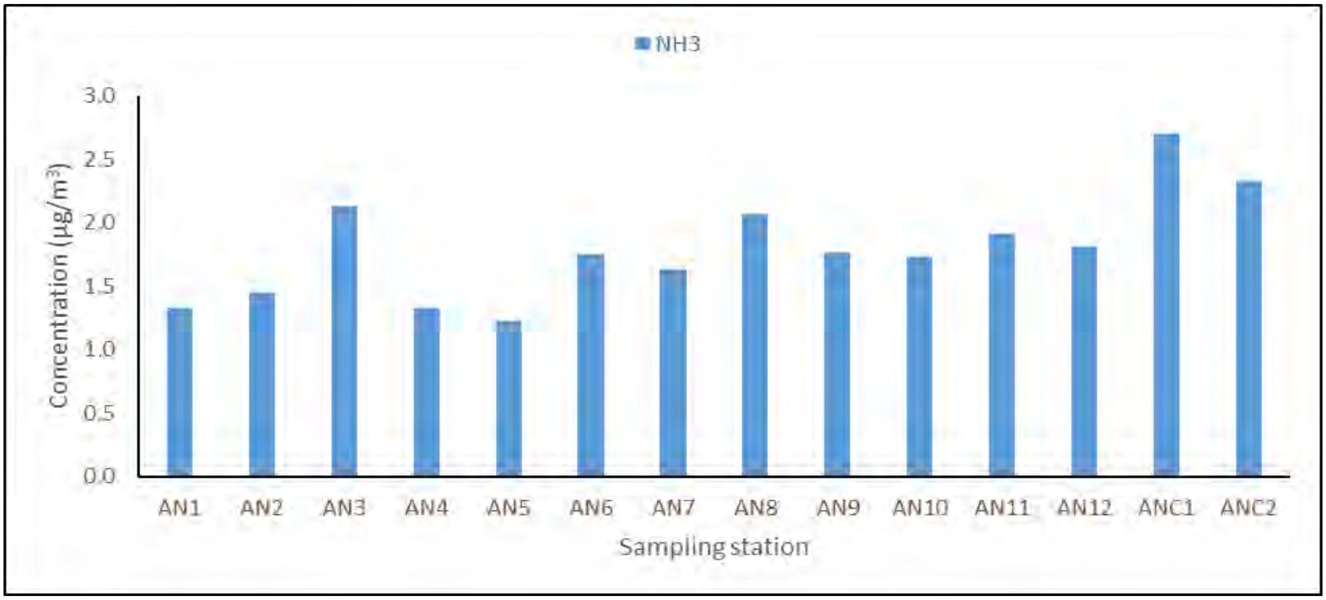


Figure 3.18: Trend in mean concentration of ammonia

3.8.5.8. PM10 Particulate Matter

The mean concentration levels of PM_{10} particulate matter obtained during field monitoring (Table 4) ranged from 11.55µg/m^3 to 13.40µg/m^3; while the dry season mean values of PM_{10} from the previous study ranged from 33.00µg/m^3 to 54.00µg/m^3. The mean values of PM_{10} are higher in the dry season than in the wet season. Figure 10 shows trend in the diurnal variations of mean concentration of PM_{10} particulate matter in comparison with regulatory standards. The minimum mean value (11.55µg/m^3) of PM_{10} particulate was obtained at AN4, located within the project site boundary; while maximum value of 13.40µg/m^3 was obtained at ANC1 (Owo ogono), located outside the project site boundary. The level of particulate matter observed in the project area may be caused by emissions from trucks, heavy duty equipment, power plants emissions as well as operation activities of earth moving equipment. The level PM_{10} obtained at control 1 was due to domestic activities. It is clearly shown in Figure 10 that PM_{10} values obtained during field monitoring are below IFC permissible limits. This result represents the baseline concentration of PM_{10} in air environment of the proposed project area before construction and operation activities.

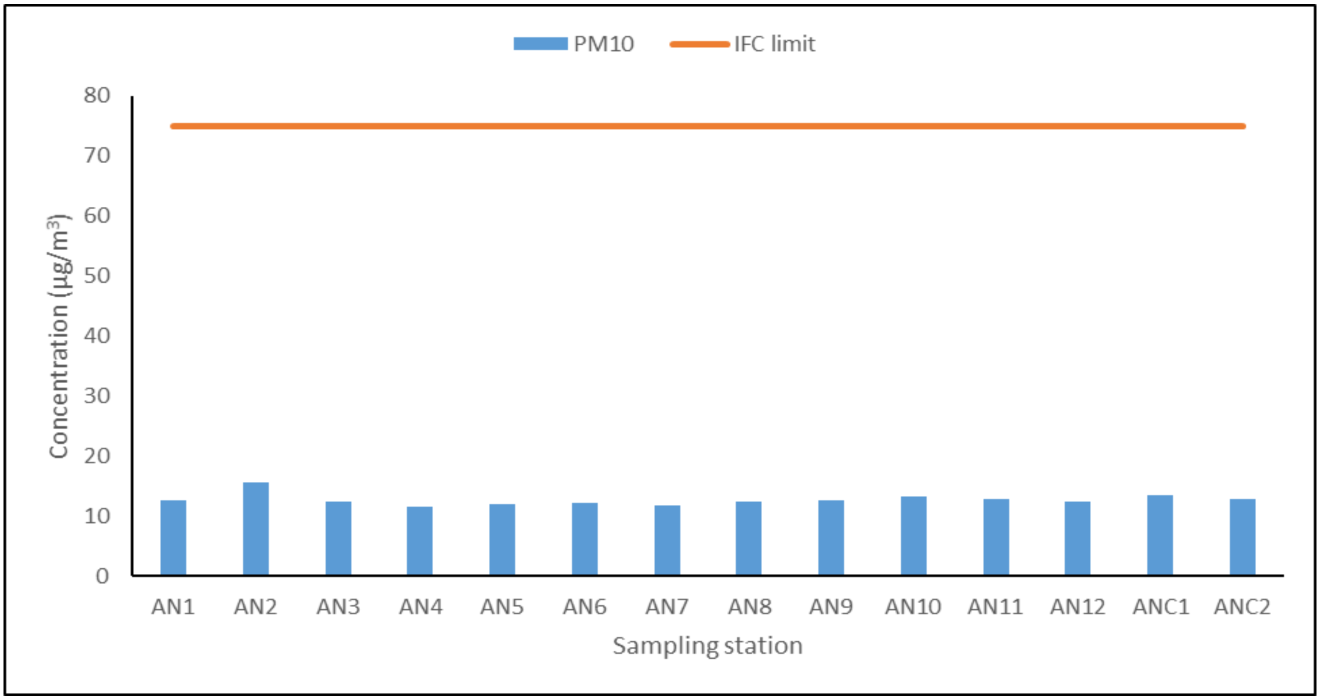


Figure 3.19: Trend in mean concentration of PM_{10} particulate matter

3.8.5.9. $PM_{2.5}$ Particulate Matter

The mean concentration levels of $PM_{2.5}$ particulate matter obtained during monitoring (Table 4) ranged from 6.18µg/m^3 to 7.63µg/m^3; while the dry season mean values of $PM_{2.5}$ from the previous study ranged from 16.00µg/m^3 to 26.00µg/m^3. The mean values of $PM_{2.5}$ are higher in the dry season than in the wet season. Figure 11 shows trends in the diurnal variations of mean concentration of $PM_{2.5}$ particulate matter in comparison with regulatory standards. The minimum mean value (6.18µg/m^3) of $PM_{2.5}$ particulate was obtained at AN8, located inside the project site; while maximum value of 7.63µg/m^3 was obtained at ANC1 (Owo ogono), located outside the project site boundary. The level of particulate matter observed in the project area may be caused by emissions from trucks, heavy duty equipment, power plants at the port as well as operation activities of earth moving equipment. The level $PM_{2.5}$ obtained at control 1 was due to domestic activities. It is clearly shown in Figure 11 that $PM_{2.5}$ values obtained during field monitoring are below IFC permissible limits. This result represents the baseline concentration of $PM_{2.5}$ in air environment of the proposed project area before construction and operation activities.

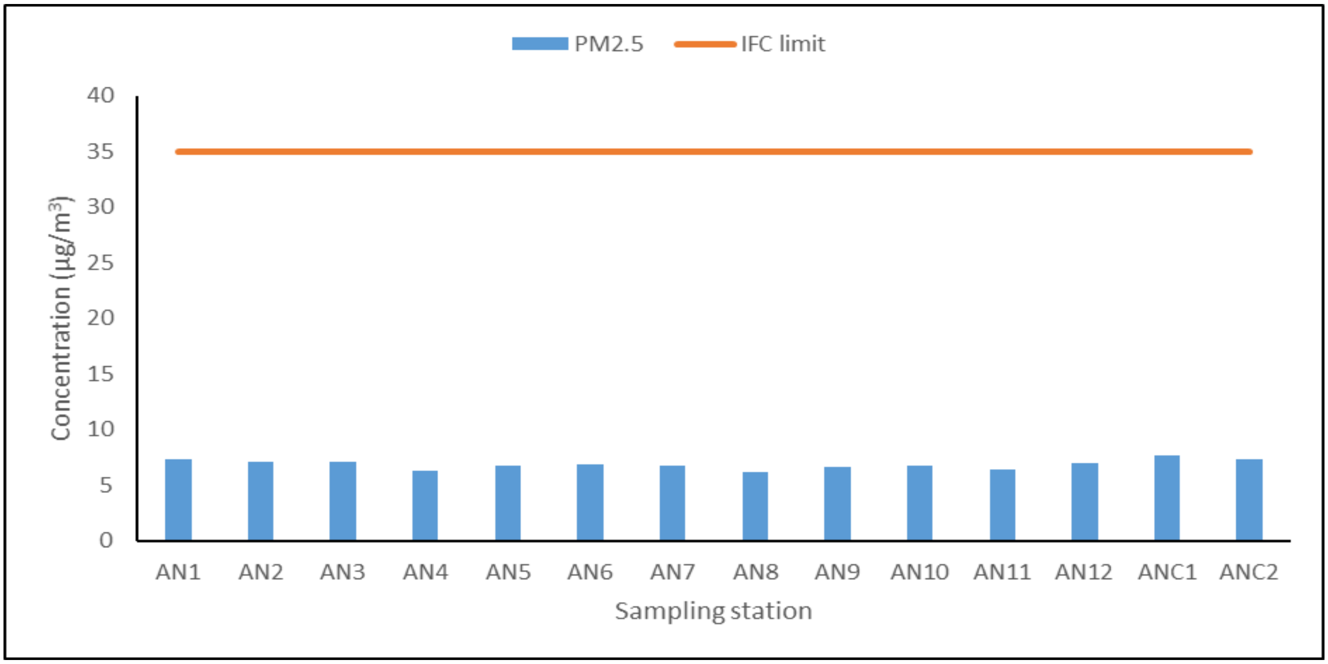


Figure 3.20: Trend in mean $PM_{2.5}$ particulate matter

3.8.6. Conclusion

Generally, the environmental baseline describing the pre-construction air quality of the project area has been conducted through intensive measurements of air pollutants and meteorological parameters of the area. Existing air quality in the proposed area is affected by the daily weather condition of the area, particularly the strength of the North-East and South-West trade winds that are prevalent in the wet and dry seasons respectively. Baseline results showed that concentrations of air pollutants in the area are generally low, and the air shed can be classified as un-degradable. Seasonal variation showed significant change in pollutant concentrations in both dry and rainy seasons. The concentrations of NO_2 and particulate matter were higher in the dry season than in the wet season. These results represented the baseline condition of the area prior to the construction and operation of the proposed project.

3.9 SOIL QUALITY ASSESSMENT REPORT

Executive Summary

A total of fourteen (14) soil samples (topsoil and subsoil) were collected and analyzed for physiochemical, heavy metal and microbiological parameters. The analysis results revealed pH values range between 6.00 to 7.40 and 5.80 to 7.50 for subsoil indicating a slightly acidic to alkaline soil. The soil physical properties such as porosity, permeability, and particle size distribution revealed good soil property indicating no form of soil compaction, good aeration, and moderate permeability for good water movement along the soil profile. The soil textural class were classified sandy soil supporting the good soil physical properties earlier mentioned. Hydrocarbon analysis revealed low concentration with THC level between 0.75-2.46mg/kg and 0.65-1.75mg/kg for topsoil and subsoil respectively indicating hydrocarbon source as biogenic. Heavy metals result revealed that heavy metal concentration recorded during the study period is typical of the Niger Delta soil environment indicating no form of pollution. Consequently, the analysis of these parameters provides insights into the soil's physical and chemical properties, helping to assess soil quality, fertility, and potential environmental concerns as it relates to proposed project. Moreso, comparison of the current laboratory results with previous study within the study area showed no significant variation in soil quality.

3.9.1. Introduction

Soil assessment is an integral part of any environmental impact assessment study. The aim and objective of studying the soil component is to establish and benchmark the existing soil condition in the proposed project site against any future occurrence. It also gives an insight for a better understanding of interaction effects between project activities (e.g., construction) and the soil environment for effective impacts analysis, management, and mitigation.

Scope of study

The scope of the study is basically to establish existing soil condition within the proposed project site through field sampling and laboratory analysis. Furthermore, to analyze possible impacts that may occur to soil components in all phases (Pre-construction, Construction and Operation) of the project life cycle and proffer the mitigation measures.

Field Approach

The study adopted both onsite and offsite approach. The onsite is majorly for soil sample collection in the field and submission of samples to laboratory, while the offsite includes laboratory analysis of samples and report writing.

3.9.2 Methodology

The study adopted standard international best practice in all aspects of the study execution ranging from field data gathering and laboratory analysis. Specifically, soil samples were collected through the use of stainless-steel soil sampling auger at two depth 0-15cm and 15-30cm, Samples for physico-chemical analysis were collected into plastic bags after being wrapped in aluminum foil and packed into containers made of high UV (Ultraviolet) resistant material. Sample labeling was done at the point of sampling with the correct Station ID, depth, and date of sampling. A total of fourteen (14) soil samples were collected comprising topsoil (7samples) and sub-soil (7 samples). During the field study, some morphological properties of soil were achieved by physical observation. The coordinates of soil sampling locations are shown in table 1, whereas the map in shown in figure below.

Table 3.13. Soil Sampling Stations

S/No	Station Code	Environmental Sphere	WGS 84	
			LATITUDE (N)	LONGITUDE (E)
1	SS1	Soil	4^0 39’ 59.6”	7^o 08’ 45.6”
2	SS2	Soil	4^0 40’ 01.8”	7^o 08’ 36.4”
3	SS3	Soil	4^0 40’ 07.2”	7^o 08’ 25.0”
4	SS4	Soil	4^0 40’ 05.7”	7^o 08’ 34.4”
5	SS5	Soil	4^0 40’ 03.9”	7^o 08’ 48.2”
6	SS6	Soil	4^0 40’ 07.0”	7^o 08’ 31.7”
7	SSC1	Soil	4^0 40’ 03.9”	7^o 08’ 48.6”

Figure 3.21: Soil Sampling Map

3.9.3 Results and Discussion

3.9.3.1. Results

Table 3.14 present summary result of soil quality within and around the proposed project site during the wet and dry season.

S/N	Parameter(s)	MM FZE & IA 2023 (Wet)			
		Min	Max	Ave	SSC
Topsoil (0-15cm)					
1	Sand (%)	83.28	86.54	84.93	85.10
2	Silt (%)	5.39	8.28	6.67	6.50
3	Clay (%)	7.46	9.46	8.40	8.40
4	Texture	0.00	0.00	~	SS
5	Porosity	37.30	41.00	39.18	37.60
6	Colour	~	~	~	Dark Brown
7	Permeability (cm/sec)×10	0.13	0.17	0.15	0.15
8	Bulk Density (g/cm3)	1.16	1.42	1.33	1.56
9	pH	6.00	7.40	6.58	6.50
10	Moisture Content (%)	7.55	12.45	9.69	7.64
11	Sulphide, S2 (mg/kg)	<0.01	<0.01	<0.01	<0.01
12	Sulphate, SO42- (mg/kg)	4.00	12.00	6.17	11.00
14	Nitrate, NO3- (mg/kg)	1.50	2.30	1.98	3.40
15	Total Nitrogen (%)	0.015	0.034	0.03	0.024

S/N	Parameter(s)	MM FZE & IA 2023 (Wet)			
		Min	Max	Ave	SSC
16	Phosphate, PO43- (mg/kg)	0.65	2.50	1.40	1.81
18	TOC (%)	0.27	0.59	0.36	0.27
19	THC (mg/kg)	0.75	2.45	1.73	2.46
21	Ammonia (mg/kg)	<0.01	<0.01	<0.01	<0.01
22	Urea (Urea)	<0.01	<0.01	<0.01	<0.01
23	Manganese, Mn (mg/kg)	1.66	12.18	4.93	32.57
24	Iron, Fe (mg/kg)	695.3	1613.8	1070.21	3,068.8
25	Zinc, Zn (mg/kg)	2.60	7.71	3.92	17.06
26	Vanadium, V (mg/kg)	<0.001	<0.001	<0.001	<0.001
27	Nickel, Ni (mg/kg)	0.08	0.41	0.25	<0.001
28	Chromium, Cr (mg/kg)	<0.001	<0.001	<0.001	<0.001
29	Lead, Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001
30	Copper, Cu (mg/kg)	<0.001	<0.001	<0.001	0.61
31	Mercury, Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001
32	Arsenic, As (mg/kg)	<0.001	<0.001	<0.001	<0.001
33	HUB (CFU/g) x 103	0.30	0.80	0.57	0.60
34	HUF (CFU/g) x 103	0.20	0.50	0.33	0.30
35	THB (CFU/g) x 105	1.10	2.80	2.10	3.50
36	THF (CFU/g) x 105	0.30	1.10	0.67	1.20
Subsoil (15-30cm)					
1	Sand (%)	82.64	86.72	84.62	84.38
2	Silt (%)	5.14	9.09	7.11	9.31
3	Clay (%)	7.42	8.75	8.27	9.31
4	Texture	0.00	0.00	~	SS
5	Porosity	36.80	40.20	38.83	37.00
6	Colour	~	~	~	Dark Brown
7	Permeability (cm/sec)×10	0.10	0.16	0.14	0.14
8	Bulk Density (g/cm3)	1.25	1.58	1.38	1.45
9	pH	5.80	7.50	6.67	6.60
10	Moisture Content (%)	8.12	12.31	10.39	8.50
11	Sulphide, S2 (mg/kg)	<0.01	<0.01	<0.01	<0.01
12	Sulphate, SO42- (mg/kg)	2.00	16.00	7.67	10.00
14	Nitrate, NO3- (mg/kg)	1.40	2.80	2.00	1.90
15	Total Nitrogen (%)	0.016	0.041	0.03	0.014
16	Phosphate, PO43- (mg/kg)	0.75	1.85	1.37	1.65
18	TOC (%)	0.19	0.47	0.29	0.17
19	THC (mg/kg)	0.65	1.75	1.24	1.40
21	Ammonia (mg/kg)	<0.01	<0.01	<0.01	<0.01
22	Urea (Urea)	<0.01	<0.01	<0.01	<0.01
23	Manganese, Mn (mg/kg)	2.03	5.77	3.48	17.38
24	Iron, Fe (mg/kg)	358.1	2109.2	988.10	2,713.0

S/N	Parameter(s)	MM FZE & IA 2023 (Wet)			
		Min	Max	Ave	SSC
25	Zinc, Zn (mg/kg)	1.97	3.05	2.60	8.32
26	Vanadium, V (mg/kg)	<0.001	<0.001	<0.001	<0.001
27	Nickel, Ni (mg/kg)	<0.001	<0.001	<0.001	0.46
28	Chromium, Cr (mg/kg)	<0.001	<0.001	<0.001	<0.001
29	Lead, Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001
30	Copper, Cu (mg/kg)	0.14	0.14	0.02	0.19
31	Mercury, Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001
32	Arsenic, As (mg/kg)	<0.001	<0.001	<0.001	<0.001
33	HUB (CFU/g) x 103	0.10	0.40	0.20	0.30
34	HUF (CFU/g) x 103	0.10	0.20	0.17	0.10
35	THB (CFU/g) x 105	0.70	1.90	1.37	2.00
36	THF (CFU/g) x 105	0.20	0.60	0.43	0.80

Source Fieldwork 2023

3.9.4. Discussion

3.9.4.1. Morphology

Morphologically, the soils of the region are classified as coastal plain sand (ultisoil), friable when dry and sticky when wet. However, observation from the field revealed the soil of the proposed project site is reclaimed with river sand, which dominated soil aggregates as recorded from the particle size distribution analysis, making it friable both at wet and dry within the two depths sampled. The soil colour was generally grey due to river sand used in site reclamation. Site topographies were observed to be generally flat with some minor slope close to the river shore.

3.9.4.2. Physical Properties

Porosity refers to the volume percentage of pore spaces in the soil. It influences the soil's ability to retain water and facilitate root growth. The porosity values for topsoil range from 37.30 to 41.00 and 36.80 to 40.20 for subsoil, indicating varying levels of pore space within the soil samples, thus indicating soil capability to encourage good soil aeration. Moreso, same range of porosity was observed at the control station. Figure 1 present the mean distribution of soil porosity.

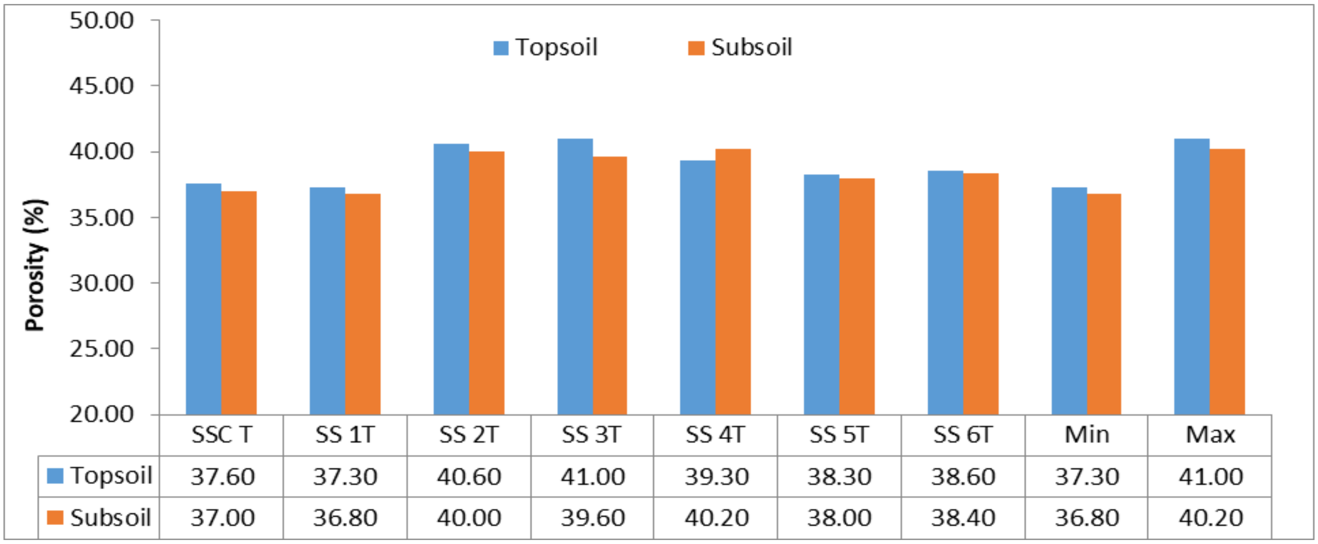


Fig 3.22 Porosity distribution across topsoil for subsoil

Permeability measures the soil's ability to allow water and air to pass through it. It is crucial for drainage and water movement in the soil. The permeability value ranged from 0.13 to 0.17cm/sec x10^3 for topsoil and 0.10 to 0.16 for subsoil cm/sec x10^3 suggesting moderate permeability in the soil samples and soil's ability to transmit water. Similar permeability results were observed at the control stations indicating no soil compaction at project site.

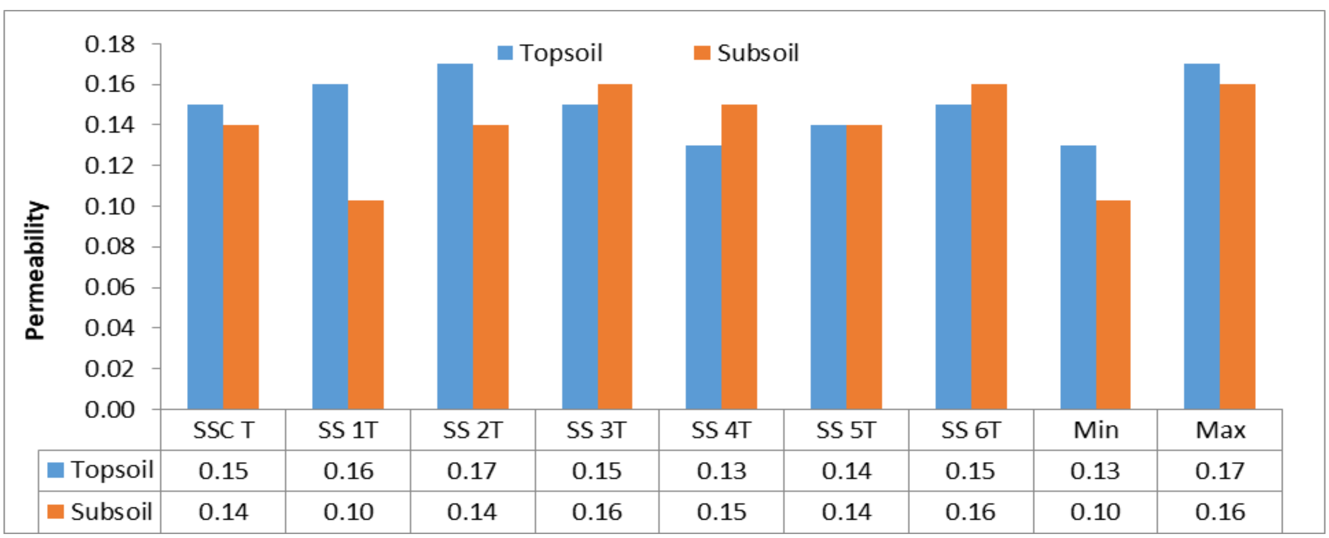


Fig 3.23 Permeability distribution across topsoil and subsoil within the study area

Texture describes the relative proportions of sand, silt, and clay in the soil. It has implications for soil structure, water retention, and nutrient availability. The soil texture within and around proposed project is sandy soil which can be deduced from the high percentage sand (83.28 -86.54% and 82.64-86.72%) for topsoil and subsoil respectively, observed from the particle size distribution and physical observation from feel method in the field.

3.9.4.3. Chemical properties

pH is a measure of the soil's acidity or alkalinity. It ranges from 0 to 14, with values below 7 indicating acidity, 7 being neutral, and values above 7 indicating alkalinity. The pH values of the topsoil range from 6.00 to 7.40 and 5.80 to 7.50 for subsoil indicating a slightly acidic to alkaline soil.

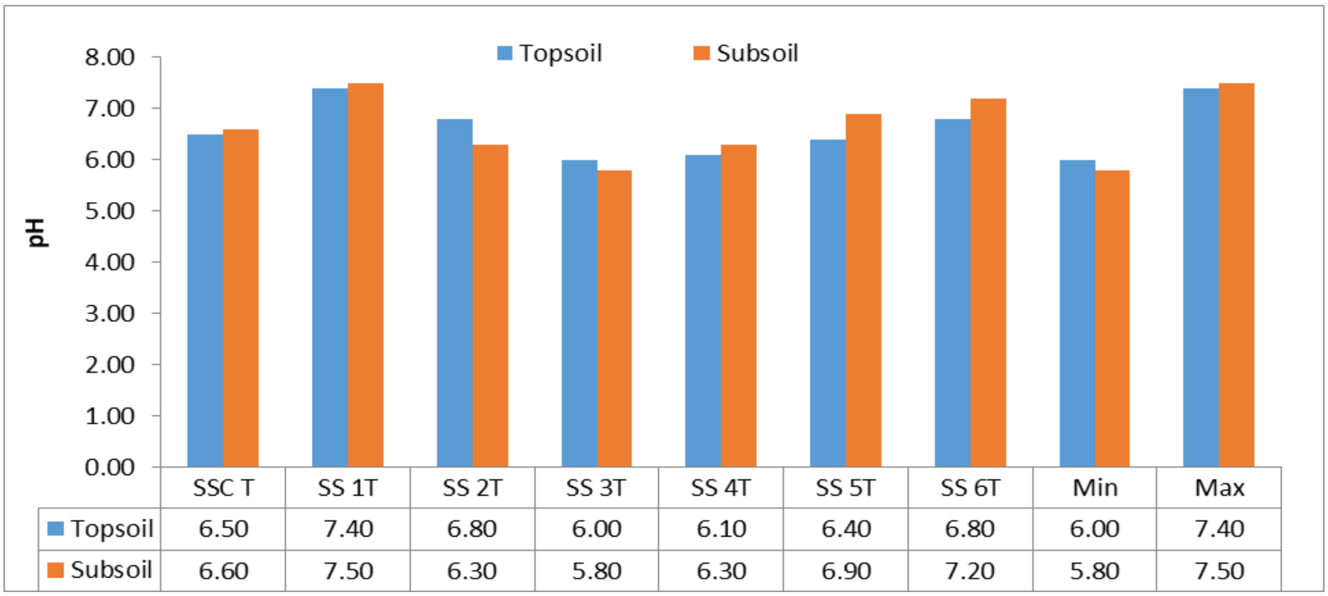


Fig 3.24 pH distribution across topsoil and subsoil

3.9.4.4. Phosphate, Sulphate and Nitrate

Phosphate ranged between (0.65-2.50mg/kg) and 0.75 – 1.85mg/kg; Sulphate (4.00 – 12.00mg/kg) and (2.00 – 16.00mg/kg); Nitrate (1.50 – 3.40mg/kg) and (1.40 – 2.80mg/kg) for top and subsoil respectively. These parameters represent the presence of various ions in the soil, which can positively affect plant growth and soil health. Higher values indicate higher nutrient availability and fertility.

3.9.4.5. Total Nitrogen and Total Organic Carbon

Figure 4 and 5 present concentrations of Total Nitrogen and Total Organic carbon within and around the study area. Figure 4 revealed Total nitrogen level ranged between 0.015 – 0.034% and 0.014-

0.041% for topsoil and subsoil respectively. While figure 5 revealed total organic carbon ranged between 0.27-0.59% and 0.17-0.47% for topsoil and subsoil respectively. These parameters are indicators of the amount of decomposed plant and animal materials in the soil. They contribute to soil fertility, water holding capacity, and microbial activity.

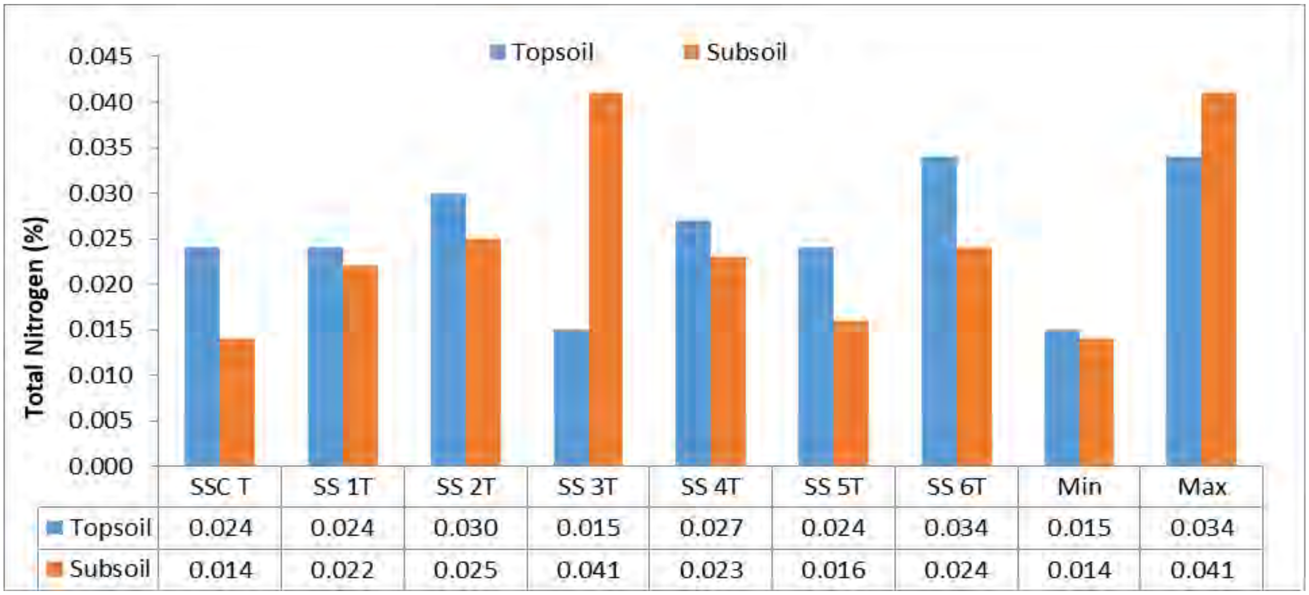


Fig 3.25: Total Nitrogen distribution across topsoil and subsoil within the study area

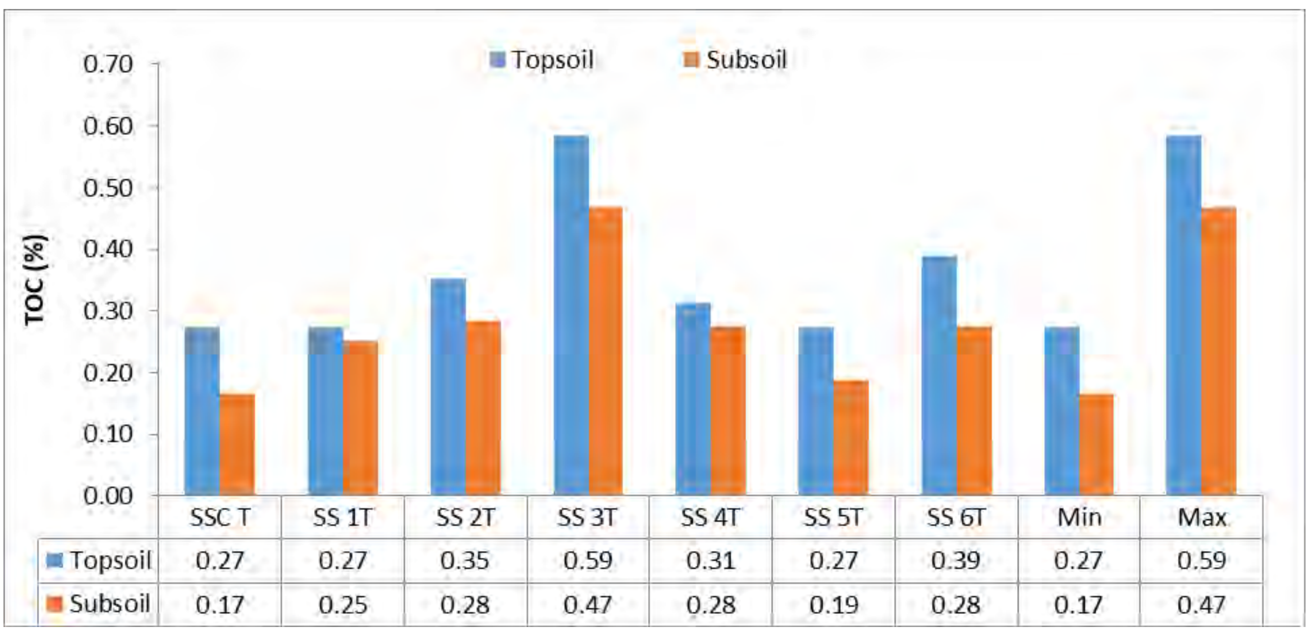


Fig 3.26: Total Organic Carbon distribution across topsoil and subsoil within the study area

3.9.4.6. Hydrocarbon

Figure 6 presents the concentration of total hydrocarbon within and around the study. The figure revealed THC ranged between 0.75-2.46mg/kg and 0.65-1.75mg/kg for topsoil and subsoil respectively with highest concentration been observed at topsoil except for SS6T. The observed THC could be attributed to biogenic process and not as a result hydrocarbon spillage.

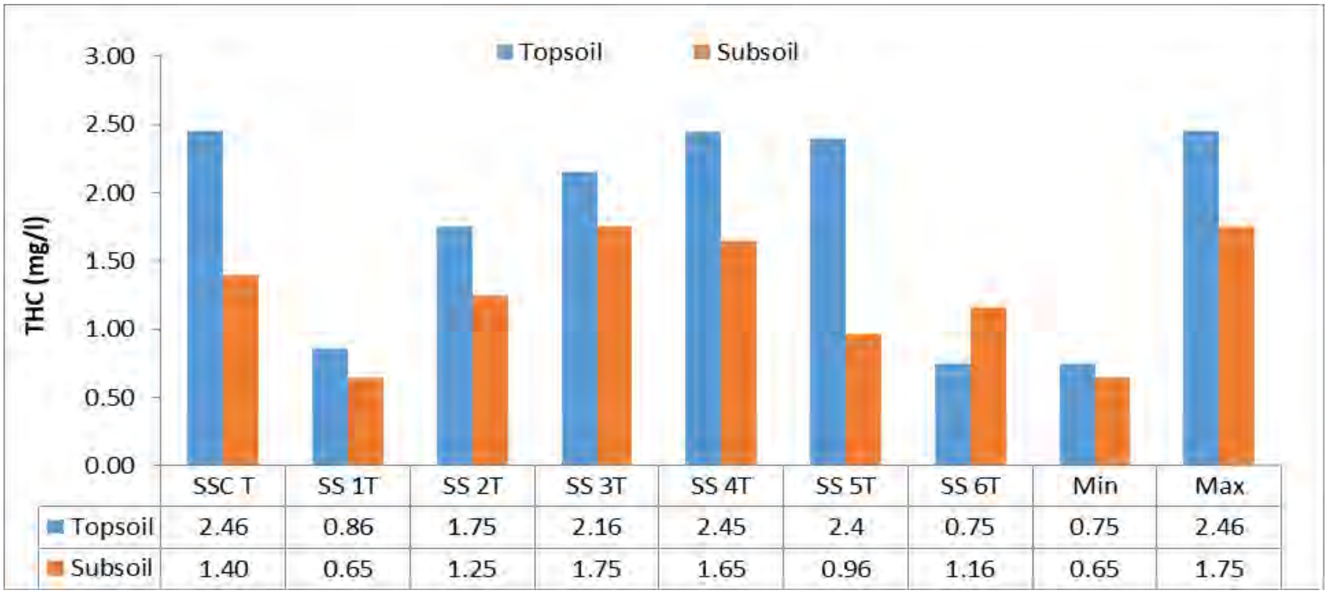


Fig 3.27 THC distribution across topsoil and subsoil within the study area

3.9.4.7. Heavy Metal

Heavy Metals (Trace elements) are chemical substances that are required in trace or very small concentrations in soils for plants growth. However, these elements can become hazardous to humans and animals if absorbed in the food chain even in small concentrations as they usually can become biomagnified. Low concentrations of heavy metals occur naturally in most soils. The concentration of these metals can however be increased to become potential pollutants if heavy metals – containing waste products from industrial or domestic activities are introduced into the environment (Bohn *et al.*, 1984). Concern over the presence of heavy metals in an environment arises from the fact that they cannot easily be broken down into non-toxic forms. Thus, once ecosystems are contaminated by heavy metals, they remain a potential threat for many years (Isirimah *et al.,* 2003).

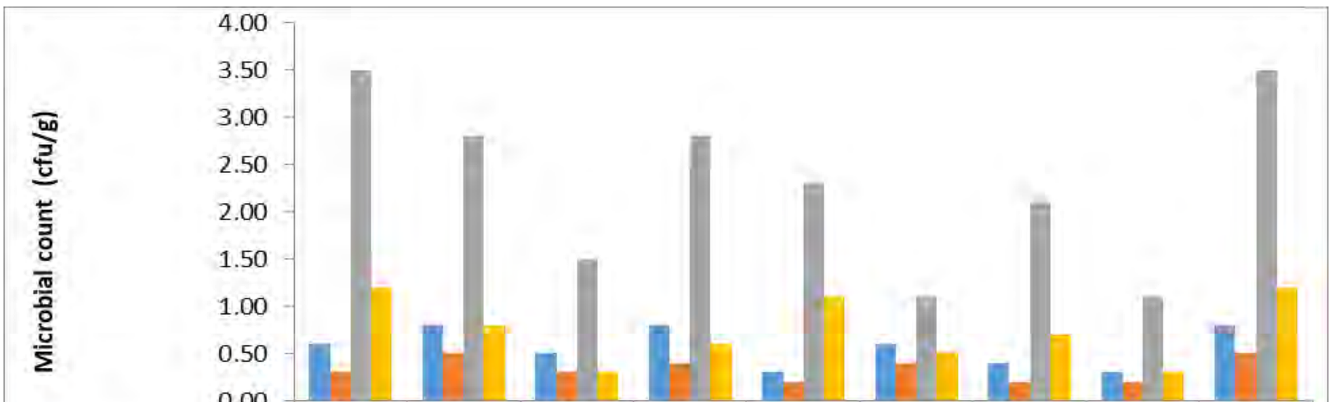
Laboratory analysis results revealed Fe ranged between (695.3 – 3068.8mg/kg) and (358.1 – 2713.0mg/kg) for topsoil and subsoil respectively, which is similar to that recorded at the control stations; Zn ranged between 2.60 – 17.06mg/kg and 1.97-8.32mg/kg for topsoil and subsoil respectively. While V, Ni, Cr, Pb, Cu, Hg and As were below detection limit except Ni and Cu at the control station.

The high iron content observed from the laboratory analysis results is typical of the Niger Delta environment due to high content of iron oxide, which is responsible for reddish and yellowish coloration observed in some soils within the region.

The analysis of these parameters provides insights into the soil's physical, and chemical properties, helping to assess soil quality, fertility, and potential environmental concerns within the proposed project site.

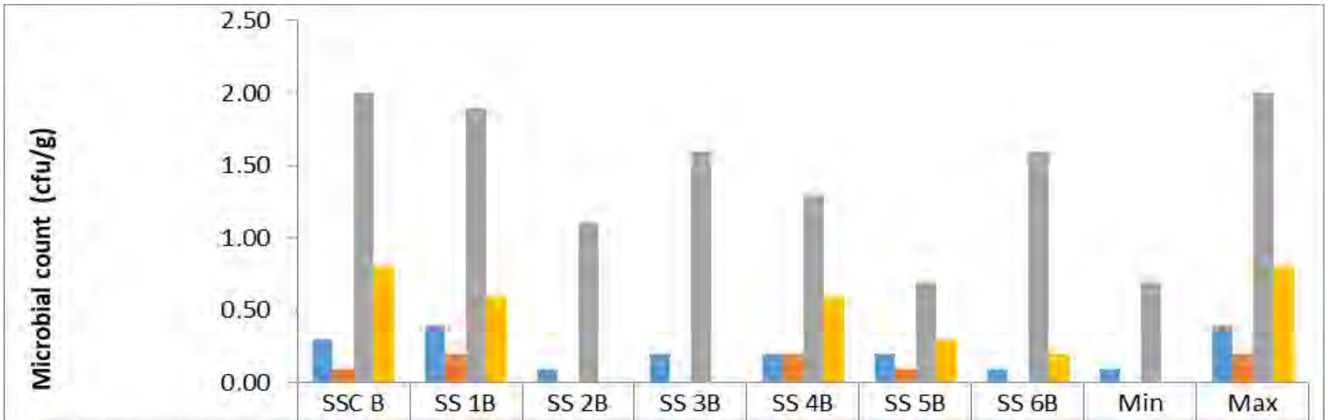
3.9.4.8. Microbiology

Figure 7 and 8 present microbial count of some microbes (HUB, HUF, THB and THF) within the study area. Figure 7 reveals dominant of these microbes on topsoil compared to subsoil, while THB were seen to have the highest count followed by THF at both depth.



	SSC T	SS 1T	SS 2T	SS 3T	SS 4T	SS 5T	SS 6T	Min	Max
HUB (CFU/g) x 103	0.6	0.8	0.5	0.8	0.3	0.6	0.4	0.30	0.80
HUF (CFU/g) x 103	0.3	0.5	0.3	0.4	0.2	0.4	0.2	0.20	0.50
THB (CFU/g) x 105	3.5	2.8	1.5	2.8	2.3	1.1	2.1	1.10	3.50
THF (CFU/g) x 105	1.2	0.8	0.3	0.6	1.1	0.5	0.7	0.30	1.20

Figure 3.28: Topsoil Microbial count within the study area



	SSC B	SS 1B	SS 2B	SS 3B	SS 4B	SS 5B	SS 6B	Min	Max
HUB (CFU/g) x 103	0.3	0.4	0.1	0.2	0.2	0.2	0.1	0.10	0.40
HUF (CFU/g) x 103	0.1	0.2	0	0	0.2	0.1	0	0.00	0.20
THB (CFU/g) x 105	2	1.9	1.1	1.6	1.3	0.7	1.6	0.70	2.00
THF (CFU/g) x 105	0.8	0.6	0	0	0.6	0.3	0.2	0.00	0.80

Figure 3.29: Subsoil Microbial count within the study area

3.9.4.9. Land use

Land use changes occur constantly and at many scales and can have specific and cumulative effects on air and water quality, watershed function, generation of waste, extent and quality of wildlife habitat, climate, and human health.

The proposed project site is located within the existing Onne Port complex in Eleme Local Government Area currently managed by Nigerian Ports Authority. The Onne Port complex was acquired by the Nigerian Government years back in order to foster industrialization and also to enable international trade via water ways. Currently, the port complex plays host to over two hundred companies. Consequently, the entire port complex is designated as an industrial area to aid international business transactions. The closest community within the Port complex is the Onne and Ogu Community. The Ogu community is located across the water. These communities especially the Onne is more of residential area and is 90% built up, while the Ogu closest community to the proposed project is Owogono is a fishing settlement with majority of the buildings a temporary structure.

A regional land use study covering the greater Eleme Local Government Area (LGA) has been performed. Table 3 presents the land changes within the Eleme LGA based on a survey carried out between 2006 and 2019. It is no surprise that as the population has grown over the period 2006 – 2019, the largest change in land use has been the built-up area (increasing from approximately 19km^2

in 2006 to 49km^2 in 2019). Figure 9 shows how the built-up area has expanded between 1986 and 2015. The increase in built-up land area has resulted in a decrease in land area covered by vegetation from approximately 93 km^2 in 2006 to 60 km^2 in 2019 (combine light and thick vegetation area).

Table 3.15: Population Growth and Land Use Change trend (2006 – 2019)

Year	Population Growth	Built-up Area (km^2)	Farmland (km^2)	Light Vegetation (km^2)	Thick Vegetation (km^2)	Water Body (km^2)
2006	6,273	18.67	24.3	76.79	16.09	2.25
2007	6,467	20.805	24.653	75.213	15.146	2.105
2008	6,686	23.12	25.006	73.636	14.202	1.96
2009	6,914	25.435	25.359	72.059	13.258	1.815
2010	7,149	27.75	25.712	70.482	12.314	1.67
2011	7,392	30.065	26.065	68.905	11.37	1.525
2012	7,643	32.38	26.418	67.328	10.426	1.38
2013	7,903	34.695	26.771	65.751	9.482	1.235
2014	8,172	37.01	27.124	64.174	8.538	1.09
2015	8,450	39.325	27.48	62.59	7.594	0.945
2016	8,737	41.64	27.83	61.013	6.65	0.8
2017	9,034	43.955	28.183	59.436	5.706	0.655
2018	9,341	46.27	28.536	57.859	4.762	0.51
2019	9,659	48.585	28.889	56.282	3.818	0.365

Source: Obende et al. 2020

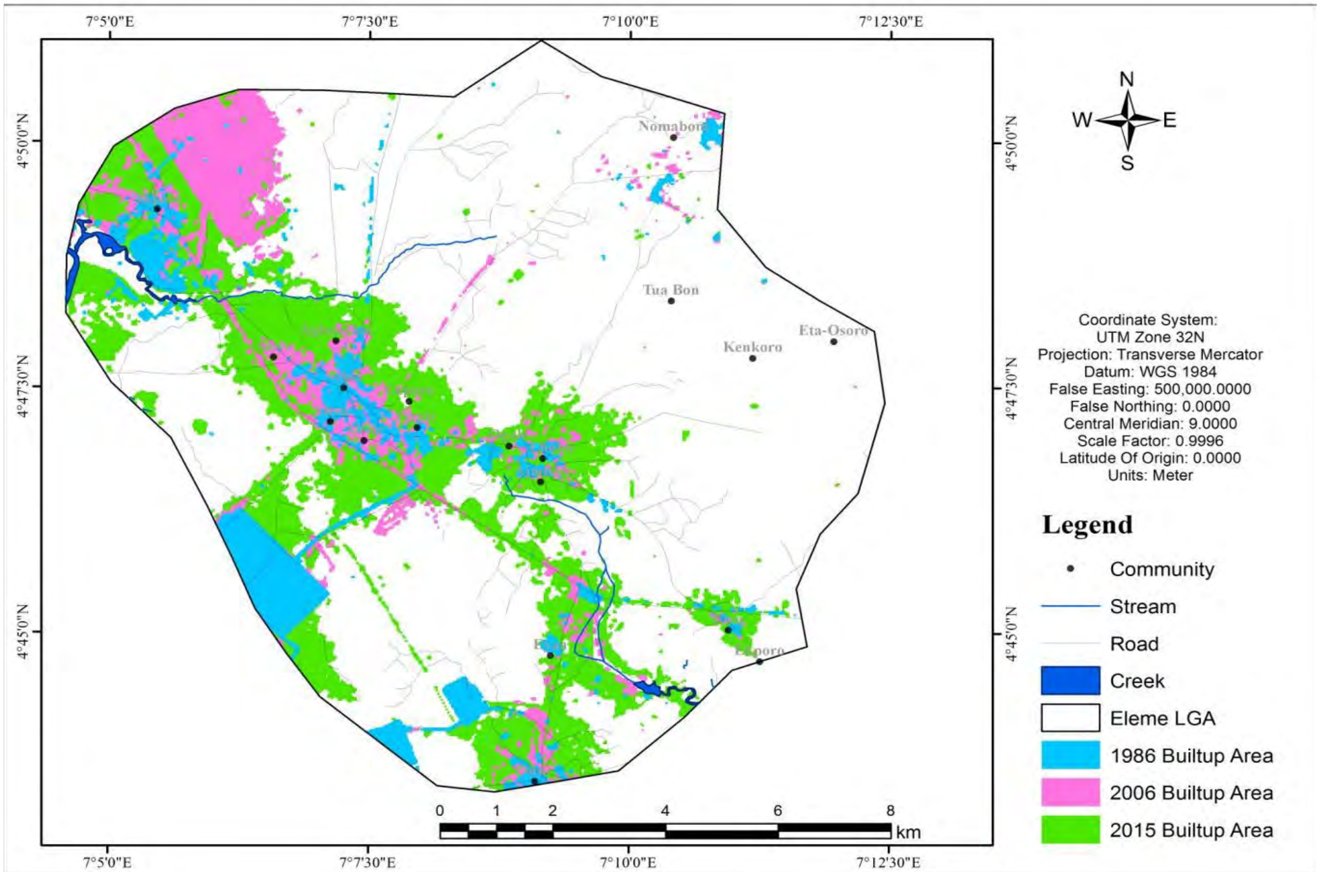


Figure 3.30: Distribution of the Built-up Area within the Eleme LGA (1986 – 2015)

Source: Obende et al. 2020

A breakdown of the primary land uses in the Eleme LGA is presented in table 4 It is evident from the field observations made that in 2019, residential made up the largest percentage (50%) of the land use, followed by industry covering approximately 35% of the area.

Table 3.16 Observed Land Use Pattern within the Eleme LGA

Land use	Percentage
Residential	50%
Industry	35%
Agriculture	10%
Undistributed forest	5%
Habitat protected area	0%

Soil Quality Results

Topsoil (0-15cm)

S/No	Parameter(s)	SS 1T	SS 2T	SS 3T	SS 4T	SS 5T	SS 6T	SSC T
1	Sand (%)	84.69	86.15	86.54	84.68	83.28	84.26	85.10
2	Silt (%)	6.05	5.39	5.81	7.20	7.26	8.28	6.50
3	Clay (%)	9.26	8.46	7.65	8.12	9.46	7.46	8.40
4	Texture	SS	SS	SS	SS	SS	SS	SS
5	Porosity	37.30	40.60	41.00	39.30	38.30	38.60	37.60
6	Colour	Light Brown	Grey	Grey	Grey	Grey	Grey	Dark Brown
7	Permeability (cm/sec)×10	0.16	0.17	0.15	0.13	0.14	0.15	0.15
8	Bulk Density (g/cm3)	1.23	1.16	1.35	1.4	1.42	1.42	1.56
9	pH	7.40	6.80	6.00	6.10	6.40	6.80	6.50
10	Moisture Content (%)	10.51	10.25	7.55	9.54	12.45	7.82	7.64
11	Sulphide, S2 (mg/kg)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
12	Sulphate, SO42- (mg/kg)	5.00	4.00	8.00	4.00	12.00	4.00	11.00
14	Nitrate, NO3- (mg/kg)	2.00	1.80	2.30	2.00	1.50	2.30	3.40
15	Total Nitrogen (%)	0.024	0.030	0.015	0.027	0.024	0.034	0.024
16	Phosphate, PO43- (mg/kg)	1.80	0.65	0.85	0.78	1.80	2.50	1.81
18	TOC (%)	0.27	0.35	0.59	0.31	0.27	0.39	0.27
19	THC (mg/kg)	0.86	1.75	2.16	2.45	2.4	0.75	2.46
21	Ammonia (mg/kg)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
22	Urea (Urea)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
23	Manganese, Mn (mg/kg)	12.18	3.31	3.18	1.66	5.72	3.51	32.57
24	Iron, Fe (mg/kg)	978.6	695.3	1,613.8	1,467.7	758.3	907.5	3,068.8
25	Zinc, Zn (mg/kg)	2.78	3.38	3.47	2.60	3.59	7.71	17.06
26	Vanadium, V (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
27	Nickel, Ni (mg/kg)	<0.001	0.41	<0.001	<0.001	<0.001	0.08	<0.001
28	Chromium, Cr (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
29	Lead, Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
30	Copper, Cu (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.61
31	Mercury, Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
32	Arsenic, As (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
33	HUB (CFU/g) x 103	0.8	0.5	0.8	0.3	0.6	0.4	0.6
34	HUF (CFU/g) x 103	0.5	0.3	0.4	0.2	0.4	0.2	0.3
35	THB (CFU/g) x 105	2.8	1.5	2.8	2.3	1.1	2.1	3.5
36	THF (CFU/g) x 105	0.8	0.3	0.6	1.1	0.5	0.7	1.2

Subsoil (15-30cm)

S/No	Parameter(s)	SS 1B	SS 2B	SS 3B	SS 4B	SS 5B	SS 6B	SSC B
1	Sand (%)	86.72	85.10	84.95	85.15	82.64	83.17	84.38
2	Silt (%)	5.14	6.37	7.63	6.37	9.09	8.08	9.31
3	Clay (%)	8.14	8.53	7.42	8.48	8.27	8.75	9.31
4	Texture	SS	SS	SS	SS	SS	SS	SS
5	Porosity	36.80	40.00	39.60	40.20	38.00	38.40	37.00
6	Colour	Brownish	Grey	Grey	Grey	Grey	Grey	Dark Brown
7	Permeability (cm/sec)×10	0.10	0.14	0.16	0.15	0.14	0.16	0.14
8	Bulk Density (g/cm3)	1.33	1.25	1.26	1.53	1.33	1.58	1.45
9	pH	7.50	6.30	5.80	6.30	6.90	7.20	6.60
10	Moisture Content (%)	12.31	11.40	8.16	8.12	11.84	10.51	8.50
11	Sulphide, S2 (mg/kg)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
12	Sulphate, SO42- (mg/kg)	8.00	2.00	16.00	10.00	8.00	2.00	10.00
14	Nitrate, NO3- (mg/kg)	2.20	1.80	2.80	1.80	2.00	1.40	1.90
15	Total Nitrogen (%)	0.022	0.025	0.041	0.023	0.016	0.024	0.014
16	Phosphate, PO43- (mg/kg)	1.40	0.75	1.25	1.25	1.69	1.85	1.65
18	TOC (%)	0.25	0.28	0.47	0.28	0.19	0.28	0.17
19	THC (mg/kg)	0.65	1.25	1.75	1.65	0.96	1.16	1.40
21	Ammonia (mg/kg)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
22	Urea (Urea)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
23	Manganese, Mn (mg/kg)	4.82	3.24	2.22	2.80	5.77	2.03	17.38
24	Iron, Fe (mg/kg)	688.3	962.2	2,109.2	1,081.3	729.5	358.1	2,713.0
25	Zinc, Zn (mg/kg)	2.47	2.35	1.97	2.75	3.02	3.05	8.32
26	Vanadium, V (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
27	Nickel, Ni (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.46
28	Chromium, Cr (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
29	Lead, Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
30	Copper, Cu (mg/kg)	<0.001	<0.001	<0.001	<0.001	0.14	<0.001	0.19
31	Mercury, Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
32	Arsenic, As (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
33	HUB (CFU/g) x 103	0.4	0.1	0.2	0.2	0.2	0.1	0.3
34	HUF (CFU/g) x 103	0.2	NIL	NIL	0.2	0.1	NIL	0.1
35	THB (CFU/g) x 105	1.9	1.1	1.6	1.3	0.7	1.6	2
36	THF (CFU/g) x 105	0.6	NIL	NIL	0.6	0.3	0.2	0.8

3.10. GEOLOGY / HYDROGEOLOGY REPORT

3.10.1 INTRODUCTION

The focus of this report is to undertake an in-depth assessment of the probable impacts of the proposed expansion on the hydrology and hydrogeology of the study area. This assessment encapsulates comprehensive evaluations of surface water flow, drainage patterns, and water quality in the vicinity of the project site. Moreover, meticulous evaluations of subsurface lithologic sequences, groundwater flow direction, groundwater quality, and potential groundwater migration pathways were conducted.

The ensuing findings, derived through systematic data collection, technical analyses, and comprehensive stakeholder consultation, will contribute invaluable insights into the dynamic interactions between the project and the extant hydrological conditions. With a specific emphasis on identifying potential risks and opportunities regarding water utilization, groundwater conservation, and water quality preservation, this report aims to devise mitigation measures to safeguard water resources and ensure environmental stewardship.

Aligned with the Environmental Impact Assessment Procedural Guidelines stipulated by the Federal Government of Nigeria, the purport of this project report underscores an unwavering commitment to sustainable development and responsible growth practices. The presentation of findings and recommendations will fortify informed decision-making and positively contribute to the overarching success of the proposed project.

3.10.2 Project Scope:

As part of the Environmental and Social Impact Assessment (ESIA) for the proposed project, a hydrogeological and stratigraphic assessment was conducted. The scope of this assessment includes investigations based on data obtained from the drilling of three boreholes within the project area (GW3, GW4, GW5). In addition to the data obtained from the drilling of three boreholes within the project area, water samples were collected from two existing nearby boreholes for water quality analysis (GW1, GW2). Furthermore, a third borehole located 2.0km away was designated as the control borehole, and water samples were also collected and analyzed from this location. The following components were examined for thorough understanding of groundwater resources and geological characteristics:

1. **Hydrogeological Investigation**: A evaluation of the hydrogeological conditions within the study area, based on the data obtained from the three boreholes, including groundwater flow patterns, aquifer properties, and groundwater-surface water interactions.
2. **Stratigraphic Analysis**: Examination of the soil profile and stratigraphy based on data from the three boreholes to comprehend geological formations and sediment layers that influence groundwater flow and storage characteristics.
3. **Depth to Groundwater**: Precise measurements of the depth to groundwater were recorded from the three boreholes, allowing for an understanding of the water table's level and fluctuations within the project area.
4. **Slug Test for Hydraulic Conductivity**: Conducting slug tests in the three boreholes to determine the hydraulic conductivity of aquifer formations and assess their ability to transmit groundwater.
5. **Water Quality Analysis**: Water quality analyses performed on water samples collected from the three boreholes to assess parameters such as pH, dissolved solids, heavy metals, etc.
6. **Control Borehole Water Quality Analysis**: Water sample collected and analyzed from the designated control borehole (GWC), situated 2.0km away, for assessment of groundwater quality.
7. **Groundwater Monitoring**: Development of a groundwater management and monitoring plan.
8. **Mitigation Measures and Best Practices**: Profound recommendations of appropriate mitigation measures and best practices based on assessment of groundwater resources and geological formations. These measures are crucial in ensuring responsible water management throughout the project's lifecycle.

3.10.3. Objectives of the Study

The objectives of this study are as follows.

1. Determination of subsurface lithologic units across the area.
2. Assessment of groundwater quality.
3. Determination of depth to groundwater.

4. Assessment of groundwater flow direction and pattern.
5. Determination of groundwater hydraulic properties.
6. Determination of groundwater hydrogeochemical facies

3.10.4. Location of the Study Area

The project site is located in Onne Port Complex, Onne, Eleme LGA, Rivers State. The area lies towards the North of the Bonny River.

3.10.5. Regional Geology of the Area

The formation of the present-day Niger Delta started in the early Paleocene era and resulted in the build-up of fine-grained sediments eroded and transported by River Niger and its tributaries. The subsurface geology of the Niger Delta consists of three lithostratigraphic units (Akata, Agbada and Benin Formations), which are in turn overlain by various types of quaternary deposits. The Benin Formation (2l00m thick) is made up of over 90% massive, porous, coarse sands with clay/shale inter-beds (Short and Stauble, 1967). This formation is the most prolific aquifer in the region. The Quaternary deposits (40-150m thick) generally consist of rapidly alternating sequences of sand and silt/clay with the latter becoming increasingly more prominent seawards. The Niger Delta can be subdivided into three major inter-gradational geomorphologic units (Andersen, 1967) from land to sea (north to south), these are:

- Dry deltaic plain with rare freshwater swamps
- Extensive freshwater swamps and meander belts
- Saltwater mangrove swamps, estuaries, creeks and lagoons

The dry deltaic plain is a geographically extensive low-lying area dominated by fluvial systems, some with braided characteristics. Few meander belts occur within this deltaic plain. Raffia palms dominate flood plains while palm trees are most common in the inter-fluvial settings. Extensive lateritic soil (approximately 12m in thickness) underlies this unit.

The Quaternary (neogene) and Tertiary stratigraphy of parts of the Niger Delta, (NDES 1995) is shown in Table 1.1. The sediments of the area, which are indicative of the Holocene geomorphologic units, are underlain by Benin, Agbada and Akata formations (Short and Stauble, 1967). The Benin

Formation, which is the continental mega-facies of the tertiary Niger Delta, comprises about 6,000m thick successions of unconsolidated sands with thin clay and lignite interbeds. The Benin formation grade very gently downwards into the paralic delta front mega-facies, represented by the Agbada Formation. The unit consists of an interbedded sequence of sands and shales about 3,150m thick on average. All the hydrocarbon reserves of the Niger Delta accumulate in the sands of the Tertiary Niger Delta. Consequently, it is dominated by shales of more than 1,380m thick. Sands constitute the major aquiferous layer in the Niger Delta and is dominated by sands, and gravelly sands. (Andersen, 1967).

The bulk of groundwater in the Niger Delta is contained in very thick and extensive sediments of the Benin Formation. In general, the hydrogeological data in the upland areas of the Niger Delta have very broad similarities not only on the sub surface lithology but also in the overall aquifer characteristics. The exploited aquifers in the Niger Delta including the Greater Port Harcourt are derived from the Benin Formation (The Coastal Plain Sands). Basically, the Benin Formation is unconsolidated and consists of very thick sediment over 2000meters thick. The sand sediments of Benin Formation are intercalated with layers of clay, and this has given rise to a multi layered aquifer system a common feature of the Niger Delta. The major recharge to the aquifers of the Niger Delta is from precipitation.

Table 3.16: Geological and Lithological Units of the Niger Delta

Geologic Unit	Lithology	Age
Alluvium	Gravel, sand, clay silt	
Freshwater back-swamp	Sand, clay, some silt, and gravel	
Meander belt		
Mangrove and salt Water / backswamps	Medium-fine sand, clay, and some silt	Quaternary
Active/abandoned beach ridges	Sand, clay, and some silt	
Benin Formation (Coastal Plain Sand)	Coarse to medium sand with Subordinate silt and clay lenses	
Agbada Formation	Mixture of sand, silt and shale	Tertiary
Akata Formation	Shale, sandy in some places	

Source: Niger Delta Environmental Survey. 1995

Based on geophysical and borehole data collected over the years the Niger Delta hydrogeological set up can be classified into (a) Impermeable/Semi permeable horizons from ground level to 10m below mean sea level. (b) A permeable/gravel sand layer up to 80 meters below sea level. (c) From 80m to 225m below sea level (masl), the formation consists of a permeable sand/gravel layer with thin impermeable/semi permeable clay/silt layers.

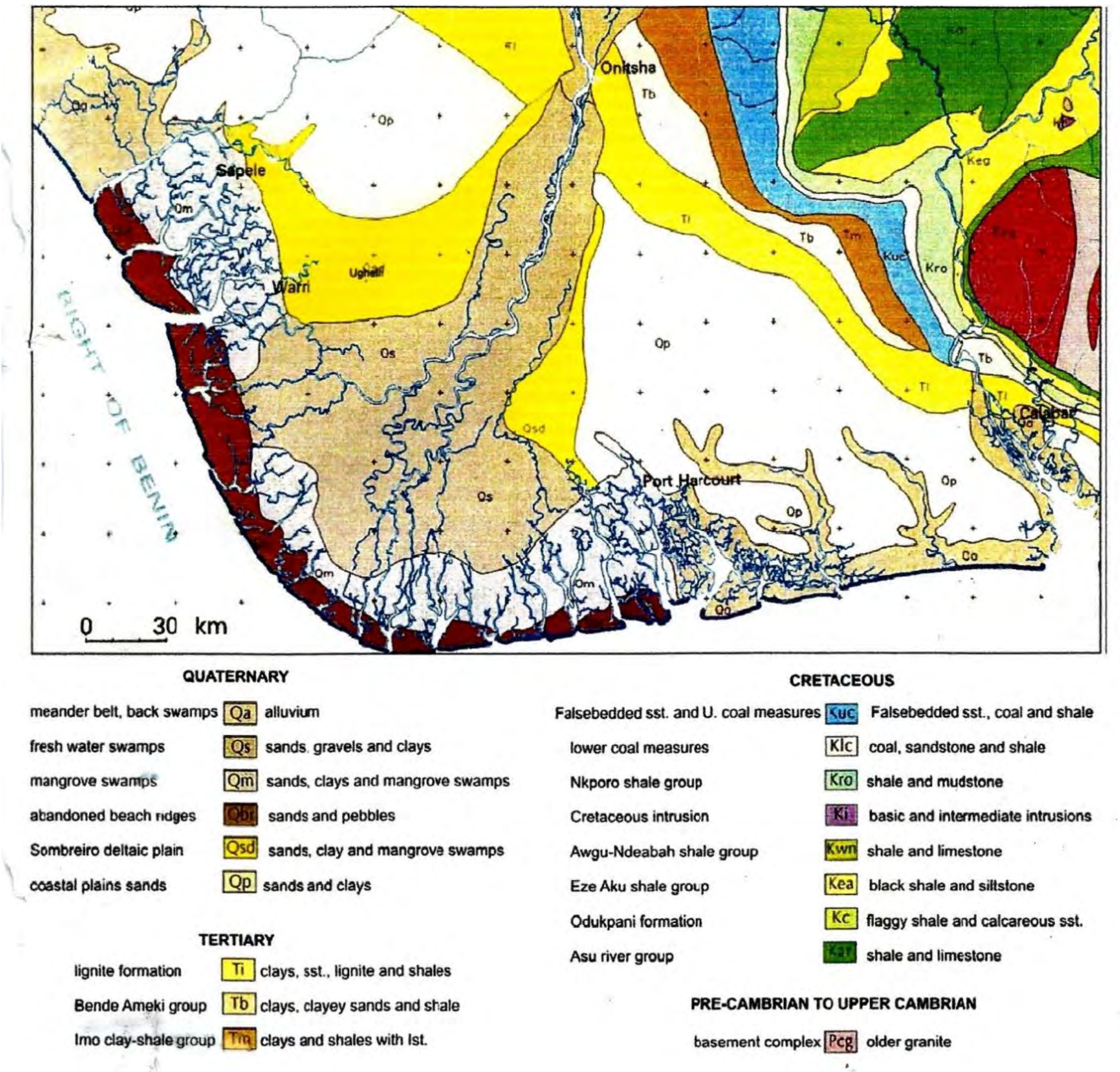


Figure 3.31: Geologic characteristics of the Niger Delta

3.10.6 Hydrogeological Settings of the Project Site

The Niger Delta geology is underlain by three principal formations, namely: Akata, Agbada and Benin Formations. The hydrogeology of the Niger delta is dominated by the Benin Formation, which serves not only as aquifer but also facilitates recharge of groundwater in the region. The Benin Formation serves as the groundwater reservoir in the area. The main body of groundwater in the Niger Delta is contained in the extensive sand and gravel layers which are interspersed with shale and clay layers within the formation. It is now well known that the Benin Formation (Miocene to Recent) posses' excellent water yielding properties even at great depths (Amajor, 1991).

Well cuttings from the logs of oil wells across the Niger delta, reveal that the Benin Formation is laterally extensive and extends to depths of 2000 m in places (Abam and Nwankwoala, 2020).

Etu-Efeotor and Odigi, (1983); Amajor (1989); and Etu-Efeotor and Akpokodje, (1990) studies indicate that the Benin Formation is differentiated into three main zones, namely, 1) a northern bordering zone consisting of shallow aquifers of predominantly continental deposit, 2) a transition zone of intermixing marine and continental materials and 3) a coastal zone of predominantly marine deposits.

Akpokodje et al. (1996) summarized the hydrostratigraphic units of the Benin Formation as consisting of four well defined aquifers in the upper 305 m that vary in thickness. The aquifers vary from unconfined conditions at the surface through semi-confined to confined conditions at depth. The aquifers are separated by highly discontinuous layers of shales, giving a picture of an interval that consists of a complex, non-uniform, discontinuous and heterogeneous aquifer system.

In 2014, an estimated groundwater recharge of 31.9 BCM/year was predicted by Japan International Cooperation Agency for the Niger delta region of Nigeria. This value is just below that of the Southeast region which is the highest in Nigeria. The high perennial aquifer recharge in the area is supported by the abundant rainfall, favorable geology, vast catchment area, North Southwards groundwater flow and presence of a rich network of freshwater rivers and streams in the area.

The project site is surrounded by Rivers, Swamps, and Creeks. Hence, apart from the huge contribution from rainfall to groundwater recharge, the likelihood of groundwater recharge in the area was highly influenced by these surrounding water systems.

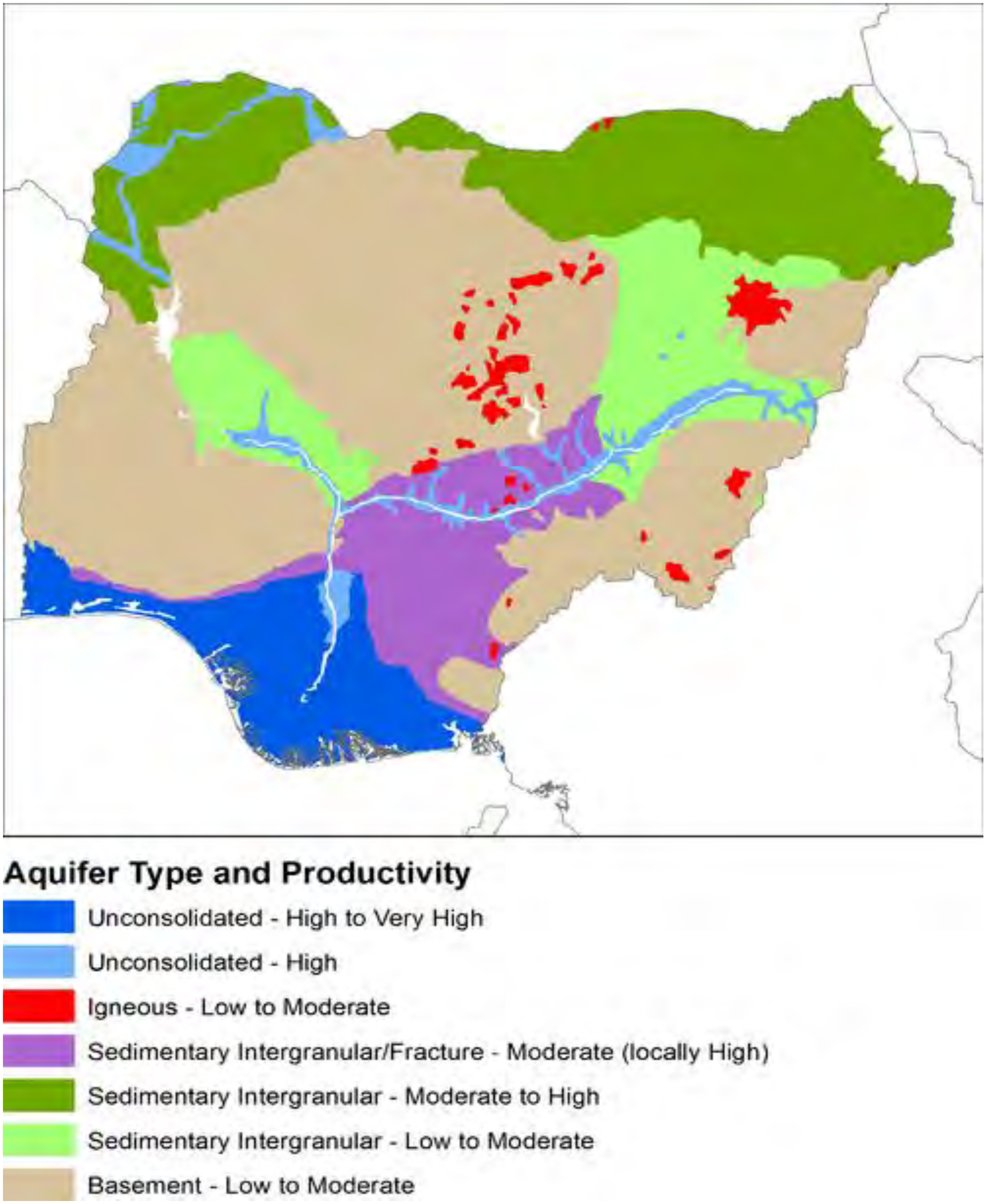


Figure 3.32: Map of Nigeria showing the aquifer types and productivity.

3.10.7. METHODOLOGY

3.10.7.1 Borehole Construction

A total of three groundwater monitoring boreholes were drilled to a depth of 30.0m to access groundwater. The goal for drilling these monitoring boreholes during the ESIA study are as follows; 1) Determination of depth to groundwater, 2) Determination of baseline groundwater quality, 3) Determination of groundwater flow direction, 4) Determination of seasonal impact of groundwater table, 5) Delineation of subsurface stratigraphic lithologies, 6) Determination of hydraulic conductivity for monitoring groundwater flow movement. The following procedures will govern the installation of all monitoring wells.

3.10.7.2. Cleaning of Equipment and Materials

A conventional boring method that consists of use of the light shell and auger motorized rig was used for the boring.

Drill rods, augers, casings, samplers, pipe wrenches, and other materials and tools were cleaned until all visible signs of grease, oil, mud, or other material were removed. Brushes were used as necessary to assist in the removal of extraneous materials or soil.

3.10.7.3. Shell and Auger Drilling Procedures

For the construction of the 50mm diameter groundwater monitoring boreholes to a depth of 30.0m, a hand auger with a cup diameter of 101.6mm was utilized for augering the initial 1.0m. In employing the hand augering method, the drilling action is applied by manually rotating a cutting blade or auger. As drilling progresses, the auger fills with soil and is periodically lifted to the surface and emptied. The soil auger is advanced by rotating it while pressing it into the soil at the same time. Due to the sand-fill nature of the site, the auger method was discontinued, and the shell and auger method adopted. The auger shell aided to give the wall of the borehole stability during the augering process and to prevent backfill of loose sands. This involved mounting a tripod stand with the rope and pulley system that helps to ease the process of drilling to the target depth of 30.0m (Fig. 2.2). In stiff clayey formations, a clay cutter was added to the drilling assembly to help soften the underlying formations and allow for safe collection of disturbed soil cuttings.

3.10.7.4. Sampling of the Formation

The sampling of the soil formation was required to establish the nature of the soils at the location of the monitoring wells. Geologic samples, retrieved through percussion drilling were required to determine the strata thickness and soil types present at various depths, and to provide the information necessary to develop an accurate log for the drilled hole. All soil samples were adequately described on site before for colour, texture, composition and lithology. All monitoring wells were properly logged, to provide a record of the lithology encountered. The soils log all follows the format established in the Unified Soil Classification System (USCS) scheme.

3.10.7.5. Sampling Interval and Type

During augering, soils within the borehole were sampled at regular intervals (1.0m interval) and at every change in lithology. The soil samples were examined for logging of the hole.

3.10.7.6. Well Construction Materials

All materials utilized or incorporated into the construction of ground water monitoring wells were new, of sound condition, and free of hazardous or toxic chemical constituents which may leach into the ground water. All paint, coatings, or inks were removed prior to installation.

3.10.7.7. Well Screens

Well screens were continuously slotted PVC plastic well screen. Well screen was designed on site based on aquifer conditions. The bottom of each screened sections was designed to accept a threaded bottom plug, which plug were designed to withstand all installation and well development pressures without becoming dislodged or damaged.

3.10.7.8. Riser Pipe

Riser pipes consisted of PVC plastic pipe meeting ASTM D1785, with flush-joint threads. Riser pipes were furnished in appropriate lengths, with all riser pipes having a minimum length of 5 feet and a maximum length of 20 feet. The diameter of the risers utilized was 50mm.

3.10.7.9. Graded Filter (Gravel) Pack

Gravel pack was the material placed in the annular space around the well screen. The pack was uniformly graded gravel, comprised of hard, durable particles which had been washed and screened. The sizing of the gravels was determined by the soil type that was encountered in the aquiferous zone. The particle size of the pack were 4 times the D15 size (15 percent of the soil is finer than this dimension) of the soil in the monitored zone and were no more than 4 times the D85 size (85 percent of the soil is finer than this dimension) of the soil in the monitored zone. The gravel pack was cleaned and free from foreign particles.

3.10.7.10. Well Installation

Prior to installation of any material in a borehole, it was verified that the borehole is stable, vertical, unobstructed, and advanced significantly within the aquiferous depth. Where the borehole tends to cave in or heave, the drill crew were advised to take the necessary steps to stabilize the borehole.

3.10.7.11. Well Component Assembly

The installation of the components of the well was as follows. All materials were cleaned. The wells screen and riser pipe were assembled by taping the male threaded portion of each component with Teflon tape, and then inserting and tightening the components by hand. The bottom plug was inserted into the bottom of the last section of the well screen. Since over 3.0m section of well screen was used, each section was joined, and hand tightened after the joints have been taped with Teflon tape. As the screen and riser pipes were assembled, the assembled sections (string) were positioned into the borehole and held in place with a slip plate and ropes, or wire cables attached to the boom of the drill rig. Once the string has been lowered to the depth of the zone to be monitored, the string was suspended in place, and the screen and riser sections positioned in the center of the borehole and vertically aligned. The riser pipe extended 1.0 meters above ground level. The final trimming of the riser to 0.50m above ground level was done after the grout was in place around the wellbore.

3.10.7.12. Placement of Gravel Pack

The gravel pack typically extended two feet above the uppermost row of slots in the well screen, except where relatively impermeable zones separating permeable strata of soil are thin and require that the gravel pack construction be limited to a shorter rise. The level of the gravel pack within the borehole was confirmed by sounding with a weighted tape, and appropriate notations were recorded in the well log with other well construction data. Since hollow-stem augers (shell and auger) were used, the gravel pack was placed by pouring the material into the annulus between the auger and the riser pipe. The auger was raised periodically, and an auger flight removed, to allow the gravel pack to fill the annulus between the well screen and the borehole wall. After withdrawing the temporary casing to a level approximately three feet above the top of the gravel pack, the pack was again sounded to determine whether the withdrawal of the casing disturbed the gravel pack, and whether the pack continues to extend at least two feet above the top of the well screen.

3.10.7.13. Placement of Bentonite Seal

After the gravel pack had been placed and sounded, a bentonite pellet seal was constructed above the gravel pack. The seal was 1.0m in thickness, and the pellets were placed and sounded in the same manner as the gravel pack.

3.10.7.14. Placement of Grout

After the bentonite grout has been placed, the boreholes were grouted. Grout was prepared and then injected into the borehole via a tremie pipe. The discharge end of the tremie pipe was placed initially on the top of the bentonite seal. As the borehole was filled with the grout, the tremie pipe was raised. The grout was pumped through the tremie pipe into the borehole until the grout flows out of the borehole at the surface. After the grout has been placed, the temporary casing was removed. Additional grout was added to maintain a continuous column of grout within the borehole which is filled completely to the surface. After the grout has set (approximately 48 hours), the riser pipe was then trimmed to 0.5m above ground level. Trimming of the riser was done in a manner to prevent pipe cuttings from entering the well.

3.10.7.15. Placement of Well Protector

A steel pipe, having an inside diameter of at least 1.33 times the outside diameter of the riser pipe, was set concentrically around the riser pipe and into the plastic grout. The bottom of the well protector was submerged at least three feet into the grout and extends at least six inches above the top of the riser pipe. The well protective casing was installed so that the bottom of the casing is terminated below the frost line, to prevent heaving of the casing and riser pipe. The grout which is forced out of the borehole due to the placement of the well protector was carefully removed so as to prevent "mushrooming" of the grout, which tends to promote heaving of the well casing and the well protector during frost conditions. The well protector was maintained plumb and concentric with the riser pipe until the grout has set. Temporary braces were used to maintain the well protector in the proper position (Fig. 2.5). A locking cap was secured to the top of the well protector pipe.

3.10.7.16. Well Development

All three (3) new monitoring wells were developed, by pumping or evacuating the well casing, in order to remove trapped soil fines in the gravel pack and soil formation just outside the pack and to produce a representative sample of the water in the formation. Well development was completed 24 hours after the well construction has been completed and prior to sampling for any water quality characteristics. Well development was accomplished using a jet pump. Pump capacity is 1.09 liters per second. Well development continued until representative formation water, free of the effects of well construction, was obtained. Representative formation water was defined as water which is generally free of sediment, and has stable pH, temperature, and conductivity when measured during a period of ten minutes. Groundwater in-situ parameters (TDS, PH, EC, Temperature) were constantly monitored (every 10 minutes) until stable results were obtained. In general, well development proceeded for 3 hours for each borehole.

3.10.7.17. Surveying and Coordinates

The geographic reference locations for each groundwater monitoring borehole were obtained using mobile Garmin Global Positioning System (GPS) precision up to ±1.0m. The measurements were obtained by keeping the GPS on each well head and after stabilization (approx. 3 minutes depending on cloud cover) measurements were recorded. Geographic coordinates were recorded for all borehole positions on site.

3.10.7.18. Groundwater Sampling and In-Situ measurements

The borewell was flushed till stable pH and conductivity was achieved. Parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Temperature and Salinity were recorded in-situ on site during sampling. Water samples were collected in pre-cleaned plastic jars using Hanna Multimeter. Groundwater samples were analyzed in-situ three (3) times and the average values were taken to represent the characteristics of the groundwater.

3.10.7.19. Ground Water Level Measurements

The objective was to determine the piezometric surface elevation of ground water at drilled borehole locations (GW3, GW4, GW5) in order to evaluate ground water flow direction, probable direction of groundwater migration, and the effect which withdrawal wells may have on the hydrogeologic environment. Water level measurements were taken using an electric water level probe, Soil Test Model No. DR-760A. Which have accuracy of + 0.01 feet.

3.10.7.20. Groundwater Flow Direction

To ascertain groundwater flow direction, knowledge of borehole point elevation and static water level depth is essential. The hydraulic head, derived from the disparity between borehole elevation and static water level, is pivotal. Hydraulic head contour mapping facilitates identification of groundwater flow paths, as water moves from higher to lower hydraulic head areas. Geological formations and human interventions like well pumping impact local flow dynamics. Repetitive static water level measurements mitigate localized pumping effects. It's crucial to recognize that groundwater flow patterns shift due to seasonal fluctuations and land use changes. Continuous monitoring of groundwater levels is thus indispensable for maintaining updated insights, aiding effective water resource management, and making informed decisions during environmental impact assessments.

3.10.7.21. Field Hydraulic Conductivity Test Measurement

A critical facet of the Environmental Impact Assessment (EIA) process involves accurately determining hydraulic conductivity near groundwater monitoring boreholes. Hydraulic conductivity is pivotal for comprehending water movement and transport in subsurface formations, directly affecting aquifer water flow rate. This insight is crucial for assessing groundwater availability, vulnerability, and contamination risks. Conducting hydraulic conductivity tests is relatively simple, taking under half an hour per well. Initially, well-specific details like completion info, depth, screen location, diameter, and water column height above the screen are collected. This aids in installing the pressure transducer at the correct depth. Essential pre-test info includes well location, borehole depth, casing specifics, groundwater depth, screen attributes, aquifer thickness, pump type, discharge rate, aquifer and well type. The procedure involves: measuring static water level multiple times, setting up a jet pump assembly and generator, fitting a non-return valve to the bottom riser, placing the pump assembly at a safe depth, and installing a data logger-equipped transducer down the borehole. A loop of the transducer cable secures its position. The transducer's parameters are programmed, followed by a minute of pumping and nine minutes of recovery. Rising head data is recorded, with flow rate monitoring. Only recovery data is used for analysis due to its reliability.

Table 3.17: Borehole parameters utilized for hydraulic conductivity test.

Borehole-ID	**GW3**	**GW5**	**GW4**
Borehole Depth (m)	30	30	27
Casing stickout (m)	0.50	0.50	0.50
Depth to Groundwater + Stickout (m)	3.62	5.83	3.92
Depth to Groundwater -Stickout (m)	03.12	4.14	3.42
Screen Length (m)	6.0	6.0	6.0
Radius of Screen (m)	0.0508	0.0508	0.0508
Radius of Casing (m)	0.0508	0.0508	0.0508
Radius of Borehole (m)	0.0762	0.0762	0.0762
Thickness of Aquifer (m)	10.0	11.0	9.0
Pump Used	1.0 hp Jet Pump	1.0 hp Jet Pump	1.0 hp Jet Pump
Pumping Rate (l/s)	1.09	1.09	1.09
Type of Aquifer	Unconfined	Unconfined	Unconfined
Type of well penetration	Partial	Partial	Partial
Transducer installed depth (m)	4.56	4.5	4.52
Pumping Duration (min)	1.00	1.00	1.00
Recovery Duration (min)	9.00	9.00	9.00

3.10.7.22. Data Analytical Procedures

The recovery test results (rising head) were then incorporated into the appropriate well flow equation to determine the hydraulic conductivity of the aquifer. The Hvorslev (1951) mathematical equation, Cooper-Bredehoeft-Papadopulos (1967) mathematical model and Bouwer and Rice (1976) empirical model were utilized for determination of hydraulic conductivities of the aquiferous intervals. The Hvorslev (1951) equation can be applied to both unconfined and confined aquifers, the Cooper et al., (1967) model is mainly utilized for confined aquiferous systems. Bouwer and Rice (1976) model apply to unconfined aquifers. Having more than one method to calculate the hydraulic conductivity of an aquifer is helpful. It is especially useful for cross-checking values for comparison purposes. If results of one method differ significantly from other, then this is helpful in detecting calculation errors.

3.10.8. RESULTS AND DISCUSSION

3.10.8.1. Local Stratigraphic Profile of the Area

The project site lies on the bank of the Bonny River. The geology of the site is composed of coarse-grained sands, medium to coarse grained sands, medium grained sands, medium to fine grained sands, sandy clay, silty clay, clayey sands, and organic clay. Figure 3.1 shows the lithologies encountered and correlated across the project site. The project site is a reclaimed sand-filled area. The stratigraphic unit in the area comprises of medium grained sands and medium to coarse grained sandy soils occupying between 4.50m to 7.0m below ground surface. This area is a sand-filled area, and the thickness of the sand-filled area decreases away from the shoreline. The sandy nature of these layers makes it permeable for surface water and potential contaminants to be transported into the subsurface realms. Underlying this layer is a thick layer of silty clay and organic clay which stretches to a depth between 12.0m and 14.0m. The 7.0m thick layer of clayey soils extends throughout the entire area and acts as a barrier that impedes surface infiltration from entering the subsurface realms. The thick clayey layer is underlain by a continuous layer of sandy clay which extends to a depth ranging from 17.0m in GW4 to 20.0m depth in GW3. This layer is underlain by aquiferous sands composed of medium sands, medium to coarse sands and coarse sands to a depth of 30.0m. The aquiferous thickness ranges from 9.0m to 11.0m. The similarity in geology encountered across all three boreholes reveals the lateral continuity of stratigraphic units across the area.

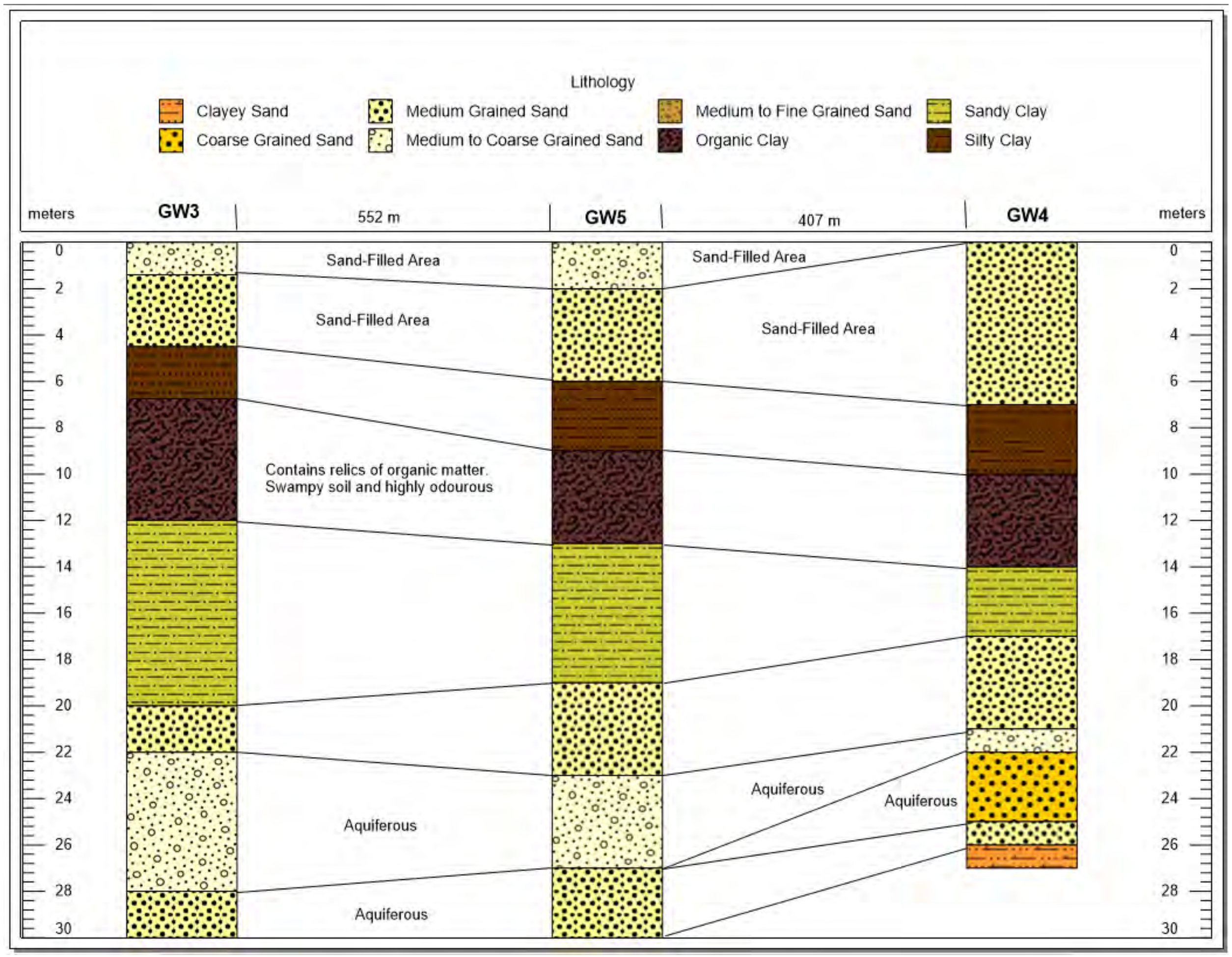


Figure 3.33: Lithologies encountered and correlated across the project site.

3.10.8.2. Groundwater Dynamics of the Study Area

The results obtained from borehole ground elevations mapping, static water level mapping and reduced groundwater elevation determined from the difference between the ground elevation and the static water levels are presented in Table 3.1. The surface elevation across the area ranges from 4.50m to 6.50m above mean sea level. The topographic profile across the area is shallower towards the coastline (4.50m) and steeper inland away from the coastline (6.50m) (Fig. 3.2).

Static water levels ranged from 3.12m to 4.14m above mean sea level (Fig. 3.3). The shallow water table makes it possible for potential contaminants from the surface to make their way into underground water resources.

Hydraulic head ranged from 1.20m to 3.40m (Fig. 3.4). Hydraulic head is higher towards the northwest and lowest towards the southern part of the study area (towards Bonny River). Groundwater flows from the northwestern part of the area towards the southeastern and southern part of the project site. Although the localized groundwater flow direction trends towards the Bonny River, over-exploitation of boreholes within the area can cause a reversal in groundwater movement withine area.

Table 3.18: Ground Elevation, static water level and reduced groundwater elevation for the study area

ID	UTM Easting (m)	UTM Northing (m)	Ground Elevation (m)	Static Water Level (m)	Reduced Groundwater Elevation (m)
GW3	293715.00	516755.00	6.50	3.12	3.38
GW4	294046.00	516188.00	4.50	3.42	1.08
GW5	294242.00	516545.00	6.50	4.14	2.36

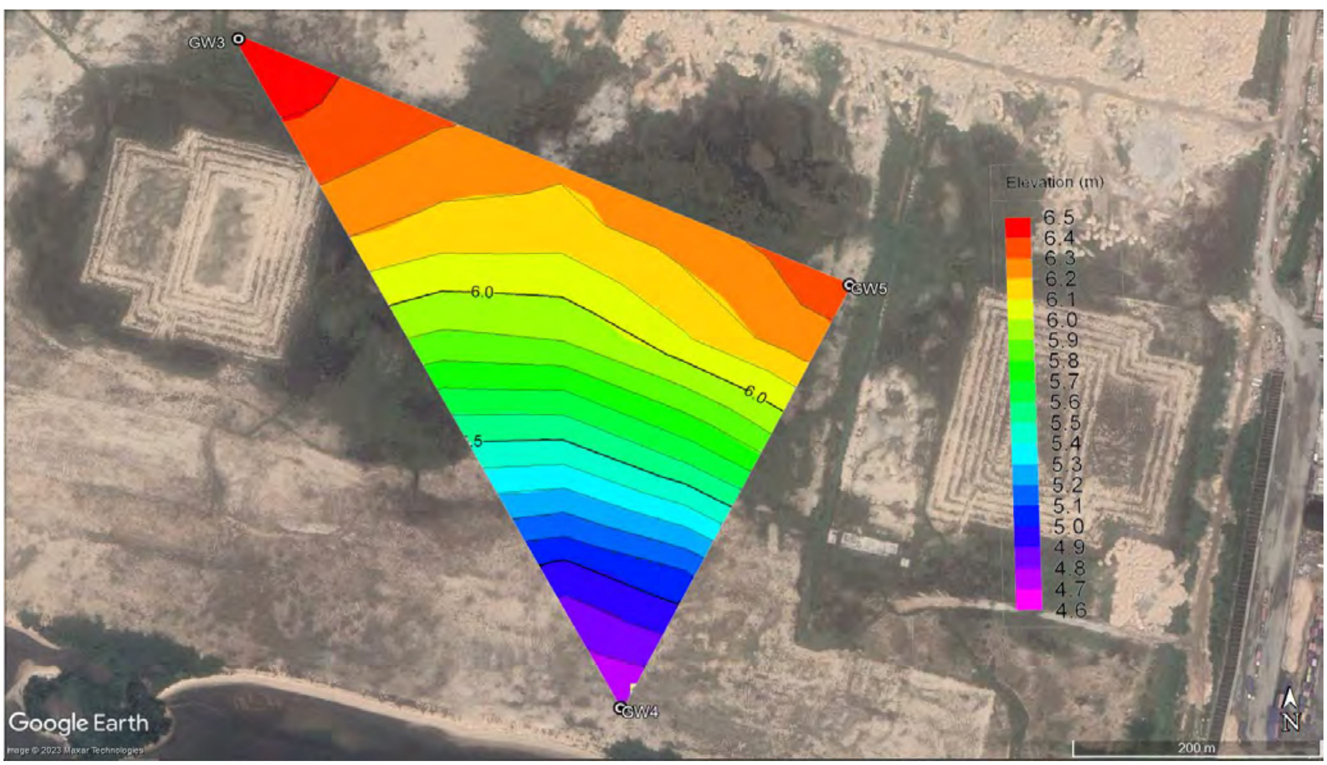


Figure 3.33: Ground surface elevation around project area

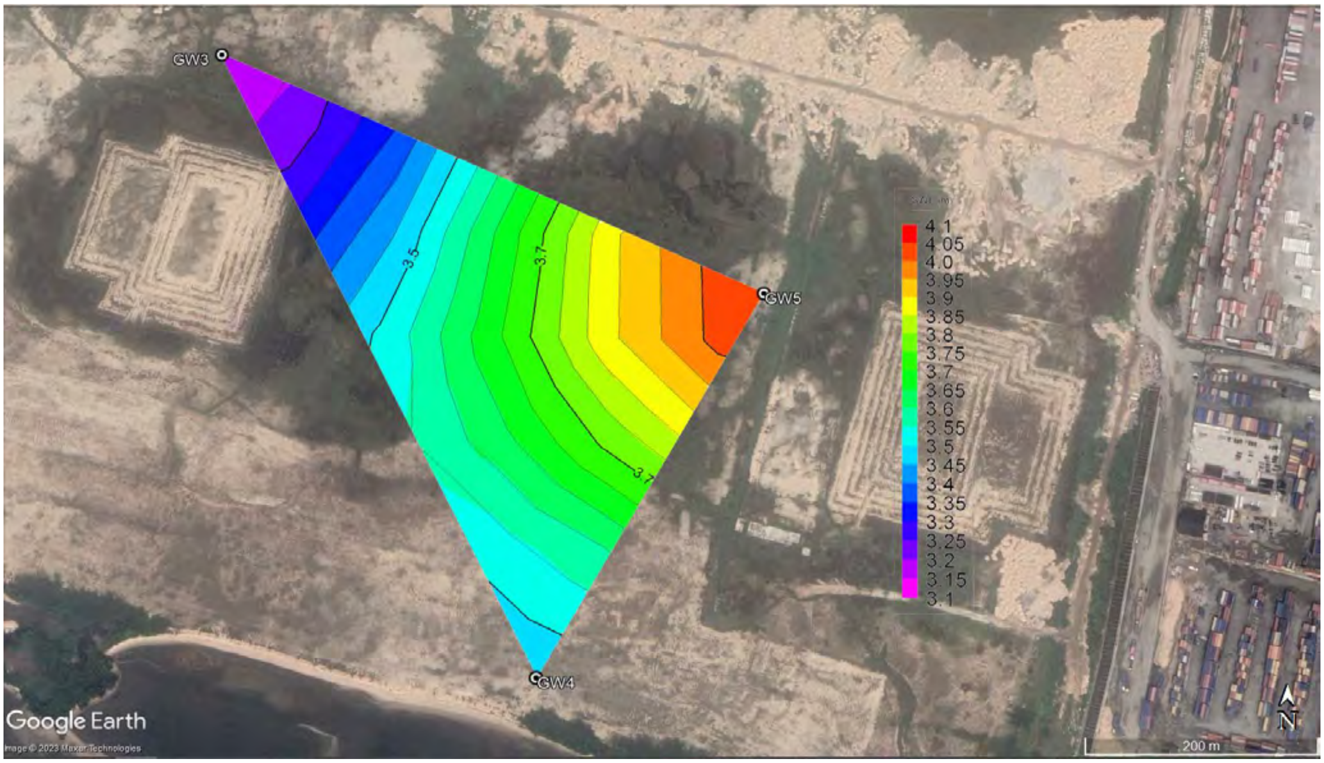


Figure 3.34: Map showing the depth to water table around project area.

Figure 3.35: Reduced groundwater elevation map showing direction of groundwater flow around project area.

3.10.8.3. Hydraulic Characteristics of the Aquifer

Data obtained from hydraulic conductivity test data acquisition were modelled using mathematical empirical equations within AquiferTest software environment. The results of hydraulic conductivity are presented in Table 3.2. Three overdamped empirical models were utilized and includes Cooper et al., (1967), Hvorslev (1951) and Bouwer and Rice (1976) empirical models. Both Cooper et al., (1967) and Hvorslev (1951) models are predominantly utilized for unconfined aquifers, whereas Bouwer and Rice (1976) mathematical model is utilized for unconfined partially penetrating and fully penetrating aquiferous systems. Data logger results obtained from hydraulic conductivity test field investigation are presented in Appendix A. Empirical models utilized for predicting hydraulic conductivity are presented in Appendix B. Graphical plots for hydraulic conductivity analysis for GW3, GW4 and GW5 are presented in Figure 3.5, 3.6 and 3.7 respectively.

The results of hydraulic conductivity recorded in this study as presented in Table 3.2 shows that Hvorslev (1951) model slightly overestimates hydraulic conductivity when compared to the other models. Based on Cooper et al., (1967) empirical model, hydraulic conductivity values range from 5.08 x 10^{-6} to 6.35 x 10^{-5} m/sec across the site. Hydraulic conductivity obtained using Hvorslev (1951) empirical model ranged from 5.39 x 10^{-5} m/sec to 9.28 x 10^{-5} m/sec across the site. Results of Bouwer and Rice (1976) ranged from 2.64 x 10^{-5} to 5.12 x 10^{-5} m/sec. Hydraulic conductivity recorded is highest in GW4 and lowest in GW5. On average, hydraulic conductivity across the site ranged from 4.96 x 10^{-5} to 6.49 x 10^{-5} m/s. This result suggests groundwater movement ranges between 4.42 m/day to 5.60 m/day. Hence, any potential contaminant dissolved in groundwater will travel a lateral distance ranging from 4.42 to 5.60 meters in a single day towards the south and southeastern part of the area.

Table 3.19: Results of hydraulic conductivity obtained from analysis of in-situ hydraulic conductivity test field investigation.

Borehole ID	Hydraulic Conductivity (m/sec)			m/sec	m/day
	Cooper et al., (1967)	Hvorslev (1951)	Bouwer and Rice (1976)	Average	Average
GW3	5.97 x 10^{-5}	6.33 x 10^{-5}	3.06 x 10^{-5}	5.12 x 10^{-5}	4.424
GW4	5.08 x 10^{-6}	9.28 x 10^{-5}	5.12 x 10^{-5}	6.49 x 10^{-5}	5.607

GW5	6.35 x 10^{-5}	5.29 x 10^{-5}	2.64 x 10^{-5}	4.96 x 10^{-5}	4.285

Software utilized for mathematical modelling: Waterloo Hydrogeologic AquiferTest Ver. 2016.1

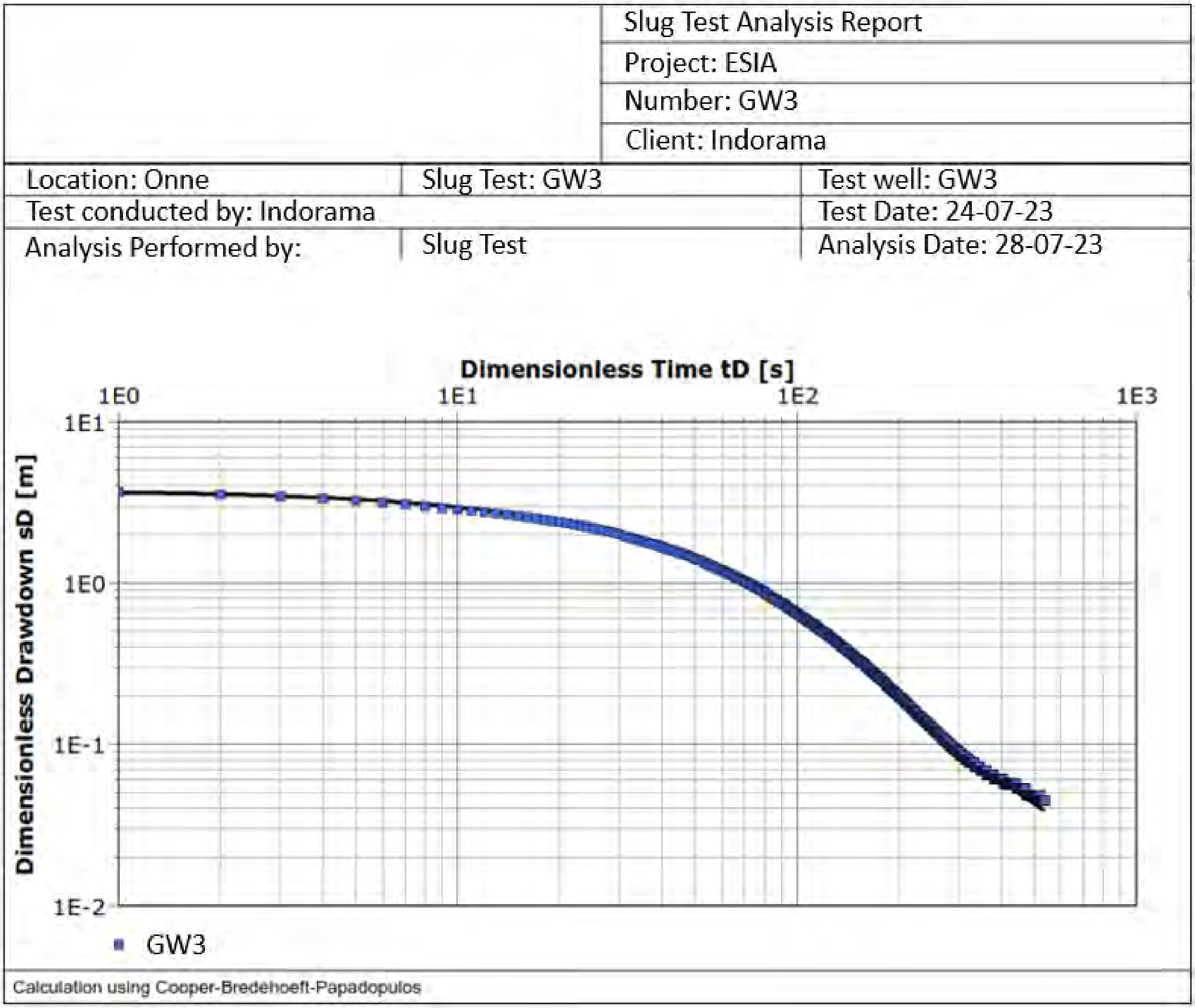
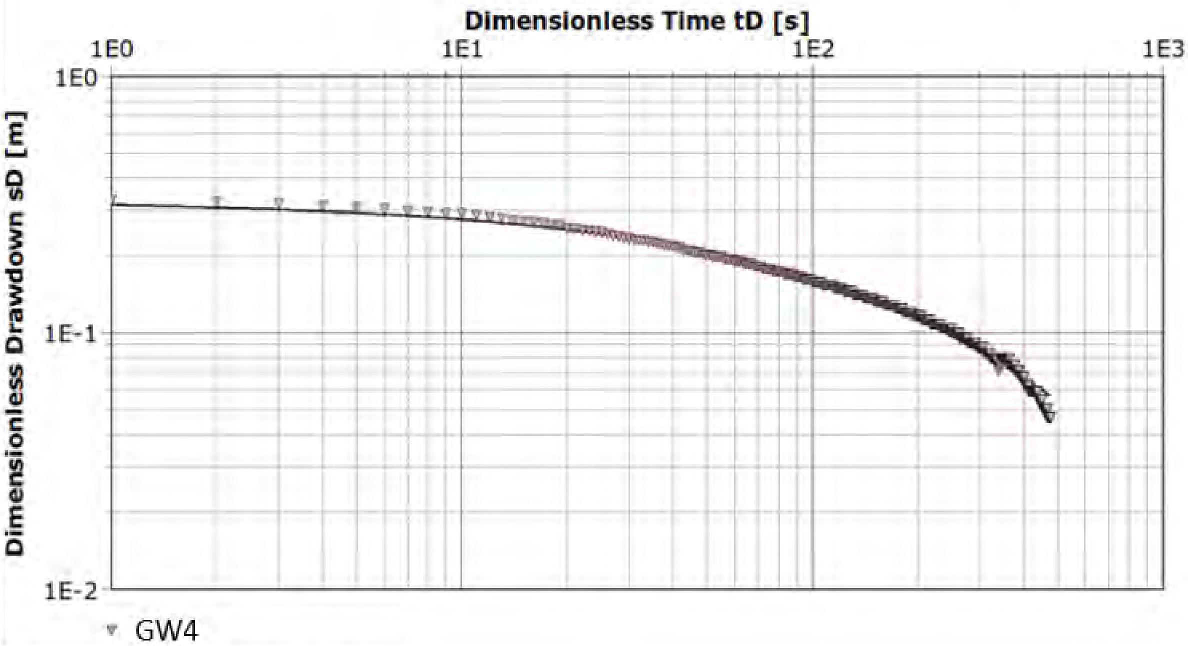


Figure 3.35: A graph of drawdown against time analysis for hydraulic conductivity determination for in-situ hydraulic conductivity test field investigation using Cooper-Bredehoeft-Papadopulos model for GW3 borehole.

	Slug Test Analysis Report
	Project: ESIA
	Number: GW4
	Client: Indorama

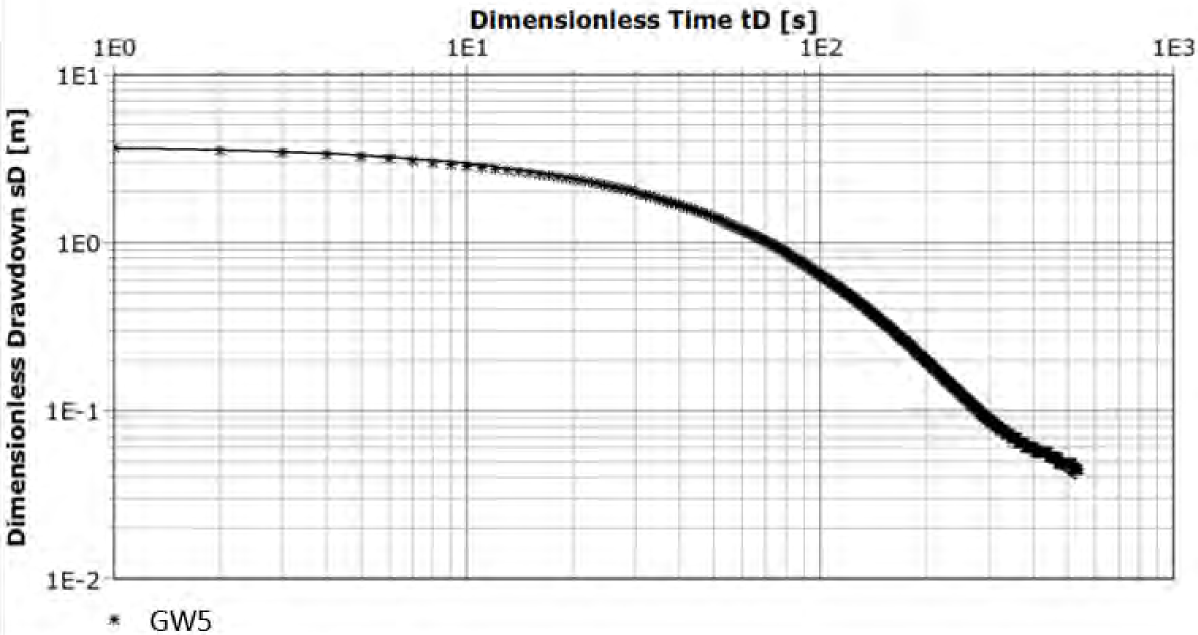
Location: Onne	Slug Test: GW4	Test well: GW4
Test conducted by: Indorama		Test Date: 25-07-23
Analysis Performed by:	Slug Test	Analysis Date: 28-07-23



Calculation using Cooper-Bredehoeft-Papadopulos

Figure 3.36: A graph of drawdown against time analysis for hydraulic conductivity determination for in-situ hydraulic conductivity test field investigation using Cooper-Bredehoeft-Papadopulos model for GW4 borehole.

		Slug Test Analysis Report
		Project: ESIA
		Number: GW5
		Client: Indorama
Location: Onne	Slug Test: GW5	Test well: GW5
Test conducted by: Indorama		Test Date: 26-07-23
Analysis Performed by:	Slug Test	Analysis Date: 28-07-23



Calculation using Cooper-Bredehoeft-Papadopulos

Figure 3.36b: A graph of drawdown against time analysis for hydraulic conductivity determination for in-situ hydraulic conductivity test field investigation using Cooper-Bredehoeft-Papadopulos model for GW5 borehole.

3.10.8.4. Groundwater Quality Indices

The results of groundwater quality analysis for four (4) groundwater samples; GW3, GW4, GW5 and GWC (control site borehole 2.0km away) obtained from boreholes within the project area are presented in Table 3.3 and Figures 3.8 to 3.14. Groundwater pH ranges between 6.90 to 7.70, indicating slightly acidic to slightly basic conditions. The pH recorded at the control site reveals acidic conditions which exceed NSDWQ (2015) regulatory limit. Total dissolved solids and electrical conductivity ranges from 1,460 to 6,320 mg/L and between 780 to 3,480 µs/cm. These values significantly exceed those recorded at the control site and also exceeds NSDWQ regulatory limits of 1000 mg/L and 500 µs/cm respectively. The high concentrations of TDS and EC suggests the likelihood of saline intrusion into coastal freshwater aquifer systems. Salinity and chloride levels are significantly very high in all three boreholes ranging between 1,482 ppm to 10,062 ppm and between 230 to 702 mg/L. The presence of salt in groundwater was clearly obvious from the saline taste of groundwater obtained from GW4. Chloride levels exceed NSDWQ standard of 250 mg/L in GW3 and GW4. Meanwhile, chloride (14 mg/L) and salinity levels (3×10^{-8} ppm) recorded from the control site were typically very low. Phosphate and Nitrate levels are significantly very low and all within regulatory limits. Sulphate is very high in GW4 water samples close to the shoreline. Ammonia, urea and oil and grease are very low and below the instrument detectable limit of <0.01 mg/L. Apart from manganese with a concentration of 0.24 mg/L in GW4 that exceeds NSDWQ limit of 0.20 mg/L, all other heavy metals recorded at monitoring boreholes and at the control site (Silver, Cobalt, Manganese, Vanadium, Nickel, Chromium, Iron, Lead, Copper, Zinc, Mercury, Cadmium and Arsenic) were either below the detection limits or had concentrations within regulatory guidelines.

The low concentration of heavy metals in groundwater samples suggest little or no anthropogenic impacts on the groundwater resources in the area. The major impact identified on groundwater quality in the area is salinity. This impact is more significant at GW4 borehole located 25m away from the coastline. Although GW3 and GW5 located inland had no saline taste, the high TDS, EC, and Chloride levels recorded suggests they are most likely to be impacted from moderate to high exploitation rates.

Table 3.20: Results of groundwater quality assessment for the Wet Season (July-Aug. 2023)

S/N	Parameter(s)	GW3	GW4	GW5	GWC	NSDWQ (2015)
1	pH	7.70	7.20	6.90	6.30	6.5 – 8.5
2	Temperature (°C)	27.7	27.8	27.6	26.8	Ambient
3	Appearance	Clear	Clear	Clear	Clear	
4	Elec. Conductivity (µs/cm)	2580	6320	1420	63	1000
5	TDS (mg/l)	1420	3480	780	38	500
6	Turbidity (NTU)	<1.0	<1.0	<1.0	<1.0	5
7	TSS (mg/l)	<1.0	<1.0	<1.0	<1.0	
8	Salinity (ppm)	1,897	10,062	1,482	3×10^{-8}	
9	Total Hardness (mg/l)	208.0	380.0	130.0	12.0	150
10	Alkalinity (mg/l)	20.0	24.0	16.0	8.0	
11	Chloride, Cl^- (mg/l)	380.0	702.0	230.0	14.0	250
12	Sulphate, SO_4^{2-} (mg/l)	25.0	100.0	20.0	2.0	100
13	Nitrate, NO_3^- (mg/l)	1.28	1.67	1.13	0.29	50
14	Phosphate, PO_4^{3-} (mg/l)	1.20	1.45	0.75	0.13	
15	Cyanide (mg/l)	<0.001	<0.001	<0.001	<0.001	0.01
16	Ammonia (mg/l)	<0.10	<0.10	<0.10	<0.10	
17	Urea	<0.10	<0.10	<0.10	<0.10	
18	Total Nitrogen (mg/l)	0.37	0.48	0.32	<0.20	
19	Oil & Grease (mg/l)	<1.00	<1.00	<1.00	<1.00	
20	DO (mg/l)	5.20	4.90	5.10	5.60	
21	BOD_5 (mg/l)	2.00	1.60	1.40	<1.00	
22	COD (mg/l)	3.40	2.50	2.40	2.00	
23	Sodium, Na (mg/l)	145.00	278.00	89.80	6.31	200
24	Potassium, K (mg/l)	52.80	109.70	31.80	2.56	
25	Calcium, Ca (mg/l)	56.80	108.20	34.60	3.50	
26	Magnesium, Mg (mg/l)	13.70	24.60	9.20	0.58	20
27	Silver, Ag (mg/l)	<0.001	<0.001	<0.001	<0.001	
28	Cobalt, Co (mg/l)	<0.001	<0.001	<0.001	<0.001	
29	Manganese, Mn (mg/l)	0.182	0.243	0.157	0.101	0.20
30	Vanadium, V (mg/l)	<0.001	<0.001	<0.001	<0.001	
31	Nickel, Ni (mg/l)	<0.001	<0.001	<0.001	<0.001	0.02
32	Chromium, Cr (mg/l)	0.025	0.038	0.017	0.016	0.05
33	Iron, Fe (mg/l)	0.246	0.295	0.119	0.137	0.3
34	Lead, Pb (mg/l)	<0.001	<0.001	<0.001	<0.001	0.01
35	Copper, Cu (mg/l)	0.084	0.097	0.065	0.092	1.0
36	Zinc, Zn (mg/l)	0.078	0.085	0.054	0.017	3.0
37	Mercury, Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	0.001
38	Cadmium, Cd (mg/l)	<0.001	<0.001	<0.001	<0.001	0.003
39	Arsenic, As (mg/l)	<0.001	<0.001	<0.001	<0.001	0.01
40	HUB (CFU/ml) x 10^2	0.20	0.40	0.10	NIL	
41	HUF (CFU/ml) x 10^2	NIL	NIL	NIL	NIL	
42	THB (CFU/ml) x 10^2	1.40	1.70	1.10	1.30	
43	THF (CFU/ml) x 10^2	NIL	NIL	NIL	NIL	
44	SRB (MPN/100ml)	0.00	0.00	0.00	0.00	
45	Fecal Coliform (MPN/100ml)	10.00	26.00	18.00	4.00	

3.10.8.5. Groundwater Hydrogeochemistry

The hydrogeochemical analysis of groundwater provides valuable information about the processes that control the water's chemical characteristics, as well as its interaction with the surrounding geologic formations and environmental factors. The piper plot in Figure 3.8 reveals Na-Cl water type for all groundwater boreholes in the area. This suggests that all boreholes (GW3, GW4, GW5, GWC) are connected to the same aquifer with significant salinity hazards.

Stiff diagrams also reveal similarity in shape for all groundwater boreholes (Figure 3.9, 3.10, 3.11, 3.12). The stiff diagram shows predominance of sodium as the major anion and chloride as the major cation, confirming the water class is Na-Cl. This water class is highly influenced by saline water intrusion into coastal aquifers.

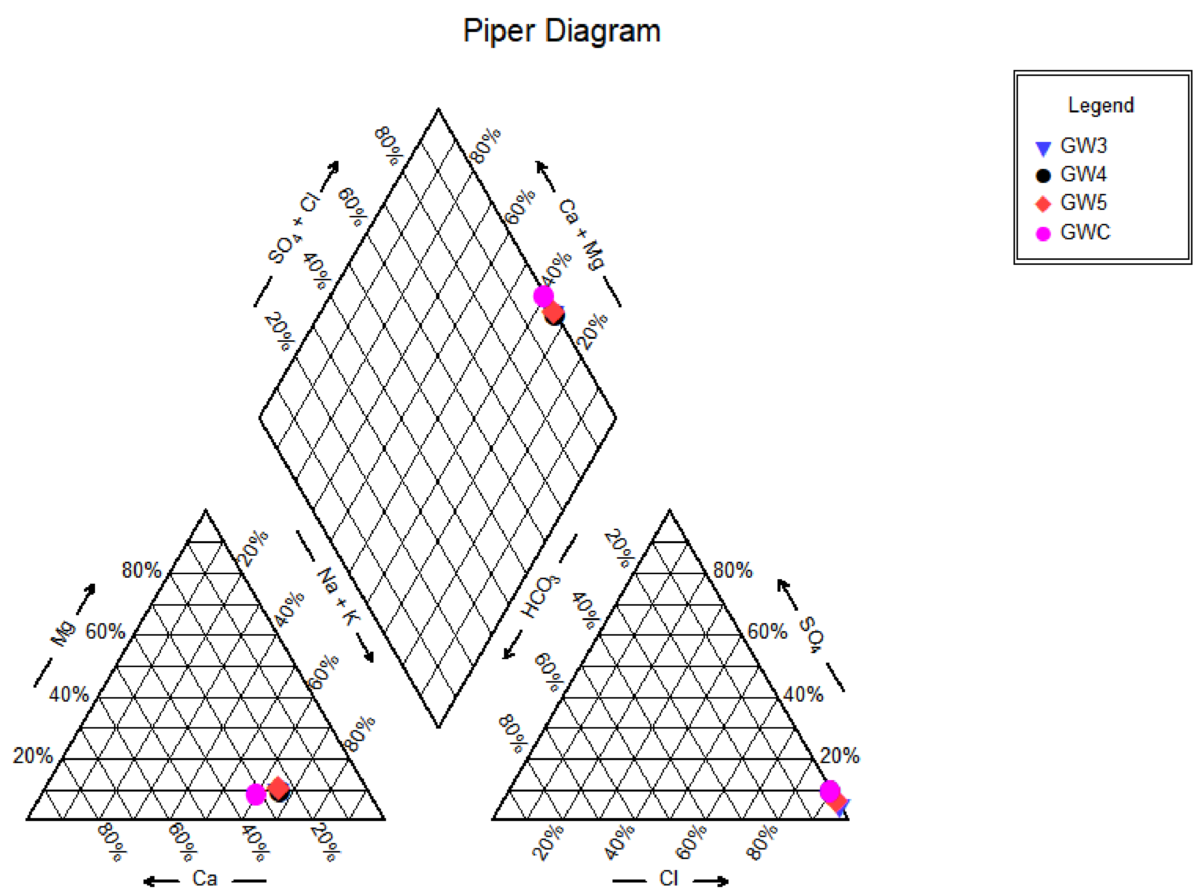


Figure 3.37: Piper diagram for groundwater samples obtained from the study area and control site.

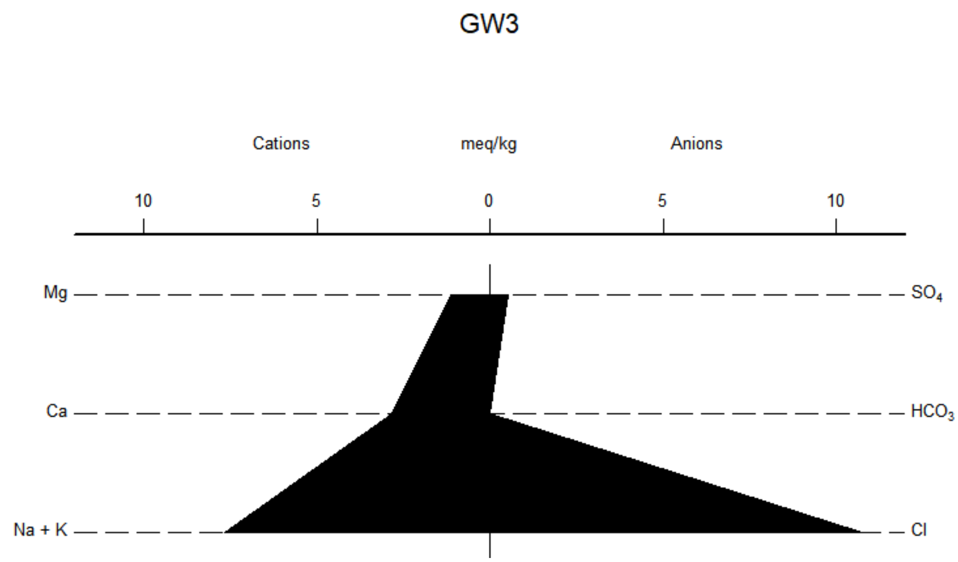


Figure 3.38: Stiff diagram for groundwater sample obtained from borehole GW3.

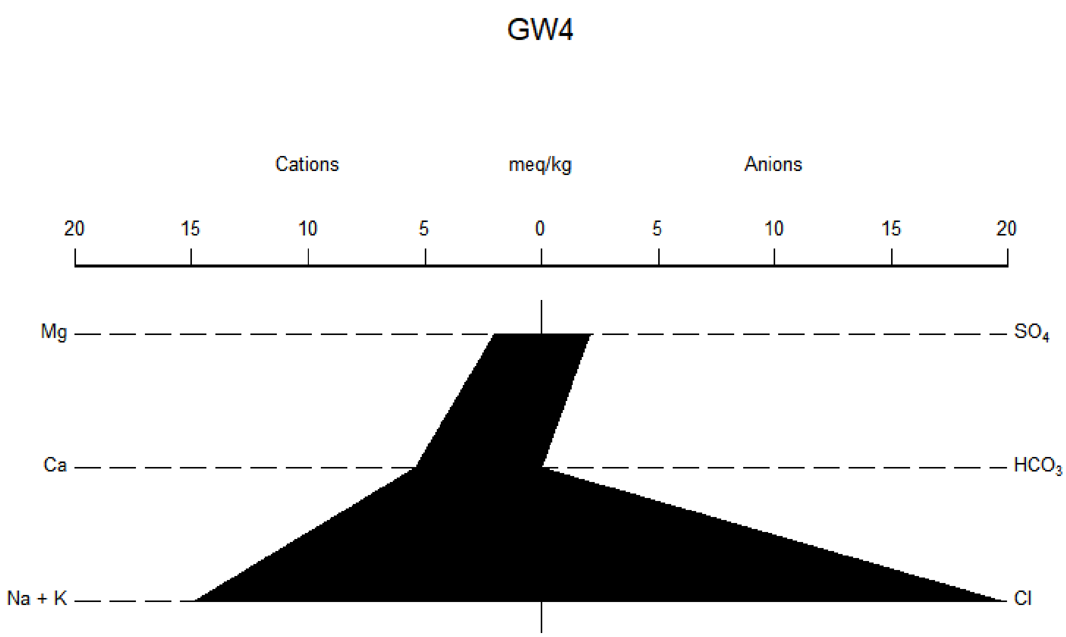


Figure 3.39: Stiff diagram for groundwater sample obtained from borehole GW4.

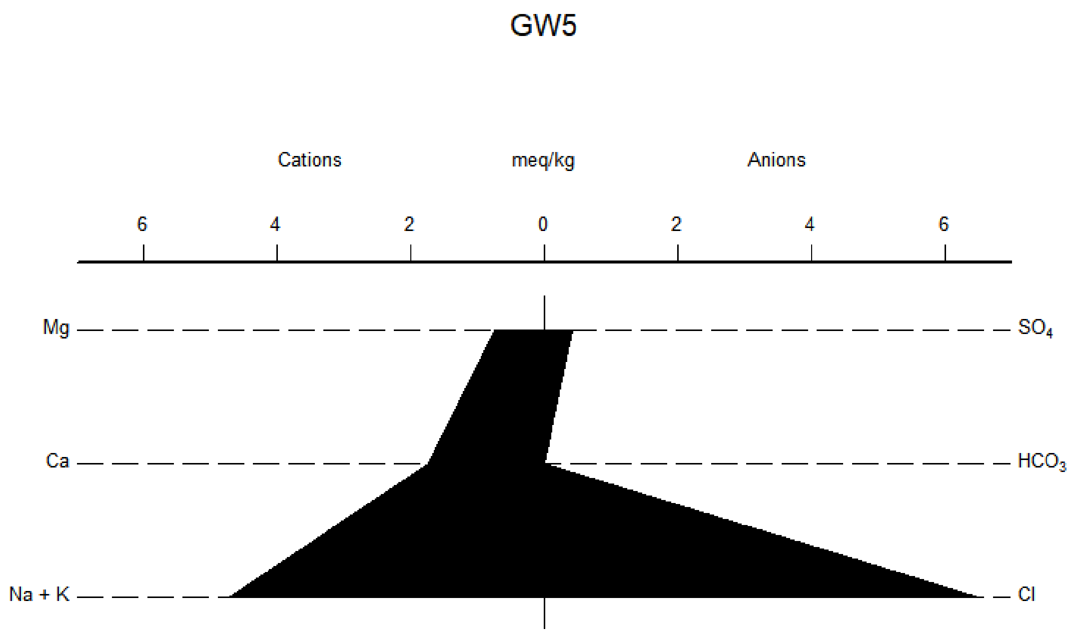


Figure 3.40: Stiff diagram for groundwater sample obtained from borehole GW5.

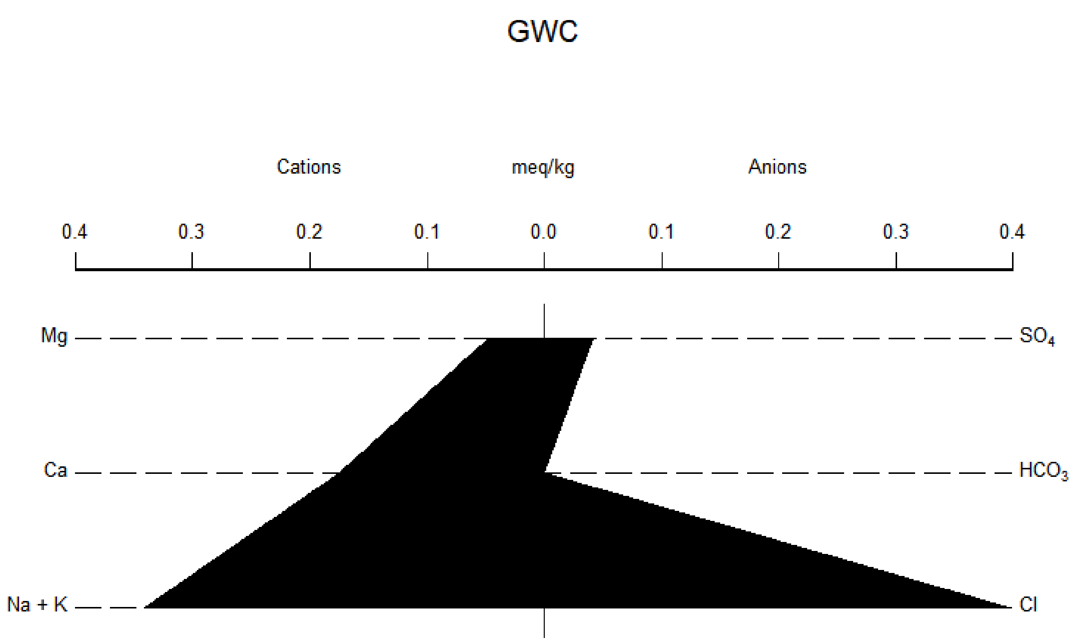


Figure 3.41: Stiff diagram for groundwater sample obtained from borehole GWC

3.10.9. CONCLUSIONS AND RECOMMENDATIONS

The project site's groundwater hydrochemistry study identifies the prevalence of Na-Cl water class, influenced by the Bonny River. High levels of dissolved solids, electrical conductivity, sodium, chloride, and salinity confirm saline water intrusion into shallow coastal systems (30.0 meters deep boreholes). Saltwater intrusion has severely compromised coastal aquifer quality. This is evident in GW4, just 25 meters from the coast, where saline taste is noticeable.

The geological composition of the area consists of an upper sandfill layer, an intermediate clayey-silty layer, and a lower aquiferous layer. The intermediate clay acts as a barrier against contaminant movement, while a thick clay layer (7.0 meters) hinders rapid rainfall recharge.

Aquifer replenishment mainly stems from saline riverine systems like Imo River and creeks. Water pH remains acceptable and lowered heavy metals content and lack of hydrocarbon contaminants in groundwater suggest minor anthropogenic influence.

Groundwater depth is shallow (<5.0 meters), flowing predominantly from northwest to south/southeast, with a migration rate of 4.42 to 5.60 meters/day. Construction of boreholes should exceed 30.0 meters and be positioned >500 meters inland to counter saline intrusion. Multiple boreholes of varying depths (30-100 meters) and spacing (>200 meters) and adequate management of abstraction rates will prevent interference and saline incursion.

Despite the localized flow direction, continuous inland borehole exploitation could trigger flow pattern reversals, necessitating careful abstraction planning. The substantial intermediate clay layer highlights limited rainfall recharge compared to lateral recharge from surrounding rivers, emphasizing the need for precaution against saline intrusion.

Hence it is recommended that routine groundwater management, including monitoring, is crucial to detect potential contaminants, particularly saline intrusion, safeguarding groundwater quality.

3.11. GROUNDWATER QUALITY REPORT ASSESSMENT

Executive Summary

The proposed project is located at the Federal Ocean Terminal (FOT) in Onne, Eleme Local government Area in Rivers State and the neighborhood of Bonny River. The ground water samples collected during wet season condition indicates slight acidity nature of water. The high electrical conductivity and TDS of the groundwater within the project site is attributed to increased ions and salinity concentrations due to intrusion from seawater. Ammonia, urea, total nitrogen and cyanide concentrations were not detected in ground water samples attributable to the absence of nitrogen yielding processes in the project environment. Dissolved oxygen is within permissible limit with BOD and COD having low concentrations indicates reduction in oxidizable matter. Heavy metals were also below regulatory limits except for Iron and Zinc. The level of the analyzed physicochemical properties shows that the ground water is portable.

3.11.1. Introduction

This work captures the Environmental and Social Impact Assessment (ESIA) study for the proposed MM Port FZE Project to be located at Federal Ocean Terminal (FOT), Onne Port Complex, Oil & Gas Free Zone, Onne in Eleme Government Area, Rivers State. The project is located on the bank of the Bonny River which opens into the Atlantic Ocean to the south. The Bonny River is the ocean line for the companies operating within the Onne Port. Groundwater is the water found under the sub surface, through soil, sand, and rock formations, moving slowly through all the geologic formations into the aquifer which is the ultimate reservoir of the water cycle. Heavy rains may cause the water table to rise, or heavy pumping of groundwater for domestic, irrigation and industrial supplies may cause the water table to fall. Groundwater is increasingly becoming a sensitive subject because its shared resource warranted the inclusion in the ESIA study of the project. The proposed project site is in an area with no particular environmental designation (not near a site with an international, national, or local designation, such as a Special Area of Conservation, a Special Protection Area, a Ramsar site, or a Site of Special Scientific Interest).

3.11.2 Scope of study

The scope of work includes:

- Delineation of five (5) sampling stations and one (1) control stations.
- Sample collection and laboratory analysis.

3.11.3. Field Approach

The existing three borewells samples were collected on 5th- 6th July 2023, whereas the three groundwater samples were collected on the 22nd from newly drilled borewells at the project site.

- Groundwater samples were collected from borewells (two existing and three newly drilled) and one other borewell from Owo-ogono community which serves as control for the determination of groundwater quality.
- Prior to collecting the groundwater samples, each container was first rinsed with the water from the borehole. To avoid possible sources contamination each tap was sterilized using 70% alcohol (spirit).
- After sterilization the tap was allowed to flow for at least 5 minutes before sampling.
- Samples for physico-chemical parameters were collected into 1-liter polyethylene bottles. The bottles were previously washed and rinsed with distilled water and with some portion of the samples water prior to sampling. For heavy metal analysis, samples were collected into 1-liter pre-cleaned glass bottles and preserved by the addition of 2 ml AR grade concentrated nitric acid to pH <2.0. For Oil & grease and THC analysis, samples were collected into 1-liter pre-cleaned glass bottles and preserved by the addition of 2 ml concentrated Sulfuric acid. Microbiology- Samples were collected into 25 ml sterilized glass bottles. BOD - Samples were collected into 300 ml amber-colored BOD bottles.
- The grab sampling methodology was adopted to collect the samples.
- Collected samples were labelled and stored at 4°C ice chest on the field before transportation to the laboratory for further storage at 4°C.
- A field laboratory samples handling chain of custody was maintained for all groundwater samples.

In-situ measurements were carried out for pH, Temperature, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Electrical conductivity (EC) and Turbidity by using calibrated instruments, (Jenway Model 430 for pH and Temperature, Hanna HI 98703 Portable Turbidity meter for Turbidity, Hanna HI 9835 for EC, TDS and Salinity, and Hanna HI 98186 for DO). The samples were preserved in ice-chest during transportation to the laboratory. Laboratory analysis was performed by M/s Anal Concept Limited, Port Harcourt, a FMEnv accredited laboratory. The laboratory analysis was witnessed by FMEnv representative. Chain of custody procedures including sample handling, transportation, logging and crosschecking in the laboratory were also performed.

3.11.4. Sampling Locations

Sampling design protocol was applied judgementally in the selection of study stations, considering ecological features, geographical location of communities and control points apparently of the project environs. Ground Water samples collected from five (5) sampling locations and one (1) control locations as shown on Table 1 and the sampling map is shown on Figure 1.

Table 3.21: Proposed sampling station

Station Code	Environmental Sphere	COORDINATES	
		LATITUDE	LONGITUDE
GW1	Ground water	4°40'12.24"N	7° 8'55.48"E
GW2	Ground water	4°40'52.65"N	7° 9'11.81"E
GW3	Ground water	4°40'20.97"N	7° 8'25.68"E
GW4	Ground water	4°40'03.15"N	7° 8'36.06"E
GW5	Ground water	4°40'14.84"N	7° 8'42.40"E
GWC1	Ground water	4°39'41.01"N	7° 9'21.21"E

Figure 3.42: Groundwater sampling map

The assessment of the groundwater quality within the project area was conducted by sampling three existing boreholes (GW1-2) and three drilled boreholes on the project site (GW3-6), while the control is from the neighborhood community (GWC1). Groundwater chemistry is controlled by the chemistry of the infiltrating water, the chemistry of the porous media including the interstitial cement or matrix of the aquifer, the rate of groundwater flow and the permeability of the aquifer (Offodile, 2002).

3.11.5. Groundwater Physico-chemistry

The result of physicochemical characteristics ground water is presented in table 2 whereas the statistical summary is shown on Table 3. The groundwater quality comparison between regional and project site is shown in table 4.

Table3.22: Groundwater analysis results

S/N	Parameter(s)	GW 1	GW 2	GW 3	GW 4	GW 5	GW C
1	pH	*6.70*	*6.20*	*7.70*	*7.20*	*6.90*	*6.30*
2	Temperature (^oC)	*27.6*	*27.6*	*27.7*	*27.8*	*27.6*	*26.8*
3	Appearance	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*
4	Elec. Conductivity (µs/cm)	*663*	*89*	*2580*	*6320*	*1420*	*63*
5	TDS (mg/l)	*404*	*54*	*1420*	*3480*	*780*	*38*
6	Turbidity (NTU)	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*
7	TSS (mg/l)	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*
8	Salinity (ppm)	$38x10^{-8}$	$4x10^{-8}$	1,897	10,062	1,482	$3x10^{-8}$
9	Total Hardness (mg/l)	*30.0*	*16.0*	*208.0*	*380.0*	*130.0*	*12.0*
10	Alkalinity (mg/l)	*12.0*	*6.0*	*20.0*	*24.0*	*16.0*	*8.0*
11	Chloride, Cl^- (mg/l)	*58.0*	*18.0*	*380.0*	*702.0*	*230.0*	*14.0*
12	Sulphate, SO_4^{2-} (mg/l)	*10.0*	*4.0*	*25.0*	*100.0*	*20.0*	*2.0*
13	Nitrate, NO_3^- (mg/l)	*0.82*	*0.45*	*1.28*	*1.67*	*1.13*	*0.29*
14	Phosphate, PO_4^{3-} (mg/l)	*0.15*	*0.16*	*1.20*	*1.45*	*0.75*	*0.13*
15	Cyanide (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
16	Ammonia (mg/l)	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*
17	Urea	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*
18	Total Nitrogen (mg/l)	*0.23*	*<0.20*	*0.37*	*0.48*	*0.32*	*<0.20*
19	Oil & Grease (mg/l)	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*
20	DO (mg/l)	*5.30*	*5.80*	*5.20*	*4.90*	*5.10*	*5.60*
21	BOD_5 (mg/l)	*<1.00*	*<1.00*	*2.00*	*1.60*	*1.40*	*<1.00*
22	COD (mg/l)	*2.20*	*2.10*	*3.40*	*2.50*	*2.40*	*2.00*
23	Sodium, Na (mg/l)	*24.39*	*7.84*	*145.00*	*278.00*	*89.80*	*6.31*
24	Potassium, K (mg/l)	*16.81*	*2.73*	*52.80*	*109.70*	*31.80*	*2.56*
25	Calcium, Ca (mg/l)	*8.72*	*3.90*	*56.80*	*108.20*	*34.60*	*3.50*
26	Magnesium, Mg (mg/l)	*1.51*	*0.78*	*13.70*	*24.60*	*9.20*	*0.58*
27	Silver, Ag (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
28	Cobalt, Co (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
29	Manganese, Mn (mg/l)	*0.127*	*0.086*	*0.182*	*0.243*	*0.157*	*0.101*
30	Vanadium, V (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
31	Nickel, Ni (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
32	Chromium, Cr (mg/l)	*<0.001*	*0.012*	*0.025*	*0.038*	*0.017*	*0.016*
33	Iron, Fe (mg/l)	*0.125*	*0.108*	*0.246*	*0.295*	*0.119*	*0.137*
34	Lead, Pb (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
35	Copper, Cu (mg/l)	*0.073*	*<0.001*	*0.084*	*0.097*	*0.065*	*0.092*
36	Zinc, Zn (mg/l)	*0.016*	*0.011*	*0.078*	*0.085*	*0.054*	*0.017*
37	Mercury, Hg (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
38	Cadmium, Cd (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
39	Arsenic, As (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
40	HUB (CFU/ml) x 10^2	*NIL*	*0.2*	*0.2*	*0.4*	*0.1*	*NIL*
41	HUF (CFU/ml) x 10^2	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*
42	THB (CFU/ml) x 10^2	*1.0*	*1.8*	*1.4*	*1.7*	*1.1*	*1.3*
43	THF (CFU/ml) x 10^2	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*
44	SRB (MPN/100ml)	*0*	*0*	*0*	*0*	*0*	*0*
45	Fecal Coliform (MPN/100ml)	*12*	*16*	*10*	*26*	*18*	*4*
46	Total Coliform (MPN/100ml)	*120*	*140*	*90*	*180*	*150*	*32*

Table 3.23: Statistical analysis of Groundwater analysis result

Parameter	GW PROJECT AREA (GW1-GW10)		GW CONTROL (GW1)		DW Limit
	Range	Mean ± SD	Range	Mean ± SD	
Colour (Pt-Co)	Clear	-	Clear	-	
pH	6.20 – 7.70	6.984± 0.50	6.30	6.30 ± 0	6.5 – 8.5
Temperature (^0C)	27.6 – 27.8	27.06 ± 0.08	26.8	26.8 ± 0	20-33
Electrical Conductvit (µS/cm)	89 –6320	2214 ± 2215.6	63.0	63.0 ± 0	NS
Total Dissolved Solids (mg/l)	54 –3480	1227 ± 1213.7	38.0	38.0± 0	NS
Turbidity (NTU)	<1.0	ND ± 0	<1.0	ND ± 0	NA
Total Suspended Solids (mg/l)	<1.0	ND ± 0	<1.0	ND ± 0	NS
Salinity (ppt)	0.04 – 0.38	0.21 ± 0.17	0.03	0.03 ± 0	NS
Total Hardness (mg/l) ($CaCO_3$)	16.0 – 380	152.0 ± 133.0	12.0	12.0 ± 0	NA
Alkalinity (mg/l)	6.0 – 24.0	15.60 ± 6.25	8.0	8.0 ± 0	NA
Ammonia (mg/l)	<0.10	ND ± 0	<0.10	ND ± 0	NS
Urea (mg/l)	<0.10	ND ± 0	<0.10	ND ± 0	NA
Total Nitrogen (mg/l)	<0.23 – 0.48	0.35 ± 0.16	<0.20	ND ± 0	NS
Oil & Grease (mg/l)	<1.00	ND ± 0	<1.00	ND ± 0	NA
Dissolved Oxygen (mg/l)	4.10 - 5.80	5.26 ± 0.34	5.60	5.60 ± 0	6.8
Biological Oxygen Demand (mg/l)	<1.00 – 2.00	1.67 ± 0.84	<1.00	ND ± 0	4.0
Chemical Oxygen Demand (mg/l)	2.10 – 3.40	2.52 ± 0.46	2.00	2.00 ± 0	4.0
Chloride Ion (mg/l)	18.0 – 702.0	277.6 ± 248.4	8.00	8.00 ± 0	NS
Sulphate (mg/l)	4.00 - 100	31.80 ± 34.9	14.0	14.0 ± 0	100
Phosphate (mg/l)	0.15 – 1.45	0.74 ± 0.53	0.13	0.13 ± 0	3.5
Nitrate (mg/l)	0.45 – 1.67	1.07 ± 0.41	0.29	0.29 ± 0	50
Sodium (*mg/l*)	7.84 – 278.0	109.6 ± 97.59	6.31	6.31 ± 0	120
Potassium (*mg/l*)	2.73 – 109.7	42.8 ± 37.36	2.56	2.56 ± 0	50
Calcium (*mg/l*)	3.90 – 108.2	42.4 ± 37.99	3.50	3.50 ± 0	180
Magnesium *(mg/l)*	0.78 – 24.6	9.96 ± 8.77	0.58	0.58 ± 0	40
Silver *(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0	NS
Cobalt*(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0	NS
Manganese *(mg/l)*	0.086 – 0.243	0.160 ± 0.05	0.101	0.101 ± 0	NS
Vanadium *(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0	NS
Nickel *(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0	0.01
Chromium *(mg/l)*	<0.001- 0.038	0.02 ± 0.01	0.016	0.016 ± 0	0.001
Iron *(mg/l)*	0.109 – 0.246	0.18 ± 0.08	0.137	0.137 ± 0	0.05
Lead *(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0	0.01
Copper *(mg/l)*	<0.001-0.097	0.08 ± 0.03	0.092	0.092 ± 0	0.01
Zinc *(mg/l)*	0.011 – 0.084	0.05 ± 0.03	0.017	0.017 ± 0	0.01
Mercury *(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0	0.001
Cadmium *(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0	0.01
Arsenic *(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0	0.05

3.11.6. Results and Discussion

Groundwater sampled had pH values ranging from 6.20 to 7.70 with an average value of 6.94, while the control sample was 6.30 with an average of 6.30. These values indicate that the water from the project site and its environs and control stations are slightly acidic. The result also shows elevated electrical conductivity mean values 2214.4µS/cm and increased concentration of total dissolved solids (TDS) mean of 1227.6 mg/l in groundwater indicated possible intrusion of seawater. DO concentration was within acceptable limit which indicated reduction of oxidizable matters in the project site. Heavy metal concentrations are below detection limits except iron and zinc content which characteristic of groundwater in the Niger Delta region.

Table 3.24: Groundwater Quality comparison of Regional and Project Site

S/N	Parameter(s)	Range (GW1-2)	Mean	Std Dev	Range (GW3-5)	Mean	Std Dev
1	pH	*6.20-6.70*	*6.45*	*0.35*	*6.90 - 7.70*	*7.27*	0.4041
2	Temperature (^oC)	*27.6*	*27.60*	*0.00*	*27.6 - 27.8*	*27.70*	0.10
3	EC (µS/cm)	*89 -663*	*376.00*	*405.88*	*1420 - 6320*	*3440.00*	2560.7
4	TDS (mg/l)	*54 - 404*	*229.00*	*247.49*	*780 - 3480*	*1893.33*	1410.9
5	Turbidity (NTU)	*<1.0*	*<1.0*	*0.00*	*<1.0*	*<1.0*	0.0
6	TSS (mg/l)	*<1.0*	*<1.0*	*0.00*	*<1.0*	*<1.0*	0.0
7	Total Hardness (mg/l)	*16.0 - 30.0*	*23.00*	*9.90*	*130 - 380*	*239.33*	127.91
8	Alkalinity (mg/l)	*6.0 - 12.0*	*9.00*	*4.24*	*16.0 - 24.0*	*20.00*	4.0
9	Chloride, Cl^- (mg/l)	*18.0 -58.0*	*38.00*	*28.28*	*230 - 702*	*437.33*	241.17
10	Sulphate, SO_4^{2-} (mg/l)	*4.0 - 10.0*	*7.00*	*4.24*	*20.0 - 100*	*48.33*	44.814
11	Nitrate, NO_3^- (mg/l)	*0.45 - 0.82*	*0.64*	*0.26*	*1.13 -1.67*	*1.36*	0.2787
12	Phosphate, PO_4^{3-} (mg/l)	*0.15 -0.16*	*0.16*	*0.01*	*0.75 -1.45*	*1.13*	0.3547
13	Cyanide (mg/l)	*<0.001*	*<0.001*	*0.00*	*<0.001*	*<0.001*	*0.00*
14	Ammonia (mg/l)	*<0.001*	*<0.001*	*0.00*	*<0.001*	*<0.001*	*0.00*
15	Urea	*<0.001*	*<0.001*	*0.00*	*<0.001*	*<0.001*	*0.00*
16	Total Nitrogen (mg/l)	*<0.20 - 0.23*	*0.23*	*0.16*	*0.16 - 0.48*	*0.39*	0.0819
17	Oil & Grease (mg/l)	*<0.10*	*<0.10*	*0.00*	*<0.01*	*<0.10*	*0.00*
18	DO (mg/l)	*5.30 - 5.80*	*5.55*	*0.35*	*0.35 - 5.20*	*5.07*	*0.00*
19	BOD_5 (mg/l)	*<1.0*	*<1.0*	*0.00*	*1.40 -2.00*	*1.67*	*0.00*
20	COD (mg/l)	*2.10 - 2.20*	*2.15*	*0.07*	*0.07 -3.40*	*2.77*	0.5508
21	Sodium, Na (mg/l)	*7.84 – 278.0*	*16.12*	*11.70*	*11.7 - 278.0*	*170.93*	96.743
22	Potassium, K (mg/l)	*2.73 -16.81*	*9.77*	*9.96*	*9.96 -109.7*	*64.77*	40.305
23	Calcium, Ca (mg/l)	*3.90 - 8.72*	*6.31*	*3.41*	*3.41 - 108.2*	*66.53*	37.753
24	Magnesium, Mg (mg/l)	*0.78*	*1.15*	*0.52*	*0.52 -24.60*	*15.83*	7.9185
25	Silver, Ag (mg/l)	*<0.001*	*<0.001*	*0.00*	*<0.001*	*<0.001*	0.00
26	Cobalt, Co (mg/l)	*<0.001*	*<0.001*	*0.00*	*<0.001*	*<0.001*	0.00
27	Manganese, Mn (mg/l)	*0.086 - 0.127*	*0.11*	*0.03*	*0.03 - 0.243*	*0.19*	0.0442
28	Vanadium, V (mg/l)	*<0.001*	*<0.001*	*0.00*	*<0.001*	*<0.001*	0.00

S/N	Parameter(s)	Range (GW1-2)	Mean	Std Dev	Range (GW3-5)	Mean	Std Dev
29	Nickel, Ni (mg/l)	0.001	<0.001	0.00	0.001	<0.001	0.00
30	Chromium, Cr (mg/l)	<0.001-0.012	0.010	0.010	0.001	0.02	0.0106
31	Iron, Fe (mg/l)	0108-0.125	0.12	0.01	0.001-0.295	0.22	0.0908
32	Lead, Pb (mg/l)	<0.001	<0.001	0.00	<0.001	<0.001	0.00
33	Copper, Cu (mg/l)	<0.001-0.073	0.07	0.05	0.05 - 0.097	0.08	0.0161
34	Zinc, Zn (mg/l)	0.011-0.016	0.01	0.00	0.054 -0.085	0.07	0.0163
35	Mercury, Hg (mg/l)	<0.001	<0.001	0.00	<0.001	<0.001	0.00
36	Cadmium, Cd (mg/l)	<0.001	<0.001	0.00	<0.001	<0.001	0.00

A comparison of regional ground water (GW1-2) quality and the three (3) boreholes drilled (GW3-5) on site is shown on table 4 above. It revealed similar groundwater quality within the study area; however, minor differences were observed in total hardness, alkalinity and the ions having slightly higher concentrations in the newly drilled boreholes can be attributed to the depth of borehole and spread of the borehole locations around the coastal location.

3.11.6.1. Groundwater Availability

Groundwater is the water present beneath the earth surface in rocks and soil pore spaces and in the fractures of rocks formations. Global groundwater storage is roughly equal to the total amount of freshwater stored in snow and ice packs. The volume of groundwater can be estimated by measuring water levels in local wells and by examining geologic records from well drilling determinations.

3.11.6.2. Groundwater Uses

Groundwater in the study area is inly used for domestic purposes such as drinking, cooking, bathing, and washing whereas a few industries operating in the area use the groundwater for industrial purposes. Groundwater use for irrigation in the study area is very limited because of fallow farming and prolonged raining season.

3.12. SURFACE WATER QUALITY ASSESSMENT REPORT

Executive Summary

The proposed project is located at the Federal Ocean Terminal (FOT) in Onne, Eleme Local government Area and the neighborhood of Bonny River in Rivers State. Bonny River receives water from the Atlantic Ocean. The Surface water samples collected during wet season study indicates that the water body are slightly alkaline. The high electrical conductivity is attributed to the high ions and salinity concentrations of the water bodies coupled with the tidal directional flow. Water quality indicates that the water body is brackish.

3.12.1 Introduction

The surface water assessment study was carried out as part of the Environmental and Social Impact Assessment (ESIA) study for the proposed MM Port FZE Project to be located at Federal Ocean Terminal (FOT), Onne Port Complex, Oil & Gas Free Zone, Onne in Eleme Government Area, Rivers State. The project is located on the bank of the Bonny River which opens into the Atlantic Ocean on the south. The Bonny Rivers is the ocean line for the companies operating within the Onne Port.

The proposed project site is in an area with no particular environmental designation (not near a site with an international, national or local designation, such as a Special Area of Conservation, a Special Protection Area, a Ramsar site, or a Site of Special Scientific Interest).

3.12.2. Scope of Study

The scope of work includes:

- Delineation of ten (10) sampling stations and two (2) control stations on Bonny River
- Sample collection and laboratory analysis.

3.12.3. Field Work Approach

Surface water sampling was conducted on the 5th – 6th July 2023 on Bonny River using a stainless-steel surface water sampler as shown in pictures below. A total of twelve surface water samples (inclusive of two controls) were collected. Prior to collecting the surface water samples, each container was first rinsed thrice with the sampled water.

- Samples for physicochemical parameters were collected into 1-litre polythene bottles.

- For heavy metal analysis, samples were collected into 1-liter pre-cleaned glass bottles and preserved by the addition of 2 ml AR grade concentrated nitric acid to pH <2.0.
- For analysis of Oil & grease and THC- Samples were collected into 1-liter pre-cleaned glass bottles and preserved by the addition of 2 ml concentrated Sulfuric acid.
- For microbiology analysis, samples were collected into 25 ml sterilized glass bottles.
- For BOD - Samples were collected into 300 ml amber-colored BOD bottles.

The composite samples were collected from the midstream with the use of water sampler at the depth of minimum 30cm of the sampled river. The collected samples were properly labeled and stored at 4°C±2 ice chest on the field before transportation to the laboratory for further storage at 4°C. Laboratory analysis was performed by M/s Anal Concept Limited, Port Harcourt, a FMEnv accredited laboratory. The laboratory analysis was witnessed by FMEnv representative. Chain of custody procedures including sample handling, transportation, logging and crosschecking in the laboratory were also performed.

In-situ measurements were carried out for pH, Temperature, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Electrical conductivity (EC), Salinity and Turbidity using calibrated instruments, (Jenway Model 430 for pH and Temperature, Hanna HI 98703 Portable Turbidity meter for Turbidity, Hanna HI 9835 for EC, TDS and Salinity, and Hanna HI 98186 for DO).

3.12.4. Sampling Locations

A Judgmental sampling design protocol was applied in the selection of study stations, taking into account ecological features, geographical location of communities and control points apparently in upstream and downstream of the project environs. The Bonny River is under tidal influence and hence control samples were collected below and above the sample locations. Sampling points 1 to 5 were approximately 100 metres from the riverbank whereas the remaining sampling points either approximately in the middle section of the river or were about 160/200 metres away. The coordinates of sampling locations are shown in Table 1 whereas the sampling map is shown in Figure 1.

Table 3.25: Sampling Station

Station Code	Environmental Sphere	Coordinates (WGS 84)	
		LATITUDE	LONGITUDE
SW1	Surface Water	4°39'39.2"N	7° 08'50.5"E
SW2	Surface Water	4°39'55.9"N	7° 08'24.5"E
SW3	Surface Water	4°40'02.8"N	7° 08'10.1"E
SW4	Surface Water	4°40'07.0"N	7° 07'47.2"E
SW5	Surface Water	4°40'14.6"N	7° 07'28.8"E
SW6	Surface Water	4°39'59.6"N	7° 09'14.7"E
SW7	Surface Water	4°40'29.6"N	7° 09'22.3"E
SW8	Surface Water	4°40'28.9"N	7° 07'00.7"E
SW9	Surface Water	4°40'24.7"N	7° 06'.45.7"E
SW10	Surface Water	4°39'30.0"N	7° 08'03.6"E
SWC1	Surface Water	4°36'38.0"N	7° 10'35.3"E
SWC2	Surface Water	4°42'44.4"N	7° 05'39.9"E

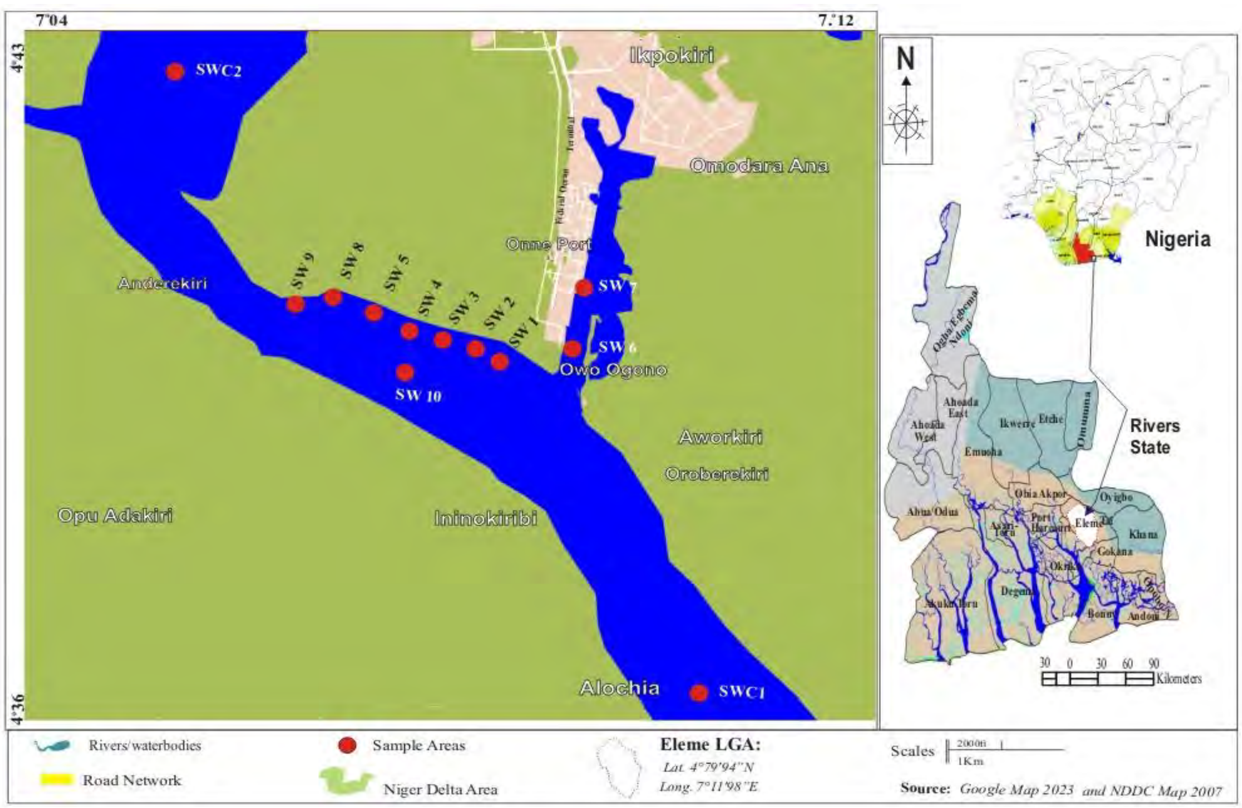


Figure 3.43: Surface water sampling map

3.12.5. Surface Water Physico-chemistry

The result of the physico-chemical characteristic of the surface water is presented in Table 2 whereas the range and mean± SD is shown in Table 3.

Table 3.26: Surface Water Analysis

S/N	Parameter(s)	SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7	SW 8	SW 9	SW 10	SWC 1	SWC 2
0	Depth (meters)	**4.8**	**4.3**	**6.5**	**4.0**	**3.5**	**6.0**	**8.7**	**8.9**	**5.2**	**6.5**	**9.2**	**7.9**
1	pH	*7.60*	*7.60*	*7.50*	*7.60*	*7.65*	*7.50*	*7.55*	*7.65*	*7.40*	*7.60*	*7.60*	*7.70*
2	Appearance	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*	*Clear*
3	Temperature (^oC)	*27.4*	*27.3*	*27.3*	*27.4*	*27.4*	*27.4*	*27.3*	*27.4*	*27.4*	*27.4*	*27.1*	*27.1*
4	Elec. Conductivity (µs/cm)	*18,900*	*19,592*	*20,980*	*20,591*	*19,972*	*20,261*	*19,718*	*20,300*	*20,439*	*20,891*	*21,400*	*15,783*
5	TDS (mg/l)	*10,395*	*10,776*	*11,539*	*11,325*	*10,985*	*11,144*	*10,845*	*11,165*	*11,241*	*11,490*	*11,770*	*8,681*
6	Turbidity (NTU)	*7.2*	*7.4*	*6.7*	*6.1*	*6.5*	*12.2*	*16.7*	*7.3*	*8.4*	*9.2*	*7.8*	*10.4*
7	TSS (mg/l)	*6.0*	*6.3*	*6.4*	*5.2*	*4.9*	*10.9*	*13.8*	*6.1*	*6.9*	*7.7*	*6.6*	*9.1*
8	Salinity (ppt)	*8.85*	*9.61*	*10.93*	*10.42*	*9.85*	*9.92*	*9.68*	*12.19*	*10.13*	*10.98*	*9.78*	*7.89*
9	Total Hardness (mg/l)	*1280.0*	*1260.0*	*1220.0*	*1200.0*	*1230.0*	*1290.0*	*1220.0*	*1180.0*	*1190.0*	*1260.0*	*1240.0*	*1090.0*
10	Alkalinity (mg/l)	*65.0*	*60.0*	*60.0*	*65.0*	*70.0*	*85.0*	*90.0*	*65.0*	*55.0*	*60.0*	*75.0*	*50.0*
11	Chloride, Cl^- (mg/l)	*6,130*	*6,150*	*6,250*	*6,220*	*6,120*	*6,100*	*6,080*	*6,190*	*6,200*	*6,160*	*6,300*	*5,560*
12	Sulphate, SO_4^{2-} (mg/l)	*380*	*410*	*350*	*380*	*430*	*370*	*350*	*400*	*450*	*360*	*590*	*340*
13	Phosphate, PO_4^{3-} (mg/l)	*1.25*	*1.60*	*1.52*	*1.45*	*1.32*	*1.20*	*1.18*	*1.30*	*1.40*	*1.25*	*1.86*	*1.35*
14	Nitrate, NO_3^- (mg/l)	*2.60*	*2.80*	*2.50*	*2.50*	*2.20*	*3.20*	*2.90*	*2.00*	*2.20*	*2.70*	*3.20*	*2.60*
15	Cyanide (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
16	Ammonia (mg/l)	*0.20*	*0.20*	*0.10*	*0.30*	*0.20*	*0.40*	*0.40*	*0.30*	*0.30*	*0.30*	*0.20*	*0.50*
17	Urea	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*	*<0.10*
18	Total Nitrogen (mg/l)	*4.98*	*5.27*	*5.21*	*5.37*	*5.29*	*6.25*	*6.86*	*5.08*	*5.37*	*5.16*	*5.47*	*6.58*
19	Oil & Grease (mg/l)	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*	*<1.00*
20	DO (mg/l)	*4.56*	*5.21*	*5.76*	*4.92*	*5.38*	*5.26*	*5.11*	*5.60*	*5.48*	*5.10*	*6.24*	*6.01*
21	BOD_5 (mg/l)	*9.20*	*10.10*	*9.70*	*9.20*	*8.50*	*10.50*	*8.90*	*8.70*	*9.00*	*8.50*	*8.70*	*9.80*
22	COD (mg/l)	*31.80*	*33.70*	*30.60*	*32.40*	*29.80*	*36.50*	*38.30*	*30.60*	*27.60*	*30.60*	*32.10*	*28.50*
23	Sodium, Na (mg/l)	*3492.32*	*3526.85*	*3565.87*	*3576.62*	*3526.59*	*3459.74*	*3494.93*	*3593.76*	*3594.09*	*3529.44*	*3701.90*	*3190.74*

S/N	Parameter(s)	SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7	SW 8	SW 9	SW 10	SWC 1	SWC 2
24	Potassium, K (mg/l)	*215.66*	*200.58*	*205.65*	*201.69*	*196.65*	*219.65*	*212.27*	*202.64*	*205.12*	*195.35*	*201.78*	*194.21*
25	Calcium, Ca (mg/l)	*275.07*	*276.52*	*275.45*	*274.52*	*278.43*	*276.41*	*271.87*	*270.93*	*274.00*	*271.03*	*273.12*	*233.74*
26	Magnesium, Mg (mg/l)	*125.31*	*122.01*	*119.25*	*117.28*	*120.31*	*131.71*	*119.84*	*113.84*	*115.12*	*118.25*	*124.15*	*112.10*
27	Silver, Ag (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
28	Cobalt, Co (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
29	Manganese, Mn (mg/l)	*0.128*	*0.098*	*0.117*	*0.129*	*0.112*	*0.192*	*0.215*	*0.097*	*0.064*	*0.107*	*0.152*	*0.101*
30	Vanadium, V (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
31	Nickel, Ni (mg/l)	*0.029*	*0.032*	*0.026*	*0.025*	*0.029*	*0.078*	*0.092*	*0.035*	*0.022*	*0.029*	*0.036*	*0.019*
32	Chromium, Cr (mg/l)	*0.018*	*0.014*	*0.013*	*0.072*	*0.055*	*0.082*	*0.091*	*0.018*	*0.019*	*0.045*	*0.052*	*0.017*
33	Iron, Fe (mg/l)	*0.176*	*0.138*	*0.129*	*0.165*	*0.176*	*0.259*	*0.268*	*0.113*	*0.122*	*0.124*	*0.143*	*0.090*
34	Lead, Pb (mg/l)	*0.011*	*0.009*	*0.014*	*0.012*	*0.017*	*0.058*	*0.065*	*0.012*	*0.016*	*0.026*	*0.035*	*<0.001*
35	Copper, Cu (mg/l)	*0.045*	*0.083*	*0.078*	*0.042*	*0.063*	*0.170*	*0.264*	*0.082*	*0.064*	*0.116*	*0.142*	*0.058*
36	Zinc, Zn (mg/l)	*0.129*	*0.170*	*0.191*	*0.086*	*0.098*	*0.199*	*0.174*	*0.102*	*0.132*	*0.153*	*0.283*	*0.138*
37	Mercury, Hg (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
38	Cadmium, Cd (mg/l)	*0.015*	*0.012*	*0.016*	*0.036*	*0.087*	*0.068*	*0.060*	*0.037*	*0.084*	*0.110*	*0.144*	*0.042*
39	Arsenic, As (mg/l)	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
40	HUB (CFU/ml) x 10^2	*1.0*	*0.4*	*0.9*	*0.6*	*0.5*	*0.2*	*0.3*	*0.6*	*0.2*	*0.4*	*0.5*	*0.2*
41	HUF (CFU/ml) x 10^2	*0.6*	*0.1*	*0.5*	*0.2*	*0.4*	*NIL*	*NIL*	*0.1*	*0.2*	*0.1*	*0.1*	*0.2*
42	THB (CFU/ml) x 10^2	*2.2*	*1.4*	*2.6*	*1.8*	*2.7*	*2.3*	*1.9*	*1.4*	*1.8*	*2.9*	*2.4*	*2*
43	THF (CFU/ml) x 10^2	*1.6*	*0.3*	*1.7*	*0.4*	*0.8*	*0.3*	*0.2*	*0.3*	*0.7*	*0.3*	*0.3*	*0.6*
44	SRB (MPN/100ml)	*3*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
45	Fecal Coliform (MPN/100ml)	*210*	*4*	*7*	*6*	*4*	*3*	*9*	*3*	*6*	*9*	*28*	*64*
46	Total Coliform (MPN/100ml)	*1,100*	*43*	*150*	*11*	*9*	*16*	*21*	*37*	*24*	*29*	*290*	*460*

Table 3.27: Statistical analysis of surface water analysis results

Parameter	SW PROJECT AREA (SW1-10)		SW CONTROL (SWC-SWC2)	
	Range	**Mean ± SD**	**Range**	**Mean ± SD**
Colour (Pt-Co)	Not Clear	-	Not Clear	-
pH	7.50 – 7.60	7.57 ± 0.08	7.60 – 7.70	7.65 ± 0.07
Temperature (^0C)	27.3 – 27.4	27.4 ± 0.05	27.1 – 27.1	27.1 ± 0
Electrical Conductivity *(µS/cm)*	18900 –20980	20164 ± 636	15783 -21400	1859 ± 3971
Total Dissolved Solids *(mg/l)*	1039 –11539	11090 ± 349.7	8681 – 11770	10225± 2,184
Turbidity *(NTU)*	6.1 – 16.7	8.7 ± 3.30	7.8 – 10.4	9.10 ± 1.84
Total Suspended Solids *(mg/l)*	4.9 – 13.8	7.42 ± 2.80	6.6 – 9.1	7.85 ± 1.76
Salinity *(ppt)*	8.85 – 12.9	10.3 ± 1.10	7.89 – 9.78	8.84 ± 1.34
Total Hardness *(mg/l) ($CaCO_3$)*	1180 - 1290	1233 ± 38.0	1090 - 1240	1165 ± 106.1
Alkalinity (mg/l)	55.0 – 90.0	67.5 ± 11.4	50.0 – 75.0	62.5 ± 17.6
Ammonia (mg/l)	0.10 – 0.40	0.27 ± 0.09	0.20 – 0.50	0.35 ± 0.21
Urea (mg/l)	<0.10	ND ± 0	<0.10	ND ± 0
Total Nitrogen (mg/l)	4.98 – 6.86	5.48 ± 0.60	5.47 – 6.58	6.03 ± 0.78
Oil & Grease (mg/l)	<1.0	ND ± 0	<1.0	ND ± 0
Dissolved Oxygen (mg/l)	4.56 - 5.76	5.25 ± 0.33	6.01 – 6.24	6.13 ± 0.16
Biological Oxygen Demand (mg/l)	8.50 – 10.50	9.23 ± 0.68	8.70 – 9.80	9.25 ± 0.78
Chloride Ion *(mg/l)*	6080 – 6220	6160 ± 54.5	5560 - 6300	5930 ± 523.2
Sulphate *(mg/l)*	350 - 450	388 ± 33.9	340 - 590	465 ± 176.8
Phosphate *(mg/l)*	1.18 – 1.60	1.65 ± 0.92	1.35 – 1.86	1.60 ± 0.36
Nitrate *(mg/l)*	2.00 – 2.90	2.56 ± 0.36	2.60 – 3.20	2.90 ± 0.42
Cyanide *(mg/l)*	0.001 – 0.001	ND ± 0	0.001 – 0.001	ND ± 0
Sodium (*mg/l*)	3459.7 -3594.0	3536 ± 45.8	3190.7 – 3701.9	3446 ± 361.5
Potassium (*mg/l*)	195.4 – 215.7	205.3 ± 8.01	194.2 – 201.8	198.0 ± 5.35
Calcium (*mg/l*)	270.9 – 278.4	274.4 ± 2.50	233.7 – 273.1	253.4 ± 27.8
Magnesium *(mg/l)*	113.8 – 131.7	120.1 ± 5.07	112.1 – 124.2	118.1 ± 8.52
Silver *(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0
Cobalt*(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0
Manganese *(mg/l)*	0.064 – 0.215	0.13 ± 0.05	0.10 – 0.15	0.13 ± 0.04
Vanadium *(mg/l)*	<0.001	ND ± 0	<0.001	ND ± 0
Nickel *(mg/l)*	0.02 – 0.09	0.04 ± 0.02	0.02 – 0.04	0.03 ± 0.01
Chromium *(mg/l)*	0.01 - 0.91	0.04 ± 0.03	0.017 - 0.052	0.03 ± 0.02
Iron *(mg/l)*	0.11 – 0.27	0.17 ± 0.06	0.090 – 0.143	0.12 ± 0.04
Lead *(mg/l)*	0.01 – 0.07	0.02 ± 0.02	<0.001 – 0.035	0.04 ± 0.02
Copper *(mg/l)*	0.05 – 0.27	0.10 ± 0.07	0.058 – 0.142	0.10 ± 0.06
Zinc *(mg/l)*	0.09 – 0.20	0.14 ± 0.04	0.138 – 0.283	0.12 ± 0.10
Mercury *(mg/l)*	<0.001	ND ± 0	0.001	ND ± 0
Cadmium *(mg/l)*	0.012 -0.110	0.05 ± 0.03	0.042 -0.144	0.14 ± 0.04
Arsenic *(mg/l)*	0.001	ND ± 0	0.001	ND ± 0

3.12.6. Results and Discussion

3.12.6.1 ***Physical Characteristics of Bonny Water***

The Bonny water is located on the immediate eastern flank of the Niger Delta between longitudes $7^o00'$ and $7^o15'$E and latitudes $4^o25'$ and 4^o50 (Folorunsho and Awosika, 2014). The strategic location of the water serves as an entrance point to the Port Harcourt and Onne ports in Rivers State. Immediately east of the water is the Bonny barrier island. The mouth of the water is jointly shared by the Caw throne channel and the New Calabar River. The width of the mouth of the water is over 13.8 km and drains a total area of 621,351 km^2 (Folorunsho and Awosika, 2014). It has an estimated area of 206 km2 and extends 7 km offshore to a average depth of about 7.5m (Folorunsho and Awosika, 2014).

Physical attributes of a water body are an important indicator of water quality. The most basic physical attribute of a stream is the path along which it flows. The Bonny River is characterized by deep and shallow channels with semi diurnal tides that generate tidal current in phase with the tidal direction. The morphology is shaped by high tidal oscillations superimposed on waves and sediments brought in by tributaries and creeks that flow into their drainage basins. The Bonny River is further characterized with strong currents, sandbars, and erosion (Folorunsho and Awosika, 2014). The land-water interchange is relatively extensive and more intimately connected with the surrounding land.

Table 3.28: Bonny River Physical Characteristics

1.	Minimum Depth	0.1 meters
2.	Maximum Depth	18.7 meters
3.	Approximate Length	173 kilometers
4.	Average Width	2.0 Kilometers
5.	Average ebb tide flow rate	1.5 meter per second
6.	Average current flowrate	0.8 meter per second
7.	Open surface area	Approx. 312 Sq. Km

3.12.6.2 *Surface water flow*

The velocity of a river is directly related to the amount of water received into the river channel. It is affected by weather, increasing during rainstorms, and decreasing during dry season. The flow is also a function of water volume and velocity. It is important because of its impact on water quality and on the living, organisms, including habitats in the ecosystem.

Bonny River is brackish tidal water body which flows and ebbs in both directions into Bonny channel. The flow rate of Bonny Channel which receives Atlantic Ocean water has increased due to dredging to increase both the depth of ship lines and shore reclamation. The flow rate of the rivers is influenced by the shape of its channel, the gradient of the slope, volume of water that the sections carry, and the amount of friction caused by rough edges within the stream bed.

Table 3.29: Sampling stations depths and flow rate

S/No	Station Code	Depth (m)	Flow rate (m/s)
1	SW1	4.8	1.1
2	SW2	4.3	1.1
3	SW3	6.5	1.3
4	SW4	4.0	1.2
5	SW5	3.5	1.2
6	SW6	6.0	0.9
7	SW7	8.7	0.9
8	SW8	4.9	1.0
9	SW9	5.2	1.5
10	SW10	6.5	1.4
11	SWC1	9.2	1.3
12	SWC2	7.9	1.4

3.12.6.3 Surface water quality

The water quality is a key determinant of resource suitability for intended purpose. The water quality is influenced by geomorphology, geology, climatic and biological factors, as well as anthropogenic activities performed. Bonny water quality is influenced by anthropogenic activities and tidal effect. The pH was slightly alkaline for all stations sampled. The high electrical conductivity is attributed to high ions and salinity concentrations in the water body coupled with the tidal directional flow. The moderate alkalinity value of surface water could be linked to the type of dissolved inorganic and organic compounds present in the water, the amount of suspended organic matter in the water (Tripathi, 2022), and the amount of bicarbonate in the water, which also evident from the elevated values of TDS recorded. The BOD and COD values observed across all sampled stations including the control stations implicates to the use of the shores as industrial site and associated surface run-off in the study area. Heavy metals concentrations were generally low.

3.12.6.4. <u>Surface water users and co-dependent habitats</u>

The numerous anthropogenic activities (oil and gas companies, import and export logistics, sand mining/dredging, waste dump) performed in and around the Bonny River. The dredging activities/Bed sweeping are required to maintain channel depth, which has modified Bonny Rivers characteristics. Bonny River is being used for navigation of marine vessels. The fishing settlements (communities) at and nearby Bonny Rivers are being involved in fishing activities, however Federal authorities have limited access to Port influence zone.

3.12.6.5. <u>Surface Water Availability</u>

The water availability of the Bonny River is relatively high, and water can be used for navigation of marine vessels without significant harm to ecosystem and other users. The Bonny River is a perennial water body which receives the Atlantic Ocean water. It consists of the main river channel with large numbers of associated creeks and creek-lets.

3.12.6.6. <u>Flood risk appraisal</u>

The risk of flooding from all flooding mechanisms for the project site from the Bonny River is low. The topography of the proposed sites is relatively flat with an average elevation of 6 meters above the mean sea level (Lagos datum). The Bonny River banks elevation is higher than the water level at high tide and the least possibility of River flooding. Also, the proposed project site has an inland drainage canal wide enough to convey storm run-off of extreme precipitation. Moreover, internal drainage will be developed within the project site to drain the surface run-off and also the quay will be at appropriate height.

3.13. SEDIMENT ASSESSMENT REPORT

Executive Summary

Sediment provides sanctuary for benthic macro invertebrates and also a sink for pollutants on any water body. Consequently, it was considered a critical aspect of MM Port FZE Project ESIA study in order to establish the baseline condition of the sediment within the project area. The sediment assessment study revealed pH ranged between 6.40 – 7.30 with pH average of 6.94 within the project influence area while pH value of 6.40 and 6.90 was recorded at the two control stations indicating that sediment with the project area is slight acidic to moderately alkaline.

Ammonia ranged between 0,70 – 0.96mg/kg within the project influence zone, while the control stations recorded 0.73 and 0.88mg/kg at control station 1 and 2. Total Nitrogen ranged between 0.108 – 0.210mg/kg within the project area, while the control station recorded 0.216 and 0.233mg/kg for control station 1 and 2. THC ranged between 7.81 – 15.10mg/kg with 10.73mg/kg average within the project influence zone while the control stations recorded 7.50 and 6.31mg/kg for control station 1 and 2 respectively. The least concentration of THC was observed at station 1 and 2 while highest was observed within the project influence zone specifically at station 7 (SED7).

Heavy metals were generally <0.001 except for Iron (Fe), Zinc (Zn) and Cobalt (Co) which were detected with iron recording the highest concentration of average of 3605.0mg/kg, Zinc 13.03mg/kg and cobalt 2.76mg/kg within the project site. Notably this is not in significant variation with the control stations' results. Microbial count revealed THB has the highest microbial count with 2.22 cfu/g x 10^6 average, followed by THF with average count of 1.06 cfu/g x 106, followed by HUB with average count of 0.62cfu/g x 103 and HUF with 0.46cfu/gx10^3 average count within the project influence zone.

The leachate test for sampled sediments revealed parameters tested for leachability were generally low and below detection limit for most parameters. While sediment sources were majorly washing from exposed soil and waste material including sewage within and around the study area.

3.13.1 Introduction

Sediments are the loose sand, silt and other soil particles that settle at the bottom of a waterbody. Sediment strata serve as an important habitat for the benthic macro invertebrates whose metabolic activities contribute to aquatic productivity (Abowei *et al* 2005). Sediment is a major site for organic matter decomposition which is largely carried out by bacteria. Important macro-nutrients such as nitrogen and phosphorous are continuously being interchanged between sediment and overlying water (Abowei *et al* 2005). Consequently, the sediment was considered a critical aspect of the environmental impact assessment of the proposed project. As such sediment samples were collected at twelve (12) stations, ten (10) within the project influence zone and two (2) as control stations. Table 2 presents the sediment quality results.

3.13.2 Scope of study

The scope of the study is to establish existing sediment condition within the through field observation during sampling and laboratory analysis of sediment samples collected from the waterbody closest to the project site. Furthermore, to analyze possible impacts that may occur to sediment component in all phases (Pre-construction, Construction and Operation) of the project life cycle.

3.13.3 Field Approach

The study adopted both onsite and offsite approach in executing the study. The onsite is majorly for sediment sample collection in the field and submission of samples to laboratory, while the offsite includes laboratory analysis of samples and report writing.

3.13.4 Methodology

The study adopted standard international best practice in all aspects of the study execution ranging from field data gathering and laboratory analysis. Specifically, sediment samples were collected using Eckman grab which is launched down the water sediment to retrieve sediments. Samples were collected into plastic bags after being wrapped in aluminum foil and packed into containers made of high UV (Ultraviolet) resistant material. Sample labeling was done at the point of sampling with the correct Station ID. A total of twelve (12) sediment samples were collected, ten (10) were located with the project influence zone and two (2) controls away from the proposed project influence zone, which is the same for surface water and aquatic biodiversity stations.

The sediments sampling station coordinates, depth and approximate distance from the riverbank are shown in table 1.

Table 3.30: Sampling stations

S/No	Station Code	Depth (meters)	Distance from bank (meters)	WGS 84	
				LATITUDE (N)	LONGITUDE (E)
1	SED1	4.8	150	4°39'39.2"N	7°08'50.5"E
2	SED2	4.3	140	4°39'55.9"N	7°08'24.5"E
3	SED3	6.5	170	4°40'02.8"N	7°08'10.1"E
4	SED4	4.0	130	4°40'07.0"N	7°07'47.2"E
5	SED5	3.5	110	4°40'14.6"N	7°07'28.8"E
6	SED6	6.0	200	4°39'59.6"N	7°09'14.7"E
7	SED7	8.7	210	4°40'29.6"N	7°09'22.3"E
8	SED8	4.9	140	4°40'28.9"N	7°07'00.7"E
9	SED9	5.2	150	4°40'24.7"N	7°06'45.7"E
10	SED10	6.5	600	4°39'30.0"N	7°08'03.6"E
11	SEDC1	9.2	600	4°36'38.0"N	7°10'35.3"E
12	SEDC2	7.9	900	4°42'44.4"N	7°05'39.9"E

3.13.5 Results and Discussion

3.13.5.1 Results

Summary results of sediment properties within and around proposed project site is presented in table 1, while the comprehensive results is presented in appendix 1. Table 2 presents the leachate test results from TCLP analysis carried out on the sediment samples, while the comprehensive results shown in table 2.

Table 3.31: Present summary results of sediment properties

S/N	Parameter(s)	Min	Max	Ave	SED C1	SED C2
1	Sand (%)	78.25	81.99	80.18	80.48	80.41
2	Silt (%)	4.45	6.33	5.34	4.87	5.84
3	Clay (%)	12.65	17.25	14.47	14.65	13.75
4	Texture	~	~	~	LS	LS
5	Porosity	0.37	0.40	0.38	0.38	0.38
6	Colour	~	~	~	Black	Black
7	Permeability (cm/sec)×10	0.17	0.2	0.18	0.18	0.20
8	Bulk Density (g/cm3)	1.27	1.53	1.39	1.36	1.47
9	pH	6.40	7.30	6.94	6.40	6.90
10	Phosphate, PO43- (mg/kg)	1.10	1.93	1.47	1.26	1.30
11	Sulphide, S2 (mg/kg)	<0.01	<0.01	<0.01	<0.01	<0.01
12	Sulphate, SO42- (mg/kg)	490	710	625.00	510	610
14	Nitrate, NO3- (mg/kg)	2.4	3.4	2.9	2.5	3.0

S/N	Parameter(s)	Min	Max	Ave	SED C1	SED C2
15	TOC (%)	1.25	2.43	1.62	2.50	2.69
16	THC (mg/kg)	7.81	15.10	10.73	7.50	6.31
18	Ammonia (mg/kg)	0.70	0.96	0.84	0.73	0.88
19	Total Nitrogen (%)	0.108	0.210	0.140	0.216	0.233
21	Cobalt, Co (mg/kg)	1.39	4.14	2.76	1.97	2.94
22	Manganese, Mn (mg/kg)	25.39	122.5	64.57	56.50	38.10
23	Iron, Fe (mg/kg)	2617.7	4333.2	3605.0	4,301.4	3,685.1
24	Zinc, Zn (mg/kg)	11.32	15.74	13.03	16.02	14.23
25	Silver, Ag (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001
26	Vanadium, V (mg/kg)	<0.001	0.29	0.16	<0.001	<0.001
27	Nickel, Ni (mg/kg)	<0.001	6.13	0.29	<0.001	<0.001
28	Chromium, Cr (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001
29	Lead, Pb (mg/kg)	3.05	3.05	3.05	<0.001	<0.001
30	Copper, Cu (mg/kg)	<0.001	0.98	0.08	<0.001	0.83
31	Mercury, Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001
32	Arsenic, As (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001
33	THB (CFU/g) x 10^6	1.2	3.2	2.22	1.1	2.2
34	THF (CFU/g) x 10^6	0.5	1.7	1.06	0.7	1.1
35	HUB (CFU/g) x 10^3	0.3	1.3	0.62	0.5	0.8
36	HUF (CFU/g) x 10^3	0.2	1.0	0.46	0.3	0.6

Table 3.32 Summary results of TCLP Analysis on Sediment samples

S/No	Parameters	Min	Max	Ave	SED C1	SED C2
1	Iron, Fe (mg/l)	2.107	8.145	5.8111	7.346	4.154
2	Manganese, Mn (mg/l)	0.258	1.434	0.7337	1.451	0.636
3	Zinc, Zn (mg/l)	0.816	2.651	1.7566	2.816	1.751
4	Vanadium, V (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
5	Nickel, Ni (mg/l)	<0.001	0.246	0.0246	<0.001	<0.001
6	Chromium, Cr (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
7	Lead, Pb (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
8	Copper, Cu (mg/l)	<0.001	0.076	0.0076	<0.001	0.065
9	Mercury, Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
10	Arsenic, As (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
11	Cobalt, Co (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001

3.13.6. Discussion

3.13.6.1 pH

Figure 1 Below presents the pH concentration of sediment within the project environment, the figure reveals pH concentration ranged between 6.40 – 7.30 with pH average of 6.94 within the project influence area while pH value of 6.40 and 6.90 was recorded at the two control stations indicating that sediment with the project area is slight acidic to alkaline.

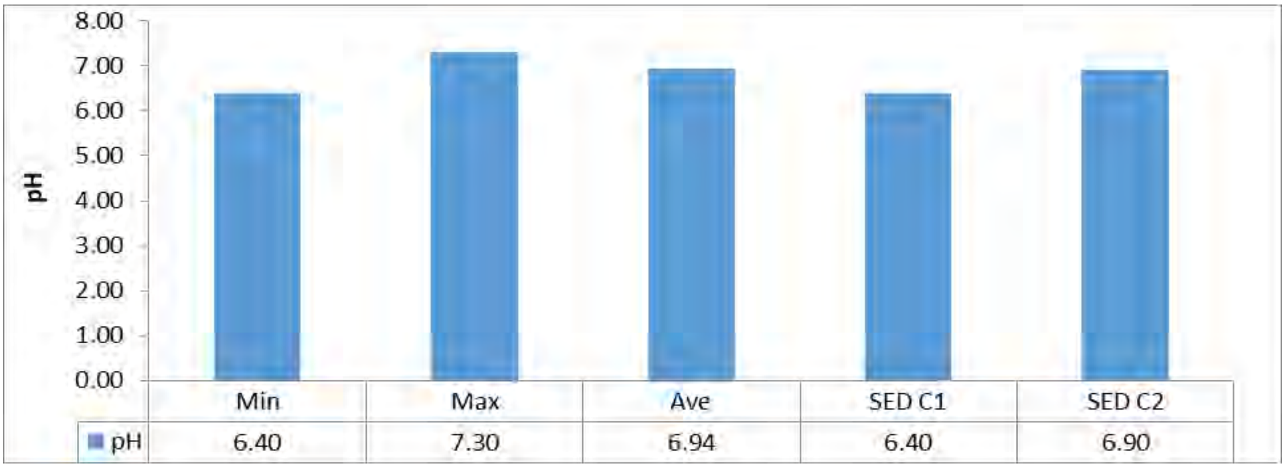


Figure 3.44: pH concentration of sediment within the project environment.

3.13.6.2. Ammonia and Total Nitrogen

Figure 3.45 presents the concentration of Ammonia and Total Nitrogen of sediment within the project area. The figure revealed ammonia ranged between 0,70 – 0.96mg/kg within the project influence zone, while the control stations recorded 0.73 and 0.88mg/kg at control station 1 and 2. Total Nitrogen ranged between 0.108 – 0.210mg/kg within the project area, while the control station recorded 0.216 and 0.233mg/kg for control station and 2. The control stations recorded the highest level of total nitrogen which is not in significant variation with the results recorded within the project influence zone.

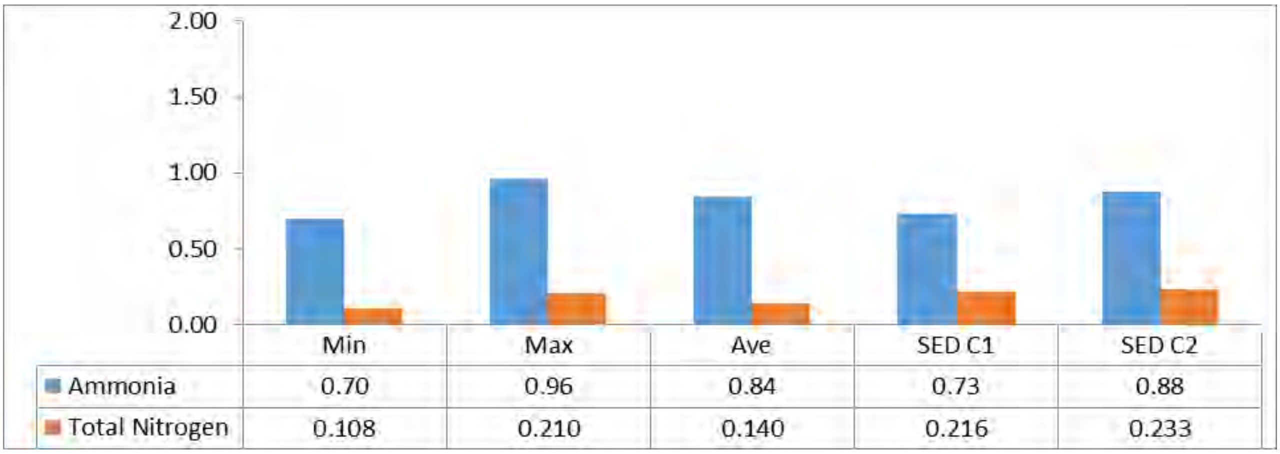


Figure 3.45: Concentration of Ammonia and Total Nitrogen

3.13.6.3. Phosphate, Nitrate and TOC

Figure 3.46 Below presents the concentration of Phosphate, Nitrate and Total Organic Carbon as observed during the EIA study. The figure revealed Phosphate ranged between 1.10 to 1.93mg/kg with 1.47mg/kg average within the project influence zone, similar concentration was also recorded at the two controls stations; while Nitrate ranged between 2.4 – 3.4mg/kg with 2.9mg/kg average with similar results been recorded at the control stations. Total organic carbon ranged between 1.25-2.43mg/kg within the project possible influence zone, while the control stations recorded 2.50 and 2.69mg/kg for control 1 and control 2 respectively. Observed phosphate is low compared to 5.5 - 15.5mg/kg observed by Adesuyi et al (2016) on Nwaja creek and 13.43mg/kg mean recorded by Daka and Moslen in Azuabie River sediment. Moreso, observed nitrate results is in agreement with the range (2.60 - 4.10 mg/kg) recorded by Ezekiel et al (2011) within study area.

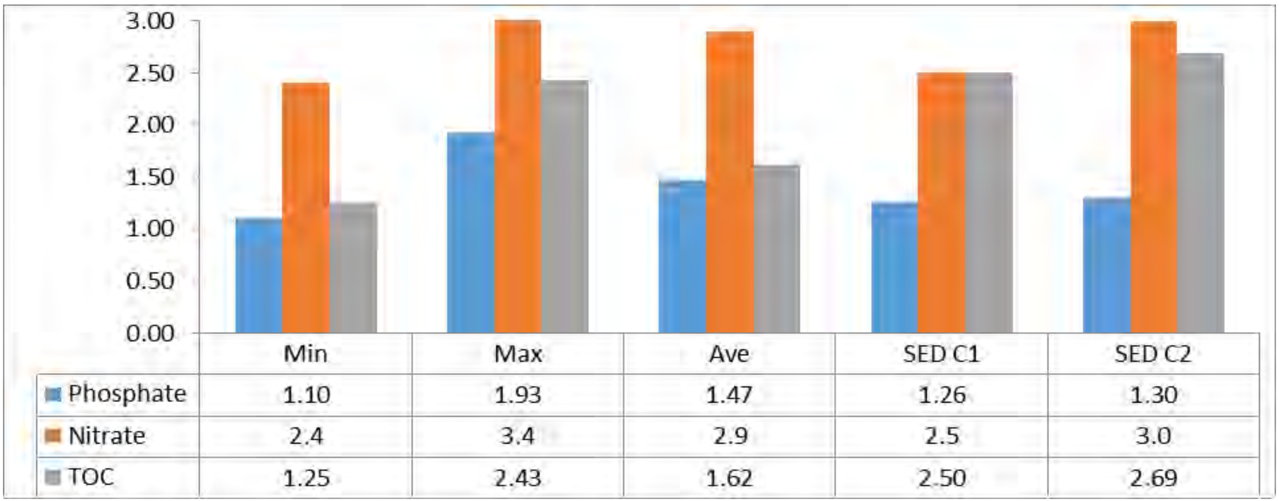


Figure 3.46: Concentration Phosphate and Nitrate and TOC

3.13.6.4. Total Hydrocarbon

Figure 4 presents the concentration of Total Hydrocarbon recorded during the field survey. The figure revealed THC ranged between 7.81 – 15.10mg/kg with 10.73mg/kg average within the project influence zone while the control stations recorded 7.50 and 6.31mg/kg for control station 1 and 2 respectively. The least concentration of THC was observed at station 1 and 2 while highest was observed within the project influence zone specifically at station 7 (SED7).

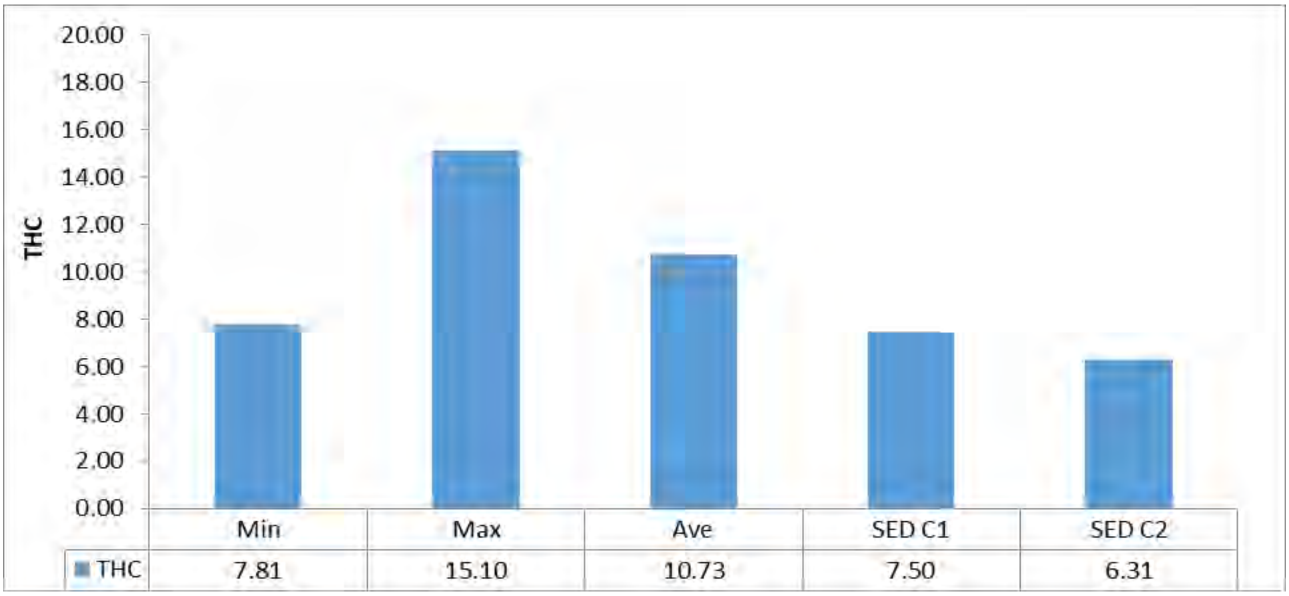


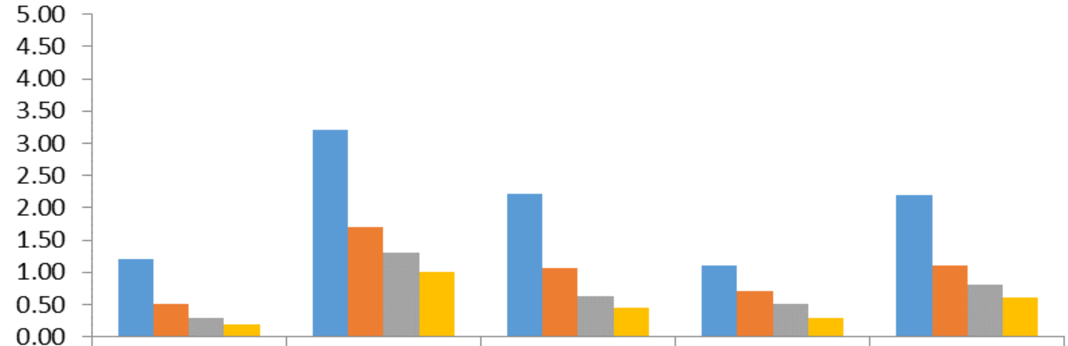
Figure 3.47: Concentration of Total Hydrocarbon and Oil/Grease

3.13.6.5. Heavy Metal

Heavy metal parameters analyzed for the EIA study includes Fe, Zn, Co, Ag, V, Ni, Cr, Pb, Cu and As, among the metals analyzed Fe recorded the highest concentration which ranged between 2617.7 – 4333.2mg/kg with 3605.0mg/kg average within the project influence zone, which is similar to concentration of 4301.4 and 3685.1mg/kg observed at the control stations 1 and 2 respectively. This is typical of the Niger Delta Environment. Zn ranged between 11.32 -15.74mg/kg; Cobalt ranged between 1.39 -4.14mg/kg which are not in significant concentration with results from the control stations. Generally, Ag, V, Ni, Cr, Pb, Cu and As were <0.001mg/kg Average concentration of 0.09>0.35>1.00>3.05mg/kg was recorded for Barium, Aluminum, Lead and Copper respectively within the project influence zone. Similar results were also recorded at control stations for these parameters.

3.13.6.6. Microbiology

Figure 3.48 presents the microbial count of sediment microbes observed during the EIA study. The figure revealed THB has the highest microbial count with 2.22 cfu/g x 10^6 average, followed by THF with average count of 1.06 cfu/g x 106, followed by HUB with average count of 0.62cfu/g x 10^3 and HUF with 0.46cfu/gx10^3 average count within the project influence zone. The microbial count recorded at the control stations are within the range observed at the project influence zone. The low concentration of HUB and HUF corroborate the low concentration of Total Hydrocarbon as observed in this study as this microbe (HUB and HUF) are attracted by the presence of hydrocarbon.



	Min	Max	Ave	SED C1	SED C2
THB (CFU/g) x 106	1.2	3.2	2.22	1.1	2.2
THF (CFU/g) x 106	0.5	1.7	1.06	0.7	1.1
HUB (CFU/g) x 103	0.3	1.3	0.62	0.5	0.8
HUF (CFU/g) x 103	0.2	1.0	0.46	0.3	0.6

Figure 3.48: Microbial count of some microbes within the project environment

3.13.6.7. Toxicity Characteristic Leaching Procedure (TCLP) Test

The TCLP analysis was carried out to establish the leachability potentials of sediment from the project area. Consequently, collected sediment samples were subjected to TCLP analysis test and the results are presented in Table 2. The table revealed Iron (Fe) ranged between 2.107 – 8.145mg/l with 5.8111mg/l average; Manganese (Mn) ranged between 0.258 – 1.434mg/l with 0.7337mg/l average and Zinc (Zn) ranged between 0.816 -2.651mg/l with 1.7566mg/l average, while other metals (V, Ni, Cr, Pb, Cu, Hg, As and Co) were <0.0001mg/l. Iron present the highest concentration, followed by Zinc and Manganese the least. The results recorded within the control stations were within the range recorded within the possible project influence zone. The leachate test for sampled sediments showed that all the parameters tested for leachability were generally low and below detection limit for most parameters.

3.13.6.8. Sediment Source

Sediment sources within the study area were generally washings from exposed soil, debris/waste, and sewage into the surface waterbody. Moreso, vessel movement and fishing activities may have the possibility to re-suspend sediment.

Table 3.33: Detail results of Sediment

S/N	Parameter(s)	SED 1	SED 2	SED 3	SED 4	SED 5	SED 6	SED 7	SED 8	SED 9	SED 10	SED C1	SED C2
1	Sand (%)	81.99	80.27	79.3	79.64	80.89	79.6	81.18	80.58	78.25	80.14	80.48	80.41
2	Silt (%)	5.15	6.33	4.45	4.6	5.75	4.6	6.17	5.84	4.5	6.03	4.87	5.84
3	Clay (%)	12.86	13.4	16.25	15.76	13.36	15.8	12.65	13.58	17.25	13.83	14.65	13.75
4	Texture	LS	LS	SL	SL	LS	SL	LS	LS	SL	LS	LS	LS
5	Porosity	0.40	0.38	0.38	0.38	0.39	0.38	0.40	0.39	0.37	0.38	0.38	0.38
6	Colour	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black
7	Permeability (cm/sec)×10	0.17	0.18	0.18	0.19	0.20	0.19	0.18	0.17	0.18	0.19	0.18	0.20
8	Bulk Density (g/cm3)	1.37	1.4	1.53	1.38	1.43	1.27	1.38	1.4	1.31	1.40	1.36	1.47
	pH	7.20	7.30	7.10	6.90	6.40	6.70	7.00	6.50	7.10	7.20	6.40	6.90
9	Phosphate, PO43- (mg/kg)	1.10	1.40	1.84	1.40	1.30	1.25	1.93	1.57	1.60	1.35	1.26	1.30
10	Sulphide, S2 (mg/kg)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
11	Sulphate, SO42- (mg/kg)	590	670	650	700	540	690	710	640	570	490	510	610
12	Nitrate, NO3- (mg/kg)	2.8	3.1	2.4	2.5	2.8	3.0	3.3	2.6	3.0	3.4	2.5	3.0
14	TOC (%)	2.43	1.64	1.85	1.29	1.36	1.68	1.57	1.25	1.47	1.72	2.50	2.69
15	THC (mg/kg)	8.81	7.81	12.10	10.30	11.56	9.40	15.10	12.31	11.30	8.57	7.50	6.31
16	Ammonia (mg/kg)	0.81	0.90	0.70	0.72	0.82	0.88	0.95	0.75	0.87	0.96	0.73	0.88
18	Total Nitrogen (%)	0.210	0.142	0.160	0.111	0.117	0.142	0.136	0.108	0.127	0.148	0.216	0.233
19	Cobalt, Co (mg/kg)	4.14	3.24	4.1	<0.001	2.92	1.39	3.43	2.42	1.78	1.42	1.97	2.94
21	Manganese, Mn (mg/kg)	112.50	44.87	73.80	25.39	122.50	29.52	110.30	63.40	35.65	27.74	56.50	38.10
22	Iron, Fe (mg/kg)	4,047.2	3,418.2	4,256.9	2,617.7	4,206.1	3,068.8	4,333.2	3,875.7	3,126.0	3,100.6	4,301.4	3,685.1
23	Zinc, Zn (mg/kg)	13.1	11.97	15.74	11.55	13.48	11.32	14.33	12.82	13.03	12.93	16.02	14.23
	Silver, Ag (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
24	Vanadium, V (mg/kg)	<0.001	<0.001	<0.001	<0.001	0.29	<0.001	<0.001	0.02	<0.001	<0.001	<0.001	<0.001
25	Nickel, Ni (mg/kg)	<0.001	<0.001	<0.001	<0.001	6.13	<0.001	<0.001	0.38	<0.001	<0.001	<0.001	<0.001
26	Chromium, Cr (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

S/N	Parameter(s)	SED 1	SED 2	SED 3	SED 4	SED 5	SED 6	SED 7	SED 8	SED 9	SED 10	SED C1	SED C2
27	Lead, Pb (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	3.05	<0.001	<0.001
28	Copper, Cu (mg/kg)	<0.001	<0.001	<0.001	0.98	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.83
29	Mercury, Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
30	Arsenic, As (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
31	THB (CFU/g) x 106	2.9	2.0	1.3	2.6	1.2	2.7	3.2	1.9	2.3	2.1	1.1	2.2
32	THF (CFU/g) x 106	1.3	1.5	0.8	0.5	0.9	1.1	1.7	0.8	1.4	0.6	0.7	1.1
33	HUB (CFU/g) x 103	0.8	0.6	0.6	0.3	0.3	0.6	1.3	0.4	1	0.3	0.5	0.8
34	HUF (CFU/g) x 103	0.2	0.8	0.3	0.5	NIL	0.2	1	0.3	0.6	0.2	0.3	0.6

Table 2A: TCLP Analysis on Sediment samples

S/No	Parameter(s)	SED 1	SED 2	SED 3	SED 4	SED 5	SED 6	SED 7	SED 8	SED 9	SED 10	SED C1	SED C2
1	Iron, Fe (mg/l)	6.847	4.847	7.105	2.107	7.21	5.751	8.145	5.61	5.345	5.144	7.346	4.154
2	Manganese, Mn (mg/l)	1.253	0.415	0.258	0.545	1.215	0.415	0.625	1.434	0.754	0.423	1.451	0.636
3	Zinc, Zn (mg/l)	1.561	2.035	2.465	0.816	1.253	0.956	1.645	2.339	2.651	1.845	2.816	1.751
4	Vanadium, V (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	Nickel, Ni (mg/l)	<0.001	<0.001	<0.001	<0.001	0.246	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
6	Chromium, Cr (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
7	Lead, Pb (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
8	Copper, Cu (mg/l)	<0.001	<0.001	<0.001	0.076	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.065
9	Mercury, Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
10	Arsenic, As (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
11	Cobalt, Co (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

3.14. AQAUTIC BIODIVERSITY STUDY

3.14.1. Introduction

Meliora Methanol FZE, Federal Ocean Terminal (FOT), Onne Port Complex, Oil & Gas Free Zone, Onne, Eleme LGA, Rivers State intent to establish Port Terminal facility from concept to design and to engineering, construction in line with the Nations and International Guidelines. Aquatic biodiversity studies were considered to be an important area of focus in undertaking the environmental and social impact assessment for the proposed project. Recent dry season data on Aquatic Biology (fieldwork 18-21 January 2022) from the approved EIA of the Upgrade Of Onne Multipurpose Terminal (Berth 9-11) Project, FOT Onne, Eleme LGA, Rivers State ICTS (2022) was considered as valid in the approval of the Terms of Reference and Scope of Work for this Study. Additional one-season (wet season) work was therefore approved to augment and close gaps in the existing data to describe the baseline aquatic biodiversity conditions of the proposed project area.

3.14.2. Scope of Study

The scope of work is in tandem with that approved TOR by regulators for the ESIA of MM Port FZE project and includes:

- Delineation of ten (10) sampling stations and two (2) control stations for wet season. This entails additional Stations and Control for broader coverage than the dry season data for which five (5) stations (inclusive of Control) were sampled.
- Field survey, sample collection and laboratory analysis.
- Data analyses and report writing

3.14.3. Fieldwork approach/Sampling

The field survey and sample collection for aquatic biodiversity for wet season was done between July 4th to 5th July 2023, with continuation for fish sampling on 10th and 19th July 2023. Twelve (12) stations were sampled for aquatic biology and fisheries study. Five (5) stations were located within the proposed quay area, five (5) stations located on waterbody on both side of flow channels, while two (2) control stations were located approximately 4 km away from the proposed project area. The sampling stations/codes and their coordinates recorded during the fieldwork are presented in Table 1 and plotted in Figure 1.

Table 3.34: Geographical coordinates of sampling stations

S/No	Station Code	Depth (meters)	Distance from bank (meters)	WGS 84	
				LATITUDE (N)	LONGITUDE (E)
1	SW1	4.8	150	4°39'39.2"N	7°08'50.5"E
2	SW2	4.3	140	4°39'55.9"N	7°08'24.5"E
3	SW3	6.5	170	4°40'02.8"N	7°08'10.1"E
4	SW4	4.0	130	4°40'07.0"N	7°07'47.2"E
5	SW5	3.5	110	4°40'14.6"N	7°07'28.8"E
6	SW6	6.0	200	4°39'59.6"N	7°09'14.7"E
7	SW7	8.7	210	4°40'29.6"N	7°09'22.3"E
8	SW8	4.9	140	4°40'28.9"N	7°07'00.7"E
9	SW9	5.2	150	4°40'24.7"N	7°06'45.7"E
10	SW10	6.5	600	4°39'30.0"N	7°08'03.6"E
11	SWC1	9.2	600	4°36'38.0"N	7°10'35.3"E
12	SWC2	7.9	900	4°42'44.4"N	7°05'39.9"E

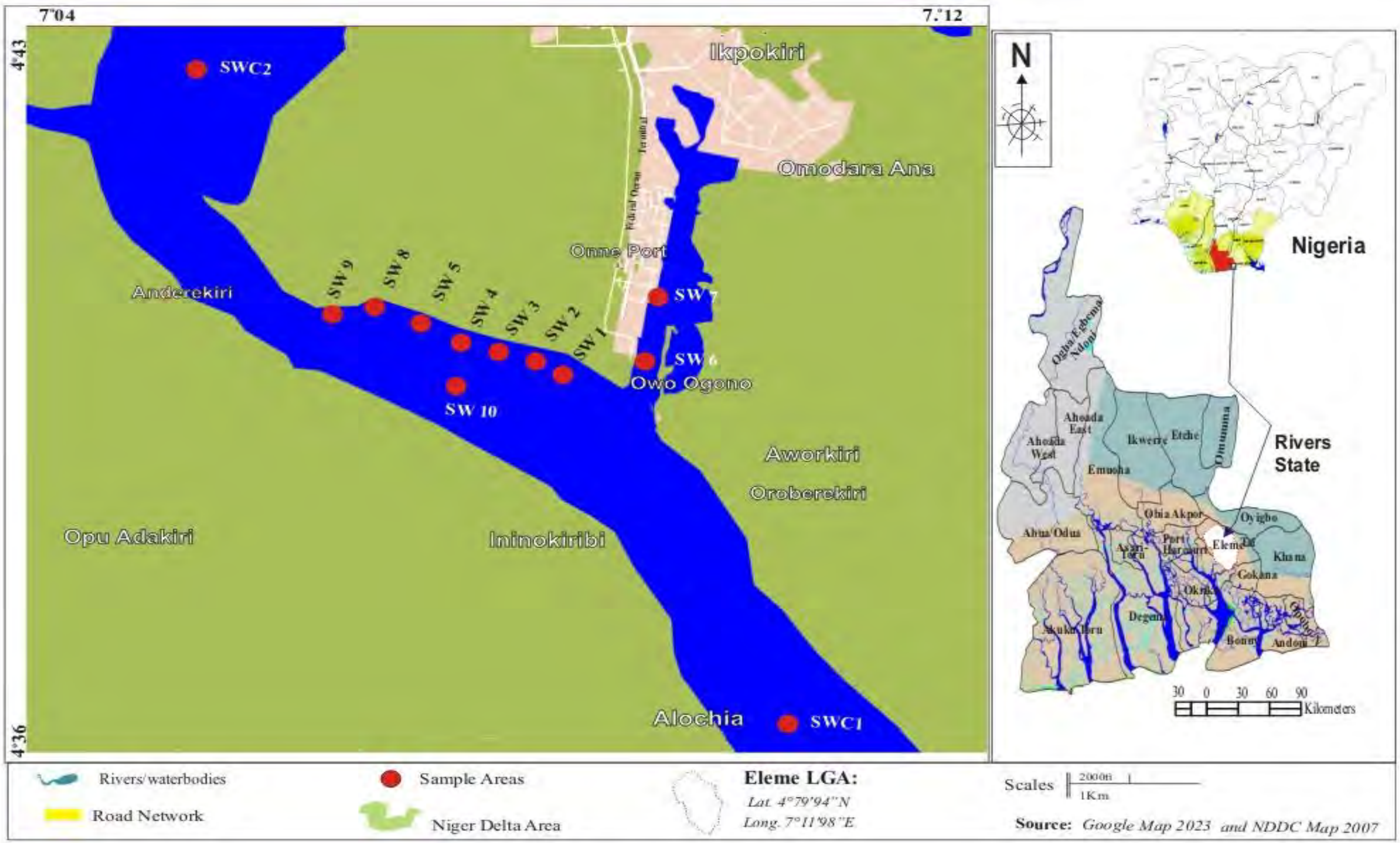


Figure 3.49: Sampling stations

3.14.4. Sample Collection and Analysis

3.14.4.1. Plankton

Plankton samples were collected with the aid of plankton net. This was done by towing plankton net (Plate 1A) for five minutes and the materials in the collection bottle was then transferred into sample containers and preserved in 5 % formaldehyde-water mixture and stained with eosin. In the laboratory, samples were made up to a uniform volume of 50 ml. Following a thorough agitation and homogenization, 1 ml sub-samples were taken using a Pasteur pipette and transferred to a Bogorov counting chamber for observation under a binocular compound microscope. The organisms were simultaneously identified and enumerated. phytoplankton were identified with the aid of a binocular microscope using appropriate keys (Durans and Leveque, (1980), Suthers, (2008), Kadiri, 1988). For zooplankton samples, keys from Barnes, (1980), Suthers, (2008), Newell and Newell, (1977) were used as guide for the identification and classification.

3.14.4.2. Benthos

A Van-Veen grab was used for the collection of sediment / benthos samples (Plate 1B). The sediment sample was collected and emptied into a plastic bucket. This was washed through a 0.5 mm mesh size sieve and the materials retained in the sieve were placed in plastic containers and fixed with 5 % formalin-water mixture and carefully packaged for laboratory analysis. In the laboratory, the organisms were sorted, identified to the lowest possible taxonomic level using Keys by Day (1967), Fauchald (1977); and individuals of each taxonomic group were counted and recorded.

3.14.4.3. Fisheries

Physical observation of fishing activities was undertaken to capture types of fishing gear and catch assessment. The use of Cast and Seine nets is common and suitable fishing gears used within the region. The use of cast net at all sampling stations will produce representative data among all station for comparison. Emmanuel *et al.* (2008) reported that cast net was not species specific. The circumference of the cast net used was 8.2m while the mesh size was 10mm; the net was made of nylon. Data from fish sampled directly at each sampling station with ten (10) cast net throws (Plate 2A). Samples were also purchased from other fisherfolks who used cast nets, seines (Plate 2B) or hooks. All samples collected were placed in labelled polythene bags and placed in ice-cooled boxes for transportation to the laboratory where they were immediately frozen until analyzed. All samples collected were placed in labelled polythene bags and placed in ice-cooled boxes for transportation to the laboratory where they were immediately frozen until analyzed. Fish were individually identified, and morphometric measurements (length and weight) were obtained.

3.14.4.4 *Floating Aquatic Macrophytes*

Floating aquatic macrophytes were studied by visual assessment in the field.

3.14.5. Data Analysis

Several statistics were used as measures of the attributes of community structure of the phytoplankton, zooplankton, and benthos samples. Diversity indices used to characterize species abundance relationships take the following into account (Ogbeibu 2019): ''the total number of species encountered in the sample, expressed as richness; how the species abundance (e.g., the number or individuals, biomass cover etc) are distributed among the species, usually expressed as evenness. Richness indices characterize species richness, while Evenness indices characterize evenness, but Diversity indices combine both species richness and evenness into a single value and therefore more informative in ecological studies.'' The indices measured in this study were species richness (Margalef, d) diversity (Shannon-Weiner H') and equitability (Pielou, J') and dominance (Simpson λ). These were used as indicators of the health status of the habitat. The formulae used for the calculation of the various indices are as follows (Pielou, 1975, Heip et al., 1988, Magurran, 1991):

- Margalef index: $d = (S-1) / \log N$
- Shannon-Weiner Index: $H' = - \Sigma_i p_i \log(p_i)$
- Pielou Evenness: $J' = H'/H'_{max} = H' / \log S$
- Simpson Index $\lambda = \Sigma pi^2$

These were computed using the Plymouth Routines of Multivariate Experimental Research (PRIMER) software.

Length-weight relationship studies of fish are considered as an important tool for understanding fish. Variation from the general length-weight relationship is indicative of the overall condition and such changes in condition have been usually analysed by means of a condition factor. Fishes with condition factor value above 0.56 are considered as in good condition (Bennet, 1970).

Fish morphometric measurements were used for the calculation of Condition Factor. The Fulton's condition factor (K) of the fish was estimated from the relationship:

- $K = W/L^3*100$

  Where:

  K = condition factor

  W = fish weight (g)

  L = Fish total length (cm)

The relationship between the length (L) and weight (W) of fish was expressed by the equation (Pauly, 1983).

$W = aL^b$

Where:

W = weight of fish in (g)

L = total length (TL) of fish in (cm)

a = constant (intercept)

b = the length exponent (slope)

The "a" and "b" values were obtained from a linear regression of the length and weight of fish. When b is equal to three (3), isometric pattern of growth occurs but when b is not equal to 3, allometric pattern of growth occurs, which may be positive if >3 or negative if <3 (Nehemia *et al.*, 2012).

Log-transforming the equation was applied: $\text{Log } W = a + b \text{ Log } L$

3.14.6. RESULTS AND DISCUSSION

3.14.6.1. Phytoplankton

The abundance and distribution of Phytoplankton community within the study area are presented in Table 2A for dry season and 2B for Wet season. In the Dry season, four major algal groups were represented namely, Bacillariophyceae (Diatoms), Chlorophyceae (Green algae), Cynaophyceae (Bluegreen bacteria) and Pyrrophyceae. The diatoms had more genera and the highest relative abundance (58%), followed by Chlorophyceae (31%), while the lowest were Cyanophyceae (7%) and Pyrrophyceae (4%) (Fig.3A). The diatom genera recorded were *Cymbella, Melosira* and *Tabelleria sp.* The Chlorophyceae was represented by *Netrium digitus* and *Micrasterias sp.* whil

Cyanophyta were *Snewella sp* and *Anabaena sp*.; and Pyrrophyta were *Ceratium sp* and *Peridinium sp*. The phytoplankton diversity indices Shannon-Wiener diversity ranged between 2.25 and 2.45, while Margalef species richness Simpson's dominance was between 0.89 and 0.91, Evenness ranged from 0.82 to 0.98 respectively.

In the wet season, a total of five genera (*Coscinodiscus,Ērataulina, Gyrosigma*l, *Nitzschia, and Synedra*) were recorded and all (100%) were diatoms (bacillariophyceae). The abundance values ranged from 11 cells/ml at SWC8 to 125 cells/ml at SW3 (Table 2). The ranges of the indices of community structure are as follows: Margalef, 0.42 (SW8) to 1.29 (SW10); Shannon-Weiner, 0.47 (SW8) to 1.36 (SW6); Pielou, 0.67 (SW7) to 0.98 (SW6); Simpson, 0.24 (SW10) to 0.70 (SW8). The dominance of diatoms is a common pattern of phytoplankton relative composition in the Bonny estuary (Ejiowhor *et al*., 2018; Daka *et al.* 2019A).

Table 3.35A: Composition, Abundance & Community Indices of Phytoplankton (Dry Season, January 2022)

TAXA	**SW1**	**SW2**	**SW3**	**SW4**	**SWC1**
BACILLARIOPHYCEAE					
Cymbella hydrida	10	14	11	8	10
Cymbella lacustris	8	12	16	10	4
Cymbella striate	14	8	11	13	12
Melosira various	11	13	10	8	14
Melosira distans	18	6	12	11	17
Tabellaria fenstrata	6	9	11	8	6
CHLOROPHYCEAE					
Netrium digitus	11	13	10	8	14
Micrasterias radiate	18	6	12	11	17
Micrasterias denticuata	6	9	11	8	6
PYRROPHYCEAE					
Peridinium cinatum	2	0	1	6	4
Ceratum hirudinella	0	0	2	4	3
CYANOPHYCEAE					
Anabaena sp.	8	5	7	8	6
Snewella rosea	3	0	3	0	1
No of Genera (S)	12	10	13	12	13
Abundance (N)	115	95	117	103	114
Margalef Richness (d)	0.87	1.98	2.52	2.37	2.53
Pielou Evenness (J')	0.94	0.98	0.94	0.99	0.92
Shannon (H')	2.34	2.25	2.42	2.45	2.37
Simpson (?)	0.11	0.11	0.09	0.09	0.11

Table 3.35B: Composition, Abundance and Community Indices of Phytoplankton (Wet Season – July 2023)

TAXA	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10	SWC1	SWC2
BACILLARIOPHYCEA												
Coscinodiscus sp	10	6	8	5	0	7	12	9	2	3	11	8
Cerataulina pelagica	0	0	0	0	0	0	0	0	0	2	0	0
Gyrosigma sp	7	3	59	17	20	5	2	0	14	4	1	4
Nitzschia sp	0	0	26	2	12	4	0	2	20	8	1	0
Synedra sp	1	3	32	7	22	4	2	0	11	5	4	2
No of Genera (S)	3	3	4	4	3	4	3	2	4	5	4	3
Abundance (N)	18	12	125	31	54	20	16	11	47	22	17	14
Margalef Richness (d)	0.69	0.80	0.62	0.87	0.50	1.00	0.72	0.42	0.78	1.29	1.06	0.76
Pielou Evenness (J')	0.78	0.95	0.87	0.82	0.97	0.98	0.67	0.68	0.86	0.93	0.69	0.87
Shannon-Weiner (H')	0.85	1.04	1.21	1.14	1.07	1.36	0.74	0.47	1.20	1.50	0.96	0.96
Simpson (⍰)	0.46	0.38	0.34	0.38	0.35	0.27	0.59	0.70	0.33	0.24	0.48	0.43

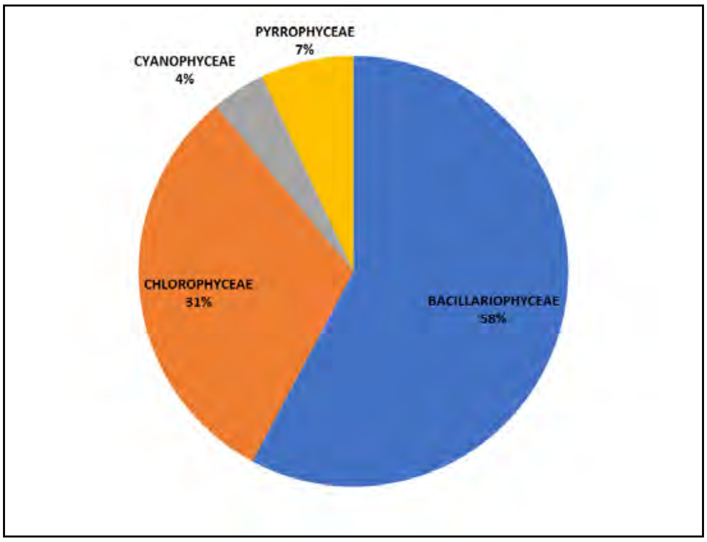


Figure 3.50A: Relative Abundance of Phytoplankton Taxa (Dry Season, January 2022)

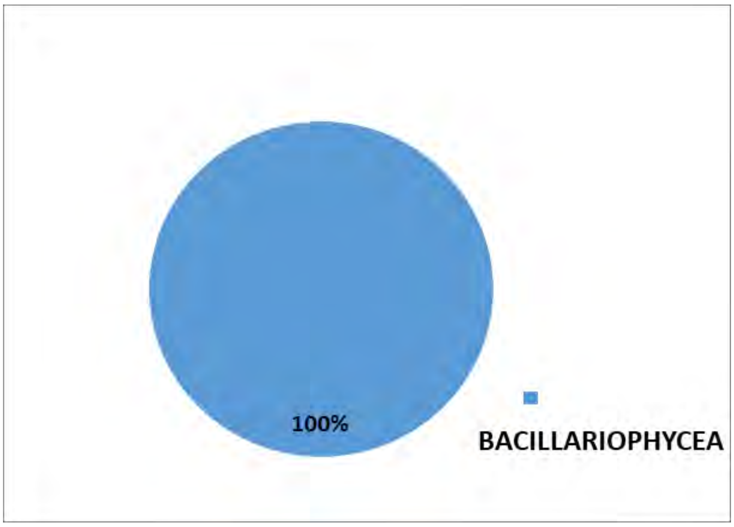


Figure 3.50B: Relative Abundance of Phytoplankton Taxa (Wet Season, July 2022)

3.14.6.2. Zooplankton

The composition, abundance, and distribution of zooplankton community in the study area are presented in Table 3A for dry season and Table 3B for wet season. In the dry season, the zooplankton community was represented by five major taxa, namely, Copepoda, Cladocera, Rotifera, Ostracoda and Decapoda. The Copepoda had the highest number of species as well as relative abundacne (81%), followed by Cladocera (10%) and Rotifera (5%) (Fig. 3A). Amongst the copepods, *Metridia lucens*, *Calamus finmarchicus* and *Anomalocere patersoni* were recorded in all sampling stations. The Cladocera, *Peniclia arirosteris* and Rotifera *Rotaria citria* were observed in only two stations. Shannon-Wiener diversity and Margalef richness ranged between 1.68 - 2.21 and 1.76 - 2.63, respectively.

The zooplankton in the wet season consisted predominantly of copepods with thirteen genera and accounted for 98.16% of the abundance (Table 3B, Figure 3B). The other taxa were decapoda (1.78%) and amphipoda (0.06%). Nauplius, *Paracalanus parvus, Tortanus* sp, *Pseudocalanus newmani* and *Oithona* sp were the most widely distributed copepods. The amphipoda was represented by a single genus (*Gammarus*) while the decapods recorded were brachyuran crab zoea, *Scyllarus* sp and *Alpheaus* sp. Abundance values ranged from 57 individuals/ml at SW4 to 559 individuals/ml at SW3 7. Shannon-Weiner diversity index ranged from 1.30 (10) to 2.07 (SW5) while Margalef index was 0.70 (SW9) to 1.68 (SW8). The Pielou Evenness measure ranged from 0.81 (SW10) to 0.99 (SW9) while the Simpson's dominance ranged from 0.14 (SW5) to 029 (SW4). The dominance of the class Copepoda is a common trend in zooplankton of in the Bonny estuary (Miebaka and Daka, 2013, Daka et al. 2019B).

Table 3.36A: Composition, Abundance & Community Indices of Zooplankton (Dry Season, January 2022)

TAXA	SW1	SW2	SW3	SW4	SWC1
COPEPODA					
Metridia lucens	5	2	8	4	11
Calamus finmarchicus	3	5	7	8	10
Acartia longiremis	0	1	4	7	9
Anomalocere patersoni	2	4	3	6	12
Pseudocalamus elongatus	0	2	4	8	14
CLADOCERA					
Peniclia arirosteris	**0**	**0**	**0**	**2**	**1**
Evadne nordmanni	**0**	**1**	**0**	**1**	**3**
Podonpolyphemides	**1**	**0**	**0**	**3**	**4**
ROTIFERA					
Rotaria citria	0	0	2	0	1
Rotaria rataria	2	1	0	2	1
DECAPOD CRUSTACEA					
Crab (larva)	0	0	2	0	1
Shrimp (larva)	2	1	0	2	1
OSTRACODA					
Conchocia spinirastris	0	0	0	2	0
No of Genera (S)	6	8	7	11	12
Abundance (N)	15	17	30	45	68
Margalef Richness (d)	1.85	2.47	1.76	2.63	2.61
Pielou Evenness (J')	0.94	0.9	0.94	0.92	0.84
Shannon-Weiner (H')	1.68	1.87	1.82	2.21	2.09
Simpson (⍰)	0.21	0.18	0.18	0.13	0.15

Table 3.36B: Composition, Abundance & Community Indices of Zooplankton (Wet Season – July 2023)

	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10	SWC1	SWC2
COPEPODA												
Nauplius	87	92	10	13	81	76	117	102	0	12	59	31
Acartia tonsa	0	2	0	0	0	0	0	1	0	0	0	0
Calanus finmarchicus	44	53	0	0	58	42	82	56	0	0	32	18
Pseudocalanus newmani	73	80	0	24	39	66	79	81	19	30	37	22
Paracalanus parvus	67	32	28	5	77	63	80	67	18	4	46	37
Parvocalanus sp	11	4	0	0	4	9	17	9	0	0	7	9
Temora sp	0	0	3	0	24	3	0	0	0	0	2	0
Tortanus sp	43	27	20	0	55	49	76	44	14	20	51	19
Oithona sp	71	52	15	13	61	34	89	72	22	0	46	44
Halicyclops fosteri	0	0	0	0	0	0	0	0	0	2	0	0
Corycaeus sp	0	0	0	0	18	7	0	12	0	0	0	0
Euterpina sp	0	0	16	0	7	0	0	7	0	0	0	0

DECAPODA												
Brachyuran crab zoea	4	0	0	0	0	12	17	7	0	0	3	0
Scyllarus sp	0	0	0	2	0	0	0	0	0	0	2	0
Alpheaus sp	0	0	12	0	0	0	0	0	0	0	0	0
AMPHIPODA												
Gammarus sp	0	0	0	0	0	0	2	0	0	0	0	0
No of Genera (S)	8	8	7	5	10	10	9	11	4	5	10	7
Abundance (N)	400	342	104	57	424	361	559	458	73	68	285	180
Margalef Richness (d)	1.17	1.20	1.29	0.99	1.49	1.53	1.26	1.63	0.70	0.95	1.59	1.16
Pielou Evenness (J')	0.90	0.85	0.93	0.85	0.90	0.87	0.89	0.84	0.99	0.81	0.84	0.95
Shannon-Weiner (H')	1.88	1.77	1.81	1.37	2.07	2.01	1.96	2.01	1.37	1.30	1.94	1.85
Simpson (?)	0.16	0.19	0.18	0.29	0.14	0.15	0.15	0.15	0.26	0.32	0.16	0.17

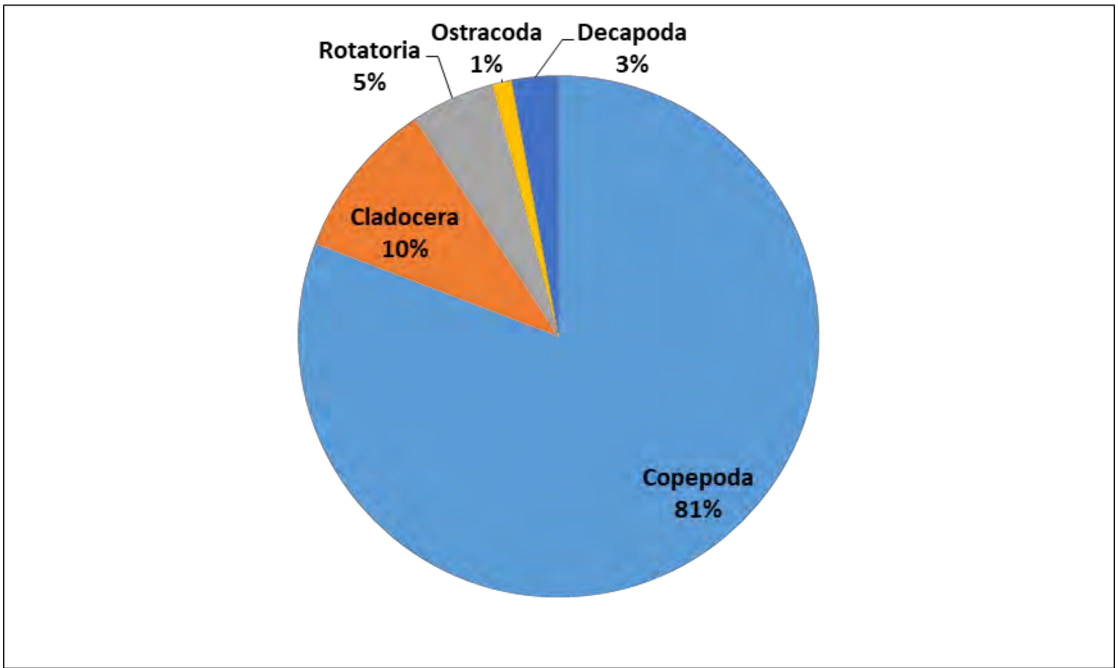


Figure 3.51A: Relative Abundance of Zooplankton Taxa (Dry Season, January 2022)

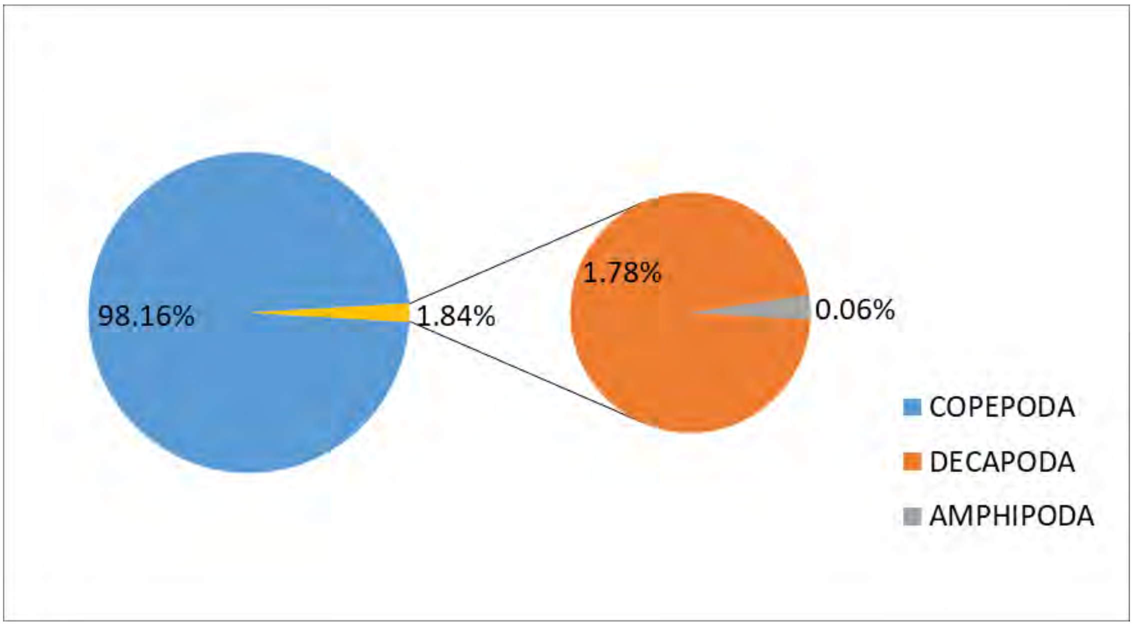


Figure 3.52B: Relative Abundance of Zooplankton Taxa (Wet Season – July 2023)

3.14.6.3. Benthos

Table 4A presents species composition, distribution, and relative abundance of benthos recorded during the dry season whereas wet season is presented in Table 4B. In the dry season, only 6 species representing two Phyla (Annelida and Mollusca) were recorded. The class Polycheata dominated with four genera and relative abundance of 96%. The Margalef richness ranged between 0.63 – 1.29 while Shannon-Wiener ranged between 1.02 to 1.39.

In the wet season, the benthos consisted of predominantly of polychaetes, with eight genara being widely distributed in all stations (apart from three stations that were azoic) (Table 4B). Polychaeta accounted for 50% of the relative abundance (Figure 4B). Crustaceans were observed in five stations accounting for 23% while other taxa were Oligochaeta (16%), Insecta (7%), Mollusca (3%) and Pisces (1%). The counts of benthic organisms ranged from 0 at SW5, SW9 and SW10 to 39 at SW4. Benthic community indices were not calculated for SW5, SW9 and SW10 (azoic); however, in the other sampling stations Shannon-Weiner diversity index ranged from 0.69 (SWC1) to 1.96 (SW4) while Margalef index was 1.03 (SW3) to 2.52 (SWC2). The Pielou Evenness measure and Simpson's dominance were (0.76-SW2 to 1.0-SW6 and SWC1) and (0.15-SW3 to 0.43-SW3) respectively. The low diversity of the benthic macro-invertebrates could be attributed disturbance by human activities such as dredging/sweeping of the waterways to increase draft for vessels.

Table 3.37A: Composition, Abundance & Community Indices of Benthic Fauna (Dry Season, January 2022)

TAXA	SW1	SW2	SW3	SW4	SWC1
POLYCHAETA					
Nereis diversicolar	5	7	11	10	14
Neathes sp	3	5	4	8	11
Martphysa sp	0	0	2	4	6
Notomastus sp	0	0	0	2	2
MOLLUSCA					
Tellina sp.	0	0	1	0	2
Melampus sp.	0	0	0	1	0
No of Genera (S)	3	3	5	6	6
Abundance (N)	16	24	35	49	68
Margalef Richness (d)	0.72	0.63	1.13	1.29	1.19
Pielou Evenness (J')	0.93	0.94	0.76	0.77	0.78
Shannon-Weiner (H')	1.02	1.03	1.23	1.38	1.39
Simpson (□)	0.38	0.38	0.35	0.32	0.31

Table 3.37B: Composition, Abundance & Community Indices of Benthic Fauna (Wet Season – July 2023)

TAXA	SWI	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10	SWC1	SWC2
POLYCHAETA												
Cossura spp	0	15	0	8	0	1	0	0	0	0	0	3
Cirriformia spp	0	3	0	0	0	0	0	0	0	0	0	1
Eunice spp	0	0	4	0	0	0	0	5	0	0	1	1
Glycera spp	0	1	1	4	0	0	0	1	0	0	1	1
Nephtys spp	7	0	0	0	0	0	0	0	0	0	0	1
Nereis spp	0	0	0	0	0	0	0	0	0	0	0	3
Polydora spp	0	0	0	0	0	0	0	0	0	0	0	1
Arenicola sp	0	1	0	0	0	0	0	0	0	0	0	0
OLIGOCHAETA												
Naididae	0	1	0	9	0	1	0	4	0	0	0	5
Lumbriculidae	0	1	0	0	0	0	0	0	0	0	0	0
INSECTA												
Chironomid larva	1	1	2	5	0	0	0	0	0	0	0	0
MOLLUSCA												

Buccinum (Gastropod)	0	0	0	2	0	0	0	0	0	0	0	0
Bivalve	0	0	0	2	0	0	0	0	0	0	0	0
CRUSTACEA												
Cumacean	7	7	0	4	0	1	0	0	0	0	0	0
Talitri spp	0	4	0	5	0	1	0	1	0	0	0	0
PISCES												
Fish	1	0	0	0	0	0	0	0	0	0	0	0
No of Genera (S)	4	9	3	8	0	4	0	4	0	0	2	8
Abundance (N)	16	34	7	39	0	4	0	11	0	0	2	16
Margalef Richness (d)	1.08	2.27	1.03	1.91		2.16		1.25			1.44	2.52
Pielou Evenness (J')	0.77	0.76	0.87	0.94		1.00		0.84			1.00	0.89
Shannon-Weiner (H')	1.07	1.67	0.96	1.96		1.39		1.16			0.69	1.86
Simpson (□)	0.39	0.26	0.43	0.15		0.25		0.36			0.50	0.19

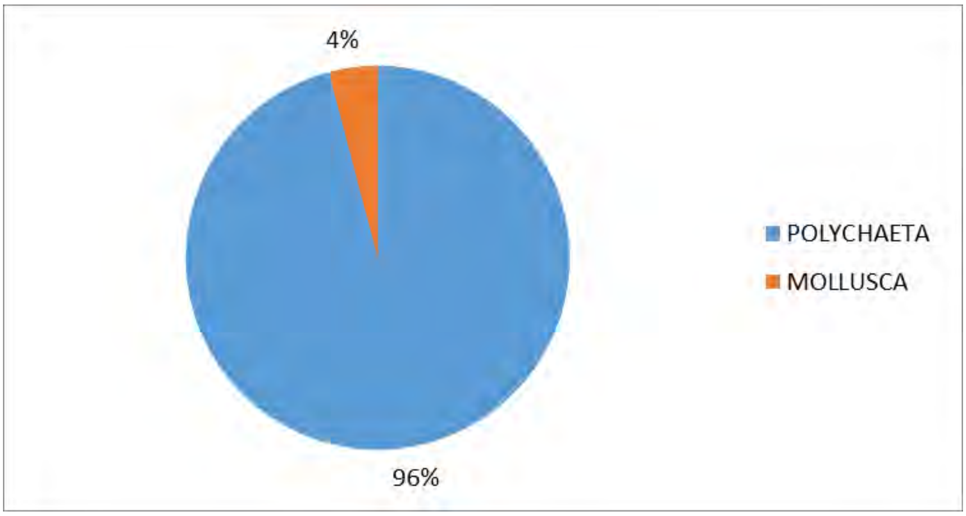


Figure 3.52A: Relative Abundance of Taxa in the Benthos (Dry Season, January 2022)

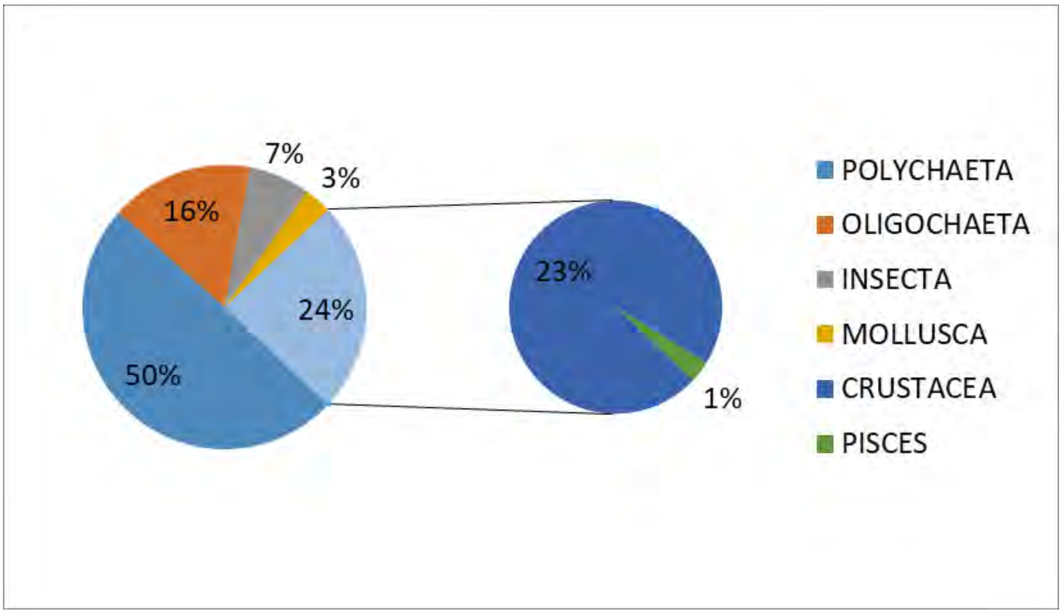


Figure 3.52B: Relative Abundance of Taxa in the Benthos (Wet Season – July 2023)

3.14.6.4. Fish and Fisheries

Fishing is also a major occupation of the communities in the project area. Fishing methods include cast net, hook and line, seine, and traps. It is mostly conducted from dug-out hand pulled wooden canoes, sometimes powered by low horsepower outboard engines. These are typical gears used by artisanal fishermen in the Niger Delta.

A checklist of finfishes reported during the dry season is presented in Table 5A, while those observed in the wet season are presented in Table 5B. Ten species from eight families were reported in the finfish assemblage of the area during the dry season (Table 5A) while fifteen species from eleven families were observed in the wet season. Clupeidae had two species in dry and wet season. Although *Sardinella maderensis* was reported to be common in both seasons, *Ethmalosa fimbriata* and *Sardinella aurita* were the dominant ones in dry and wet seasons respectively. Other families reported in both seasons and the number of species were Cichlidae (1 dry, 2 wet), Mugilidae (1 dry, 2 wet), Haemulidae (1 dry, 2 wet). Lutdjaniae and Bagridae were also reported in both seasons with 1 species. Sciaenidae and Gobiidae were reported only in the dry season, while Serranidae, Gerreidae, Carangidae, Alestidae and Tetraodontidae were observed in the wet season samples. The types of fish caught may depend on season and tidal cycle, dominance of bonga fish in the landed catches from the dry season is attributable to season. Bonga fish is a marine fish that moves inshore of estuaries in the dry season when salinity is usually elevated due to low precipitation and high evaporation.

Shellfish caught during the study are presented in Table 6. These were the giant tiger shrimp (*Penaus monodon*), swimming crab, (*Callinectes amnicola*) and lizard mantis (*Lysiosquilla hoevenii*)**.**

Table 3.38A: Composition of fish reported during the study (Dry Season – January 2022)

Family	Scientific name	Common Name	Local (Okrika) Name	Abundance Score	IUCN Red List Status	CITES
Clupeidae	*Ethmalosa fimbriata*	Bonga	Kigbo	Dominant	LC (2019)	NE
	Sardinella maderensis	Sardine fish	Songu	Abundant	VU (2014)	NE
Sciaenidae	*Pseudotolithus enlongatus*	Bobo Croaker	Ona	Abundant	LC (2020)	NE
	Pseudotolithus epipercus	Guinea Croaker	Ona	Common	LC (2020)	NE
Mugilidae	*Mugil cephalus*	Mullet	Beme	Common	DD (2019)	NE
Bagridae	*Chrysichthys nigrodigitatus*	Marine catfish	Aga	Common	LC (2019)	NE
Lutjanidae	*Lutjanus goreensis*	Snapper	Agbara	Common	LC (2013)	NE
Haemulidae	*Pomadasys jubelini*	Spotted Grunt	Owolo	Common	LC (2018)	NE
Cichlidae	*Sarotherodon melanotheron*	Tilapia	Omoda	Abundanta	LC (2020)	NE
Gobiidae	*Porogobius scheligelii*	Goby	Ikinji	Rare	LC (2019)	NE

DD = Data Deficient; LC = Least Concern; NT=Near Threatened; VU = Vulnerable; NE=Not Evacuated

Table 3.38B: Composition of fish observed during the study (Wet Season – July 2023)

Family	Scientific name	Common Name	Local (Okrika) Name	Abundance Score	IUCN Red List Status	CITES
Cichlidae	*Sarotherodon melanotheron*	Black-chin tilapia	Omoda	Abundant	LC (2019)	NE
	Coptodon guineensis	Guinean tilapia	Atabala	Abundant	LC (2019)	NE
Haemulidae	*Pomadasys jubelini*	Sompat grunt	Owolo	Abundant	LC (2013)	NE
	Plectorhinchus macrolepis	Biglip grunt	Olokpo	Common	LC (2013)	NE
Mugilidae	*Mugil cephalus*	Striped mullet	Beme	Common	DD (2019)	NE
	Neochelon falcipinnis	Sickle-fin mullet	Gbulu	Common	DD (2013)	NE
Lutjanidae	*Lutjanus agennes*	African red snapper	Agbara	Common	DD (2011)	NE

Clupeidae	*Sardinella maderensis*	Madeiran sardinella	Songu	Common	VU (2014)	NE
	Sardinella aurita	Round sardinella	Asara	Dominant	LC (2012)	NE
Serranidae	*Epinephelus aeneus*	White grouper	Orom	Common	NT (2016)	NE
Gerreidae	*Eucinostomus melanopterus*	Flagfin mojarra	Otubulu	Rare	LC (2010)	NE
Carangidae	*Caranx hippos*	Crevalle jack	Okwe	Common	LC (2018)	NE
Bagridae	*Chrysichthys nigrodigitatus*	Bagrid catfish	Aga	Rare	LC (2019)	NE
Alestidae	*Brycinus nurse*	Nurse tetra	Ogein	Rare	LC (2013)	NE
Tetraodontidae	*Sphoeroides pachygaster*	Blunthead puffer	Ibupu	Rare	LC (2011)	NE

DD = Data Deficient; LC = Least Concern; NT=Near Threatened; VU = Vulnerable; NE=Not Evacuated

Table 3.39: Composition of shellfish observed during the study (Wet Season – July 2023)

Family	Scientific name	Common Name	Local (Okrika) Name	Score	IUCN Red List Status	CITES
Portunidae	*Callinectes amnicola*	Swimming crab	Ipa	Abundant	NE	NE
Penaeidae	*Penaeus monodon*	Giant tiger prawn	Ipoli	Abundant	NE	NE
Lysiosquillidae	*Lysiosquilla hoevenii*	Lizard mantis	Siko	Common	NE	NE

NE=Not Evacuated

The Fulton's condition factors of the fish showed that the lowest and highest mean values of a mean values of 0.81 and 2.13 for *Neochelon falcipinnis* and *Sarotherodon melanotheron* respectively (Table 7). According to Bennet (1970), Fulton's condition factor of 0.56 is considered as well-being benchmark value of a fish; hence fishes with condition factor values above the well-being benchmark were considered to be in good condition.

The length-weight relationship of some fish determined by regression following log-log transformation is presented in Figure 5. The equations derived showed that the mugilids fish exhibited a negative allometric growth pattern while the cichlids exhibited positive allometric growth pattern.

Table 3.40: Statistical Summary of Condition Factors of some Fish Species (July 2023)

Species	**Mean**	**SD**	**Min**	**Max**	**N**
Lutjanus agennes	1.49	0.13	1.30	1.84	68
Pomadasys jubelini	1.34	0.10	1.16	1.63	41
Sarotherodon melanotheron	2.04	0.13	1.73	2.29	33
Coptodon guineensis	2.13	0.18	1.85	2.55	32
Neochelon falcipinnis	0.81	0.11	0.67	1.06	9
Mugil cephalus	0.82	0.10	0.71	0.95	5
Epinephelus aeneus	1.17	0.17	1.00	1.41	4
Caranx hippos	1.38	0.07	1.30	1.45	3
Plectorhinchus macrolepis	2.03				1
Eucinostomus melanopterus	1.49				1
Sardinella aurita	1.24				1
Chrysichthys nigrodigitatus	0.93				1

3.14.6.5. Floating Aquatic Macrophytes

No floating aquatic macrophytes were observed in any of the sampling stations. This is not surprising as species common in the Niger Delta such as *Nymphaea lotus, Eichonea crassipes* are known to be intolerant of saline water are not reported in the Bonny estuary.

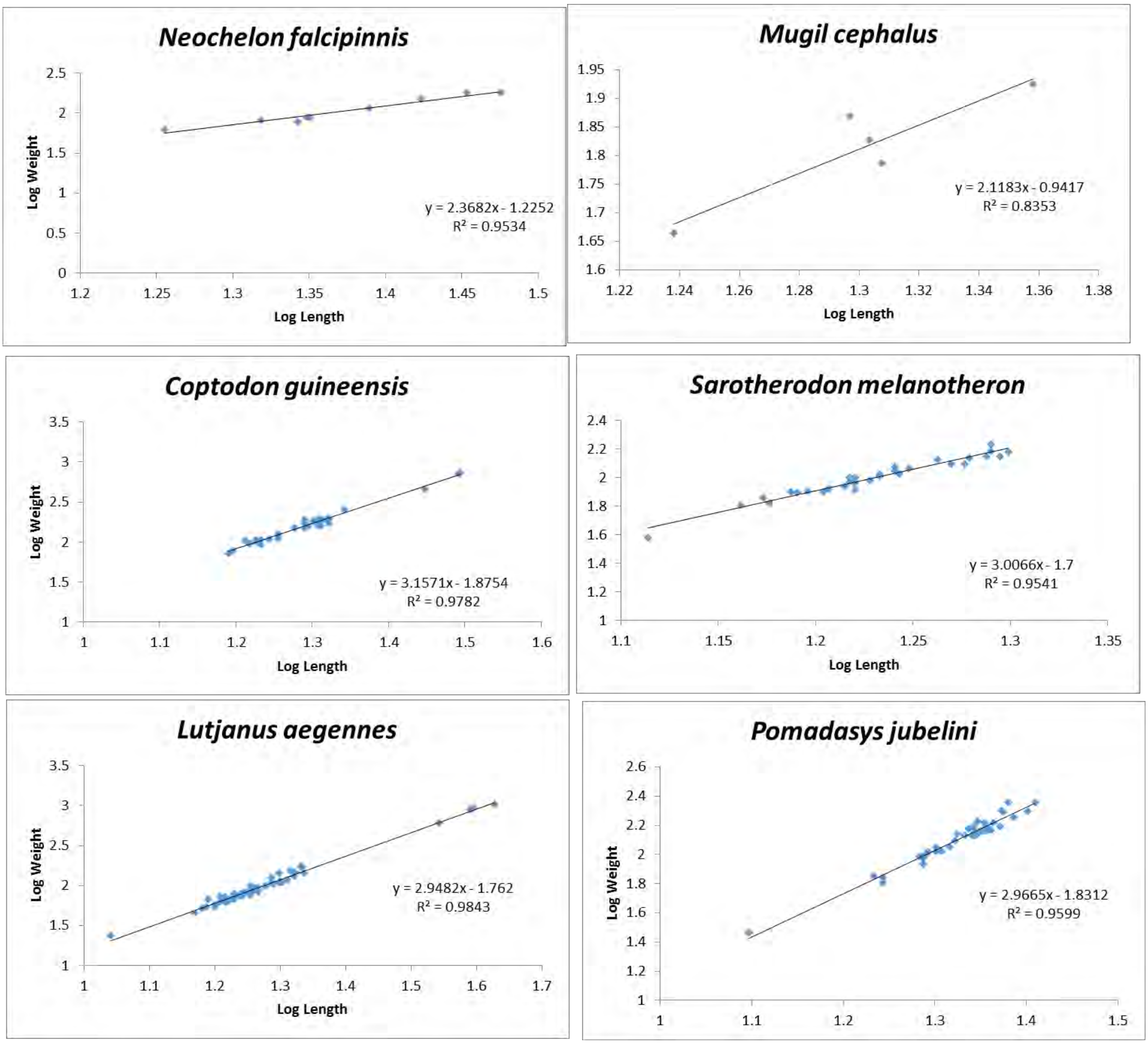


Figure 3.53: Length –Weight Relationships of some fish in the study area (July 2023)

3.14.7. Conservation Status

The spatial boundaries of the project port facility at the federal ocean terminal at Onne, Eleme Local Government Area of Rivers State do not fall within any national legally protected area or an internationally recognized area. Nigeria presently has 11 sites designated as Wetlands of International Importance (Ramsar Sites), with a surface area of 1,076,728 hectares spreading across the six geopolitical regions in Nigeria. (https://www.ramsar.org/news/nine-new-ramsar-sites-in-nigeria). It is not an aquatic critical or sensitive fish habitat. There are no endemic species;

the IUCN status of the fish were mostly Least Concern (LC) or Data Deficient (DD) except for *Sardinella maderensis* which is globally Vulnerable (V) and *Epinephelus aeneus* as near threatened (NT). All the species recorded fall in the Not Evaluated (NE) category in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). All the shell fishes observed were NE for both IUCN and CITES.

3.14.8. Ecosystem Services of the Onne axis of the Bonny Estuary

Fisheries provisioning services is one of the most important ecosystem services provided by river/estuaries. Fishing is a major occupation of the communities in the area, albeit done at artisanal and subsistence levels. Fish are reasonably priced and are a major source of income to the resident and itinerant fisherfolks. There are no species that support recreational fisheries, or culturally important fisheries. The ecosystem services of plankton and benthos are support services premised on their ecological roles in the ecosystem.

3.14.9. Key Stressors/Threats to Aquatic Biodiversity and Ecosystem Function

Several human activities including oil and gas exploration, dredging, invasive plant infestation and wetland reclamation in addition to increased exploration, population growth and weak governance have led to increased case of water pollution/contamination and fish migration of the Niger Delta (Adekola and Mitchell, 2011, Izah 2018) thus becoming threats to aquatic biodiversity and ecosystem function. According to Dirisu and Edwin-Wosu indiscriminate harvest of fisheries, unregulated navigations, illegal activities of crude oil products and transportation activities pose some threats to the estuary sustainability. Major anthropogenic influences that could affect aquatic biodiversity and ecosystem function in the proposed project area are Port operations, movement of marine vessel and dredging. Some illegal fishing with toxic chemicals is also reported to be an occasional occurrence.

3.15. TERESTRIAL BIODIVERSITY STUDY REPORT

EXECUTIVE SUMMARY

As a part of ESIA, wet season field data gathering exercise, this study was conducted between 4 to 7th July 2023 and covers biodiversity/ecological component (vegetation and wildlife) study within and around the Project Site, and the nearby communities i.e., Owo-Ogono and Ele-Ogu.

Vegetation Characteristics: The study area contains secondary forests and bush-fallow in the Owo-Ogono and Ele-Ogu communities, and modified vegetation (patches of riparian and grasses/sedges) within the proposed project site. A total of 85 species belonging to 75 genera, and 33 families were identified in the study area and comprised of trees, shrubs, and herbs. The herbs were the predominant group of the species identified. The proposed project site contains mainly grasses and sedges with a few species of mangrove at the bank of the river. Some of the plant species identified useful to the residents of the study area as food, medicine, construction, and general environmental sustainability however these important species are dominant in the Owo-Ogono and Ele-Ogu communities which are about 3.0km away from the proposed project site. The vegetation health in the area could be described as good. None of the IUCN endangered (EN), vulnerable (VU), and Near Threatened (NT) plants species were identified in the study area. Also, there is no conserved area within the project site and its environs. There are no known biodiversity hotspots or Important Bird Area (IBA), nor any flora of conservation concern within the study area.

Wildlife Characteristics: The birds constituted more than 75% of the fauna species physically observed during the fieldwork while the records of the other fauna were based on interviews with the hunters and workers in the adjoining facilities. Among the fauna groups (mammalian, reptilian, avian, and mollusks), the avian constituted 38 species (40%), mammalian 30 species (31%), and the reptilian 25 species (26%). The avian are more frequently seen and reported by the locals. This could be attributed to the fact that they are not easily restricted by barriers. Also, during fieldwork, we observed the majority of the bird species in the open areas of the proposed project site. There is no known biodiversity hotspot or Important Bird Area (IBA), neither is there any flora of conservation concern within the study area and the IUCN status of all the avian species identified in the study area Least concern (LC) except *Rhyticeros cassisix* which is on the vulnerable (VU) status. The IUCN status of the mammalian species indicated that *Cephalophus* spp and *Phataginus tetradactyla* are vunerable (VU), *Cercopithecus nictitans* is endangered (EN) while other mammals identified are on the least concern category. Among the reptiles, *Amblyrhynchus cristatus* and *Bitis arietans* are on the the vulnerable (VU) list while *Python Regius* is on the Near threatened (NT) list. Other reptile species are on the Least concern (LC) list. These particular mammalian, reptilian, and avian species were not sited within the proposed project site but were only reported by the hunters as one the fauna seen in the secondary forests which are more than 2.0km away from the proposed site. This however asert that the proposed project area is not inhabited by these species and the birds sited during the fieldwork are not resident on the proposed project site since there is no nest or breeding sited observed within the proposed site.

Ecosystem Services: The ecosystem services associated with the study area include provisioning (timber, genetic resource, firewoods, wild food, bush meat, fisheries, medicinal plants, and water supply), supporting (habitat for fishes, nursery ground for mangrove and nypa species, and primary production), and regulating (nutrient cycle, and erosion control). Wildlife studies was out mainly through interviews with relevant people of nearby communities. The local markets were also surveyed to identify wildlife species that are on sale and obtain information on their occurrence in the area. Field activities includes inspection and observation of wildlife spoors, feeding and nesting ground, feathers nets, holes, etc.

3.15.1. VEGETATION AND WILDLIFE STUDY

3.15.1.1 Background information

Indorama operates a Petrochemical and Fertilizer manufacturing facilities within the Indorama Complex in Eleme, Port Harcourt, Rivers State, Nigeria having manufacturing capacity of 2.8 MMTA of Urea & 400 KTA of Polymers (Polyethylene & Polypropylene) utilizing Natural Gas & Natural Gas Liquids as feedstock. The Petrochemical manufacturing facilities comprising of the Cracker, Polyethylene and Polypropylene plants have been in operation since 2006. The Fertilizer manufacturing facilities consists of two trains of 2,300 TPD & 4000 TPD each of Ammonia and Urea, respectively. While the first line of Fertilizer was commissioned in 2016, the second line was commissioned in May 2021.

Based on the design capacities of Ammonia and Urea plant, Post IEFCL-Train3 Project commissioning, there will be a surplus ammonia of 375 MTPD over and above the requirement of Urea plants. Indorama is planning to export this surplus liquid ammonia and 1.4 million tons of Urea produced by IEFCL-Train3 project, through MM Port Terminal. In compliance with FMEnv guidelines and procedure decided to conduct ESIA for the proposed MM Port FZE.

3.15.2. SCOPE OF WORK

The vegetation and wildlife aspects of the environmental and social impact assessment covered vegetation and wildlife study within and around the proposed project site. The main points of vegetation and wildlife study of the environmental component are emphasized below.

- Vegetation (Flora): This included trees, shrubs and herbaceous species composition and family composition of plant species in the area.
- Wildlife (Fauna): This included reptiles, primates, and mammals.
- Plants diseases and elemental analysis
- Ethnobotanical value/uses of flora species and ecological status of wildlife species.
- To establish existing flora, fauna species and their habitat within and around the proposed project site
- Brief impact assessment and mitigation measures

3.15.3. LOCATION

The proposed MM Port FZE Facility at Federal Ocean Terminal (FOT), Onne Port Complex, Onne, Eleme LGA, Rivers State for the storage and export of Urea and Ammonia. The proposed project site is already sand-filled, and grasses/herbs could be found colonizing the reclaimed area.

3.15.4. SAMPLING METHODOLOGY

Characterizations of the vegetation and wildlife species in the project area were carried out initially by a general surveillance to determine the natural stratification of the plant community. The vegetation distribution, composition, abundance, and diversity were determined.

3.15.4.1. Sampling Method (Flora)

The study technique adopted the quadrants methods. In each six quadrats were marked at about 25m intervals for easy field estimate. Random quadrants of varying dimensions of 10m x 10m (for tree enumeration), 5m x 5m (for shrubs enumeration), and 1m x 1m (for herbs enumeration) were enumerated in each quadrat (**Fig. 1)** and plant identification were carried out ((Brower and Zar 1984, Nambu 2001), and counted according to Mueller-Dombois and Ellenberg (1974), Kershaw (1975), and Nambu (2001). All plant species as far as possible were identified with unknown species collected, labeled, pressed, and taken to University of Port Harcourt Herbarium for identification. Further plant identification was based on Hutchinson and Dalziel (1954), Keay (1989) Okezie and Agyaakwa (1989) and Okezie et al. (2016) and ethno-botanical uses of the plants were derived from the local interviews.

The Shannon evenness index, abbreviated as SEI, of the plant species were calculated as

$SEI = 1/ \sum pi2$.

Where Pi = The proportional representation of each habitat (pi). ...

Also, the diversity of the plant species was calculated using Shannon index as follows:

$$H = \sum_{i=1}^{s} - (P_i * \ln P_i)$$

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Where Pi = The proportional representation of each habitat (pi). ...

Also, the diversity of the plant species was calculated using Shannon index as follows:

$$H = \sum_{i=1}^{s} - (P_i * \ln P_i)$$

where p = the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

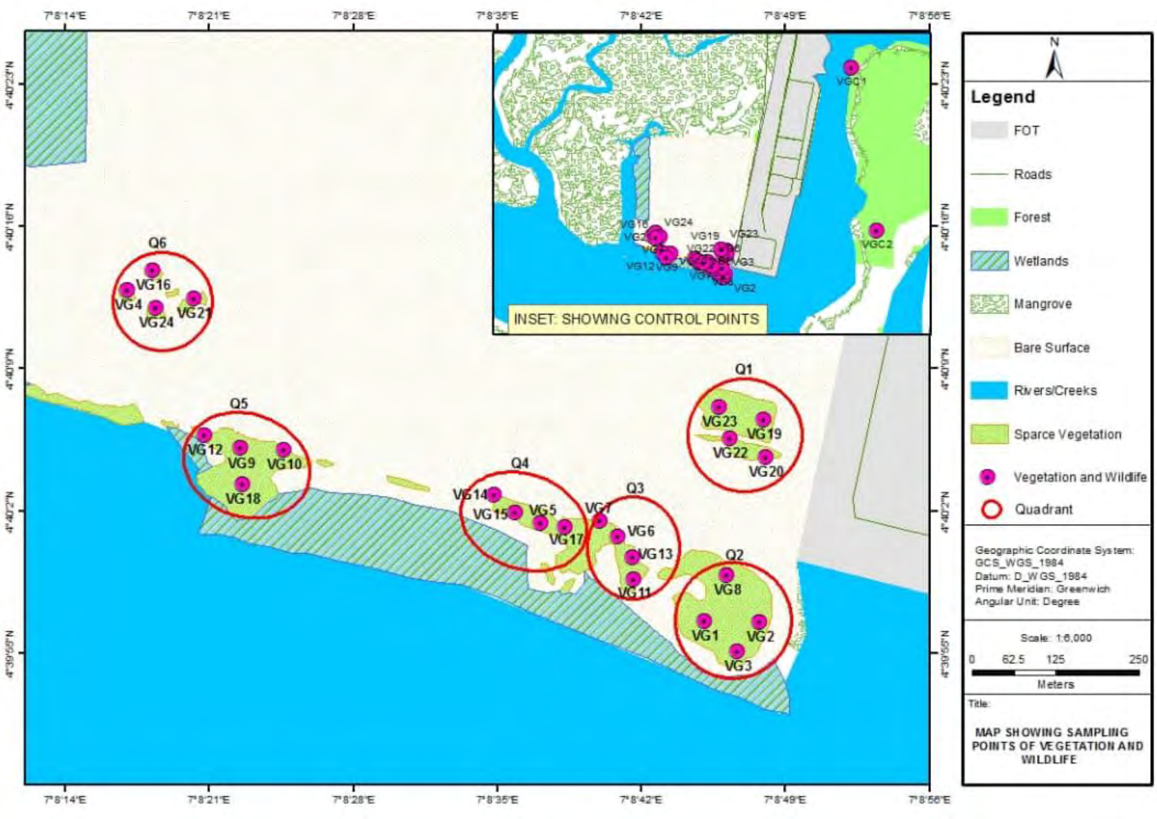


Figure 3.54: Layout of the location and quadrats

Table 3.41: Coordinates

SAMPLING LOCATION	EASTING	NORTHING
VG1	7° 8' 45.15" E	4° 39' 56.60" N
VG2	7° 8' 47.80" E	4° 39' 56.52" N
VG3	7° 8' 46.71" E	4° 39' 55.09" N
VG4	7° 8' 17.10" E	4° 40' 12.86" N
VG5	7° 8' 37.15" E	4° 40' 01.41" N
VG6	7° 8' 40.95" E	4° 40' 00.74" N
VG7	7° 8' 40.06" E	4° 40' 01.51" N
VG8	7° 8' 46.23" E	4° 39' 58.85" N
VG9	7° 8' 22.60" E	4° 40' 05.09" N
VG10	7° 8' 24.71" E	4° 40' 05.02" N
VG11	7° 8' 41.68" E	4° 39' 58.64" N
VG12	7° 8' 20.84" E	4° 40' 05.76" N
VG13	7° 8' 41.64" E	4° 39' 59.74" N
VG14	7° 8' 34.92" E	4° 40' 02.81" N
VG15	7° 8' 35.96" E	4° 40' 01.92" N
VG16	7° 8' 18.33" E	4° 40' 13.85" N
VG17	7° 8' 38.37" E	4° 40' 01.23" N
VG18	7° 8' 22.69" E	4° 40' 03.31" N
VG19	7° 8' 48.03" E	4° 40' 06.51" N
VG20	7° 8' 48.10" E	4° 40' 04.64" N
VG21	7° 8' 20.35" E	4° 40' 12.45" N
VG22	7° 8' 46.35" E	4° 40' 05.58" N
VG23	7° 8' 45.85" E	4° 40' 07.14" N
VG24	7° 8' 18.48" E	4° 40' 12.01" N
VGC1	7° 9' 40.46" E	4° 41' 24.02" N
VGC2	7° 9' 50.90" E	4° 40' 14.78" N

3.15.4.2. Sampling Method (Fauna)

Sampling quadrats used for flora studies were equally used for fauna wildlife. Two main methods of fauna sampling were adopted. Direct evidence (sighting) and indirect evidence.

Direct observations: 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. Visual encounter survey consists of timed habitat search within a specified area. The number of observers, weather variables and start time of the survey is recorded and then personnel move throughout the area, searching all potential habitats without spatially overlapping. Efforts are made not to disturb the animals seen and to avoid counting the same individual twice. Birds' species were sampled during the morning hours between the period 6:30 am -9:30 am which is the time that the birds are active in search of food and other requirements. The bird's species were observed, identified, and counted by opportunity (for those flying through/across), direct encounter in the niches and habitat along the created transects. On the other hand, direct field observation and enumeration was also repeated between the hours of 4pm – 6.30pm in the evening when the sun goes down. This is also another active period for avian species in terms of their interaction with their ecosystems.

Indirect Observations: Indirect signs such as footprints, scats/faeces, feeding activity, nests, tracks, holes/diggings or scratching, carcasses. The recorded evidence was represented both by direct (collections and observations) and indirect (tracks, footprints, scats/faeces, feeding activity, nests, tracks, holes/diggings or scratching, carcass, and identification by local residents).

Examination of road kills and meat markets: Interview of hunters, farmers etc. to gain better insight into the faunal distribution pattern, seasonal migration, local names, and economic importance. The conservation status and threats to biodiversity status of censored species was retrieved from IUCN. At their homes, the hunters were also urged to present for examination, animal remains or trophies including, horns, skins, skull/skeleton, shells, hoofs, etc in their bags as well as say the last time they sighted or killed each animal presented. Night sampling was also done to listen to the vocalization of nocturnal animals. Raking quadrants (2m x 2m) for litter amphibians and reptiles were also employed. Inspection of broad-leaved hydrophytes for tree frogs, lifting of stones, logs, plants, panels, plastics, etc for any hiding fauna were conducted. The use of appropriate field data sheets to capture information like date of sampling, block/plot number, species list with scientific, common, and local names, and abundance.

In addition, wildlife data were obtained from tracing of animals' routes/paths, scent/smell, burrows, nesting sites/nest, calls, scales, food cuttings, footprints, droppings, fur, and sighting. However, 60% of the checklists on mammalian, avian, rodentia and reptilian species were obtained from hunters, farmers, and gatherers of non-timber forest products (NTFPs) in the community.

Moreover, other features of ecological importance to the environment were recorded with a high-resolution digital camera. Moreover, representative plant species were collected in polythene bags for subsequent analysis in the laboratory. Plants were also observed for disease symptoms/conditions. The Field equipment employed for the study included machetes, used newspapers, quadrants, digital camera, Binoculars, measuring tape, masking tape, presser, and booths etc.

3.15.5. DATA ANALYSIS

Data obtained from vegetation and wildlife species in the project environs was analyzed using descriptive statistics. The descriptive tool employed included tables, frequencies, graphs and charts, google earth imageries, and digital photographs.

3.15.6. QUALITY ASSURANCE

With regards to quality control, vegetation was sampled along designated quadrats and duly geo-referenced. Also, vegetation samples were taken to the herbarium for proper identification. Besides, vegetation samples were identified for disease and stress conditions in-situ. Caution was exercised, particularly on the use of machetes to avoid "near miss" and any action that may lead to accident.

3.15.7. VEGETATION CHARACTERISTICS

The study area contains modified and sand-filled areas (dominated by grasses and sedges) patches/relics of riparian mangrove vegetation, and secondary forest consisting of mangrove swamps vegetation (across the river body, about 2.3 km away for the proposed project site). Generally, the vegetation within the proposed project site is predominated by grasses (*Digitaria* *argiilacea, D. longiflora, Panicum laxum, Paspalum conjugatum, Mariscus ligularia, and Eragrostis* spp.) and sedges (*Fimbristylis ferruginea*).

3.15.8. FLORISTIC COMPOSITION OF THE STUDY AREA

3.15.8.1. MODIFIED AND SAND-FILLED AREAS

This is the majority of vegetation observed in the proposed project site. It is predominated by grasses (*Digitaria argiilacea, D. longiflora, Panicum laxum, Paspalum conjugatum, Mariscus ligularia, and Eragrostis* spp.) and sedges (*Fimbristylis ferruginea*) and few herbs namely *Gomphrena celosiodes, Emilia praetamissa, Euphorbia heterophylla, Bidens pinnata, Desmodium* spp.*etc*, and few shrubs viz. *Chromelaena ordorata, Urena lobate, etc*. Also, the puff mushroom was among the species in this area.

3.15.8.2. PATCHES/RELICS OF RIPARIAN MANGROVE VEGETATION

In this forest system, mangrove species are juxtaposed with non-mangrove species and swamp forest vegetation. These mosaic-modified vegetation types exist on the bank of the river (southern flank, Q2, Q3, Q4 and Q5) of the proposed site. They are characterized by either seasonal or permanent flooding or tidal influence. They have scanty species of *Rhizophora racemosa***,** *Rhizophora mangle***,** *Rhizophora harrisonii***,** *Laguncularia racemose, Aviacinia Africana, Nypa fruticans, Acrostichum aureum.* Other plant species observed here include *Alchornea cordifolia, Chromelaena ordorata, Hyptis lanceolate, Fimbristylis* spp., etc.

3.15.8.3. MANGROVE SWAMP VEGETATION

The mangrove ecosystem occupies the tidal flats in the water ways within the study area. The land system is dominated by mangrove forest. It is found on the southern flank of the proposed site and in the adjoining community settlements. It is dominated by *Nypa* sp and *Rhizophora* species and show zonation of the main species, roughly parallel to the coast, with *R. racemosa* at the coast and *R.harrisoii* and *R. mangle* successively further inland and *Nypa* sp on the outer fringe on the coast. Relatively, little ground vegetation occurs within the mangrove forests. The mangrove swamp forest was observed mainly at the control stations with little or small patches in quadrats (Q2, Q3, Q4 and Q5). The mangrove trees are the dominant vegetation type fringing the banks of creek and creek-lets (**Plate 4**). The mangrove forest consists of species, namely *Rhizophora racemosa***,** *Rhizophora mangle***,** *Rhizophora harrisonii***,** *Laguncularia racemosa,* and *Aviecinia* *africana*. Also, non-mangrove species were observed in this mangrove zone and include *Nypa fruticans, Acrostichum aureum*; grasses such as *Paspalum vaginatum*, and dicot herbs such as *Dalbergiaecastaphyllum.* The zoning of the mangrove swamp forest more is or less parallel to the shoreline. *Rhizophora racemosa* is the most abundant species in this ecosystem. Patches of *Acrostichum aureum* (mangrove salt fern plant) were distributed among the mangrove plants**.**

3.15.9. VEGETATION STRUCTURE

The life-form spectrum in this mangrove swamp forest is dominated by meso-phanerophytes, megaphanerophytes and microphanerophytes, constituting about 40% of the total life-form types and represented by *Rhizophora racemosa***,** *Rhizophora mangle***,** *Rhizophora harrisonii. Laguncularia racemosa* and *Aviecinia africana.* This makes the forest woody. The non-mangrove species consist of *Nypa fruticans, Acrostichum aureum and Paspalum vaginatum* which constitute about 55%. The physiognomic features of this mangrove forest are stilt roots of *Rhizophora* spp, which holds the plant firmly to the soft alluvial soil. The stilt roots also allow the passage of water and nutrients into the plant while acting as filter against salt. The viviparous nature of *R. racemosa* enables the seed to germinate while still attached to the parent tree and the seed develops a prominent and conspicuous radical before it falls onto the ground. Due to this advanced development of the seedlings, a relatively short time is required for it to establish itself in the mud. The mangrove forest is characterized by daily tidal immersion, mobility of the substrate, fluctuating salinity, and anoxia conditions.

3.15.10 VEGETATION DIVERSITY, EVENNESS, AND RELATIVE ABUNDANCE

The diversity of species in the study area using Shannon index showed that the control stations were the most diverse compared to the proposed project site. Also, the numbers of plant species identified in the control stations were more than the ones in the proposed project site. This is because the proposed project site is highly modified by sand-filling (**Table 1 and Appendix 1**). Similarly, the Shannon evenness for the control stations were the highest while quadrats-6 had the least number of species including Shannon index, and evenness. This is followed by quadrats-2 and 5. This is evident because these areas have highly modified habitats and contain mainly grassed and sedges introduced during the sand-filling of the proposed site.

The grasses (Poaceae, 33.05%) and the sedges (Cyperaceae, 27.55%) were the most abundant plant species identified during the sampling (**Fig. 2**). These are followed by Fabaceae (5.52%), Asteraceae (4.92%), Rhizophoraceae (4.78%), and Acanthaceae (3.13%), Rubiaceae (2.51%), Euphorbiaceae (2.32%), and Malvaceae (2.08%) families. The relative abundance of the mangrove species was more in control quadrats than the quadrats within the proposed project site. On the other hand, the abundance of grasses and sedges are more in the quadrats within the proposed project site. This can be attributed to the fact that the proposed project site is modified as a result of anthropogenic activities and the mangrove vegetation/species have been removed during the sand-filling and non-native grasses, sedges, and associated species introduced.

Table 3.42: Plant Species diversity and evenness

	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5	Quadrat 6	Control 1	Control 2
Number of species	32.00	18.00	21.00	26.00	17.00	9.00	36.00	38.00
Shannon diversity	2.89	2.29	2.55	2.41	2.00	1.69	3.36	3.36
Shannon evenness	0.84	0.79	0.84	0.74	0.71	0.77	0.94	0.92

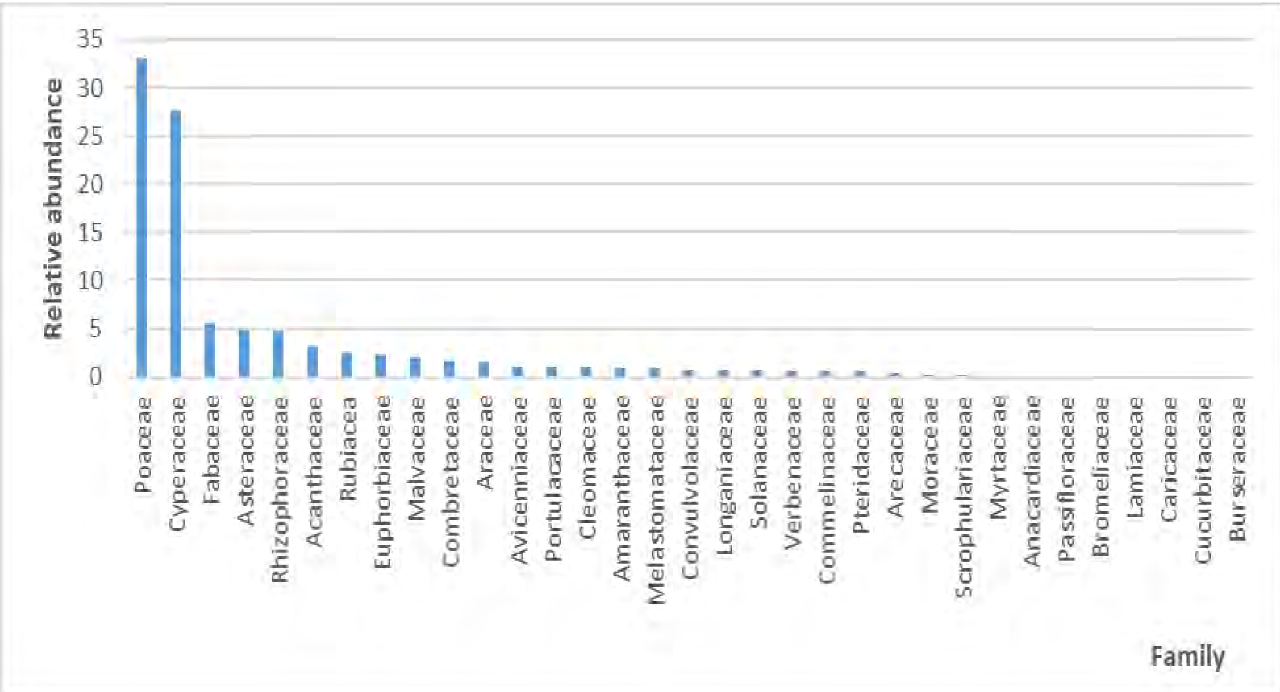


Figure 2: The relative abundance of different plant families in the study area

3.15.11. RIVERINE/ESTUARINE

The proposed project site is characterized with modified habitats with patches of riparian zone (**Plate 6a**), tidal plains (**Plate 6b)**, and marshy areas (**Plate 6c and 6d**). The mollusks use the roots of the *Rhizophora* spp for breeding. Also, the crabs inhabit the tidal plains by borrowing into the soil/sediment (**Plate 7**). Furthermore, the floodplain serves as nursery ground for mangrove and *Nypa* seedlings. The riparian zone harbour some hydrophytes such as *Rhizophora* spp., *Sesuvium portulacastrum, Ipomoea pes-caprae,* etc (**Plate 9**).

3.15.12. PLANT DISEASES

The plants within the proposed project site were healthy and disease free.

3.15.13. CONSERVATION STATUS

None of the plants species identified in the study is the IUCN endangered (EN), vulnerable (VU), and Near Threatened (NT) list. Also, there is no conserved area within the proposed project site. There is no known biodiversity hotspot or shrines (Sacred groves), nor is there any flora of conservation concern within the study area.

3.15.14. FAUNA

3.15.14.1 FAUNA CHARACTERISTICS OF STUDY AREA

The birds constituted more than 75% of the fauna species physically observed during the fieldwork while the records of the other fauna were based on interviews with the hunters and workers in the adjoining facilities (**Plate 10, Table 2, 3, and 4**). Also, a lot of insect species thrive in the study area (**Plate 11**).

Table 3.43: Avian Resources of the Study Area

S/N	Common name	Scientific name	Family	IUCN status	Local Names
1	The sparrow hawk	*Accipiter nisus*	Accipitridae	LC	
2	West African goshawk	*Accipiter tachiro*	Accipitridae	LC	
3	African black swift	*Apus barbatus*	Apodidae	LC	
4	White-rumped swift	*Apus caffer*	Apodidae	LC	
5	Cattle egret	*Ardeola ibis*	Ardeidae	LC	
6	African spotted eagle-owl	*Bubo africanus*	Strigidae	LC	

S/N	Common name	Scientific name	Family	IUCN status	Local Names
7	Cattle Egret	*Bubulcus Ibis*	Ardeidae	LC	Áwárá
8	Trumpeter hornbill	*Bycanistesbucinator*	Bucerotidae	LC	
9	Sand piper	*Calidoris* spp	Accipitridae	LC	
10	Sun bird (scarlet breasted)	*Chalcomitrasenegalensis*	Nectariniidae	LC	
11	Copper Sun Bird	*Cinnyris cupreus*	Nectariniidae	LC	Ágyéẹ̀b
12	Sunbird	*Cinnyris pulchellus*	Nectariniidae	LC	
13	African pied crow	*Corvus albus*	Corvidae	LC	
14	Sun birds (green headed)	*Cyanomitraverticalis*	Nectariniidae	LC	
15	African grey woodpecker	*Dendropicosgoertae*	Picidae	LC	
16	Little egret	*Egretta garzetta*	Ardeidae	LC	
17	The southern red bishop	*Euplectesorix*	Ploceidae	LC	
18	Falcon	*Falcon* spp.	Falconidae	LC	
19	Bush Fowl	*Fruncolinusbilacoratus*	Phasianidae	LC	
20	Bush Sparrow	*Gymnorisdentata*		LC	
21	White Throated Swallow	*Hirundoalbigularis*		LC	
22	Bee-eater	*Maropsnubicus*	Meropidae	LC	
23	Afican Black Kite	*Milvus migrans*		LC	
24	African Bush fowl	*Numida meleagris*	Numididae	LC	
25	Guinea fowl	*Numida* sp	Tetrameridae	LC	
26	Owl	*Otussenegalensis*	Strigidae	LC	
27	Village Weaver birds	*Ploceuscucullatusbohndorffi*	Ploceidae	LC	
28	Hawk	*Polyboroidesradiatus*	Accipitridae	LC	
29	African grey parrot	*Psittacus erithacus*	Psittacidae	LC	
30	Northern white-faced owl	*Ptilopsis leucotis*	Strigidae	LC	
31	Common garden bulbul	*Pycnonotus barbatus*		LC	bẹẹ²
32	Red-billed Quelea	*Quelea Quelea*		LC	Ogazi
33	Knobbed hornbill	*Rhyticeroscassisix*		VU	Hnà
34	Heron bird	*Scopus umbretta*	Scopidae	LC	
35	Laughing Dove	*Spilopeliasenengalensis*		LC	
36	Red-eyed dove	*Streptopreliasemitorquata*	Columbidae	LC	
37	African pied hornbill	*Tokusfasciatus*	Bucerotidae	LC	
38	Sandpiper	*Tringa* spp	Scolopacidae	LC	

Note: A - Abundant C – Common, O – Occasional, R – Rare, and LC - Least concern VU – vulnerable (Source: Fieldwork 2023)

Table 3.44: Mammalian Resources of the Study Area

S/N	Scientific Name	Common Name	Family	IUCN Status	Local Name (Ogoni)
1	*Arvicanthis niloticus*	The Nile rat	Muridae	LC	
2	*Atherurus africanus*	Brush-tailed Porcupine		LC	Bínàhyúu
3	*Cephalophus* spp	Duiker		VU	Gbam
4	*Cercopithecus nictitans*	Putty Nose Guenon		EN	Hwìnì
5	*Civettictis civetta*	The African civet	Viverridae	LC	
6	*Cricetomysgambianus*	Gambian pouched rat	Nesomyidae	LC	
7	*Cricetomysgambianus*	Giant rat		LC	Lúé
8	*Crocidura* sp.	Shrew	Soricidae		
9	*Ctenosaurasp*	Iguana	Iguanidae	LC	
10	*Cypsiurussp.*	Afrcan Palm Switft	Apodidae	LC	
11	*EpixerusWilsoni*	Biafran Bight Palm Squirrel		LC	
12	*Epomophorus spp.*	Bat	Pteropodidae		
13	*Epomopssp*	Bat	Chiroptera	LC	
14	Funisciuruspyrrhopus	African striped tree squirrel	Sciuridae	LC	
15	*Galago* sp.	Bush baby	Galagidae	DD	
16	*Geosciurusinauris*	African Ground squirrel	Sciuridae	LC	
17	*LemniscomysSpp*	Stripped Grass Mouse		LC	hyúu²
18	*Lemniscomysstriatus*	Spotted grass mouse	Muridae	LC	
19	*Micropteropuspusillus*	Fruit Bats		LC	Byãà
20	*Phataginus tetradactyla*	African, black-bellied pangolin	Manidae	VU	
21	*Philantomba maxwellii*	Antelope	Bovidae	LC	
22	*Potamocho eruslarvatus*	Bush pig	Suidae	LC	
23	*Potamocho erusporcus*	BushPig		LC	Akpã
24	*Protoxerus stangeri*	The forest giant squirrel	Sciuridae	LC	
25	*Raltusrattus*	Common rat	Muridae	LC	
26	*Rattusfuscipes*	Bush Rat		LC	
27	*Scotophilusdinganii*	The African yellow bat	Vespertilionidae	LC	
28	*Taphozouspeli*	Giant Pouched Bat	Emballonuridae	LC	
29	*Thryonomysswinderianus*	Cane Rat	Thryonomyidae	LC	Bínà
30	*Xerus erythropus*	Stripped Ground Squirrel	Sciuridae	LC	

Table 3.45: Reptalian Resources of the Study Area

S/N	Scientific Name	Common Name	Local Name (Ogoni)	Family	IUCN Status
1	*Agama agama*	West African Rainbow Lizard	Gbèrè	Agamidae	LC
2	*Amblyrhynchus cristatus*	Marine Iguana	Byã		V
3	*Amietophrynus superciliaris*	African giant Toad		Bufonidae	LC
4	*Bitis arietans*	Puff adder	Bom		V
5	*Chamaeleo africanus*	The African chameleon		Chamaeleonidae	LC
6	*Crocdylus niloticus*	Nile Crocodile	Atèkúrú	Crocodylidae	LC
7	*Dendoaspisjamesoni*	The green mamba		Elapidae	LC
8	*Gastropyxissmaradgina*	Emerald, green snake,		Elapidae	LC
9	*GrayaSmithii*	Smith's African water snake			LC
10	*Hemidactyluskyaboboensis*	Forest gecko		Gekkonidae	LC
11	*Kinixys belliana*	Tortoise		Testudinidae	LC
12	*Lampropholisguichenoti*	Skink		Scincidae	LC
13	*Lycodonomorphusinornatus*	Olive House Snake			LC
14	*Mabuyumaculilabris*	Skink		Scincidae	LC
15	*NajaNigricincta*	Spitting Cobra			LC
16	*Najanigrocollis*	Black-necked spitting cobra		Elapidae	LC
17	*Osteolaemustetraspis*	Dwarf Crocodile	Pa		LC
18	*Python Regius*	Royal python	hyóọ		NT
19	*Python Sebae*	African Rock Python	hyóọ		LC
20	*Sclerophrysregularis*	Common African Toad		Bufonidae	LC
21	*Tarentolagomerensis*	Wall gecko		Gekkonidae	LC
22	*Trachylepisaffinis*	Skink		Scincidae	LC
23	*Trachylepissp*	Stripped Skink		Scincidae	LC
24	*Varanusniloticus*	Nile Monitor Lizard		Varanidae	LC
25	*Varanusvarius*	Monitor lizard		Varanidae	LC

Note: A - Abundant C – Common, O – Occasional, R – Rare, NT – Near threatened, and LC - Least concern (Source: Fieldwork 2023)

3.15.14.2 RELATIVE ABUNDANCE OF FAUNA

Among the fauna groups (mammalian, reptilian, avian, and mollusks), the avian constituted 38 species (40%), mammalian 30 species (31%), and the reptilian 25 species (26%) (**Fig. 3**). The avian are more frequently seen and reported by the locals. This could be attributed to the fact that they are not easily restricted by barriers. Also, during fieldwork, we observed the majority of the bird species in the open areas of the proposed site.

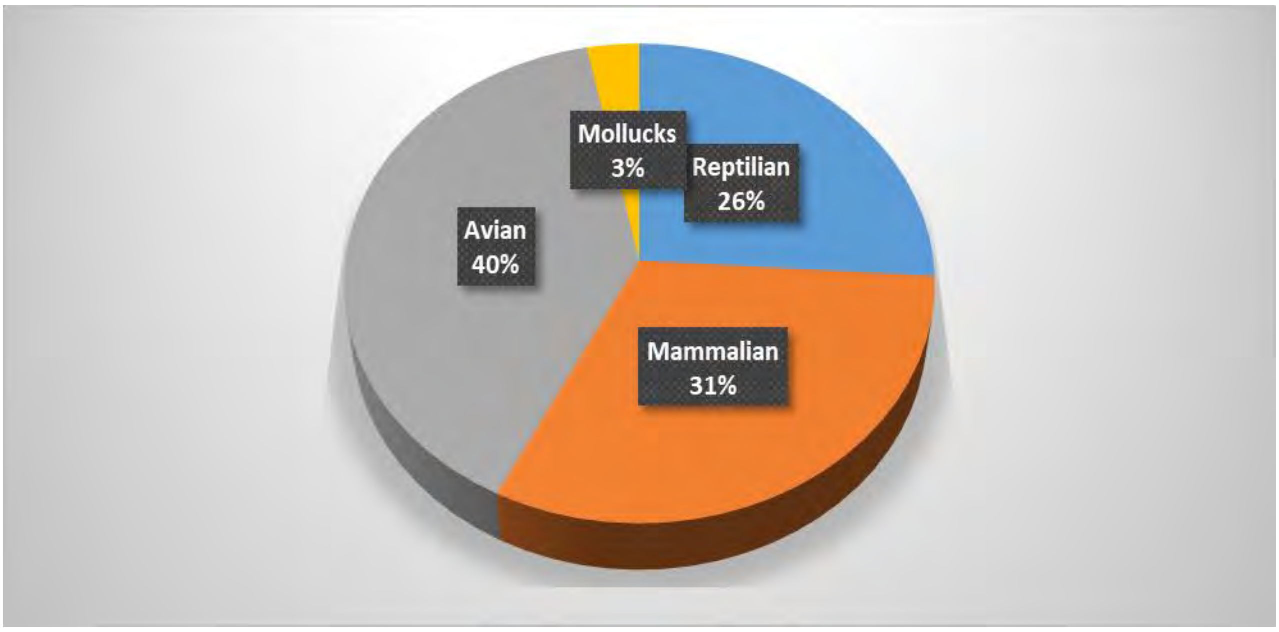


Figure 3.55: Relative abundance of mammalian, reptilian, avian, and mollusks

3.15.14.3 CONSERVATION STATUS FAUNA

It is worthy to note that the proposed project site does not have enough vegetation that can serve as habitats that can hobour the fauna species (mammalian, reptilian, and avian). Also, there is no known biodiversity hotspot or Important Bird Area (IBA), nor is there any flora of conservation concern within the study area. Furthermore, the IUCN status of all the avian species identified in the study area Least concern (LC) except *Rhyticeros cassisix* which is on the vulnerable (VU) status. The IUCN status of the mammalian species indicated that *Cephalophus* spp and *Phataginus tetradactyla* are vulnerable (VU), *Cercopithecus nictitans* is endangered (EN) while other mammals identified are on the least concern category. Among the reptiles, *Amblyrhynchus cristatus* and *Bitis arietans* are on the the vulnerable (VU) list while *Python Regius* is on the Near threatened (NT) list. Other reptile species are on the Least concern (LC) list.

These particular mammalian, reptilian, and avian species were not sited within the proposed project site but were only reported by the hunters as one the fauna seen in the secondary forests which are more than 2.0km away from the proposed site. This however asserts that the proposed project area is not inhabited by these species and the birds sited during the fieldwork are not resident in the proposed site since there is no nest or breeding sited observed in the proposed site.

3.15.15. ECOSYSTEM SERVICES

The biodiversity of the area includes both flora and fauna species and its ecological complexes which they are part thereof. The value and uses of flora diversity in the area as stated by the indigenous peoples and residents of the area ranged from economic, social, cultural, and environmental to health. However, the value and uses were in the areas of food, medicine, timber, fuelwood and energy, ornamentals, gums, protection of streams and water bodies and soil erosion prevention.

The faunal value and uses were source of protein (meat/fish), income, animals hide and skin for cultural activities, feathers, medicine, dispersion of seeds, spores, buds and stems for further regeneration, pollination, and cultivation of plants. The faunal species play roles in ecosystem functionality, resilience, adaptation, longevity, and stability. Beyond the socioeconomic and cultural gains of biodiversity, the ecosystem services extend to regulating hydrological cycles regime, local and ambient air quality, carbon sequestration, recreation, and environmental aesthetics.

The ecosystem of the proposed project environs is modified. However, the direct and indirect ecosystem services offered by the biodiversity in the area were also enumerated and ascertained by the locals as shown table below.

3.15.15.1 *ECOSYSTEM SERVICES AND PROVISIONING IN THE STUDY AREA*

Table 3.46

S/N	FLORA	FAUNA	AVIFAUNA	MULLUSC	INSECTS
1	Herbs for medicine	Meat	Production of feathers	Source of food for man and animals	Pollination
2	Gums	Fats and oil for medicine	Pest control	Sources of protein	Plants dispersion
3	Timber	Cultural affiliation and belief systems (dances, totem, masquerades,	Pollination	Income and revenue	Production of honey

S/N	FLORA	FAUNA	AVIFAUNA	MULLUSC	INSECTS
		rhymes, and rhythms)			
4	Organic matter	Hide and skin	Seed dispersion	Substrates for animal feed production	Food and source of protein
5	Regulation of local climate	Pets	Meat and food	Used for decoration	Environmental indicators
6	Regulation of hydrological cycle	Soil forming factors and processes	Planters of trees and fruits	Soil forming factors and processes	Soil forming factors and processes
7	Soil aeration and moisturization	Addition of nutrients to the soil	Cultural attachments and indication of progress via continuous nesting	Soil aeration and moisturization	Decomposers and detritus's feeders
8	Fruits, nuts, seeds, and snacks	Guardian spirits	Production of eggs and source of protein	Detritus feeders and decomposers	Pest and weed control
9	Edible leaves and vegetables	Pollination	Nutrient recycling	Landscaping and aesthetics	Maintenance of wildlife species
10	Spices	Seed dispersal	Provision of organic matter	Medicine	Provides food for other organisms especially birds and insect eating animals
11	Shelter for wildlife	Pest and weed control	Environmental beauty	Provision of shelter and protection for other insects against predators	Nutrients cycling
12	Recreation and leisure		Community timekeepers and regulators	Shells used for jewelries	
13	Watershed protection		Natural town criers/informants		
14	Materials for cultural artifacts		Pets and partners		
15	Environmental aesthetics and beautification		Ecosystem indicators/restorers		

In summary, the ecosystem services associated with the study area include provisioning (timber, genetic resource, firewood, wild food, bush meat, fisheries, medicinal plants, and water supply), supporting (habitat for fishes, nursery ground for mangrove and *Nypa* species, and primary production), and regulating (nutrient cycle, and erosion control).

Table 3.47: Checklist of plants identified in the study area, relative abundance, diversity, and evenness.

S/N	Species Name	Family	Q1	Q2	Q3	Q4	Q5	Q6	Cont. 1	Cont. 2	Rel. Abundance
1	*Acanthus* sp	Acanthaceae	0	0	0	0	10	0	0	4	**0.33**
2	*Acrosticumaureum*	Pteridaceae	0	0	0	0	27	0	26	9	**0.53**
3	*Ageratum conyzoides*	Asteraceae	10	3	0	8	0	0	19	0	**0.96**
4	*Amaranthus*sp	Amaranthaceae	0	0	0	0	3	0	9	0	**0.29**
5	*Ananascomosus*	Bromeliaceae	0	0	0	0	0	0	5	0	**0.12**
6	*Andropogon tectorum*	Poaceae	12	7	0	0	0	0	0	0	**0.45**
7	*Asystasiagangetica*	Acanthaceae	0	0	0	9	0	0	12	28	**1.17**
8	*Avicenniaafricana*	Avicenniaceae	0	0	0	3	6	0	8	30	**1.12**
9	*Bidenspinnata*	Asteraceae	48	37	0	0	0	0	0	0	**2.03**
10	*Bulbostylisbarbata*	Cyperaceae	0	34	39	0	0	0	10	0	**1.98**
11	*Cajanuscajan*	Fabaceae	4	0	0	0	0	0	0	0	**0.10**
12	*Carica papaya*	Caricaceae	0	0	0	0	0	0	3	0	**0.07**
13	*Chamaecristamimosoides*	Fabaceae	0	0	0	0	0	0	0	5	**0.12**
14	*Chromoleanaordorata*	Asteracea	0	0	0	0	0	7	0	0	**0.17**
15	*Cintrocemapurbesense*	Fabaceae	3	0	7	0	0	0	0	34	**1.05**
16	*Cleome viscosa*	Cleomaceae	0	23	0	0	0	19	0	0	**1.00**
17	*Colocasiaesculenta*	Araceae	0	0	0	0	0	0	12	0	**0.29**
18	*Commelina*spp	Commelinaceae	0	0	0	0	0	0	13	10	**0.55**
19	*Cyathulaprostrata*	Acanthaceae	0	0	0	0	0	0	45	10	**1.31**

S/N	Species Name	Family	Q1	Q2	Q3	Q4	Q5	Q6	Cont. 1	Cont. 2	Rel. Abundance
20	*Cynodondactylon*	Poaceae	0	0	0	16	0	0	12	0	**0.67**
21	*Dacryodesedulia*	Burseraceae	0	0	0	0	0	0	2	0	**0.05**
22	*Derris* sp	Fabaceae	14	0	0	7	12	0	0	45	**1.86**
23	*Desmodiumscorpiurus*	Fabaceae	0	5	0	0	0	0	0	0	**0.12**
24	*Desmodium*sp	Fabaceae	10	0	0	0	0	0	0	0	**0.24**
25	*Desmodiumtortuosum*	Fabaceae	0	0	0	0	0	0	12	0	**0.29**
26	*Digitariaargillacea*	Poaceae	59	20	0	0	299	0	0	0	**9.03**
27	*Digitarialoniflora*	Poaceae	0	0	69	0	74	0	19	0	**3.87**
28	*Diodiasarmentosa*	Rubiacea	0	0	0	0	0	0	0	15	**0.36**
29	*Eclipta alba*	Asteraceae	3	0	19	0	0	0	19	0	**0.98**
30	*Elieasguinnesis*	Arecaceae	0	0	0	0	0	0	5	13	**0.43**
31	*Eluesineindica*	Poaceae	0	0	0	19	0	0	25	0	**1.05**
32	*Emilia praetermissa*	Asteraceae	5	0	17	0	0	0	0	4	**0.62**
33	*Eragrostis*sp	Poaceae	0	208	0	89	75	0	0	0	**8.89**
34	*Euphorbia heterophylla*	Euphorbiaceae	10	0	0	0	0	0	0	34	**1.05**
35	*Ficus*sp	Moraceae	2	0	0	5	0	0	0	5	**0.29**
36	*Fimbristylis*sp	Cyperaceae	100	0	56	8	4	96	13	0	**6.62**
37	*Fimnbristylisferruginea*	Cyperaceae	38	20	25	90	59	70	0	0	**7.22**
38	*Finbristylislitterolis*	Cyperaceae	45	84	0	0	207	10	0	0	**8.27**
39	*Gomphrenacelosioides*	Amaranthaceae	4	10	0	0	0	0	0	15	**0.69**

S/N	Species Name	Family	Q1	Q2	Q3	Q4	Q5	Q6	Cont. 1	Cont. 2	Rel. Abundance
40	*Heritiera*sp	Malvaceae	0	0	0	0	10	0	0	7	**0.41**
41	*Heterotisrotundifolia*	Melastomataceae	0	0	0	**9**	0	0	19	9	**0.88**
42	*Hyptislanceolata*	Lamiaceae	0	0	0	**0**	0	5	0	0	**0.12**
43	*Ipomoea aquatica*	Convulvolaceae	0	0	3	**0**	0	0	5	14	**0.53**
44	*Ipomoea pes-caprae*	Convulvolaceae	6	0	4	**0**	0	0	0	0	**0.24**
45	*Kyllingaperuviana*	Cyperaceae	13	13	20	**0**	0	0	0	0	**1.10**
46	*Laguncularia racemosa*	Combretaceae	19	0	0	**6**	0	0	15	4	**1.05**
47	*Lumnitzera*sp	Combretaceae	2	0	0	**3**	0	0	2	10	**0.41**
48	*Mangiferaindica*	Anacardiaceae	0	0	0	**0**	0	0	3	1	**0.10**
49	*Mariscusligularia*	Cyperaceae	30	0	6	**0**	0	0	8	55	**2.37**
50	*Mimosa invosa*	Fabaceae	0	4	4	**0**	0	0	0	0	**0.19**
51	*Mimosa pudica*	Fabaceae	5	0	0	**0**	0	0	0	0	**0.12**
52	*Momordicacharantia*	Cucurbitaceae	0	0	3	**0**	0	0	0	0	**0.07**
53	*Nelsoniacanescens*	Acanthaceae	0	0	0	**0**	0	4	0	10	**0.33**
54	*Nypafructicans*	Araceae	3	0	0	**5**	0	0	15	19	**1.00**
55	*Oldenlandiaherbecea*	Rubiacea	0	33	0	**0**	0	0	3	18	**1.29**
56	*Panicumlaxum*	Poaceae	0	34	0	**78**	0	0	23	12	**3.51**
57	*Panicum maximum*	Poaceae	3	0	0	**18**	0	0	0	0	**0.50**
58	*Paspalumconjugatum*	Poaceae	0	17	0	**0**	67	0	0	16	**2.39**
59	*Passiflorafoetida*	Passifloraceae	3	0	3	**0**	0	0	0	0	**0.14**

S/N	Species Name	Family	Q1	Q2	Q3	Q4	Q5	Q6	Cont. 1	Cont. 2	Rel. Abundance
60	*Pennisetumpedicellatum*	Poaceae	20	0	13	**0**	0	0	0	0	**0.79**
61	*Perseaamericana*	Annacadiacea	0	0	0	**0**	0	0	2	0	**0.05**
62	*Phyllanthusamarus*	Euphorbiaceae	0	0	2	**0**	0	22	0	29	**1.27**
63	*Psiduimgujava*	Myrtaceae	0	0	0	**0**	0	0	7	0	**0.17**
64	*Pterocarpussantalioides*	Fabaceae	0	0	1	**3**	0	0	0	7	**0.26**
65	*Purariaphaseoliodes*	Fabaceae	3	0	0	**0**	18	0	0	5	**0.62**
66	*Rhizophoraharrisonii*	Rhizophoraceae	0	0	0	**5**	4	0	32	39	**1.91**
67	*Rhizophora mangle*	Rhizophoraceae	0	0	0	**3**	5	0	23	47	**1.86**
68	*Rhizophoraracemosa*	Rhizophoraceae	0	0	0	**2**	0	0	17	23	**1.00**
69	*Rhynchelytrumrepens*	Poaceae	0	0	0	**2**	0	0	0	0	**0.05**
70	*Rice grass*	Poaceae	30	0	13	**0**	0	18	0	0	**1.46**
71	*Schwenckiaamericana*	Solanaceae	0	0	0	**0**	0	0	17	12	**0.69**
72	*Scopariadulcis*	Scrophulariaceae	0	0	0	**4**	0	0	8	0	**0.29**
73	*Sesuviumportulacastrum*	Portulacaceae	45	0	0	**0**	0	0	0	0	**1.08**
74	*Seteria pumila*	Poaceae	0	0	13	**3**	0	0	0	0	**0.38**
75	*Sidaacuta*	Malvaceae	0	18	0	**2**	0	0	0	0	**0.48**
76	*Spermacoceverticilata*	Rubiacea	12	0	10	**7**	0	0	0	7	**0.86**
77	*Spigeliaanthelmia*	Longaniaceae	0	18	0	**0**	0	0	0	14	**0.76**
78	*Stachytarphetacayennensis*	Verbenaceae	0	0	0	**0**	5	0	0	21	**0.62**
79	*Terminalia catappa*	Combretaceae	0	0	0	**2**	0	0	0	6	**0.19**

S/N	Species Name	Family	Q1	Q2	Q3	Q4	Q5	Q6	Cont. 1	Cont. 2	Rel. Abundance
80	*Tridaxprocumbense*	Asteraceae	7	0	0	**0**	0	0	0	0	**0.17**
81	*Trimphettacordifolia*	Malvaceae	0	0	**7**	**0**	0	0	20	0	**0.65**
82	*Urenalobata*	Malvaceae	0	0	**5**	**0**	0	0	15	3	**0.55**
83	*Vigna*sp	Fabaceae	5	0	0	**4**	0	0	0	0	**0.22**
84	*Vigna*sp2	Fabaceae	0	0	2	**0**	0	0	3	9	**0.33**
85	*Xanthosomamaffafa*	Araceae	0	0	**0**	**0**	0	0	13	0	**0.31**
Number of Species			**32.00**	**18.00**	**21.00**	**26.00**	**17.00**	**9.00**	**36.00**	**38.00**	
Shannon Index			**2.89**	**2.29**	**2.55**	**2.41**	**2.00**	**1.69**	**3.36**	**3.36**	
Shannon Evenness			**0.84**	**0.79**	**0.84**	**0.74**	**0.71**	**0.77**	**0.94**	**0.92**	

4.0. SOCIO-ECONOMIC AND CULTURAL HERITAGE REPORT

4.1. Introduction

Social and health impact assessment are important components of environmental social impact assessment (ESIA) study. The environmental and social impact assessment (ESIA) is a process that begins with the conceptual design stage of a project and continues throughout project design, construction, operation, and decommissioning. The purpose of an ESIA is to identify the probable positive and negative impacts caused by project implementation. This is assessed through an analysis and synthesis of the effects resulting from interaction between environmental and social components and the various activities of a project and its development including temporary (for example during construction) and associated facilities. The implication of the ESIA of MM PortFZE in the study area are to; adhere to core principles of global ESIA processes, establish a robust understanding of the existing environment and social setting, identification of the potential impacts upon the environment and local communities (both positive and negative) as a result of the proposed changes and ensure that the design, implementation, operation and subsequent decommissioning of the development is carried out in such a way as to minimize adverse impacts on, and maximize potential benefits to the environment and affected communities.

4.2 Project Scope and Objectives

The study was carried in Onne and Ogu communities of Rivers State, Nigeria. The purpose was to collect, analyze, interpret, and establish baseline socioeconomic and health conditions in the proposed project area. The study considered but not limited to the following major variables:

1. Population Structure and Dynamics
2. The Rural Economy-Livelihoods, Economic Characterization and Measure of Activity Systems, employment.
3. Social, Cultural, Physical and Institutional Infrastructure including Health, Safety and Education
4. Social Organization
5. Rural Governance Systems
6. Existing infrastructure
7. Uptake of Healthcare Services
8. Human rights

4.3. Brief description of the study area

Ogu is in Ogu-Bolo Local Government of Rivers State, while Onne is in Eleme Local Government areas of Rivers State, Nigeria. As of the 2006 census, Ogu-Bolo has an area of 125.3 km2 with a population of 75,282 and population density of 864.4 per km2. Eleme has an area of 150.1 km2 with a population of 190,194 and population density of 1,823 per km2. Per 2006 census, Ogu-bolo LGA had 51.21% male & 48.79% female population whereas Eleme LGA had 51.71% male & 48.29% female population. The population above 65 years was 3.5% in Ogu-bolo whereas 2.9% in Eleme LGA. From 1991 to 2006 census, both LGA showed 2.3% annual population growth rate which was slightly lesser than Rivers State population growth rate (2.85%).

The Onne Port complex is situated at the bank of the Bonny River, which is about 25 km away southern side of Port Harcourt, Rivers State, Nigeria. Eleme LGA and Ogu-Bolo LGA share a boundary with Bonny River.

The Onne Port Complex was established as a 'Free Port Zone' (FPZ) to serve as the focal point for the oil and gas industry in West Africa. This complex, which started in 1982 as the Federal Lighter Terminal (FLT) has grown over the years to a very enviable state, due largely to Public/Private Partnership. The Onne community of Eleme LGA and the Ogu community of Ogu-Bolo LGA are the host communities of this port complex.

Indorama operates a port terminal "OIS Indorama Port Limited" for Urea export which is located within Onne Port Complex. The key community stakeholders for this entity are Onne and Ogu. As the proposed project site is within Onne Port Complex, the same communities (Onne & Ogu) are considered for socio-economic and cultural heritage survey and for further engagements.

4.4. Survey Methodologies

The socio-economic survey was conducted in Ogu and Onne communities of Ogu-Bolo and Eleme LGA respectively in Rivers State. Socio-economic survey conducted by using consultations, interviews, structured questionnaire, and statistics from various agencies. Targeted groups for information include Local Government Officials, Chiefs, Farmers, Hunters, Women, Youth, and Institutions/Governments agencies with interest on environment and social aspect. To get the input of stakeholders from project planning especially during the ESIA, the proponent has organized a Scoping workshop. A survey of health institutions, patent medicine stores, trade-medical and traditional treatment facilities in the study area was conducted. The survey will also document the various and common medical conditions in the area. Possible Risk and Hazards of the Project which may impinge on health and safety has documented. **Cultural heritage** of the project host communities and immediate environment were studied by both visual observations at historical site where they exist, historical photographs and, also in literature review of known scholarly articles as it relates to project host community and its environs.

4.5. Sampling Rationale, Data Collection and Analysis

The rationale for sample procedure was premised on known locations (Onne and Ogu Communities) and a non-proportional sampling size procedure was adopted. Due to the settlement peculiarities in the study area, a multi-stage sample technique was adopted in the selection of respondents for the study. The number of respondents sampled for the study was two hundred and fifty (250). The questionnaire administered was proportionate to the size of the sampled population. In order to obtain qualitative information, three (3) Focus Group Discussions (FGDs) and two (2) Key Informant Interview (KIIs) Sessions were conducted in each community. The respondents consisted of adults (males and females), students across primary to tertiary levels, various classes of Chiefs and the King of Onne, traders, fisher folks and farmers, youth Presidents/Chairmen. Also, a Participatory Rural Appraisal Approach (PRAA) was deployed across the studied communities to buttress interactions across diverse community issues and dynamics. Personal observations and snow-balling techniques were also used to obtain salient socioeconomic data related to community history and culture. Quantitative and qualitative data collected were analyzed with the use of descriptive statistics and results are presented in tables, charts, figures, and photo plates. Similarly, secondary data were sourced from official publications of National Population Commission (NPC) for population related figures, National Bureau of Statistics (NBS) for national/state socio-economic related data among others. The inclusion of community members to participate in the assessment exercise was to strengthen support and assistance to ensure proper data gathering for the study. The services of educated native assistants were used to interpret the questionnaire and fill in the responses accordingly. The targeted population were drawn from Onne and Ogu which are within Eleme and Ogu-Bolo Local Government Areas of Rivers State.

4.6 Discussion of Survey Findings

Table 4.1: Estimated Population of the Study Area

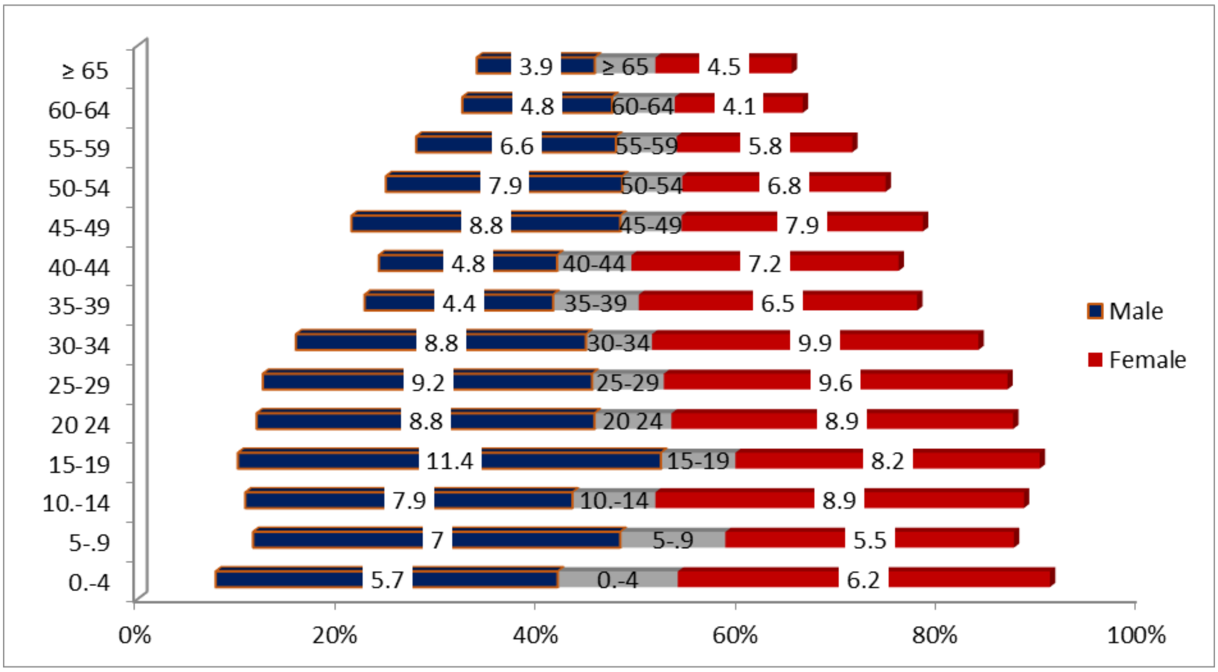
LGAs	Population 1991 Census	Population 2006 Census	Population Projected 2022	Population Projected 2025	Growth Rate (%)
Eleme	-	190,194	273,500	292,977	2.3
Ogu-Bolo	-	75,282	100,300	115,965	2.3

Source: Computed Values of Estimated Population in the Study Area, 2023 Using NPC, 1991/2006 as Base-year Values

Table 1 above shows the expected population in the study area given a 2.3% growth rate. By 2025, Eleme and Ogu will likely have an estimated population of 292,977 and 115,965 people.

4.7. Age and Sex Composition in the Study area

Figure 4.1: Age – Sex Cohort of the Respondents

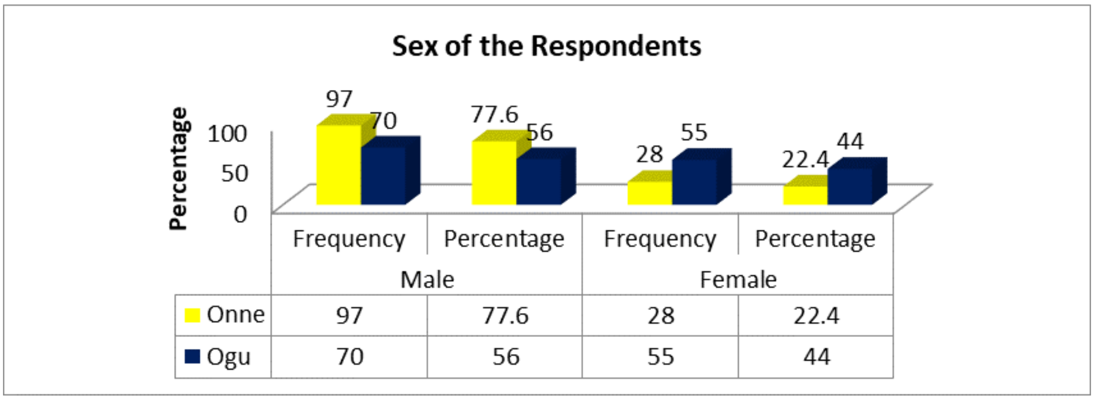


Source: Field Survey, 2023

The age-sex cohort in the study area is presented in Figure 1 above. Result revealed that, 60% of the respondents were females while 40% were males. The result is consistent with the ESIA study of OMT (2022) which stated that, those with age range from 46-65 years were over 60%. The result implies that, there are more female population in the study area than the males.

4.7.1. Sex Distribution

Figure 4.2: Age – Sex of the respondents

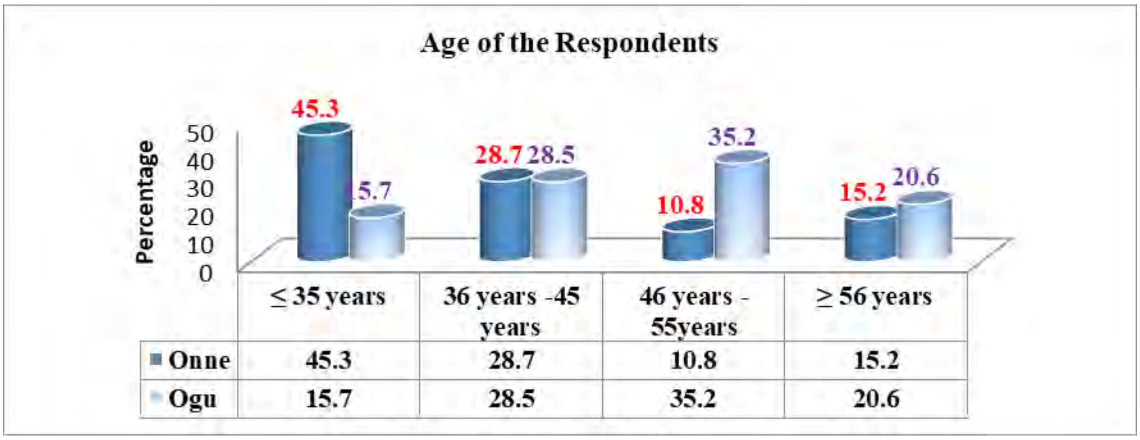


Source: Field Survey, 2023

Figure 2 shows the sex distribution of respondents in the proposed project area. Result revealed that, 77.6% were males, 22.4% were females in Onne communities. In Ogu 56% were males while 44% were females. The result revealed a patriarchal structure common in traditional institutions in the study area and region in general.

4.7.2. Age Distribution

Figure 4. 3: Age of the Respondents

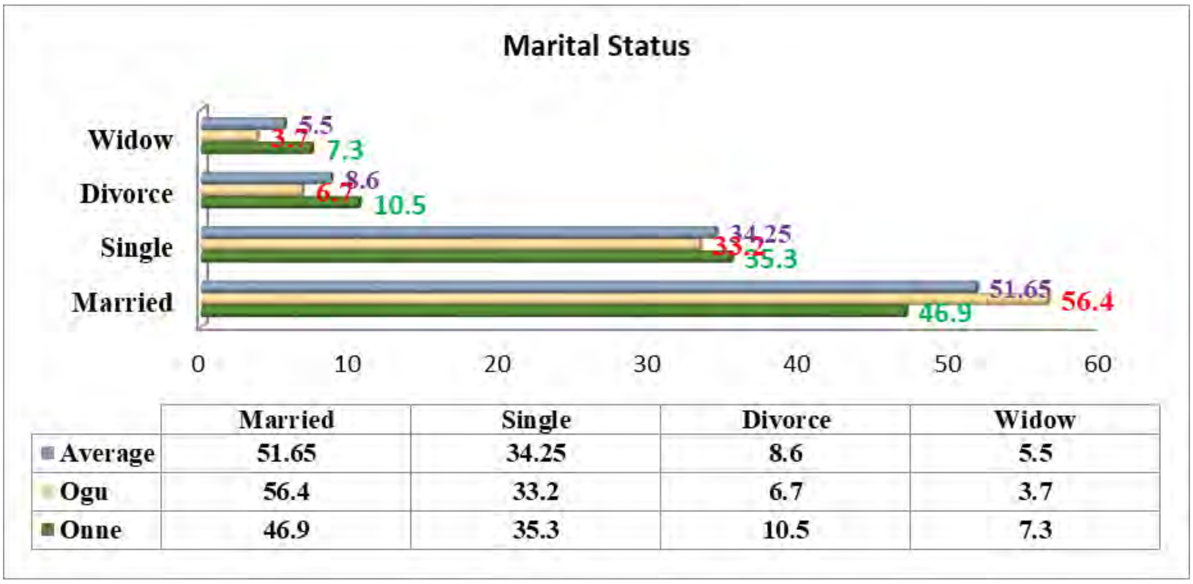


Source: Field Survey, 2023

Age is an important demographic variable that determines the percentage of the population that is either active or inactive in a given area. Result presented in Figure 3 above shows the age distribution of respondents in the study area. In Onne, majority (45.3%) of the respondents were either less or equal to or less than 35 years (≤ 35 years), 28.7% were within 36-45 years, 15.2% were either equal to or above 56 years and 10.8% were within the age bracket of 46-55 years old. In Ogu community, the majority (35.2%) falls within the age bracket of 46-55 years, 28% were within the age bracket of 46-55 years, 20.6% were greater than or equal to 56 years and 15.7% were less than or equal to 35 years. The result revealed that over 70% of the respondents were in their active age and capable of carrying out economic activities that enhance income required for upkeep of their family and care for the aged.

4.8. Marital Status

Figure 4. 4: Marital Status of Respondents

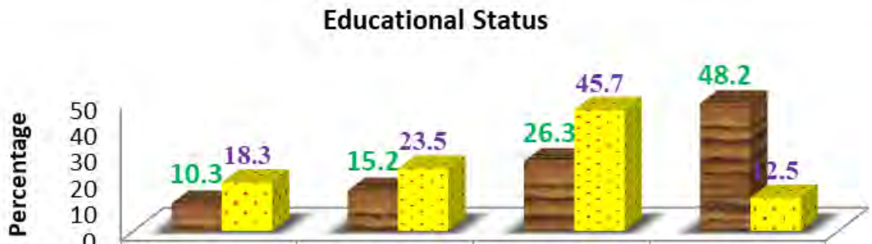


SSource: Field survey, 2023

Several studies have linked societal stability to family coherence and coexistence. Result presented in Figure 4 shows the status of respondents in terms of marriage. Result revealed that, in Onne and Ogu communities' respondents with married status were 46.9% and 56.4% respectively. Those that are single were 35.3% and 38.2% respectively. Those with divorced status are 10.5% and 6.7% respectively, while widowhood status is represented with 7.3% and 3.7% respectively. An average progression shows 51.65% for married, 34.2% for single, 8.6% for divorce and 5.5% for widowhood. The result implies that, greater number of married respondents and population will drive development as responsible people are being consulted for decision making regarding project implementation in the study area.

4.9. Educational Attainment

Figure 4.5: Educational Status of Respondents



	Non Formal Education	Primary Educatio	Secondary Education	Post-Secondary Education
Onne	10.3	15.2	26.3	48.2
Ogu	18.3	23.5	45.7	12.5

Source: Field survey, 2023

Table 4.2: ***Educational Attainment in the Region***

SN	State	Adult literacy (%)	Attainment of Primary School (%)	Attainment of Secondary School (%)	Attainment of Post-Secondary School (%)	No. of Jobs in Sector 2000
1	Abia	84.1	39.6	43.6	16.8	9,276
2	Akwa Ibom	76.3	54.4	44.4	8.3	13,683
3	Bayelsa	78.7	38.8	49.3	11.9	3,515
4	Cross River	82.2	44.6	42.8	12.6	11,4255
5	Delta	77.4	37.9	43.6	18.5	15,720
6	Edo	69.7	49.3	38.8	11.9	10,959
7	Imo	79.3	46.1	42.7	11.2	14,145
8	Ondo	78.8	45.0	44.2	10.8	12,342
9	Rivers	79.9	33.4	49.5	17.1	4,011
	The region	*78.7*	*43.3*	*43.2*	*13.5*	*95,076*

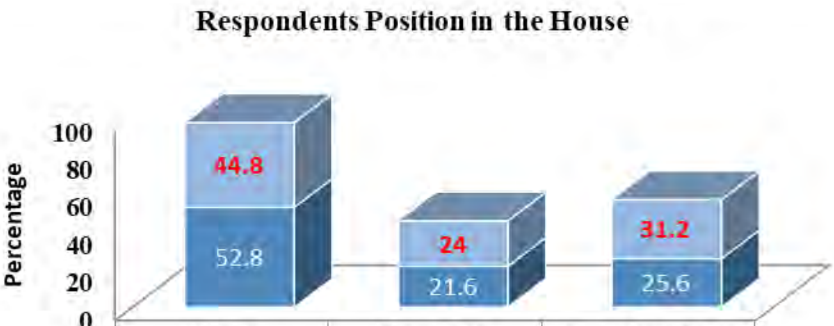
Source; Niger Delta Regional Development Master Plan (NDDC, 2006)

Figure 5 and Table 2 presents the result of educational attainment both in the study area and the Niger Delta region. Result revealed that, among the states in the region, Rivers State exceeded the adult literacy by 79.9% a value higher than the Niger Delta Regional value of 78.7%, attainment of primary school is 33.4% against 43.3% in the region, attainment of secondary education is 49.5%

against 43.3% in the region, post-secondary school attainment is 17.1% higher than the regional value of 13.5%. Similarly, figure 5 shows the educational attainment in the study area. Result revealed that, majority (48.2%) of the respondents in Onne attended up to post-secondary education, while 45.7% had secondary education in Ogu. 26.3% and 23.5% of the respondents in Onne and Ogu had secondary and primary education respectively, 15.2% had primary education in Onne. Respondents with non-formal education is represented by 18.3% and 10.3% in Ogu and Onne respectively. Only 2.5% of respondents from Ogu had tertiary education. The result implies that over 80% of the study population were literate and their contributions to the project was very objective.

4.10. Status of Respondents in the Household

Figure 4.6: Household Status of the respondents



	Head	Spouse to head	Son/Daughter
Ogu	44.8	24	31.2
Onne	52.8	21.6	25.6

Source: Field survey, 2023

Figure 6 presents the result of the status of respondents in the household. Result revealed an expected proportionate representation of household members in the study area. Most (52.8% and 44.8) of the respondents from Onne and Ogu respectively, were household heads, 31.2% and 25.6% were sons/daughters in the household from Onne and Ogu respectively. Also, 24.0% and 21.6% were spouse to head (husband or wife) from Onne and Ogu respectively. The result implies that proportionate representation enhances balanced information and communication across all the age group and household-headship status. This approach reduced unnecessary tension and cohesion among household members and between families.

4.11 Occupation and Employment

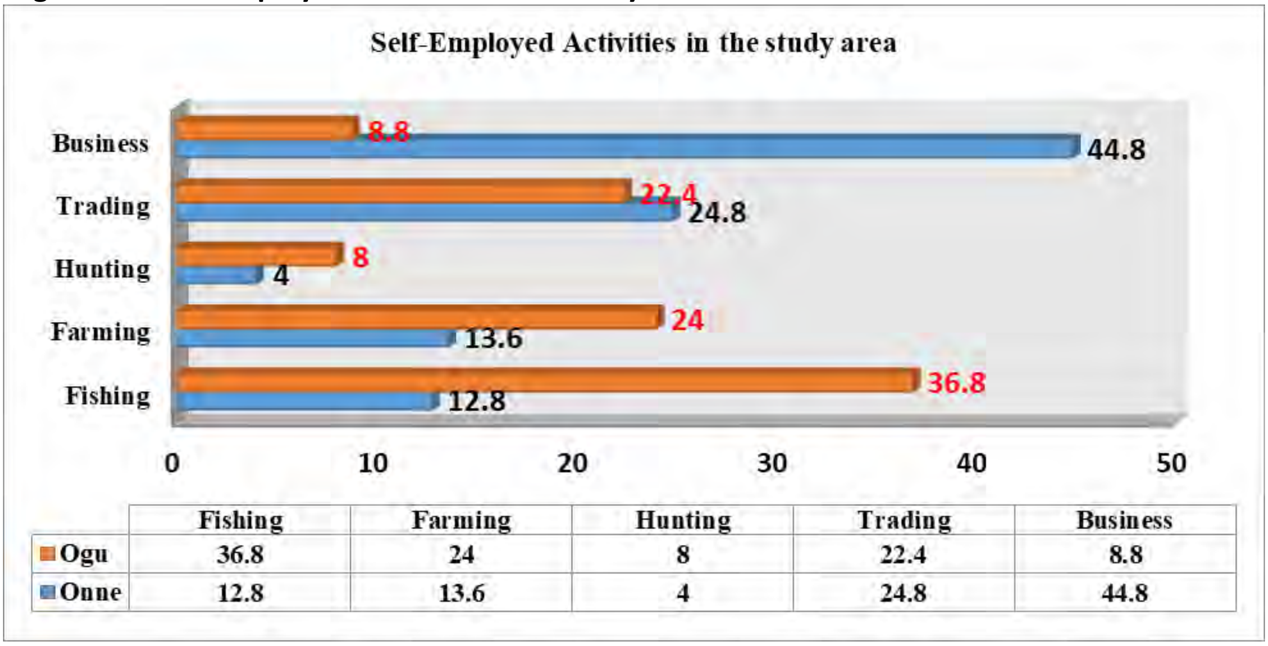
Figure 4.7: Primary occupation and employment status

	Onne Frequency	Onne Percentage	Ogu Frequency	Ogu Percent	Average
Public	18	14.4	10	8	12.6
Company	20	16	66	52.8	38.7
Self-Employed	56	44.8	22	17.6	35.1
Not Employed	31	24.8	27	21.6	26.1

Source: Field study, 2023

Figure 7a above shows the result of the respondents occupational and employment status in the study area. Result shows that, respondents are engaged in public/civil/company, self-employed. In Onne, for instance, 44.8% of the respondents are self-employed, 16% works in the companies, 14.4% are public servants, while 24.8% are unemployed. In Ogu, the results revealed that 52.8% are company workers, 17.6% are self-employed, 8% are public servants while 21.6% are not employed. Across the study area (Onne and Ogu), 38.7% are company workers, 36.1% are self-employed.

Figure 4.8: Self-employed Activities in the study area

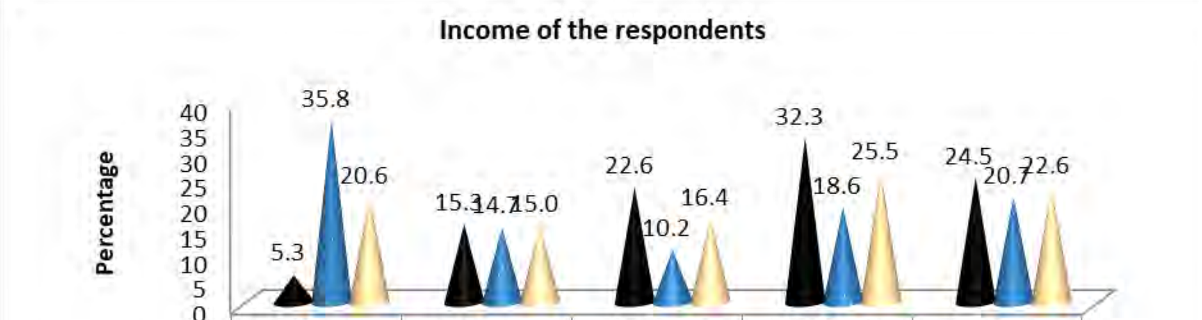


Source: Field survey, 2023

The study identified self-employed activities such as trading, hunting, fishing, farming, contractual business with companies, etc. In Onne, 44.8% of the respondents are into commercial business ventures, 24.8% are into trading (in open markets, shops and chiocks), 13.6% are into fishing, 12.8% are farmers while 4% are into hunting. In Ogu, 36.8% are in to fishing, 24% in farming, 22.4% in trading, 8.8% and 8% in business ventures and hunting respectively. The result revealed that self-employment activities are related to natural resource availability. With a large volume of water in Ogu, fishing and other commercial business activities are mostly carried out in the area compared with Onne. The result collaborates with similar studies in the area. Plates 5 a, b and c show samples of self-employment activities in the Study area.

4.12 Income Distribution

Figure 4.9: Income Distribution in the Study Area



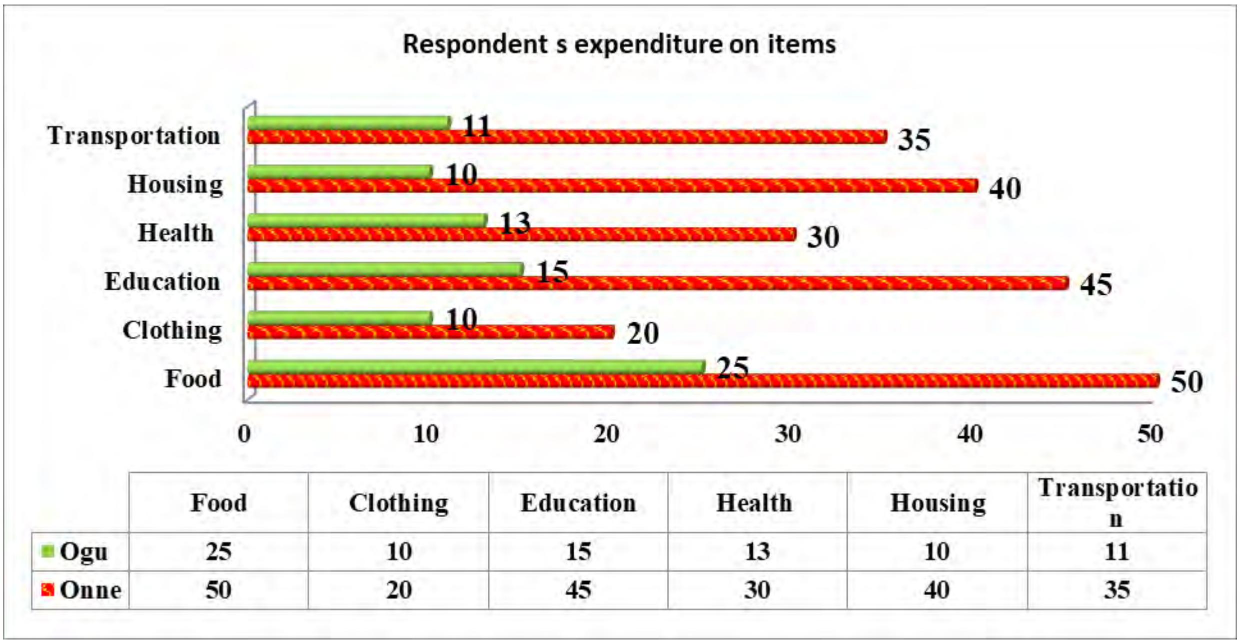
	≤ N25,000	N 25,001-35,000	N35,001-N 45,000	N 45,001-N 55,000	≥ N 55,001
Onne	5.3	15.3	22.6	32.3	24.5
Ogu	35.8	14.7	10.2	18.6	20.7
Average	20.6	15.0	16.4	25.5	22.6

Source: Field survey, 2023

Income is an important economic variable that determines households' welfare in terms of consumption, expenditure, savings, and investments. Figure 8 above shows the income distribution in the proposed project area. In Onne 32.3% of the respondents earns between 45,000 to 55,000 monthly, 24.5% earns above 55,000, 22.6% earns between 35,000 to 45,000, 15.3% earns between 25,000 to 35,000 while 5.3% earns less than or equal to 25,000. In Ogu, 35.8% of the respondents earn less than or equal to 25,000 monthly, 20.7% earns greater than or equal to 55,000, 18.6% earns between 45,000 to 55,000, 14.7% earns between 25,000 to 35,000 only, 10.2% earns between 35,000 to 45,000. The average income distribution in the study area is shown in Figure 8. The result revealed that 20.6% earns less than or equal to 25,000, 15% earns between 25,000 to 35,000, 16.4% earns between 35,000 to 45,000, 25.5% earns between 45,000 to 55,000 while 22.6% earns above 55,000 per month.

4.13 Expenditure Profile of the Respondents

Figure 4.10: Household Expenditure on Items.

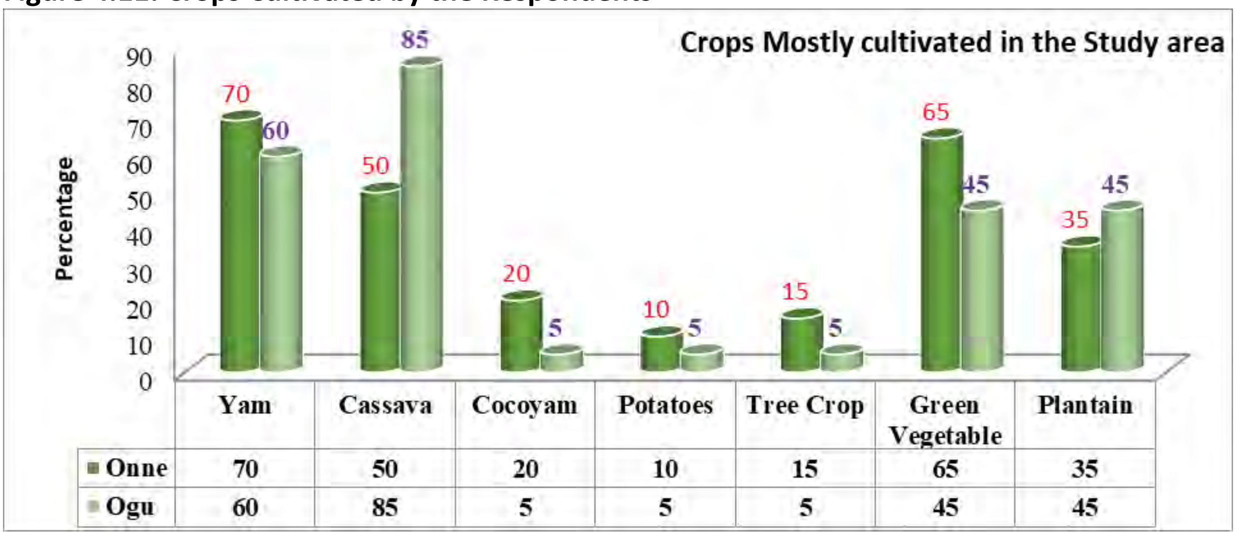


Source: Field survey, 2023

The expenditure profile of the respondents is presented in Figure 9 above. Result shows that, in Onne, most (over 50%) of the respondents spent their income on food, education, housing and transportation. 30% of their income is spent on health while 25% of their income is spent on clothing. In Ogu, a similar expenditure pattern was reported. Most (25%) of income is spent on food, education (15%), health (13%), transportation (11%), clothing (10%). The result revealed that most (70%) of their incomes were spent on basic necessities of life which include food, accommodation and clothing. Expenditures on transportation and education are increasing across the study communities.

4.14 Crops Mostly Cultivated in the Study Area

Figure 4.11: Crops Cultivated by the Respondents



Source: Field survey, 2023

Figure 10 presents the crops mostly cultivated by the respondents in the study area. Result revealed that, in Onne, the mostly (60%) cultivated crops are yam, green vegetables, cassava and plantain with few (40%) cocoyam, potatoes, tree crops, etc. In Ogu, cassava, yam, green vegetables, and plantain are mostly (60%) cultivated crops while potatoes, tree crops, cocoyam are among the few (40%) crops cultivated in the project area. Similar trends are generally observed in the study area. During FGD session respondents reported that palm trees, especially oil pals are recently cultivated in some areas.

4.15 Gender Dimensions by Economic Activities

Table 4.3: Gender Dimensions of Economic Activities in the Study Area

Occupational Activities	**Gender Disposition**				
Income Activities	Male	Female	Total	%	
Crop farming	21	43	64	13.3	Agric. And Agric Related Activities 78.94%
Animal husbandry	9	10	19	3.95	
Aquaculture	5	6	11	2.29	
Capture Fishing	31	78	109	27.71	
Fish Processing	11	21	32	6.67	
Trading on fish etc	12	19	31	6.46	
Trading on fishing gears/accessories	10	17	27	5.63	
Trading on foodstuffs and provisions	10	22	32	6.67	
Logging	15	4	19	3.95	
Forest resource gathering	12	23	35	7.29	
Civil/Public Service	9	4	13	2.71	NON-AGRIC 21.06%
Oil company Worker	6	3	9	1.88	
Artisants	13	20	33	6.88	
Transportation (water and land)	19	12	31	6.46	
Politics	6	3	9	1.88	
Others*	4	2	6	1.25	
Total	193	287	480	100	

Source: Field Survey, 2023

Table 3 shows the gender dimensions of economic activities of the respondents in the study area. Result revealed that, most (70%) of the women are involved in agricultural related activities (78.94%) (fishing, trading on food stuffs crop farming, processing, etc) while 3% of males are into production and sales of fishing gears. Result further illustrate that in the non-agricultural activities (21.06%), women (40%) are into forest resource gathering, artisans, etc. while men (60%) are involved in wood logging, transportation (water and land), company workers etc. The result implies that gender roles are scaled based on certain activities in the study area. More women are into farm and fishing related activities but played supportive roles in the various spheres of activities in the study area.

4.16. Prevalence prices sampled of food and Non-food items in the Study Area

Table 4.4: Price of Selected Food Items in the Study Area

SN	Commodities	Prevalent Prices (2022)
1	Beans	150-180 a cup
2	Garri	4 cups for 200
3	Rice	200-230 a cup
4	Beef	600-800 a kilo
5	Palm oil	700 a bottle
6	Groundnut oil	1200a bottle
7	Salt	100-150 per cup
8	Fresh periwinkle	100- 200 a cup
9	Eggs	50 per Egg
10	Banana	1500-2000 a bunch
11	Stock Fish	2300-2500 No.
12	Magic Seasoning	250-300 a packet
13	Crayfish	950 a plate
14	Shirts	200-500 a modu
15	Roasted fish (average size)	200-250
16	Skirts	500-2000
17	Wrist Watches	1000-3000
18	Wrapper	10000-25000 (Nigeria Wax)
19	Rubber Slippers	250 a pier
20	Pepper (fresh)	200 a plate

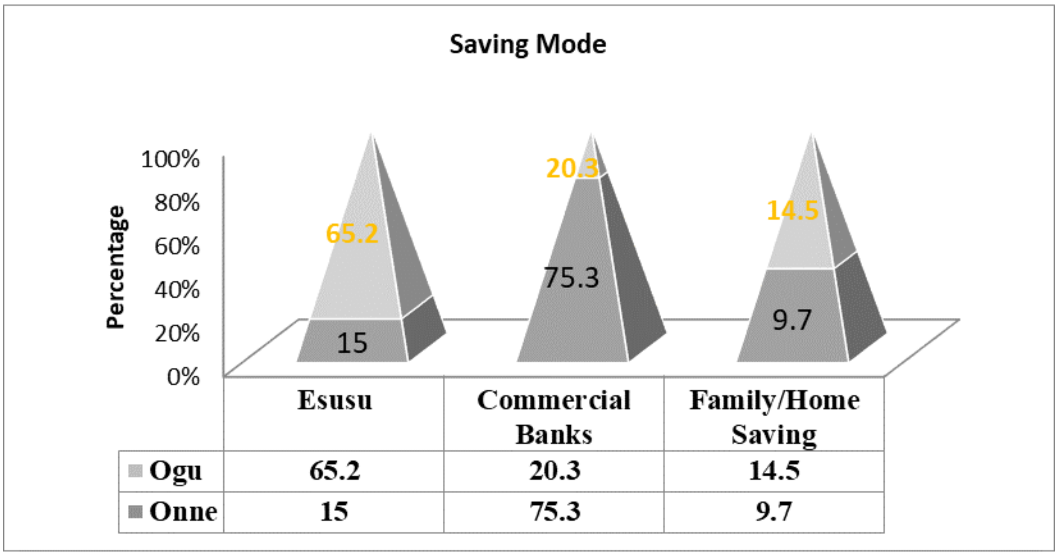
21	Tomatoe	150 a tin
22	Equisi	250 per cup
23	Ogbono	400 a wrap
24	Cover Shoes (open marker price)	1500-2500
25	Plastic buckets (medium size)	500
26	Fresh fish (average size)	1500
27	Plantain	2000-2500 a bunch
28	Paw-Paw/ Pineapple/Quara	200-500

Source: Field survey, 2023

Table 4: presents the prevalence prices of food and non-food items in the study area. The result revealed that there is increase in prices of items in the study area. Most (70%) of food prices were increased due to hike in petroleum products. Some respondents in the study area attributed increase in food prices, low agricultural production, inadequate land for agricultural production, etc. In Table 3, beans were sold for 150.00 to 180.00, rice is 200 to 230, groundnut oil is 1200 a bottle, a bunch of bananas was sold for 1500 to 2000, a packet of seasoning was sold for between 250 to 300, fresh fish of an average size was sold for 1500. Other prices are as presented in Table 4 above.

4.17. Savings Mode in the Study Area

Figure 4.12: Saving mode.

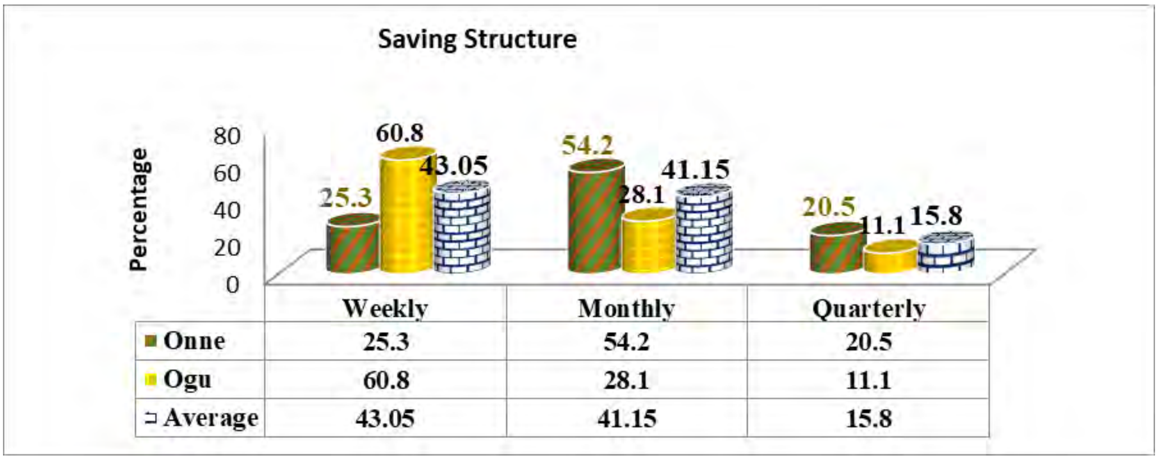


Source: Field survey, 2023

Figure 11 presents the various savings institutions in the study area. Result revealed that, 75.3% of the respondents in Onne saves money in commercial banks located in Port Harcourt town as well as high patronage of Point on Service Operators, 15% saves with the ***esusu*** group while 9.7% keeps their money at home/family member. The result further revealed a clear departure from Onne in terms of saving modes in Ogu community. In Ogu 65.2% of the respondents resorted to saving money with the ***esusu*** group, 20% save with the commercial banks while 9.7% of the respondents save money with family members or decided to keep their monies at home. The result implies that, the closer the community is to urban center, the more the number of formal financial institutions available and accessible to the respondents for savings.

4.17.1. Saving Structure

Figure 4. 13: Saving Structure in the Study Area

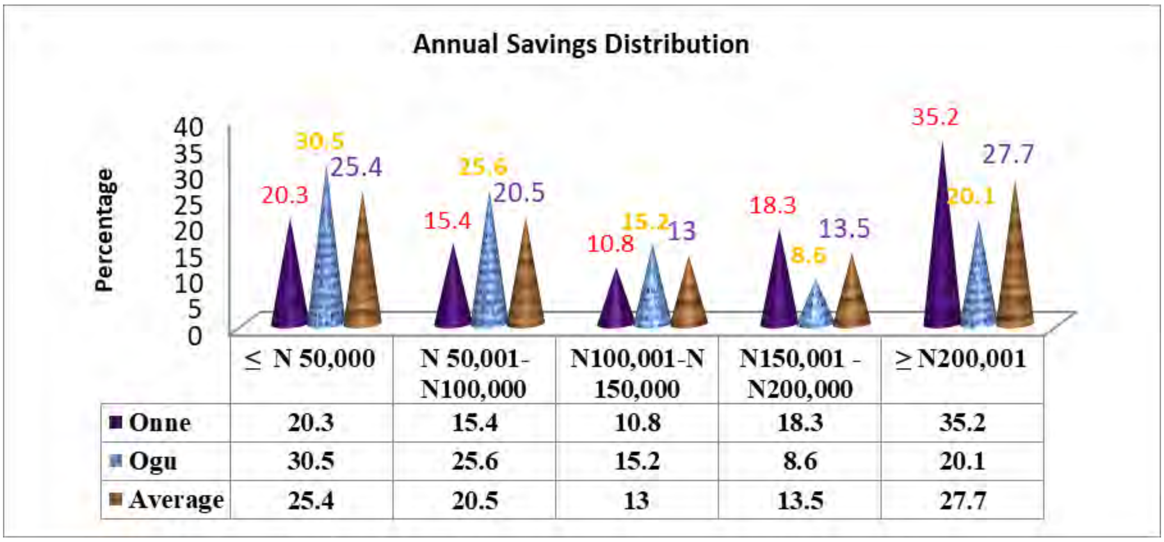


Source: Field survey, 2023

The saving structure in the study area is presented in Figure 12 above. Result shows that, in Onne, 54.2% of the respondents does their savings monthly, 25.3% and 20.5% saves on weekly and quarterly basis respectively. In Ogu, 60.8% of the respondents save their money weekly, 28.1% and 11.1% save on monthly and quarterly basis respectively. On average, the saving structure in the study area revealed that 42.05% and 41.15% of the respondents save their money on weekly and monthly basis while 15.8% saves every quarterly. During an FGD session, it was revealed that saving patterns in the study area are dependent on the type of occupation of the respondent.

4.17.2 Annual Savings Distribution

Figure 4.14: Annual Savings in the Study Area

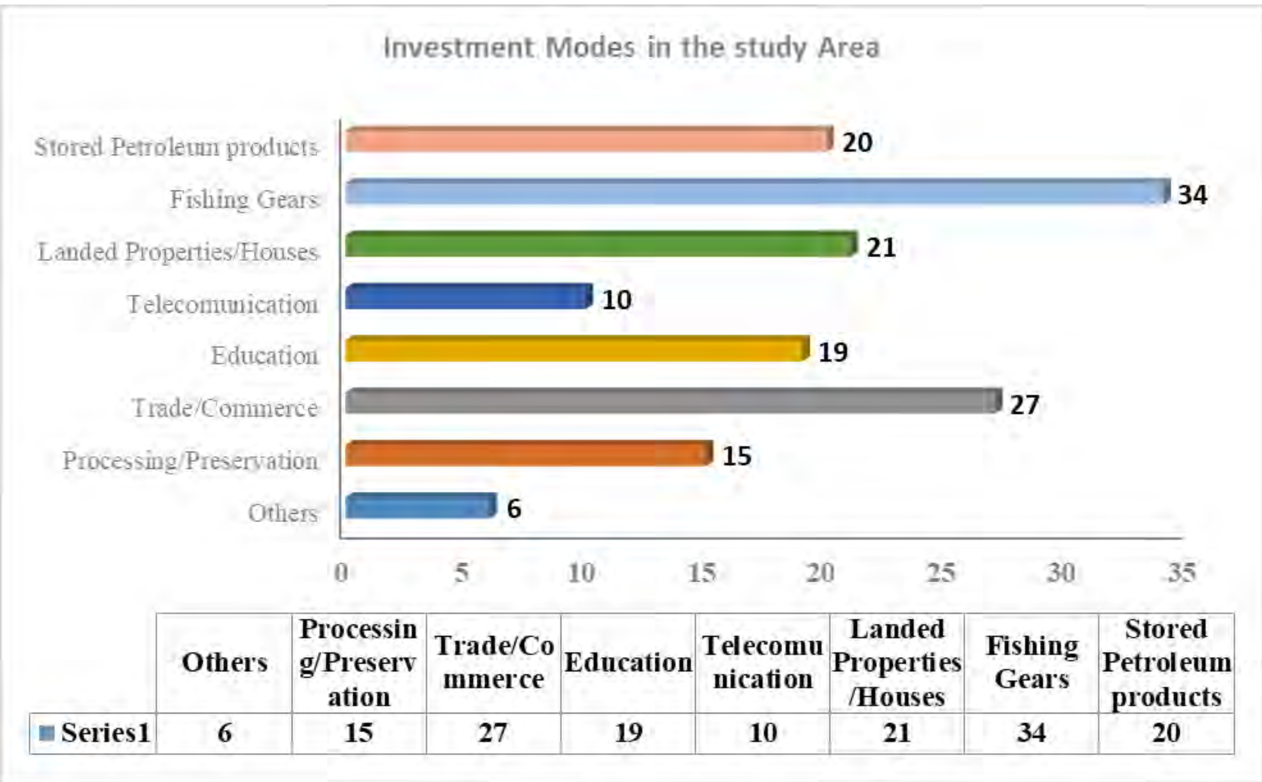


Source: Field survey, 2023

The annual savings by respondents in the study area is presented in Figure 13 above. Result shows that, in Onne 35.7% of the respondents saves between 50,000 to 100,000 annually, 29.2% saves between 101,000 to 150,000 while 35.2% saves from 200,001 and above annually. In Ogu 30% saves less than or equal to 50,000 annually, 25.6% saves 50,001 to 100,000, 15.2% saves 100,001 to 150,000, 20.1% saved from 200,001 and above while 8.6% saved 150,000 – 200,000 annually. The average annual savings in the project area are 25.4% for income group of ≤50,000, 20.5% for income group of 50,000 to 100,000, 13% for 100,001 to 150,000, 13.5% for income group of 150,000 to 200,000 and 27.7% for income group of 200,001 and above. The implication of this result is that respondents due to their economic and livelihood performance develop strong saving culture which in turn serves as a safety net to curb financial stress and enhances investment in the study area.

4.18 Modes of Investment in the Study Area

Figure 4.15 Investments Modes



	Others	Processing/Preservation	Trade/Commerce	Education	Telecommunication	Landed Properties /Houses	Fishing Gears	Stored Petroleum products
Series1	6	15	27	19	10	21	34	20

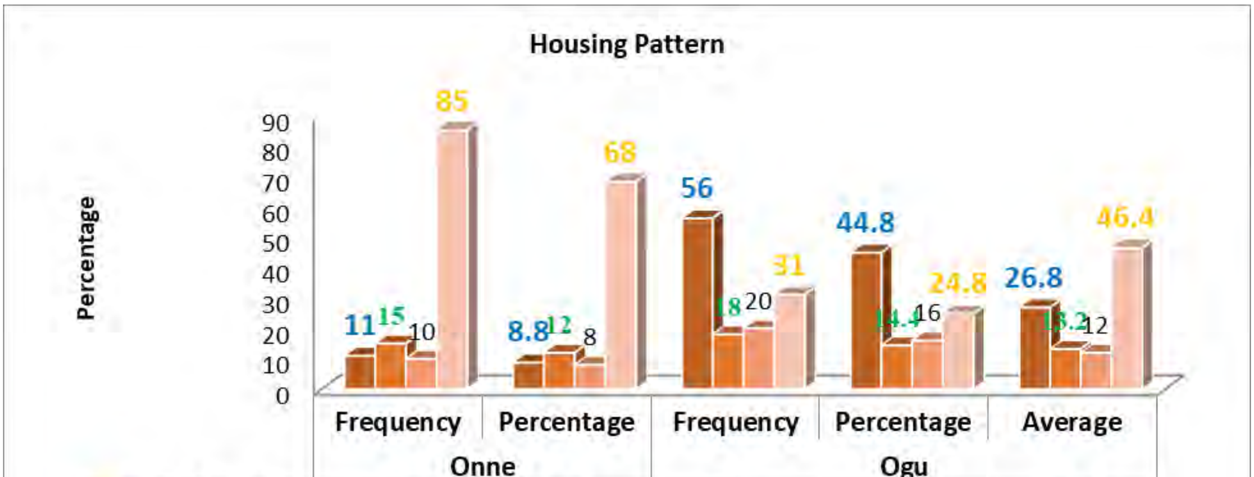
Source: Field survey, 2023

Figure 14 presents the investment modes by respondents in the study area. The result revealed that stored petroleum products, fishing gears, education, trade and commerce, telecommunication, landed properties and processing/preservation facilities are some of the modes of respondent's investment in the study area. Besides savings in commercial banks or with thrift associations (esusu), the respondents preferred to invest their money in the above ventures for ease of recycling their income.

Living Environment and Quality of Life

4.19 Housing Pattern

Figure 4.16: Housing pattern



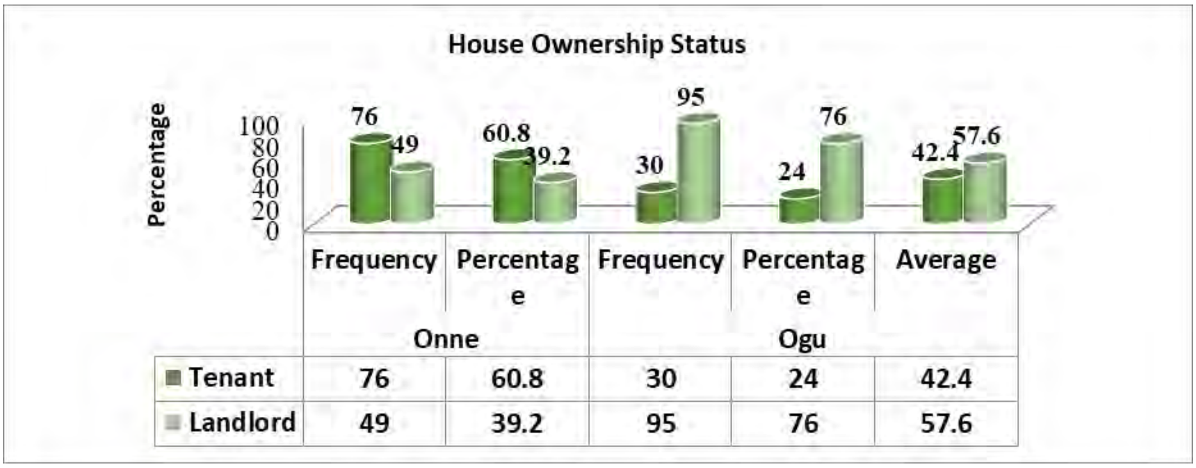
	Onne Frequency	Onne Percentage	Ogu Frequency	Ogu Percentage	Average
Thatch/Mud	11	8.8	56	44.8	26.8
Thatch/Cement	15	12	18	14.4	13.2
Zinc/Mud	10	8	20	16	12
Zinc/Cement	85	68	31	24.8	46.4

Source: Field survey, 2023

Shelter is one of the basic necessities of life. Expenditure on housing was found to be above 35% of total household income. The result presented in Figure 4.19 revealed that, most (80%) of the houses in Onne are built with block cemented walls and zinc roof. 12% of the houses are built with thatched zinc and cement walls, 8.8% are built with thatched roof and mud walls. In Ogu, 44.8% are thatched roof and mud walls, 24.8% of the houses were built with cement block walls and zinc roof, 16% were built with zinc and mud walls while 14.4% were built with thatched roof and cement block walls. Generally, the average result of housing pattern in the study area shows that, 46.4% of the houses were built with cement blocks and zinc roof, 26.8% with thatched and mud walls, 13.2% with thatched roof and cement block walls while 12% of the houses were built with zinc roof and mud walls.

4.20. House Ownership Status

Figure 4.17: Status of house ownership

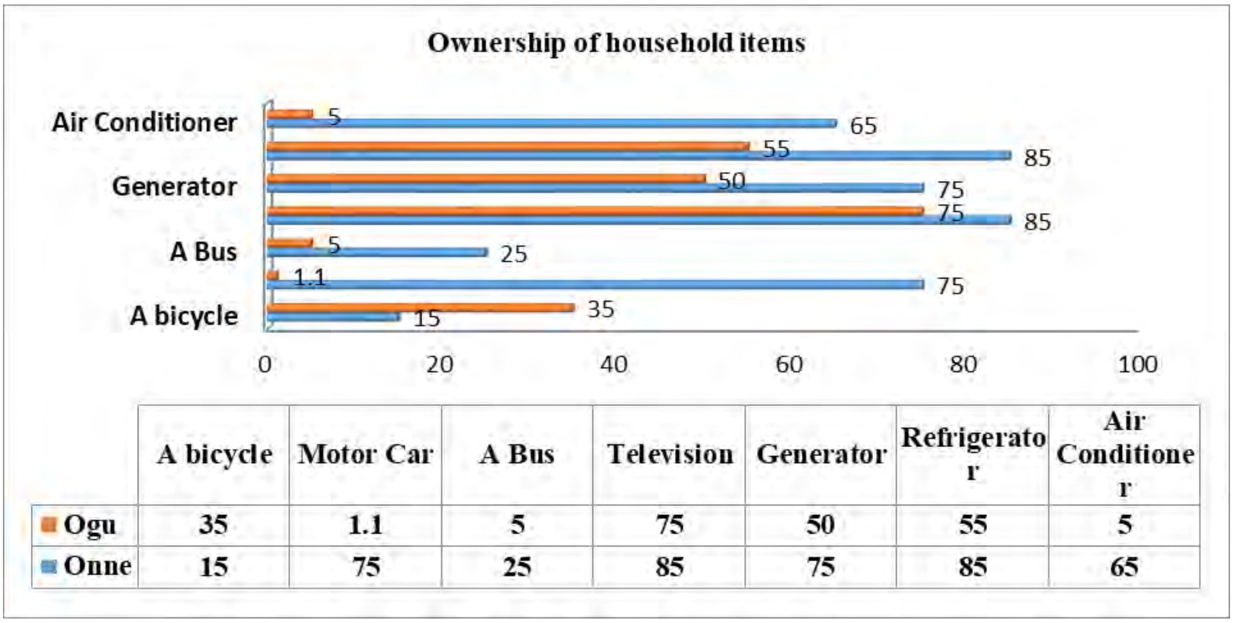


Source: Field survey, 2023

The status of house ownership in the study area is presented in Figure 16 above. Result revealed that, in Onne 60.8% of the respondents are tenants, while 39.2% are landlords. In Ogu, 76% are landlords while 24% are tenants. On the average, 57.6% are landlords while 42.4% are tenants in the study area. The result implies that, Onne being highly urbanized has more tenants that the landlords while Ogu has more landlords than the tenants. The result is consistent with previous studies in the area.

4.20.1 Ownership of Housing Items

Figure 4.18: Household Items

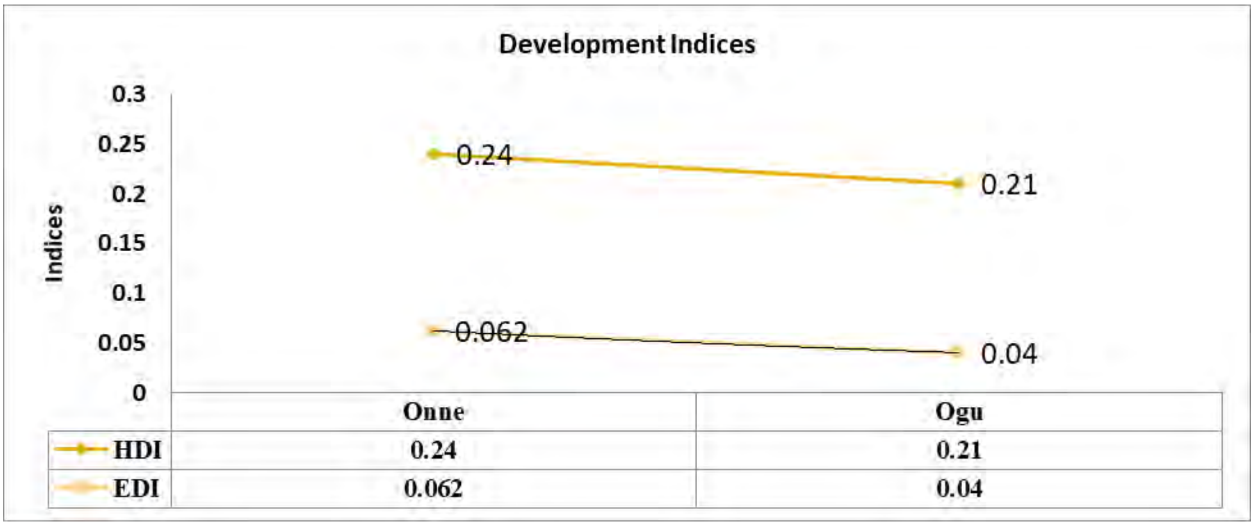


Source: Field survey, 2023

The household items owned by the respondents are shown in Figure 17 above. Result revealed that most (80%) of the respondents owns household items such as air conditioners, refrigerators, generators, television, motor cars, buses, especially in Onne, while 20% owns similar household items including bicycle.

4.21 Development Indices in the Project Area

Figure 4.19: Development Indices

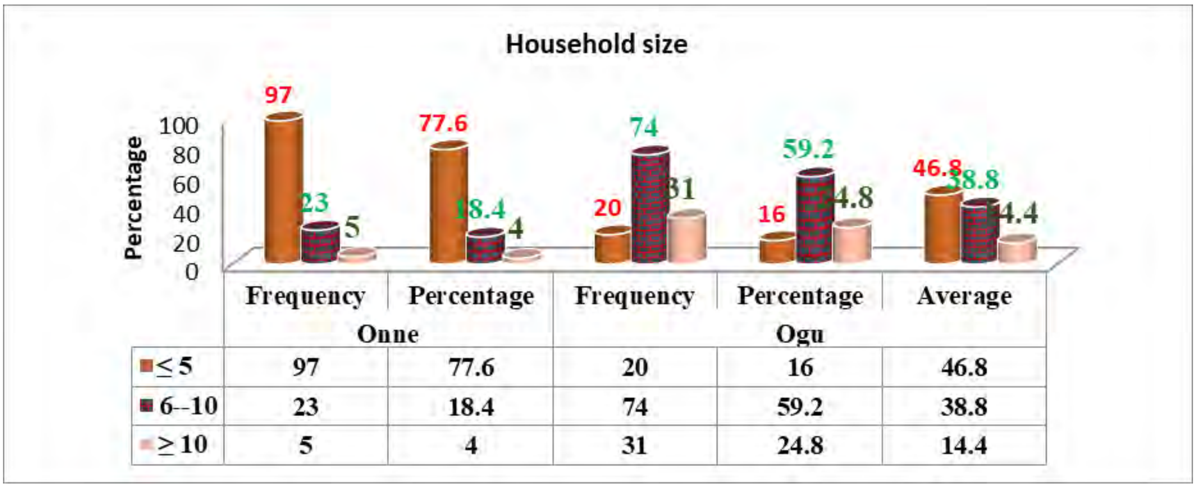


Source: Field Survey, 2023

According to United Nations (2018), the human development index serves as a comparative and reliable tool for vigorous public debate on national priorities- education, health, and income. Figure 4.19 shows the micro-level economic development indices in the study area. Result revealed that, in Onne, there is high health (0.24) and economic (0.062) development indices. This implies that, with the available health facilities in the study area, respondents had much access to the facilities, thereby leading to improved health conditions of the respondents as compared with Ogu community with a health and economic indices of 0.21 and 0.04 respectively.

4.22 Household Size

Figure 4.20: Household Size in the Study Area



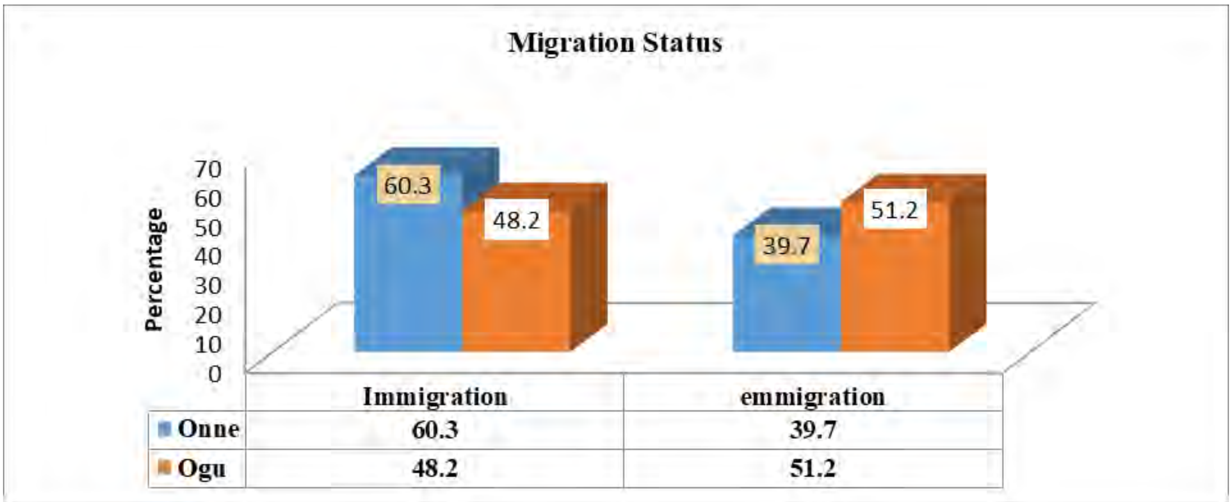
	Onne Frequency	Onne Percentage	Ogu Frequency	Ogu Percentage	Average
≤ 5	97	77.6	20	16	46.8
6--10	23	18.4	74	59.2	38.8
≥ 10	5	4	31	24.8	14.4

Source: Field survey, 2023

Figure 4.20 presents the result of the household size in the study area. It revealed that, in Onne 77.8% of the respondents has less than or equal 5 persons in a given household, 18.4% had between 6-10 persons while 4% had above 10 persons in a household in the study area. In Ogu, 59.2% had between 6-10 persons, 14.8% for greater than 10 persons and 16% for persons less than or equal to 5. The average for the two communities revealed that 46.8% of the respondents had less than or equal to 5 persons, 38.9% had less than or equal to 5 persons, 38.9% had 6-10 persons and 4.4% had less than or equal to 10 persons in the study area. This result implies that communities close to the shorelines tends to have more household sizes due to fishing activities in the area.

4.23 Migration Status

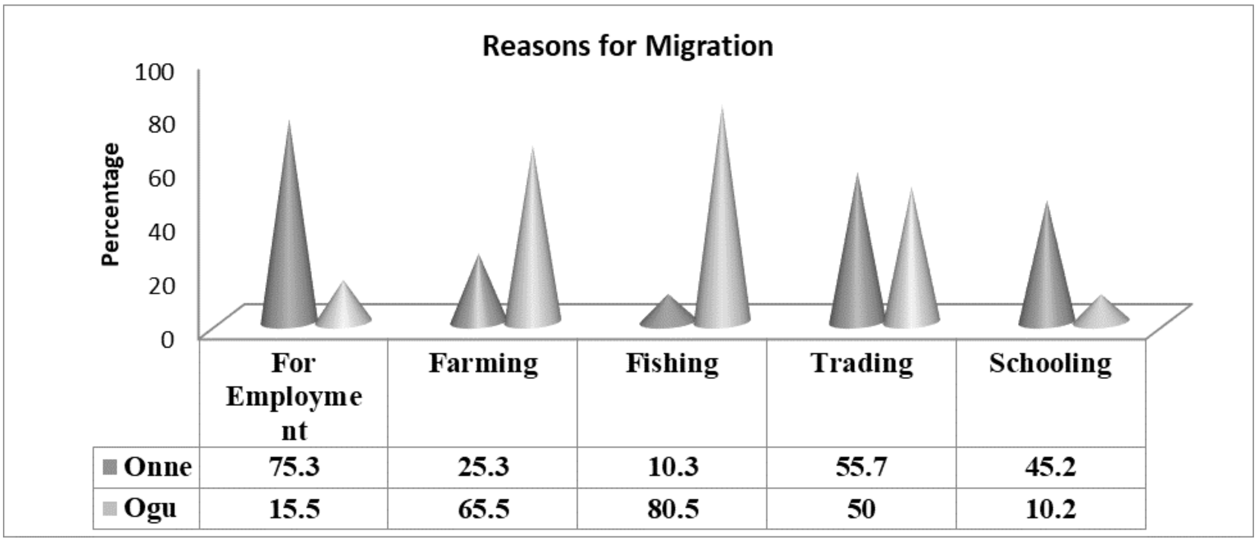
Figure 4.21a: Migration Status in the Study Area



Source: Field survey, 2023

Migration is another important demographic variable that determines/measures the movement of people in-and-out of a given place. Migration in the study area is a common phenomenon considering the settlement history, resource abundance and tempo of economic activity in the area. The migration status is the study area is shown in Figure 20 above. Result revealed that in Onne, 60.3% are immigrants while 38.7% were emigrants. In Ogu, 51.8% were emigrants while 48.2% were immigrants. The immigration/emigration survey considered the native or indigenes since age and others came in the area from another communities. This result is consistent with Akpan (2022), that resources availability in a given area determine the immigration status.

Figure 4.21b: Reasons for Migration



Source: Field survey, 2023

Figure 4.21b, clearly shows multiple responds for reasons why people migrate in the study area. The result revealed that; employment (75.3% and 15.3%), farming (25.3% and 65.5%), fishing (10.3% and 80.5%), trading (58.7% and 50%) and education (45.2% and 10.2%) in Onne and Ogu respectively.

4.24 Typology of Conflicts, Causes and Resolution Mechanisms

Table 4.5: **Causes and Resolutions of Conflict in the Study Area**

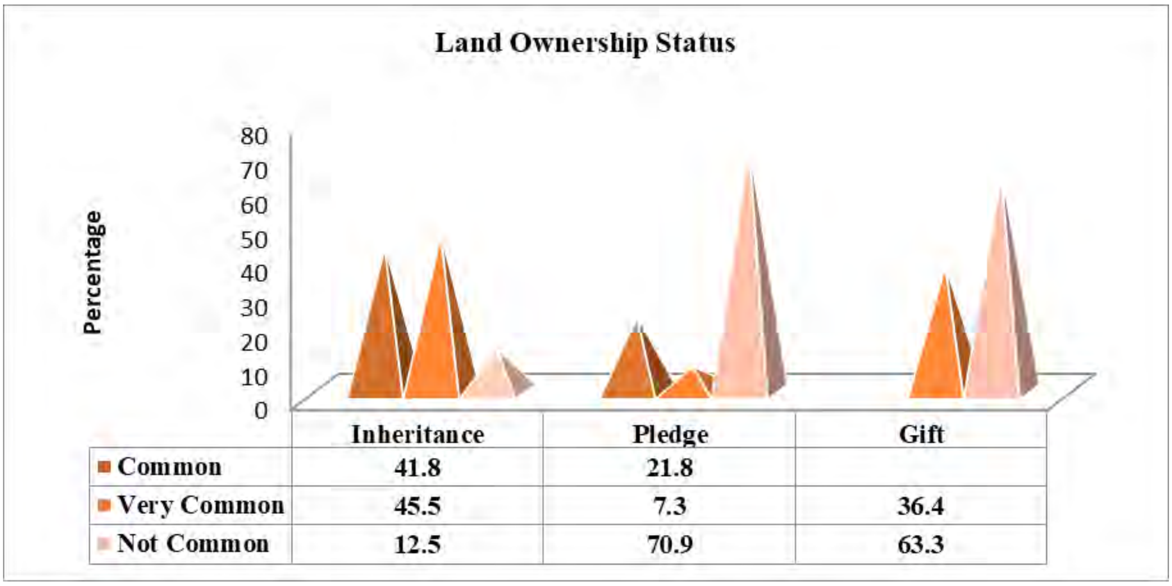
S/N	Type of Conflict	Major Causes	Resolution Mechanisms
1.	Conflict within families	Poverty, unemployment and marital infidelity kids	Family Head through dialogue
2.	Conflict between families	Power and authority, property sharing and rights	Family Head by dialogue.
3.	Conflict within communities and interest groups	Leadership tussle, resource sharing, sectional/family dominance and marginalization	Dialogue
4.	Conflict between communities	Resource ownership mainly water, land and forest reserves)	Dialogue/Conflict
5.	Conflicts between communities and companies	Not honouring MOU agreement, slow pace to community development	Dialogues and/or court ruling
6.	Conflicts between communities and government	Inadequate (lack) of infrastructural development projects	Dialogue/Court ruling

Source: Field survey, 2023

Conflict is inevitable in human and community relations. The critical issue is the capacity to manage conflicts when they arise. Table 4.5 above presents the types of conflicts, their major causes and possible resolution mechanisms in the study area. Conflicts do arise within families, communities, and interest groups, between communities and companies and with government. The major cause was traced to marital infidelity, power and chieftaincy titles, resource (water/land) ownership and infrastructure gap. The resolution mechanisms adopted include dialogues, and court adjudication.

4.25. Land Use and Inheritance

Figure 4.22: Land ownership status



	Inheritance	Pledge	Gift
Common	41.8	21.8	
Very Common	45.5	7.3	36.4
Not Common	12.5	70.9	63.3

Source: Field survey, 2023

Land is a free gift from nature, and it is a very important resource upon which human activities and livelihood is depended on. Figure 4.22 presents the status of land ownership in the study area. Result revealed that, 87.3% of the respondents in both Onne and Ogu communities admitted that the commonest means of land ownership is by inheritance; over 70% admitted that land ownership by pledge and gift is not common in the area. Though a very negligible number of people or communities do give their land either on pledge or by gift. Under these categories (pledge/gift), there are certain conditions attached to these methods. First, either the intended land seeker is a non-indigene who must have lived and contributed immensely to the development of the community for over 30 -40 years. Secondly, if he has the financial capacity to buy land in the area based on certain conditions given by the landlords.

4.26. Forest and Water Resources in the Area

Forest and water resources abound in Ogu and Eleme communities and other fishing ports in the study area. The aquatic resources especially fish, shrimps, lobsters, periwinkles, etc., are obtained from the rivers and creeks that are in the landlord communities and settlements. The communities are blessed with secondary vegetation and water swamps. Some of the forest's products are obtained from these forests. They include non-timber products such as fuel wood, wild fruits, medicinal plants, snails, vegetables, and spices. There are wide range of wildlife such as monkeys, crocodiles, snails, bush rats, birds, and vast variety of reptiles including snakes, grass cutters. There are no serious restrictions to access of forest resources shrines and other deities are located/revered.

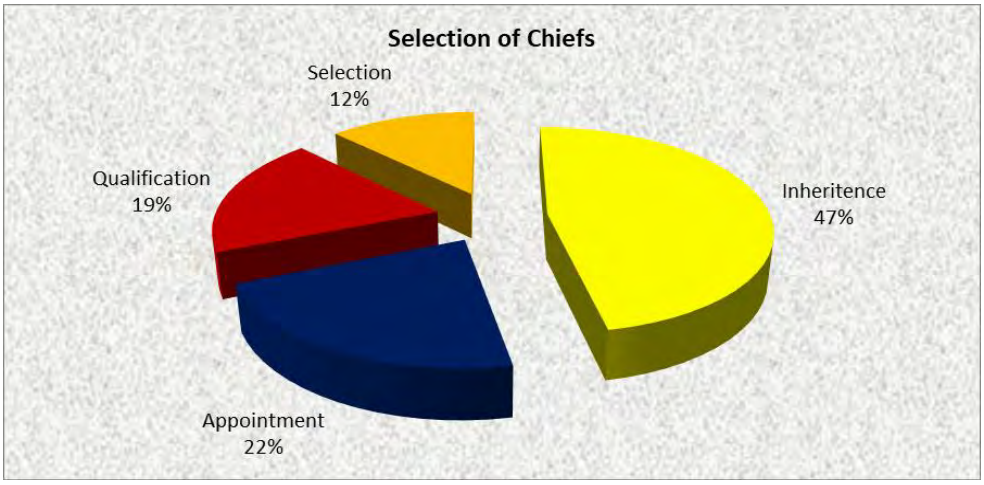
4.27. Traditional Institution and Power Structure

Figure 4.23: Structure of Traditional Administration and Power Structure

Village Head	Amanyanabo (Natural Ruler)
↓	↓
Village Chairman	Amadabo
↓	↓
Village Council	Paramount chiefs
↓	↓
Family Heads	CDC's
↓	↓
Households (Families)	Families

Figure 4.24a: Traditional governance structure at the community level

Figure 4.24b: Traditional governance structure at the ethnic level



Source: Field survey, 2023

The principal ways of selecting Traditional Rulers are shown in Figure 22c above. Selection by inheritance (47%), appointment (22%), qualification (19%) while election/selection (12%). These four (4) principals' methods were identified in the study area.

4.28. Religious Affiliation

Figure 4.25: Religious Institutions and Affiliation in the Study Area.

	Christianity	Islam	Free Thinker
Onne	88.5	5.2	6.3
Ogu	89	8.7	2.3
Average	88.75	6.95	4.3

Source: Field survey, 2023

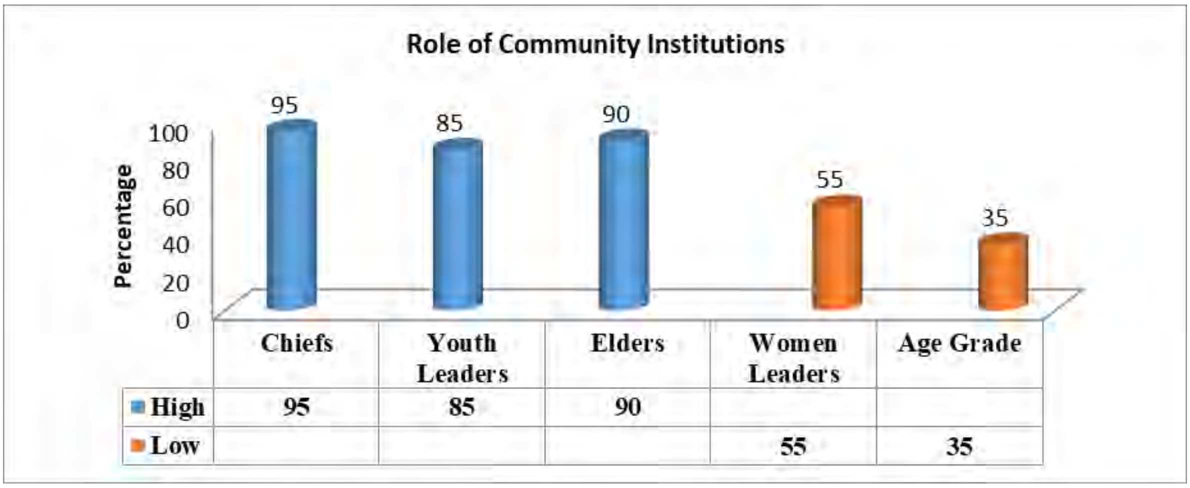
Religious affiliations in the study area are presented in Figure 23 above. Result shows that, in Ogu most (89%) are Christians, 8.7% are Islam, 2.3% are pagans/free thinkers. In Ogu, similar trend was observed as in Onne, as 88.5% of the respondents were Christian worshippers, 5.2% were Islam while 6.3% were pagans/free thinkers. See plates below.

4.29. Emerging Power Brokers in the Study Area

Stakeholders' analysis revealed that youth groups or organisations are wielding enormous power that seemingly interferes with the village council decisions. These groups are community Executives'/Village councils, youth association/youth executives, women associations, community development committee (CDC) Oil and gas committees. The aforementioned groups are very strong in terms of participation and influencing development decisions of the communities including the vigilante groups that work with respective village heads at the micro-level of governance and chairmen to ensure that laws and order made and effectively enforce in the project communities and other fishing settlements.

4.30. Roles of Community Institutions/Leaders

Figure 4.26: Roles of Community Leaders in the Study Area



	Chiefs	Youth Leaders	Elders	Women Leaders	Age Grade
High	95	85	90		
Low				55	35

Source: Field survey, 2023

There is a clear definition of roles played by each organ of traditional structure in the study area. Figure 24 above presents the result of the various roles and responsibilities of members in the project communities. Over 95% of the respondents admitted that the chiefs(kings), elders and youth leaders play a prominent role in ensuring that laws made are properly executed by the youths. Development projects and engagement with major stakeholders are properly implemented in line with agreed terms and conditions. The women and age grades which made up of 5% contributed to general sanitation, trade, agriculture, and security aspect in the communities.

4.31. Social Organization and Participation

Figure 4.27: Participation of Social Organizations in the Study Area

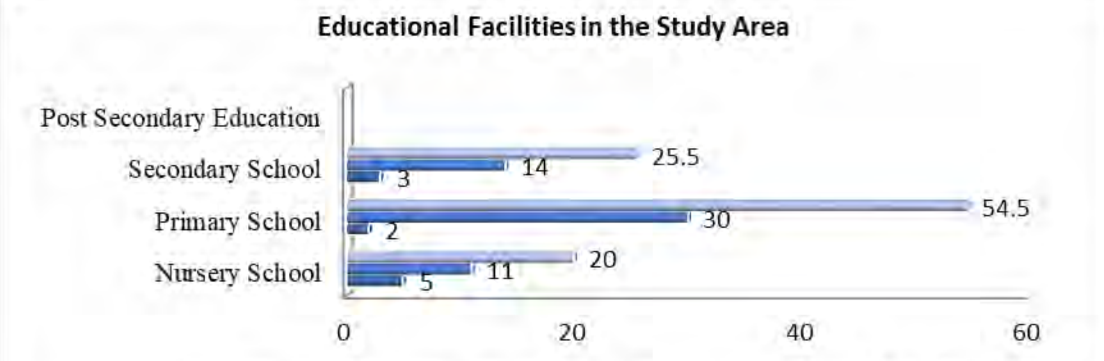
	Political Party	Cooperative Society	Social Club	Educational Group	Religious Organization	Cultural Organization
Onne Yes	75	55	70	50	30	65
Onne No	25	35	45	20	25	35
Ogu Yes	55	85	75	35	65	60
Ogu No	45	35	25	55	25	35

Source: Field survey, 2023

Result presented in Figure 25 above, revealed that across the two communities over 86% of the respondents admitted that participation in cooperative society meetings, social clubs, political parties, religious cultural organizations, education took center stage in the study area. Very few (14%) rarely do not attend to social organization meetings.

4.32. Infrastructural Facilities Mapping

Figure 4.28: **Educational Facilities**



	Nursery School	Primary School	Secondary School	Post Secondary Education
Percentage	20	54.5	25.5	
Frequency	11	30	14	
Number	5	2	3	

Source: Field survey, 2023

The educational facilities in the study area are presented in figure 26 above. The result revealed that primary and nursery schools provided by government and private individuals dominate (70%) the area to meet the educational needs of children in the area. Secondary education facilities (25%) are made available in the study area while tertiary education infrastructure constitutes only 5%. During FGD session, it was gathered that, most (80%) public schools are poorly equipped for pupils/students for learning and teaching. Besides, the facilities inadequacy, teachers to student ratio is very high (1:60 pupils) and (1:75 students) for the primary and secondary sections respectively.

4.33. **Mapping of Infrastructure**

Table 4.6 Infrastructural Facilities in the Study Area

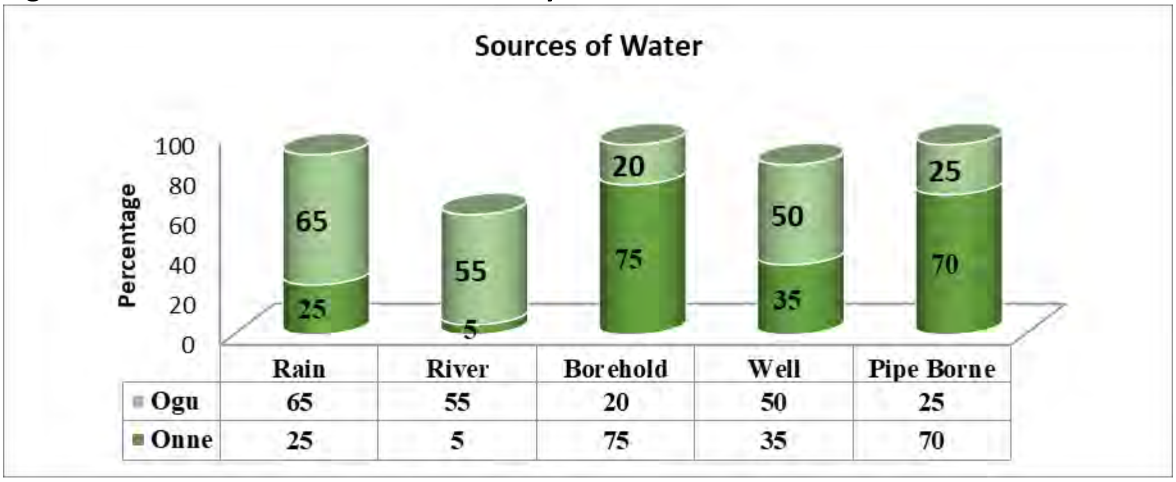
	Initiated		Completed		Donor Organization			
	Yes	No	Yes	No	Federal Govt.	State Government	NDDC	Local Govt.
Road/Bridges			100		√	√	√	
Health Center	80	20	100		√		√	
Electricity	80	20	100		√	√		√
Scholarship	90.5	9.5	100			√	√	√
Water Supply	4	96	100				√	
School Block	2	98	100				√	
Market Stalls	30.5	60.5	50	50			√	√
Micro-Credit Facility	15	75	100		√	√	√	

Source: Field Survey,2023

Table 5 presents the status of infrastructural facilities in the study area. Most health, educational, market and water and sanitation facilities were initiated, some have been completed and put to use while some have been abandoned. The mapping exercise revealed that these facilities were initiated by the federal, state, other agencies of government and companies operating in the study area. Other soft components of the facilities (scholarship, micro-credits, etc.) were provided in the study area.

4.34 Sources of Water Supply

Figure 4.29: Sources of Water in the Study Area



Source: Field survey, 2023

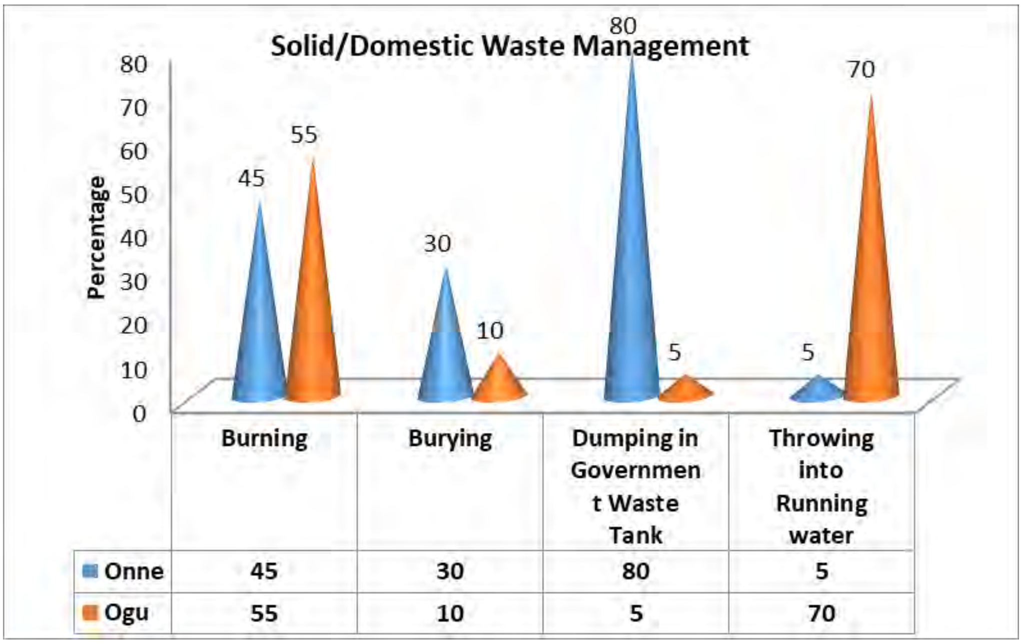
Water is one of the basic necessities of life. Its uses cut across domestic and industrial. Water plays a vital role in human health. Result shown in Figure 27 above revealed that, In Onne, 75% of the respondents relied on borehole as major source of water in the area and 25% in Ogu. The same result was obtained for respondents who depend on pipe borne water. In Ogu community and its environment, 65% depend on rainwater against 25% in Onne community. Also, 55% of the respondents in Ogu community depend on the river as major source of water against 5% in Onne. Both communities used Well as a source of water in the study area.

4.35. Domestic Energy

Energy is an important resource used by the respondents. FGD sessions revealed that most respondents make use of firewood especially in Ugu while most households in Eleme make use of gas as a major source of household energy in the study area.

4.36. Waste Management

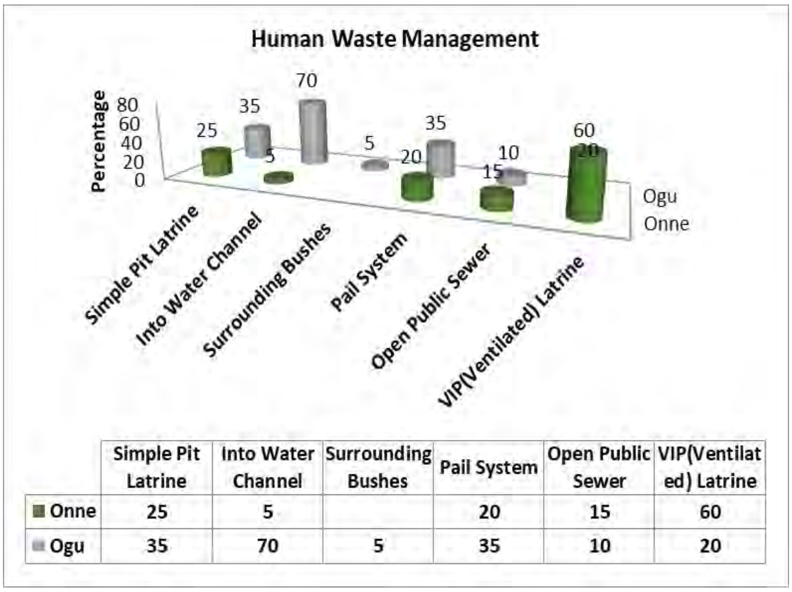
Figure 4.30: management of Solid/Domestic waste in the study Area.



	Burning	Burying	Dumping in Governmen t Waste Tank	Throwing into Running water
Onne	45	30	80	5
Ogu	55	10	5	70

Source: Field survey, 2023

Figure 4.31: Human Waste Management



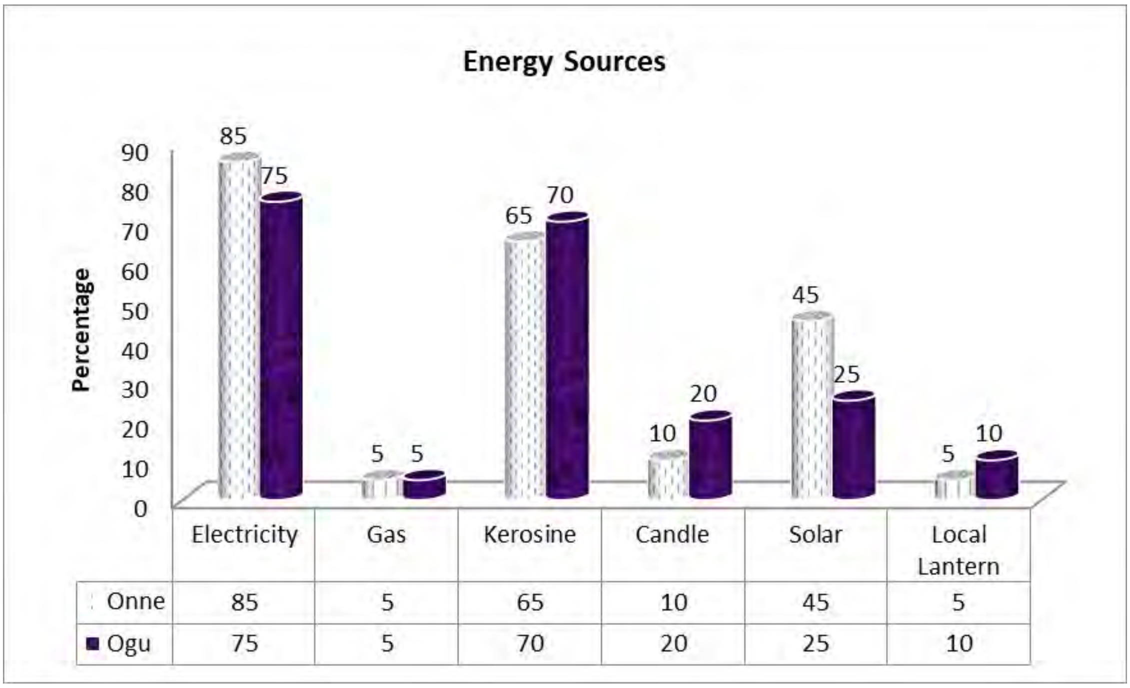
	Simple Pit Latrine	Into Water Channel	Surrounding Bushes	Pail System	Open Public Sewer	VIP(Ventilat ed) Latrine
Onne	25	5		20	15	60
Ogu	35	70	5	35	10	20

Source: Field survey, 2023

Waste has dual implications for human health. Poor waste management could lead to serious community health and disease outbreaks. Figure 28 above shows the different approaches/methods of waste management in the study area. In Ogu, 70% of domestic waste generated by households are thrown into the water, while only 5% of the respondents uses similar method in Onne. Similarly, in Onne over 80% of waste generated are dumped in government designated waste tank, while 5% of the same method is practiced in Ogu community. Result also shows that, burying of waste (30% in Onne and 10% Ogu) and burning (45% in Onne and 35% in Ogu) were methods of waste disposal. The various methods of human waste (faeces) disposal are shown in figure 28b. result revealed that, over 60% and 20% of the respondents in Onne and Ogu uses ventilated Latrine (VIP) respectively. In Ogu, 70% of the respondents use water channels, 35% each uses bucket system and simple pit toilet, while 10% uses open public sewer and 5% uses nearby bushes. In Onne, 25% uses simple pit latrine, 5% uses water channels (bodies), 20% uses open public sewer as methods of waste disposal in the study area. The implication of the result revealed improper waste management which could lead to outbreak of diseases in the study area,

4.37. Energy Sources

Figure 4.32a: Power Generation

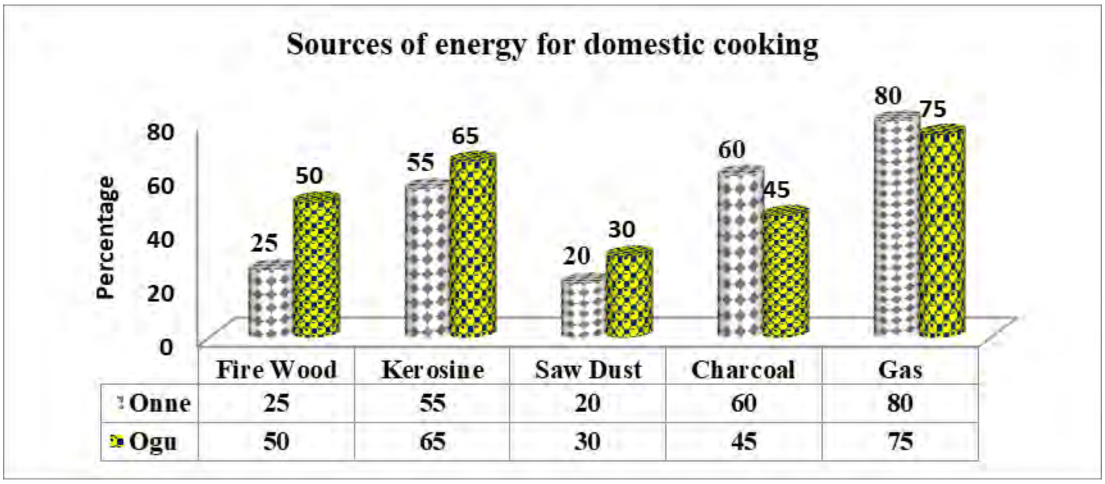


	Electricity	Gas	Kerosine	Candle	Solar	Local Lantern
Onne	85	5	65	10	45	5
Ogu	75	5	70	20	25	10

Source field Survey, 2023

Figure 29a presents the various sources of power generated in the study area. Both communities mostly use electricity as the major (over 80%) as the major source of energy to power electrical appliances in their homes. Other sources included kerosene (70%), solar energy (0ver 20%), local lantern (10%) and candle (over 20%). The general reaction by the respondents was the persistent increase in prices of these energies' sources in the study area.

Figure 4.32b: Energy Sources for Domestic Cooking



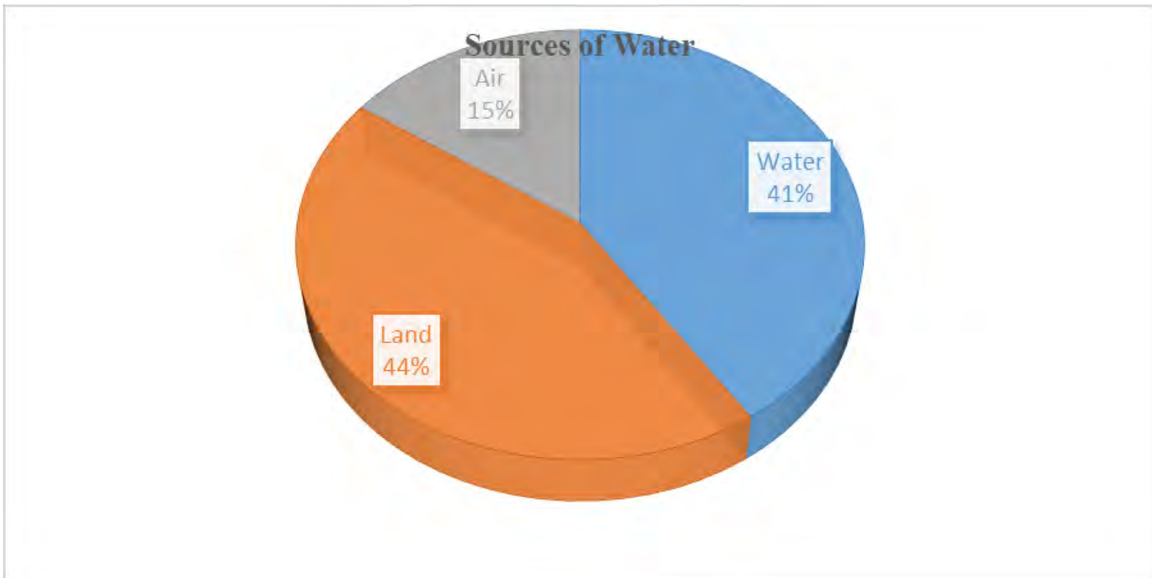
	Fire Wood	Kerosine	Saw Dust	Charcoal	Gas
Onne	25	55	20	60	80
Ogu	50	65	30	45	75

Source: Field Survey, 2023

The sources for domestic energy utilization for cooking are presented in Figure 29b above. The result revealed that, most (over 70%) use flammable gas, 0ver 40% uses charcoal, above 60% uses kerosene in both communities. In Ogu, saw dust and firewood were mostly used than the Onne households. Interaction with the respondents revealed that prices for gas and kerosene were relatively high despite the increased demand for these energies.

4.38. Mode of Transportation in the study Area

Figure 4.33 Mode of Transportation



SouSource: Field Survey, 2023

Figure 30 shows the result of the mode of transportation in the study area. land and water transportation are the commonest means of transportation and is represented with 44% and 41% respectively. Most of the heavy cargo materials are transported through water bodies to other countries. Mostly ships are used. Engine boats and other vessels are also massively used for this purpose.

4.39. Human Rights

A human rights impact assessment (HRA) is a process to systematically identify, predict and respond to the potential impact on human rights of a development project. There is no standardized global approach to addressing human rights issues with an ESIA. The study identified a quantitative model that and grouped human rights abuses as follows:

$$\frac{who\ may\ be\ affected}{elderly, people\ linimg\ im\ poverty} \quad \frac{from\ vulnerable\ to\ mangialized}{RWD, youth, migrants, minotities, influencial\ people\ etc.}$$

According to IFC (2023), the purpose of an ESIA is to identify the positive and negative impacts caused by a project. This is assessed through an analysis of the effects resulting from interaction between environmental and social components and the various activities of a project and its development.

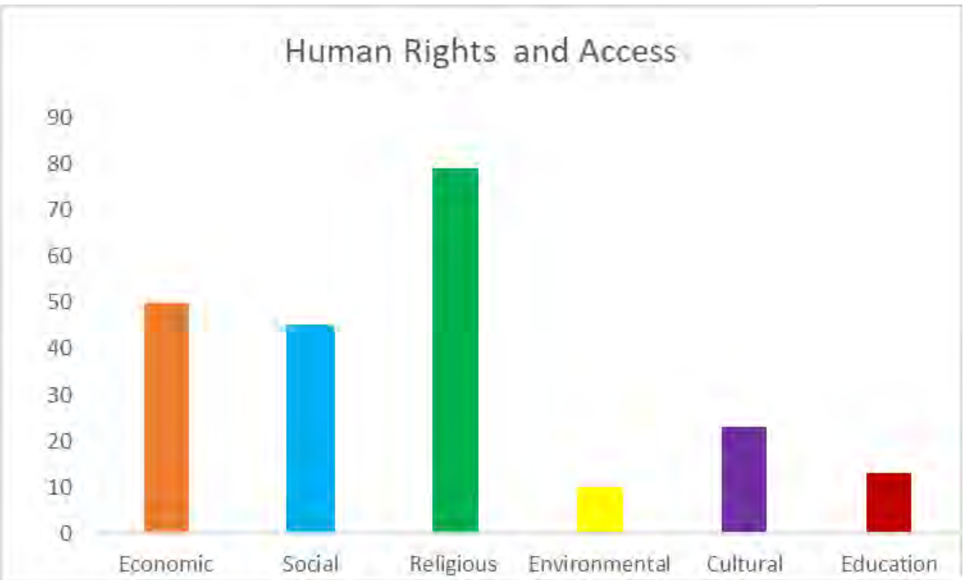


Figure 4.34 Source: Field survey. 2023

The result presented above shows the various areas of right denial in the study area. Over 70% of the respondents affirmed their rights and freedom to worship, 50% and 20% of the respondents reported that their rights to participation in economic and cultural activities respectively are not denied. The right to participate in cultural activities was promoted in the study area. Some respondents admitted that natural resources in the environment are affected which may cause some form of environmental and health problems in the area.

4.40. Cultural Heritage

The objective of a cultural heritage baseline study is to collect data/information in order to undertake an assessment of the potential effects of a proposed project upon cultural heritage sites and receptors within defined study area. Receptors can be tangible or intangible.

Tangible cultural heritage can include.

1. Archaeological and paleo-environmental sites and artefacts.
2. Historic and/or architecturally significant structures and buildings.
3. Historic districts
4. Historic or cultural landscapes
5. Religious sites, including cemeteries and cultural or sacred/spiritual sites.
6. Paleontological sites

Intangible cultural heritage can include.

1. Cultural traditions
2. Traditional knowledge
3. Festivals
4. Ceremonies
5. Music, songs, dance, and artistic expressions
6. Traditional lifestyle and customs.

The studied communities do not have tangible cultural heritage sites. Also, the project site is a sand filled site and not expected to have any cultural heritage. However, the studied communities have intangible cultural heritage. The study identified the following as the major cultural properties in the study area.

4.40.1. Food

Eleme main food crop is yam (***Esaa***). This is supplemented with Cassava (***Ojaku, Ojakpo***), which can be made into ***Nja Garri*** (Garri)***, Nja Ojaku (***Foofoo/Loiloi), ***Pipini ojaku*** (Tapioka slice cassava), ***mbiri*** (grinded cassava flavoured with ripe plaintain, a sort of moimoi but richer and costly than ordinary moimoi), Cocoyam (***Edente (Etoo Eleme), Etoo Akara, Echuru, Etoo Mmi –*** these can be cooked and eaten as ***obaa etoo*** or be pounded with enough palm oil and eaten with ***looloo mbalo*** as ***nja etoo)***.

4.40.2. Regulation of Behaviors

The behavior of Eleme indigenes groomed within the locality is regulated by the belief in the continued presence of the ancestors of each family as well as existence of deities endowed with supernatural powers. The average Eleme person will readily made confession when interrogated on issues for which he/she had knowledge or participation to avoid society's rejection if the matter goes to the level of swearing before a deity or in its name.

4.40.3. Eleme Traditional Dressing

Eleme culture regulates the type and manner of dressing that suits different occasions. That accounts for the prescription of different dressings for both sexes at any given occasion and this promotes decency and morality among the people of Eleme. Eleme culture forbids a man dressing like a woman, while a woman must not dress like a man.

4.40.4. Folktales and Story Telling

Stories and songs are instrumental in retaining languages and culture. Eleme folktales are particularly entertaining as they usually include a song with which the listener joins in. Stories are usually told in the evening to entertain adults and children alike. In addition to original songs, there is a rich culture for original composition of hymns – written and performed.

4.40.4. Arts and Crafts

Eleme people were once efficient craftsmen and women who produced mortals, pestles, drums, facemasks and masquerades, ladles, combs, chairs, boxes, among others. To meet their needs the Eleme people also produce clay pots, weave baskets, mats, etc. Painting is done mainly as a body decoration during festivals like wrestling, marriage, and ***ekpete*** dance.

4.40.5. Music

Traditional music in Eleme was developed out of the desire to transmit information. Singing and drumming were also developed for different types of occasions and ceremonies. Music is also an essential part of the Eleme culture.

Eleme cultural music includes: Mkpaa Ekoro, Mkpaa, Egɔni, Egelege, Ogolo, Ngelenge, Esɔ Mba, Esɔ Akɛ, Esɔ Ngwe, Esɔ Okea Ebiɛ, Kukunɛnɛ, Ebɔni, Ogolo Ejɛ, Ogolo Akɛ, and Kprikpɛ

- **Mkpaa Ekoro** – This is a dance music in which men demonstrate their bravery and/or affluence. It is as old as Eleme.
- **Mpkaa Egɔni** – It dates back to 1840 and remains a major talking drum of Eleme. Expert drummers use it to sing praises, encourage skills and bravery. Mkpaa Egɔni is the premier drum that is entirely indigenous to Eleme. It is customarily used for chieftaincy installation ceremonies and for yam title ceremonies. The burial of any traditional title holder is incomplete without mkpaa egɔni.
- **Egelege**– This is a talking drum whose drummers are versatile and is used to convey a lot of information that remains people of the past thus gingers them into wrestling or warns about the consequences of an individual's intended actions. Wrestling is the most popular sport in Eleme and egelege remains the special music for wrestling.
- **Ogolo**– This is a local xylophone played as major dance music during celebrations. There are three major drummers, each handling 4, 7, or 3 of the wooden instruments. There are other drummers that handle the *Ogũ*, *Okpo*, and *Ekere.*
- **Ngelenge**– Ngelenge has a similar setting like Ogolo. The distinguishing feature between Ogolo, Ngelenge and other forms of Eleme traditional music is that while the songs related to Ogolo and Ngelenge are rendered entirely through drumming, the songs associated with Egelege, Esɔ Mba, Esɔ Ngwe, and Esɔ Okea Ebiɛ are rendered by designated singers.
- **Esɔ Mba –** Esɔ mba is a musical group whose membership is confined to married women and widows. There are always Esɔ Mba groups in every Eleme clan or town and the group consists of two efficient singers and a concerted membership. Their instruments are "Egbe", "Ekere", and "Nsisaa". Their songs related to matrimonial problems and their solutions and are inspiring. Esɔ mba is also used to exposed immorality and control social behaviour among women folks.

- **Esɔ Okeaɛbiɛ –** Esɔ okeaɛbiɛ is rendered by a designated singer and is concerned with revealing whatever offence that was committed in secret. Because Esɔ Okeaɛbiɛ convened a lot of information concerning evil deeds or deviant behaviours of individuals and families, it acted as, ***"social or cultural means by which systematic and relatively consistent restrains are imposed upon individual behaviour and by which people are motivated to adhere to traditions and patterns of behaviour that are important to the smooth functioning of a group or society".***
- **Esɔ Akɛ** – This consists of songs specially designed to encourage wrestlers. There is the lead singer and another person who sings an undertone to support him as well as maintaining the *Ekere* that provides the rhythm.
- **Esɔ Ngwe** – This is another set of songs that relate to farming of yams and/or agriculture and the glory of acquiring the highly esteemed Eleme Yam Titles of Aachu, Obo, Obɛrɛ Obo, Otaa Obo, and Achuete. Esɔ Ngwe is known to have given much encouragement to individuals who ordinarily were not inclined to taking any of these titles, as it made them reflect on their ancestors and proceed to taking two or more Yam Titles.
- **Kukunɛnɛ, Ebɔni** and **Ogolo Ejɛ** – These are ancient music played by warriors or secret cults in Eleme. They can be played at any time or day, especially during emergency or community threat; or at midnight and only members of the cults concern participate. A lot of secrecy is associated with them, but they ginger their members into action. They are played mostly during funeral ceremonies of members or during their meetings or initiations.
- **Esɔ Eduduu, Kprikpɛ** and **Ogolo Akɛ** – These are music of warriors, community defenders ***(Oku Ejɛ)*** and wrestling champions.

4.40.6. Musical Instrument

Eleme musical instruments include, musical pot, gong, flute, horn, wooden drum, split wooden drum, egbe, nsisaa, okpo, ogu, ogela, ekere, and so on which produce sounds by hitting, shaking, beating, blowing in the air, and rubbing them against one another.

4.40.7. Dance

Eleme Dance refers to the dance of Eleme people. Eleme dances teaches social patterns and values; and help people work, mature, praise, or criticize members of the community while celebrating festivals and funerals, competing, reciting history, proverbs, and poetry as well as to encounter the gods.

Few Eleme dances worthy of mention include:

1. **Eje Ekpete** - This is a common dance among the Eleme women folks.
2. **Eje piopiopioo** – It is the girls that dance piopiopioo. The style is exciting, percussive footwork danced bear footed at a particular temple on whistle, fiddle or mouth music. That is beating one's heels, toes, and feet in as many ways as possible and imaginable, keeping time with the rhythms of the music in reel and jig time.
3. **Eje Alikirijã** – There are many styles of alikirijã dance that can be demonstrated. The style has never been prescribed, except dancing steps neat and close to the floor. Many alikirijã dancers have their own individual style and steps they like to do to particular tunes.
4. **Eje Agala-** Dance for the boys and girls.
5. **Eje Mbɔkɔ/Ngelem** – Wedding dance for new brides.
6. **Tamkpe Eje** – Dance for both male and female irrespective of age.
7. ***Okeri Eje*** This is the most popular dance step in Eleme. It is waist dance that is performed by both men and women. ***Okeri Eje*** dance step has been perfected in Eleme that both men and women use it to dance all types of music.
8. ***Eje Echīi Osila*** This is first daughter dance. In Eleme, every first daughter is entitled to this dance (as of right), and it is the only dance in which the dancer's legs never touch the ground. The new bride, who must be first daughter, is usually dressed in a mountain of expensive clothes arranged in concentric circles round her waist. She will put on her legs/ankles heavy bracelets (***abarachwa)***, heavy coral beads round her neck and both wrists, together with a ceremonial staff with white handkerchief tied on top of it. She also wears short skirt with her body exposed, carried on the shoulder of an able-bodied young man, and she dances the ***ngelem*** music to and from the market, hailed all along by jubilating crowd of admirals.

Let it be stated here that Eleme traditional music and dance and accompanying activities are now on the decline because the generation of expert singers, drummers, wrestlers, and so on has given way to another generation of footballers, disco dancers, and cultural alienators.

4.40.8. Traditional Festivals

Eleme traditional festivals include:

- ***Agba Esaa–*** This is the ceremonial conferment of graded traditional yam titles of Aachu, Obo, Obere Obo, Otaa Obo, Achuete, and Ewoachunsin. These degrees conferred on the recipient certain rights, privileges, and honours, and are recognized throughout the Eleme country.
- ***Agba Esun –***Agba Esun (or New Yam Festival) is celebrated to express gratitude to the ancestors and to the living elders. The sacrifice known as "Ɔtɛbɛ Enu" is offered annually, usually in October, in the belief that the ancestors who have transformed to spirits upon their death are still very much around, seeing everything they are doing and trying on their part to guide and protect them; and who labored to cut the virgin forest and gradually reduced them to farmlands desired the first fruits. The sacrificial offering usually consists of one cradle (now basin) of good yams, drink, fish, fowl, or goat and other condiments.
- ***Ogbo Nja***– This is a cultural festival for children and new brides where parents, husbands, mothers-in-law, and fathers-in-law present gifts to their children, new brides, and relatives; where children make new friends and eat happily and freely from community to community; and where women in their best and newest dresses sing, dance, and rejoice for being hardworking, healthy and sensible enough to sustain the growth of their children throughout the year.
- **Ogbo nja** is celebrated between the 13^{th} and 20^{th} of July annually depending on the position of the moon and traditional weekday known as Ɔkɔɔ. Ogbonja festival is celebrated for two consecutive days. Day one known as Ɔkɔɔ Ɔbibai Etoo is for women while the next day called Mma Agba Okundo is for men.
- **Agba Nkikɛɛ –** This festival is celebrated annually on Ochu within the second week of March in honour of Nkikɛɛ, the Earth goddess, and to mark the beginning of the planting season. Five days thereafter, precisely on the next Ochu another related ceremony called "Agba Etenchi" is marked, again to inform all and sundry of the commencement of the year's farming season. Although only the initiated elders (Oku Nkpɔrɔ and Oku Nyoa) are involved in both festivals, it is used to communicate the beginning of a farming season, which resulted in both the young and old participating actively in farm work.
- **Obira Asã –** This is lovers' festival or celebration day; a sort of Valentine Day. It is also the final day for wrestling competitions across Eleme.

- **Ɔla Mba** – This is Eleme's wedding festival day. It was previously celebrated once a year, in June.
- Other festivals worthy of mention are: **Agba Mba, Agba Okundo, Oɔe Akɛ,** and **Agba Obibai Etoo.**

4.40.9. Masks and Masquerades

Masks and masquerades are important elements of culture. In Eleme masks and masquerades are generally called ***Owu***. Most owu are named after their bearers. However, there are few outstanding masks and masquerades in Elemeviz: Ebɔni, Ete Okolaa, Nkɔnkɔ, Ogolo Kurukuru, Akparaloloo, Dededede Ebiri

4.40.10. Marriage

Marriage is a highly respected institution in Eleme culture. The Eleme culture recognizes marriage as a union between man and woman in holy matrimony. To the people of Eleme, marriage is not only the coming together of man and woman in holy matrimony but, also a union of two families and two people for mutual benefits. The Eleme culture promotes polygamy and encourages intra Eleme marriage. An Eleme man is expected to marry Eleme woman as first wife and is then free to marry from any other tribe or ethnic nationality. Because the culture frowns at Eleme man marrying first wife from outside, it accords no marriage recognition to those who do so, and they are exempted from participating in several cultural activities including taking of yam titles, admission into Ogbo Nkporon and conferment of traditional chieftaincy titles. This once cherished tradition has been bastardized. Do not ask me how and why because we all know it.

4.40.11. Greetings

Greetings remain an important aspect of culture. Greeting is regarded as a sign of good behavior. It is expected that children greet their parents, teachers, and elders whenever and anywhere they see them. Eleme has no special way and manner of greeting. Although, the mode of greetings in Eleme has changed over the years, perhaps proving that culture is dynamic, this has been highly influenced by the English Language and tailored in that direction of our colonial masters. To my mind, ***Ade Ageta*** (Good Morning), ***Nnyimɛ Eɔera*** (purported to mean, Good Afternoon) and ***Mmuji Abã*** (Good Evening) are acceptable manner of greeting which should be adopted by all in keeping with changing times.

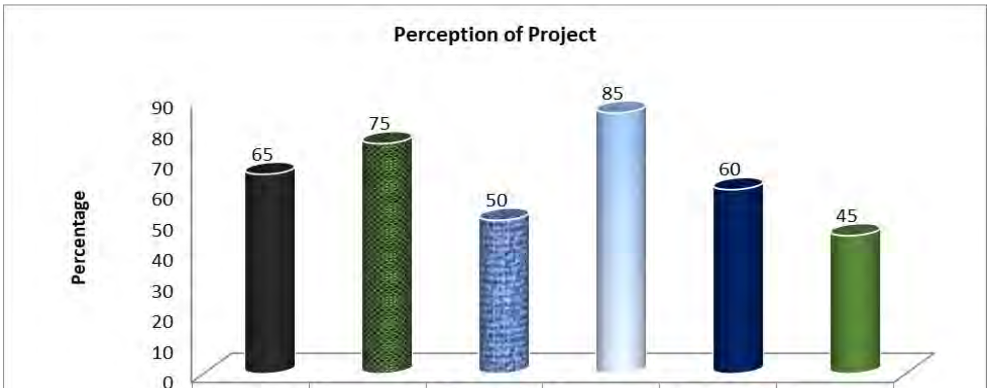
4.40.12. Traffic and Transport

Traffic is potentially a critical community safety concern. Survey indicates reasonable volumes of vehicular movement in the study area which include Cars, Trucks, Lorries, motorcycles including Bicycle etc.

4.40.13. Modern Means of Communication and Security Apparatus in the Study Area

Communication is very vital in human society. Besides the use of drums and palm fronts in the study area and in traditional settings, the study found that, there are several modern means of communication with the use of mobile phones, internet services etc. by various telecommunication providers in the study area. They are MTN, glo mobile, airtel, Etisalat etc. These means of communication also make use of certain platforms such as WhatsApp, twitter, etc. These facilities enhance financial transactions and other communication needs in the study area. There are heavy security agencies to ensure the protection of life and properties in the area.

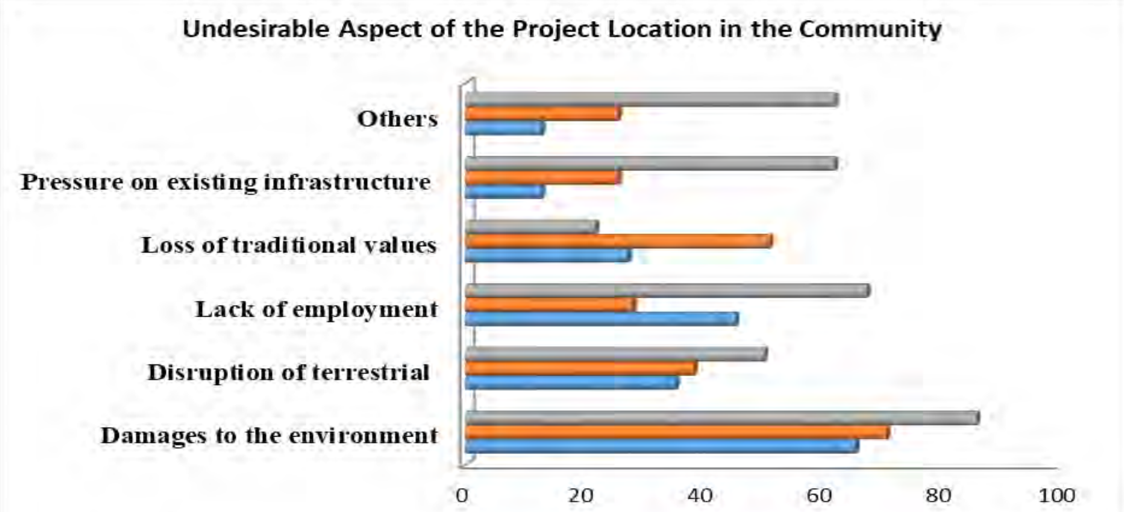
4.41. PERCEPTION OF RESPONDENTS



	Increase Employment	Improvement in Infrastructure	Scholarship	Taxes to Government	Opportunities for Contract	Improvement in Social Services
Percentage	65	75	50	85	60	45

Figure 4.35: Perception of Respondents

The figure above shows the perceived expected benefits of the proposed project by the respondents in the study area. Result shows that, over 85% of the respondents admitted that the proposed project will generate taxes to the government, 75% of the respondents were of the opinion that the project will bring about improvement in infrastructures, employment opportunities (65%), scholarship (50%) and improvement in social services (45%)



	Damages to the environment	Disruption of terrestrial	Lack of employment	Loss of traditional values	Pressure on existing infrastructure	Others
5.1-10.0 (%)	85.6	50	67.2	21.8	61.8	61.8
3.1-5.0 (%)	70.5	38.2	28.1	50.9	25.5	25.5
1.0-3.0 (%)	65.3	35.2	45.2	27.3	12.7	12.7

Figure 4.36: Source: Field Survey, 2023

Given the beneficial effect the project will bring to the communities, respondents also view their undesirable perceptions of the project. From the figure below, the perceived adverse effects by the respondents on the establishment of the proposed project in the communities are ranked according to order of importance. Results show that 85.6% of the respondents expressed concern about the destruction/ damages of their environment by the project, which was rank high, 67.2% were of the opinion that it will create unemployment. Respondents also admitted that their ancient culture and tradition will be taken away from their proper positions and may lose over time, but their land must be developed (27.3%).

4.42. HEALTH IMPACT ASSESMENT

This section presents the baseline health data based on information generated from sampled groups in the study communities. The data relies on self-reporting, presumptions by respondents in the survey and data from the health centers in the area. The methods of data collection include but are not limited to questionnaire responses, focus group discussion, interviews, and personal observations.

4.42.1. Consultations

The study deeply engaged the relevant stakeholders in the communities as well as the health personnel in the facilities visited using relevant consultation approaches required in the community health assessment. Consultation is the process of asking for information about the environmental health implications of projects subject to Impact Assessment process from designated bodies, organizations or persons with environmental responsibilities or interest. Practices relating to consultation and particularly to public participation was strongly influenced by the culture, the educational level and the political consciousness in the jurisdiction concerned.

4.42.2. Health-care facilities

The communities of Onne and Ogu are blessed with primary Healthcare Service Centers. There is however a lot of private clinics, maternities, medical laboratories, and pharmaceutical/chemist shops in Onne than Ogu. Some of these health facilities include general hospitals, Primary Health Care Centers, Private medical clinics, and Maternities.

Table 4.7: Health-care facilities

Health Facilities	ONNE	OGU
Health Center	Community Health Center Onne	Bolo Comprehensive Health Center Ogu/Bolo 10
	Model Primary health center	Wakama-Ama Primary Health Center Ogu/Bolo 11
		Chuku-Ama Primary Health Center Ogu/Bolo 3
		Ogu Model Primary Health Center Ogu/Bolo 4
		Ogu Model Primary Health Center Ogu/Bolo 5
		Ikpo-Ama Primary Health Center Ogu/Bolo 6
		Opuama Primary Health Center Ogu/Bolo 6
General Hospital	General Hospital Onne	Ogu General Hospital Ogu/Bolo 4
		Owuogono Primary Health Center Ogu/Bolo 6

In the communities the medical team identified many traditional medicine practitioners, few Traditional Birth attendants who in their limited capacity still assist and complement orthodox Healthcare delivery.

4.42.3. Facilities Available in Communities

Communities	G Hospital	Primary Health Centre	Private clinic	Traditional
Onne	√	√	√	√
Ogu/Bolo	√	√	√	√

√ Presence; X Absence

4.42.4. Utilization of Primary Health Services.

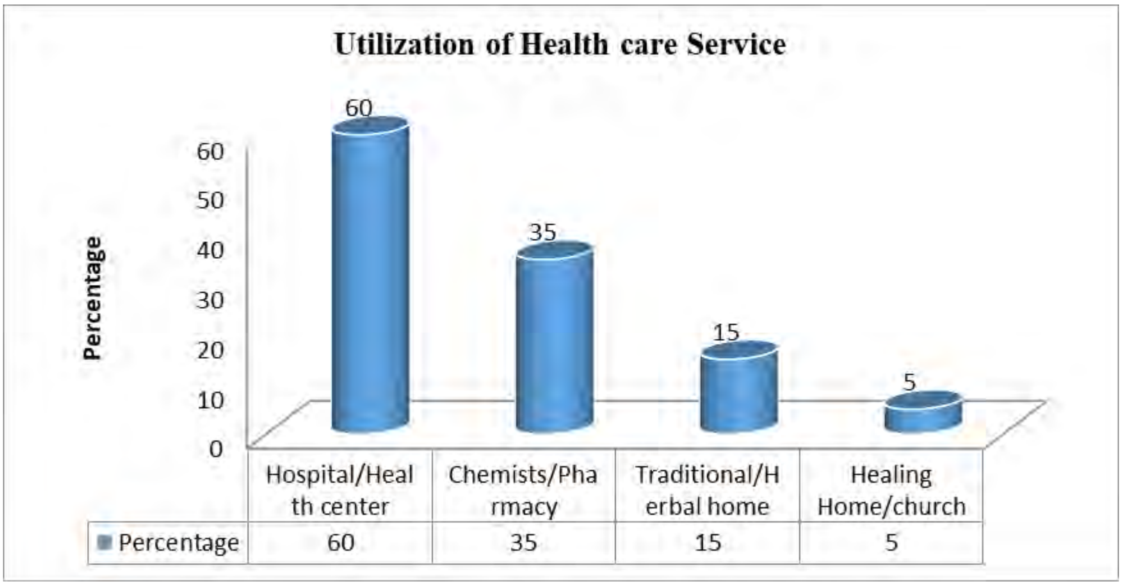


Figure 4.37: Utilization of Health care Service

The figure above shows the utilization of health service by the respondents in the project communities. From the figure, on average, 60% 0f the respondents utilize hospital/ health center as their preferred source of medical treatment, 35% patronizes chemist/pharmacy while 15% and 5% utilizes traditional medical practitioners and churches respectively. Surprisingly the use of clinics for birth delivery is relatively low. Patients prefer to go to traditional medical practitioners, churches, and untrained traditional birth attendants. The reasons are many and varied according to our informants. Some of the reasons include but not limited to

4.42.5. Reasons for the Preferred Choice

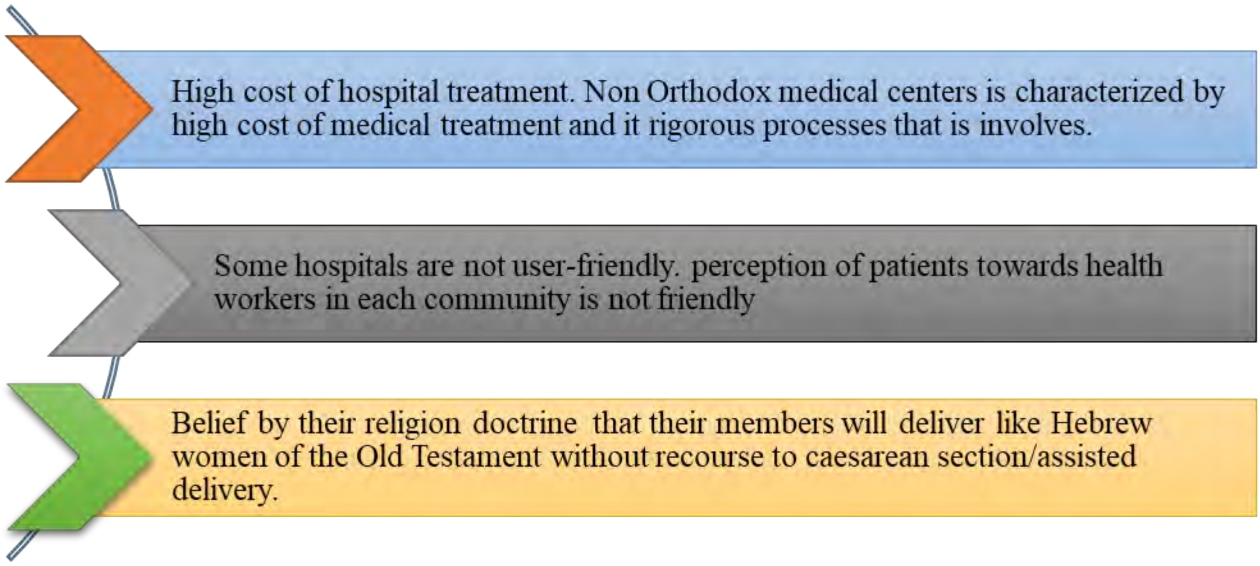


Figure 4.38: **Reasons for the Preferred Choice**

From the personal interview with the respondents and health workers in the project communities, it was gathering that patients come back to the hospital when there are problems/complications such as prolonged/traumatic labor, due to pelvic insufficiency, or cases of breach. There could also be obstetrics pelvic infections due to actions/inactions of birth attendants and pregnant mothers during pregnancy and labor/vaginal examinations, use of unsterile gloves or taking deliveries in an unhygienic conditions/environment can lead to infections and even infertility and death. Obstetric pelvic infection is almost always a result of intervention during labor or delivery. Poor hygienic conditions and non-observance of aseptic procedures at places of delivery in maternity homes, traditional and alternative settings outside orthodox facilities are important factors.

4.42.6. Prevalent Diseases

The commonest forms of ill health in the communities as indicated above are malaria and typhoid fever. Other prevalent ailments are upper respiratory tract infections, skin diseases, measles, dysentery, and diarrhea. Non-communicable diseases like hypertension and diabetes have increased in the communities.

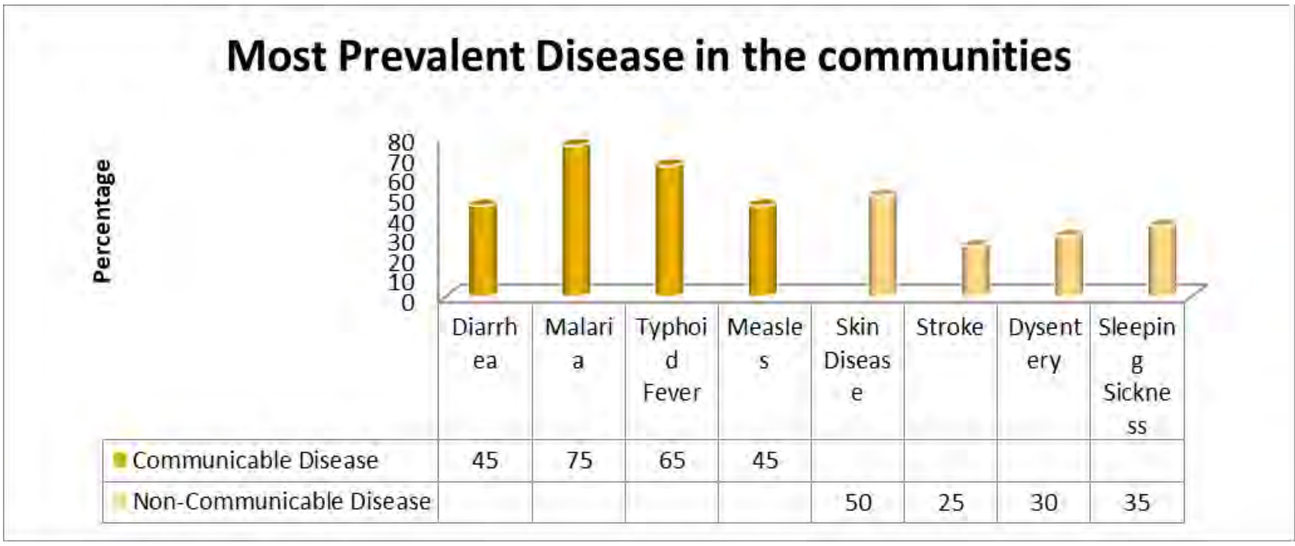


Figure 4.39: Most Prevalent Disease in the Communities

The commonest forms of ill health in the community as indicated above are malaria and typhoid fever. Other prevalent ailments are skin diseases, measles, dysentery, and diarrhea. Non-communicable diseases like hypertension and diabetes have increased in the community. The most basic health risk in the community is consumption and domestic use of unclean water. Another big challenge is the disordered sanitation facility and habit.

4.42.7. Sanitation and Hygiene

The general sanitary status of the living environments in the communities were rated as good based on a set of WHO criteria. communities had good sanitary status of the living environments.

4.42.8 Sanitation Facility and Waste Management

Residents use different kinds of toilet facilities including water closet, pit latrine, and riverside elevated latrine. In places where pit latrine is used, one facility is shared by several local households. The respondents in the project community use two different ways to get rid of their solid waste. On average the most prevalent waste disposal system is the open dumping system (56%), then refuse incineration (65%) while some household practice 50%.

4.42.9. Human Waste Disposal System

Figure 4.40: Human Waste Disposal

The common refuse and sewage disposal method in the communities varies depending on the location of the community. From the figure above, on average 49% of the respondents use water closet, 27% uses pier head, 18% uses pit latrine while 6% use bush. Results from FGD reveal that most of these wastes eventually end up in the water bodies around the area or are carried and deposited in other communities.

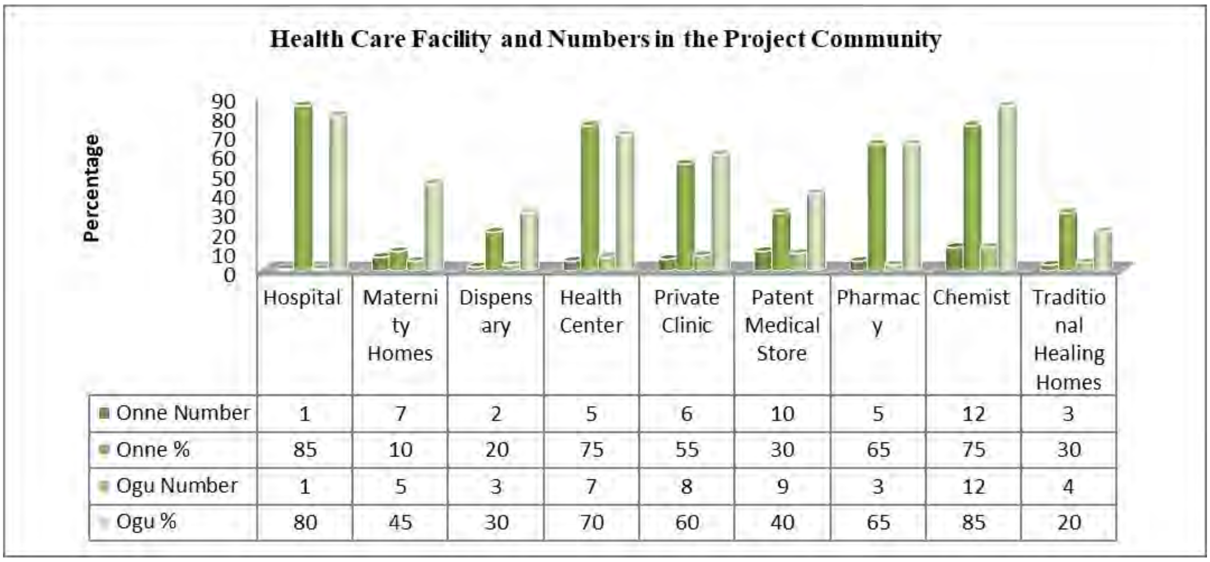
4.42.10. Solid Waste Disposal

The figure above shows household waste disposal in the study area. From the result, on average 70% of household waste are collected by government environmental waste management system, 55% of the respondents dump their household waste in general dumping site, 50% disposes their waste using commercial waste packers, 30% of the respondents burnt their waste while 10% and 5% of the respondents bury and uses private dumping site.

Figure 4.41: Household Solid Waste Management

4.42.11. Health Seeking Behavior of the Respondents

Heath Care Institution in the Communities



	Hospital	Maternity Homes	Dispensary	Health Center	Private Clinic	Patent Medical Store	Pharmacy	Chemist	Traditional Healing Homes
Onne Number	1	7	2	5	6	10	5	12	3
Onne %	85	10	20	75	55	30	65	75	30
Ogu Number	1	5	3	7	8	9	3	12	4
Ogu %	80	45	30	70	60	40	65	85	20

Figure 4.42: Health Care and Numbers in the Project Community

Availability of basic health care facilities in a community determines how the health of the members of the community is paramount. The number of health care facilities varies across communities. For onne community, respondents on average identify numbers and types of health facilities available of health facilities 85% identified 1 hospital, 75% identified 5 heath centers, 65% identified 5 pharmacy presents in their community and 30% identified 3 traditional healing homes, 55% identified

	Private Open Dump	Public Open Dump	Organized Collection by Government	Organized Collection by commercial firms	Burning	Burying
Percentage	5	55	70	50	30	10

6 private clinics in the study area. While for Ogu community, 80% of the respondents identified I hospital, 70% identified 7 health centers and 80% identified chemist.

4.42.12. Sources of Water

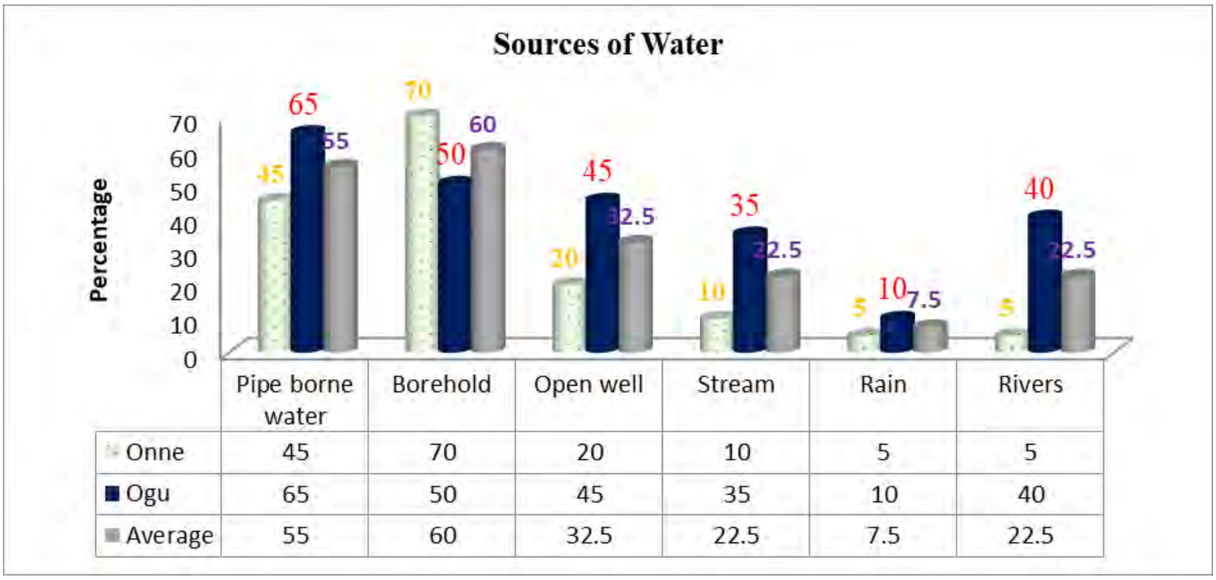


Figure 4.43: Sources of Water

Sources of Water in the project communities include River Water, Rainwater, Pipe-Borne Water, Bottled/Sachet Water, stream and open well. From the study, on average majority 60% of the respondents get water from boreholes, 55% from pipe-borne water provided by agencies, 32.5% from well, 22.5% from rivers and stream respectively, while 7% from rainwater. Focus group discussion reveals that most respondents in the community avoid the use of rainwater due to pollution caused by gaseous emissions from gas flaring in the community. For this reason, it is only limited to washing clothes. Also, for drinking purposes, many residents also rely on sachet/bottled water, rainwater and even river water treated with alum.

4.42.13. Nutritional Status

Although the studies population generally appreciates the link between good food and good health, low income, large family size and environmental factors affect the dietary pattern of the people. The nutritional status was good because of the availability of fish, fish products, and other sea foods which supplied proteins, vitamins, and other mineral salts. The people engage in farm ing and rich calorie foods like yams, garri, rice, corn; are produced from their farms. To determine the nutritional status of the people we had to look at background histories and nutritional parameters which are determined by anthropometric measures, or assessment – height, weight, skin fold thickness, arm muscle circumference and other parameters.

4.42.12. Food hygiene

The level of food hygiene in the community was low right from collection/marketing of the food items through handling, preparation, and service. Environmental health problems arising from poor standard of food hygiene can be alleviated through education and effective health education. Food is often contaminated by exposure during marketing, preparation and serving. The channels of contamination can be removed by good rural marketing practice and improved personal hygiene.

4.43. REPORT ON JETTY COMMUNITIES CSR PROJECTS

Two (2) communities have been identified as jetty communities and they are.

- Onne
- Ogu

Indorama company has implemented several corporate social responsibility initiatives from inception in 2016 till date. The CSR program varies from the construction of a health centre and doctor’s quarters, rehabilitation of health centre, construction of street solar light, skill acquisition for youths, bursary payment for students etc.

Table 4.8 CSR projects:

Below is the breakdown of all the CSR projects:

Community	Year	Projects	Amount	Phase	Stages
Onne Community	2016	Purchase and installation of Transformer	N5,000,000	I	Completed
Onne Community	2022	Rehabilitation of Onne Community Health Centre	N45,000,000	II	Completed
Onne community	2023	Provision of learning desks, table, chairs etc for 5 schools in Onne community	N18,000,000	III	Ongoing
Ogu Community	2016	Construction Health Centre	N5,000,000	I	Completed

Ogu Community	2017	Fencing & interlocking of Health Centre	N7,000,000	II	Completed
Ogu Community	2018	Health Centre Equipping / Furnishing/Delivery Room Setup	N7,000,000	III	Completed
Ogu Community	2019	Doctor's and Nurse's Quarters Construction/ Generator set.	N15,000,000	IV	Completed
Ogu Community	2020	Construction of Solar streetlight	N15,000,000	V	Completed
Ogu Community	2021	Construction of Solar Street Light phase 2	N15,000,000	VI	Completed
Ogu Community	2022	Construction of Solar Street Light phase 3	N15,000,000	VII	Completed
Ogu community	2023	Construction of public lavatories in remote riverine ogu community	N18,000,000	VIII	Ongoing

4.43. 1. Skill Acquisition Program:

The Skill Acquisition Program is an OIS INDORAMA-driven initiative aimed at empowering her Jetty communites/individuals with valuable skills that enhances their employability and promotes economic growth.

- The program focuses on providing training in various in-demand skills to individuals from her host communities backgrounds. This program focused on 24 youths (male & female) for 22 days in Onne & Ogu-Bolo Jetty Host Communities, in Rivers State, focusing on steel fixing and scaffolding for the men, household product creation and hair dressing for the women.
- The Skill Acquisition Program has made a significant positive impact on the community, empowering individuals, and fostering socio-economic development.
- The program has also instilled confidence and self-belief in individuals, empowering them to pursue their goals and overcome challenges. Many participants have reported an increased sense of self-worth and pride in their acquired skills.

4.43. 2. BURSARY PAYMENT FOR 2021 & 2022

Eight (8) students from the jetty communities benefited from the bursary payment for the year 2021 & 2022. Each of them was paid one hundred thousand naira only (N100,000) as a way of helping them through their studies. It is one off payment.

4.44. Stakeholders Engagement

The Company have considered the stakeholders identified for the Indorama OIS Port Limited, Onne as one of the benchmarks for the project stakeholder identification process.

Having identified the level of interest of each of the stakeholders, the level of engagement with each stakeholder varies in accordance with the interest and influence the stakeholders have on the project.

Table 4.9 Engagements performed in view of ESIA process

The following engagements were performed in view of ESIA process.

S. No.	Date	Stakeholder	Purpose
1	08th Dec'22	FMEnv – EA Dept, Team leaders; total attendees 07	Discuss proposed project and draft ToR (Institutional Consultation)
2	17th Jan'23	FMEnv, RSMEnv, E&CS & Proponent reps; total attendees were 12.	Site verification required for Project categorization (Institutional Consultation)
3	12th Apr'23	FMEnv, RSMEnv, Eleme LGA, Relevant Stakeholders, E&CS & Proponent reps; total 47 were attendees.	Scooping workshop with Onne Community for ESIA, ToR/SoW (Institutional and Public Participation)
4	13th Apr'23	FMEnv, RSMEnv, Eleme LGA, Relevant Stakeholders, E&CS & Proponent reps; total 36 were attendees.	Scooping workshop with Ogu Community for ESIA, ToR/SoW (Institutional and Public Participation)
5	04th July'23	FMEnv, RSMEnv, E&CS Team Proponent & Community reps; total 23 were attendees.	Kick-off meeting for field data gathering exercise to streamline sampling strategy and techniques
6	11th July'23	Ogu community stakeholders - Community Chiefs, CDC, Women Leader and Executive, Community Youth President and Executive, Farmers, Traders etc. Attendees 20.	Educate participants on the proposed project scope, environmental, social, economic and health aspects. Possible impacts of the project and community perspective (expectation, benefits, and perception etc.).

S. No.	Date	Stakeholder	Purpose
7	12th July'23	Onne community stakeholders - Community Chiefs, CDC, Women Leader and Executive, Community Youth President and Executive, Farmers, Traders etc. Attendees 20.	Educate participants on the proposed project scope, environmental, social, economic and health aspects. Possible impacts of the project and community perspective (expectation, benefits, and perception etc.).

4.44.1. Engagements with Executives of Environment Assessment Department (EAD) of Federal ministry of Environment (FMEnv), Nigeria

Date : 08th Dec'22

Venue : Conference Room, EAD, Abuja

Stakeholders Present: FMEnv, EA Dept Officials

Disclosure: Proponent, Head of Environment Dept

The engagement session commenced at about 10:00am with introduction of participants which include executives of EAD and Proponent Rep. Total 7 attendees in the session.

The Summary of Brief is stated below:

1. The Project proponent Rep explained the concept behind the proposed Project and the design, in addition with various unit and ancillary facility that will be on ground for smooth operation of the proposed port facility.
2. The draft Terms of Reference / Scope of Work for the EIA study/report for the proposed project was presented.
3. The discussion on the various aspects of the project covering technical, environmental, social, financial etc. aspects.
4. The EAD executives appreciated the efforts of Proponent and made assurance to support the EIA approval process. They advised submitting the EIA registration application with relevant documents and evidence of payment of statutory fee.
5. Director EAD informed that after submission of application, the EAD will register the project for EIA approval as per first step of EIA approval process, the FMEnv officer along with State Ministry of Environment Rep will visit the site which is required for categorization of the project.

6. After session, the EIA registration application, project proposal, draft ToR along with statutory fee was submitted to offices of Director EAD and Minister of Environment FMEnv.

4.44.2. Site Verification by Environment Assessment Department (EAD) and Rivers State Ministry of Environment (RSMEnv) officers

Proceedings

Date : 17th Jan'23

Venue : OIPL Conference Room and Project Site

The site verification engagement session commenced at about 9:30am with introduction of participants which include Reps of FMEnv Abuja, FMEnv Zonal Office Port Harcourt, Rivers State Ministry of Environment (RSMEnv), Lead Consultant of E&CS and Proponent reps. Total 12 attendees in the session.

The summary of engagement session is as below.

1. The Project Proponent Rep explained the proposed project unit by unit and ancillary/utility facility that will be on the ground for smooth operation of the project.
2. The FMEnv reps explained the purpose of the visit, which was supported by RSMEnv rep.
3. The FMEnv rep explained that EIA site verification visit is aimed to categories the project considering various environmental & social aspects.
4. The Lead Consultant of E&CS, FMEnv accredited environment consulting firm, presented the broad view of physical, biological, & socio-economic environment of proposed project.
5. The Team visited the Project Site and gathered info/photographs. After the site visit, the FMEnv Team concluded the meeting indicating that MM FZE will get a feedback of site verification visit.
6. The FMEnv letter reference number FMEnv/EA/EIA/6791/Vol.1/86 dated 30th January 2023 indicated that the Ministry has placed the Project in Category One (1) with one (1) season baseline data gathering for the ESIA report. The Ministry also instructed to conduct

a Scoping Workshop under observation of FMEnv & RSMEnv, involving relevant stakeholders in attendance.

7. The Ministry further instructed to submit a Scoping Workshop report and revised Terms of Reference (TOR) incorporating significant issues raised at the Scoping Workshop and a detailed sampling frame for review and approval.
8. The Ministry was informed about the Scoping Workshop Program and the Ministry confirmed the participation vide letter no. FMEnv/EA/EIA/6791/Vol.1/88 dated 06th April 2023.

4.44.3(a): Scoping Workshop Proceedings with Attendance sheet

As instructed by the Federal Ministry of Environment (FMEnv) vide letters reference number FMEnv/EA/EIA/6791/Vol.1/86 (MM FZE Port) and FMEnv/EA/EIA/6793/Vol.1/79 (IA FZE Port) of 30th January 2023, the scoping workshop involving stakeholders was conducted on 12th April and 13th April 2023. The meeting with Onne stakeholders was conducted on 12th April, while with Ogu stakeholders was on 13th April 2023.

4.44.3(b). Scoping Workshop Meeting On 12th April 2023 with Onne Stakeholders

Venue : Kal Classic Hotel Limited, Onne, Eleme, Rivers State

The workshop commenced at about 10:15 am with welcome remarks, opening prayer, introduction of participants, safety briefing and opening remark by FMEnv representative. The key stakeholders in attendance were:

1. Representatives of the Federal Minister of Environment
2. Representatives of the Ministry of Environment, Rivers State
3. The Chairman, Eleme LGA
4. The Leader, Eleme Legislative Assembly
5. Onne community
6. Youth Leaders
7. Women Leaders
8. Paramount Rulers of Onne
9. E & S consultant team
10. The Indorama Team

A total of 47 attendees in scoping workshop and the attendance sheet is appended as annexure 1.

Opening remarks by FMEnv Representative

Dr. (Mrs.) Mfon Aroh welcomed all participants to the meeting with regards from the Minister for the Environment. She applauded the organizers for the gender friendly nature of the meeting. Scoping workshop is the second stage in the Environmental Impact Assessment (EIA) approval process, which is mandatory by law for any development. She informed that the Proponents have registered the proposed Jetty Projects with Federal Ministry of Environment and site verification has been conducted. The need therefore arises to engage interested parties and stakeholders to give a clear impression of the project, possible positive & negative impacts and make necessary contributions that may not have been covered in the scope of the EIA studies while solicit their maximum support for a hitch free project execution.

Presentation of Scope of The EIA Studies on the Proposed Projects

The lead consultant of M/s Environmental & Chemical Services Limited (FMEnv accredited Environmental and Social Consultancy firm), Engr. Olu Andah Wai-Ogosu first informed the participants about the Proponents and background of the projects before diligently reviewing the Scope of the EIA work which covered description of the project and the physical and biological content of the components of the environment in proposed EIA study. He claimed that the EIA study would cover Onne and Ogu communities for socio-economic studies. He emphasized that the socio-economic study would cover socio-economic variables, Occupational and normal health aspects, waste related issues, Transportation, Cultural Heritage. He informed that the EIA report will also cover associated and potential (positive and negative) impacts of the proposed projects during construction and operations phases of the project implementation and explained the EIA study approach. He did not leave out the report format, deliverables and necessary management plans which will enhance the value of the projects not only on the community resources but also on the economy of the local, State and Federal Government. He closed by stating that the EIA study will be carried out with reference to National and International Environmental Regulations. The presentation made to stakeholders is appended as annexure 3.

Questions and Comments

Hon. Robert Ogosu, the Local Government Counselor thanked the company for being open with the presentation and the corporate social responsibility. He enquired to know how the negative impact found out during the EIA will be mitigated. Is there a way to prevent the negative impact than mitigating as the Life expectancy of the Onne community indigenes has reduced. Is there a plan for a follow-up of the EIA study?

Chief Casca Ogosu said that the greatest destroyer of human development is Man. For companies to be developed, plants and greeneries are destroyed without it being replanted. The waterways in the community are blocked and the people suffer from flooding at any little rainfall. Afterwards he asked how the company can help the community in this regard as there is no robust plan stated in the presentation about replanting fallen trees and developing greeneries. He went further to say that it has been the experience in Onne that company-community relations are only noticeable during construction phase of development after which the company distances itself from any meaningful relationship. So, the community needs a commitment from the owners of this project as to what the company will do.

Dr G Chujor asked to know the time frame of the project as well as the percentage of the workforce that will be allocated to the community. He also said that the level of air pollution due to exhaust emissions from the vehicles is high and a lot is being inhaled by the indigenes. He suggested that the company consider the use of electricity powered trucks for its trucking activities.

Rev (Dr.) Grace Nkpornwi a female from the Onne community asked how the substances that may be released into the atmosphere can be reduced so that the effect cannot be felt by the community occupants. She also asked about the percentage of employment for the Host Community, specifically for women.

Chief Gregory Ollor reminded the company that the Onne people owns the Land as well as the Water. The proposed manufacturing plants mapped out to be built in Aleto should be considered to build here in Onne as it would also save cost of transportation. He also said that several demands have been made by the host community to its operating sister company and it would be good if it sets up another forum where all the demands will be addressed.

The Youth Vice President, Sunny Nkpornwi asked that the company makes its facility a youth friendly zone where youths are given involvement in the smooth running of company-community relations. He said that the youths have always ensured a free and easy passage of trucks along the Onne route while ensuring Traffic gridlock does not occur during truck movement processes. He also asked the company to caution its drivers to use only the speed lane while leaving the service lane as markets are located along that lane, to ensure the safety of the traders.

Bar. Olu Josiah said that the companies operating in free zone have an EIA but no MoU, why? He further said that the community needs assurance that after the EIA report, the MOU will be drafted and implemented.

Responses

Engr. Olu Wai-Ogosu took the first floor in giving responses where he explained in detail that:

- The EIA report is not a hidden document as there are processes, the report would be displayed 21 working days at the LGA, State Ministry of Environment and Federal Ministry of Environment; and be open for review by stakeholders whose comments would be sent direct to FMEnv, which will be subjected to another scrutiny and critique at a public Panel Review. FMEnv would give approval & certificate, if the EIA report passes test of approval for the commencement of the project.
- The EIA study is to help give more information that may improve the design of the project so that negative impacts that may arise during construction and operation phases of the project are reduced and positive impacts are enhanced.
- At operating OIPL facility (Group company) in Onne, gaseous emissions are proactively controlled by using compressed Natural Gas (CNG) as a 70% clean fuel & 30% diesel in power generators and running CNG fuel-based trucks. The proposed projects will use CNG for power generation and as fuel in customized trucks.
- Likewise, group companies are maintaining and enhancing greeneries in the parent Indorama Complex. The proposed projects will also adopt the same philosophy.
- The proposed jetty would not have any emissions, it’s just a product handling facility. The company will ensure regulated safety and maintenance program with Standard Operating Procedures (SOP) and Standard Maintenance Procedures (SMP). There are also Federal agencies who will monitor the company’s activity.
- Environmental Audit is a follow up program of the EIA and it’s carried out every 3 years after EIA approval has been received from the Ministry and project is constructed and commissioned.

Mr. Kendrick Oluka, General Manager Community Relations and Government Affairs also gave Reponses as follows:

- Indorama Group companies are stakeholder friendly and ready to cooperate with its host community in order to thrive well.

- MOU has a lot of restrictions around it with the NPA, OGFZA and Port Authorities but the community is advised to get united and approach the company with meaningful community development projects.
- On Employment, he stated that the ratio for community employment is per existing practices with priority to the community candidates.

Closing Remarks

Message from Executive Chairman - Eleme Local Government

The Local Government Chairman, Hon Obari-Ollormate informed the company that he understands what the projects are and material to be stored there. The company should please see how to manage the people's demands going forward. He also asks the company to build some amenities in the community to ensure the immediate remedy of any impact that would be felt by the activities of the company such as fire station, eye clinic, water supply system etc. He went further to advise that a Project Advisory Committee (PAC) be set up to look at project related aspects. He also advised to include effective waste management plan as waste production will directly or indirectly be increased in the community due to increased trucking activities. He informed the community to rightly channel its needs to the company so it can be featured in the CSR programs. He reminded me that Indorama promised to provide 10,000 tree seedlings for planting around the communities in Eleme and asked Environmental supervisor to inform Indorama about plantation schedule.

Message from FMEnv Minister's Rep

The Federal Ministry of Environment appreciated the community for the peaceful and accommodating atmosphere stating that it exceeded her expectations of community stakeholder's forum and encouraged the community to continue with same peaceful manner.

As regards the MOU, the community was advised to come together, have one voice, set up a committee to dialogue with the relevant authorities / joint associations to get what they want; document every agreement so it can bind both parties. She affirmed from the community that the Federal Ministry of Environment take-home from the meeting is that the community welcomes the project; that the development should be of help to the community. She assures the community that there will be another stakeholder gathering for deliberations to reach a standpoint before approval is given to the company to commence the work.

Message from the State Ministry of Environment (Commissioners' Rep)

The Commissioners' Rep expressed satisfaction on the Proponent attitude in observing the EIA protocol against the backdrop of poor performance of other companies in the region.

Message from Crown Head of Onne

The Crown Head of Onne Chief Representative gave his message from the Royal Majesty Chief S. N. Jiala, that the Chief is happy with the proposed developments and wishes that the company treats the community well. He said that his Highness would be happier if Indorama Group continues blazing the trail than having hundred companies not sensitive to the needs of the Community. He also asked Community Relations & Development Officers to be close to him and always approach him whenever there is an issue. He also advised giving timely notice of such meetings as he needs to meet with his council of chiefs and get stakeholders informed before any important action is taken. He advised the government representatives to follow up on all that has been presented and ensure it is implemented.

Vote of thanks & closing prayers

The meeting was concluded with a vote of thanks given by Mrs. Ngozi Rowland-Gomba, on behalf of the Proponent, and the closing prayers were said alongside the vote of thanks. After that, everyone present in the meeting was treated to refreshment.

4.44.4. Scoping Workshop Meeting on 13th April 2023 with Ogu Stakeholders

Venue : Sweet Spirit Hotel, Port Harcourt, Rivers State

The workshop commenced at about 09:30 am with welcome remarks, opening prayer, introduction of participants, safety briefing and opening remark by FMEnv representative. The key stakeholders in attendance were:

1. Representatives of the Federal Minister of Environment
2. Representatives of the Ministry of Environment, Rivers State
3. Paramount Rulers of Ogu
4. Ogu community
5. Youth Leaders

6. Women Leaders
7. E & S consultant team
8. The Indorama Team

A total of 36 attendees in scoping workshop and the attendance sheet is appended as annexure 2.

Opening remarks by FMEnv representative

Mr. Friday B. Ikomah welcomed all participants to the meeting with regards from the Minister for the Environment. He informed that scoping workshop is the second stage in the Environmental Impact Assessment (EIA) approval process, which is mandatory by law. He informed that the Proponents have registered the proposed Projects with Federal Ministry of Environment and site verification has been conducted. The need therefore arises to engage interested parties and stakeholders to give a clear impression of the project, possible positive & negative impacts and make necessary contributions that may not have been covered in the scope of the EIA studies while solicit their maximum support for a hitch free project execution.

Presentation of Scope of the EIA Studies on the Proposed Projects

The lead consultant of M/s Environmental & Chemical Services Limited (FMEnv accredited Environmental and Social Consultancy firm), Engr. Olu Andah Wai-Ogosu has presented the details of projects and EIA study components as he did on 12th April during engagement with Onne stakeholders. The same presentation was used for this engagement too.

Questions and Comments

Chief S. Anga, asked where is the location of the proposed project (Ikpokiri, Owogono, Port Complex, across the river)?

Ms. Blessing Derefaka, asked what benefit will accrue to women from the proposed project?

Mr. Eli Koroma asked what the position of the community in employment/contract matters will be. What are the effects of the project on our cultural heritage, flora, and fauna.

Response

The Lead Consultant, Olu Andah Wai-Ogosu responded to questions as follows.

- EIA is a deliberate program intended to generate baseline indices that will guide the proponents to proffer solutions of expected and unexpected problems that will emanate in course of the project activities for sustainable development of the environment, socioeconomics, etc.

- The essence of these engagements across gender is to obtain relevant information of how the project will interfere with the biophysical, occupational and health status of the locality so as to inform the proponent to evolve suitable Environmental and Social Management Plans across affected gender.
- The pictorial impression of Chief S Anga was corrected referencing the Facility Layout Drawing, which clearly shows that the project will be located close to Onne Multipurpose Terminal (OMT).
- In view of the cultural heritage, both tangible and intangible heritages, artifacts and human rights will be properly documented in the EIA report.
- Final copies of EIA and other documents will be published and displayed as stipulated by the EIA law for review by the public and comments will be forwarded to the Federal Ministry of Environment.
- Furthermore, Mr. Kendricks Oluka harped on the existing favorable disposition between the company and Ogu community as he mentioned ongoing skill acquisition program for youths and women, and building of staff quarters, health center, etc.

Closing remarks

Mr. Friday Ikoma representing the Minister, FMEnv thanked the stakeholders for attending the meeting and advocated for mutual understanding between the community and the company to foster development and benefits to all stakeholders.

Dr. Kenneth Okoro of Rivers State Ministry of Environment expressed his approval of the Proponent observing the EIA protocols against the backdrops of some companies. He sued for collaboration, peace, and development since increase in products line attracts corresponding growth to the society.

Chief Adokie A. expressed his confidence in the Federal Ministry of Environment and applauded the Lead Consultant for a worthy presentation. He appreciated the company for choice of his locality for such investment, assured cooperation and requested for continuous consultations for effective delivery.

Vote of Thanks & Closing Prayer

Mrs. Esther Anga of OIS Indorama Port gave the vote of thanks with assurance of the company doing more and offered the closing prayer. After that, everyone present in the meeting was treated to refreshment.

Conclusively, both meeting held for scoping workshop went well, and stakeholders participated actively to enrich the Scope of the EIA study work. The stakeholder’s inputs are incorporated in revised Scope of Work (SOW)/ Terms of Reference (TOR) for both the Projects.

4.44.5. Field Data gathering Exercise – Kick-off meeting & Field Data gathering

Proceedings

Date: 4th July 2023

Venue: OIS Indorama Port Complex, Onne

The kick-off meeting for ESIA study data gathering exercise was held within OIS Indorama Port Complex on 4th July 2023. Participants include Regulators, Consultant Team and Proponent representatives see attendance sheet attendance. Total attendees were 23.

Highlight of the meeting includes:

- Proponent Rep welcomed Regulators and Consultant team and explained about the Project. The FMEnv Reps explained the expectations from the Consulting Team & Proponent during/post exercise. The Lead Consultant explained the approved TOR and execution plan. After discussion the teams were moved to the field for data gathering.

4.44.6. Stakeholder's Engagement - Ogu Community

Date of Engagement: 11th July 2023
Venue Ogu Community Town Hall
Facilitator Lead Consultant

Stakeholder's Groups Present

i. The Paramount Ruler of Ogu Community
ii. Ogu Community Chairman
iii. Fishermen and Hunters Association
iv. E&CS limited.
v. Ogu Security Guards
vi. Ogu youth President and Executives
vii. Women Leader and Executives
viii. Cross section of Ogu Community

Attendance of participants by Gender

i.	Male	-	15
ii.	Female	-	5
	Total	**-**	**20**

Aim and Objective of the Engagement

To educate participants on the proposed project scope, environmental, social, economic and health aspects. Possible impacts of the project and community perspective (expectation, benefits, and perception etc.).

Proponent Disclosures

In keeping with National and International best practice in producing Environmental Impact assessment, MM FZE carried out a public consultation to get the buy-in and opinion of Ogu community and residents concerning the proposed project.

Highlight of the disclosure made during the engagement includes:

- The purpose of embarking on the development of the Port project in Onne Port complex.
- The product, services expected from the development and the socio-economic relationship between the communities/environment as well.
- Elaborate management plan established to sustain the numerous benefits (employments, development of trained/skilled manpower, CSR projects, social welfare packages, educational support programs etc) associated with the project as well as control the fears associated with the proposed project.

Questions and issues raised.

- Where will the project located?
- How will the community benefit from the project?
- What about employment for our young teaming youths?

Response

Responding to the questions the lead consultant clarifies to them that project will be located adjacent to Onne Multipurpose Terminal beside the Navy. He further mentioned to them the possible benefits that accrue for the project which include employment, contracts etc.

4.44.7. Stakeholder's Engagement – Onne Community

Date of Engagement: 12th July 2023

Venue Palace of the King

Facilitator Lead Consultant

Stakeholder's Groups Present

ix. The Paramount Ruler of Onne Community

x. Onne Community Chairman

xi. Fishermen and Hunters Association

xii. E&CS limited.

xiii. Onne Security Guards

xiv. Onne youth President and Executives

xv. Women Leader and Executives

xvi. Cross section of Onne Community

Attendance of participants by Gender

iii. Male - 15

iv. Female - 3 identified from the attendance sheet.

Total - 20

Aim and Objective of the Engagement

To educate participants on the proposed project scope, environmental, social, economic and health aspects. Possible impacts of the project and community perspective (expectation, benefits, and perception etc.).

Proponent Disclosures

In line with National and International guideline developing a good quality Environmental Impact assessment for a sustainable development, MM FZE is carried out this public consultation to get the buy-in and opinion of Onne community and its residents concerning the proposed Port Project. Consequently, the highlight of the disclosure made during the engagement includes:

- The need for the proposed Port project in Onne Port complex.
- The usage and the socio-economic relationship between the communities/environment as well.
- Elaborate management plan established to sustain the numerous benefits (employments, development of trained/skilled manpower, CSR projects, social welfare packages,

educational support programs etc) associated with the project as well as control the fears associated with the proposed project.

Questions and issues raised

When is the project taking place

How will the community benefit from the project?

What about employment for our young teaming youths?

Response

Responding to the questions the lead consultant told them the construction can only being after the EIA study has been completed and approved by all relevant authorities. He further mentioned that possible benefits that will accrue throughout the project life cycle include employment, contracts, new skill acquisition and transfer of skill.

4.45. TRAFFIC SURVEY REPORT

4.45.1 . Introduction

Traffic survey is an important aspect of traffic management system. Traffic surveys involve the counting of vehicular movement on a particular road of interest taken cognizance of the origin, destination, vehicle types and road conditions.

It is against this backdrop the MM Port FZE Environmental and Social Impact Assessment (ESIA) scope of work considered it an important aspect of the assessment study to benchmark the current traffic situation within the proposed project influence zone for the benefit of proper planning prior onboard the proposed Port facility in the existing Onne Port complex.

4.45.2. Methodology

The traffic count was conducted manually, using a traffic survey data sheet on an hourly basis from 6am to 8pm daily. Six (6) people were stationed on a particular station, three (3) persons on the morning shift and three (3) others on the evening shift. One (1) person counting coming and the other one (1) person counting going vehicles, while the other one (1) person is on standby. The study was conducted for seven (7) days from 13/07/23 to 19/07/23. The counting stations established in the course of the assessment as stated below.

Table 4.10 Traffic Count location

Point ID	Counting route	GPS Coordinates		Road condition
TC1	East-West Highway by New Road Junction	N4º45'21.5	E007º 9' 51.2	Asphalt, dual carriage (2 lanes) with no shoulder approx. 12m wide each
TC2	NPA Dual Carriage way First Roundabout by Onne Health Centre	N4°44' 58.6"	E007° 9' 20.4"	Asphalt, dual carriage (4 lanes) with no shoulder approx. 10.7m wide each

TC3	NPA Dual Carriage way, Second Roundabout by NAFCON Junction	N4°44'04.1"	E007° 9' 13.7"	Asphalt, dual carriage (4 lanes) with no shoulder approx. 10.7m wide each
TC4	NPA Main Entrance Gate	N4°43’10.4	E007° 9’ 22.9	Asphalt, dual carriage (2 lanes) with no shoulder approx. 10m wide
TC5	WACT/OMT Entrance Off FOT Dual carriage Road	N4°40'39.1"	E007° 9' 05.7"	Asphalt, dual carriage (2 lanes) with no shoulder approx. 10.7m wide
TC6	New WACT/OMT Road under construction	N4°40'47."	E007° 8' 60.1"	Earth road with drainage approx. 10.7m wide
TC7	New WACT/OMT Road to Project site	N4°40’11.8	E007° 8’55.7	Narrow and untarred road

Map 1: Traffic count locations

4.45.2. 1 Vehicle category

Vehicle types were grouped into four (4) vehicle category according to international standards as stated below:

4.45.2. 2Motorcycles/Tricycles

A motorcycle (also called a motorbike, bike) is a two- or three-wheeled motor vehicle. Motorcycle design varies greatly to suit a range of different purposes: long distance travel, navigating urban traffic, cruising, sport, racing and off-road riding.

4.45.2. 3 Cars and Light Vans

A car is an automobile for carrying a limited number of passengers (not more than nine). The original van was a large, covered wagon. A modern van is a kind of vehicle used for transporting goods or people. There are vans in all shapes and sizes, ranging from the classic van version of the tiny Mini to much larger vehicles such as cargo vans and other commercial transport vehicles. Vans run up to about 4 tons and are classified as Light or Medium Duty Trucks (North America) or Light Commercial Vehicles (Europe).

4.45.2. 4. Medium and Heavy Goods Vehicles (Lorries and Trucks)

A large goods vehicle (LGV), also heavy goods vehicle (HGV), is the European Union term for any truck with a gross combination mass (GCM) of over 3,500 kilograms (7,716 lb). Sub-category N2 is used for vehicles between 3,500 kilograms (7,716 lb) and 12,000 kilograms (26,455 lb) and N3 for all goods vehicles over 12,000 kilograms (26,455 lb). The term **Medium Goods** Vehicle (MGV) is used within parts of the UK government to refer to goods vehicles of between 3.5 and 7.5 tones, which according to the European Union (EU) are also 'Large Goods Vehicles'.

4.45.2. 5. Buses and Coaches

A coach (also motor coach, often simply called a bus) is a type of bus used for transporting passengers on excursions and on longer distance inter-city bus service or even between countries. Unlike transit buses designed for shorter journeys, coaches often have a luggage hold that is separate from the passenger cabin and are normally equipped with facilities required for longer trips, including comfortable seats and sometimes a toilet. The term 'coach' was previously used for a horse-drawn carriage designed for the conveyance of more than one passenger, the passengers' luggage, and mail that is covered for protection from the elements. The term was applied to railway carriages in the 19th century, and later to motor coaches (buses**).**

4.46. Results and discussion

4.46.1. Survey Results

4.46.1.1 EAST-WEST HIGHWAY BY NEW ROAD JUNCTION (IN)

Table 2 and figure 1 present traffic situation on the East-West highway by the new road junction as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 2 revealed the highest traffic volume of 13977 was recorded on Wednesday, followed by Saturday with a traffic volume of 12569, while the least traffic volume of 7321 was recorded on Friday. The weekly based hourly average volume of traffic was peak between 8 – 9am morning hours with average count of 1414.9, while the lean period was observed between 6 – 7pm with average count of 513.7.

Table 4.11: Weekly traffic volume on East-West highway by the new road junction (in)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	2888	2653	3133	3074	3116	2907	3244
Cat 2 (Car and Light Vans)	4344	3281	7237	3640	4569	4833	9456
Cat 3 (Lorries and Trucks)	1462	1059	1436	947	1375	1365	922
Cat 4 (Buses and Coaches)	428	328	763	323	501	475	355
Total	**9122**	**7321**	**12569**	**7984**	**9561**	**9580**	**13977**

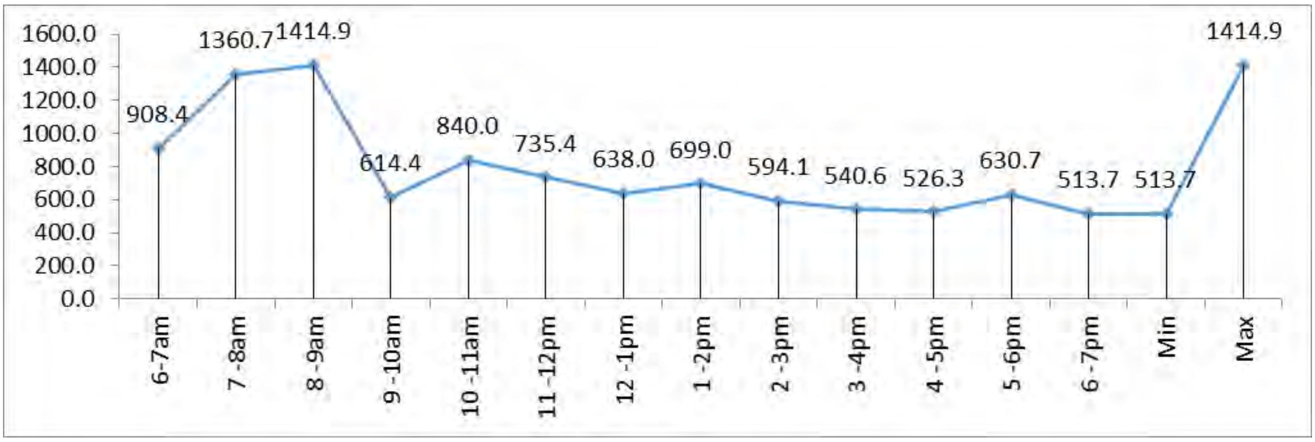


Figure 4.44a: weekly average hourly traffic volume on East-West highway by the New road junction (in)

4.46.1.2. EAST-WEST HIGHWAY BY NEW ROAD JUNCTION (OUT)

Table 3 and figure 2 present traffic situation on the East-West highway by the new road junction (out) as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 3 revealed the highest traffic volume of 9168 was recorded on Wednesday, followed by Monday with a traffic volume of 9026, while the least traffic volume of 7101 was recorded on Friday. The weekly based hourly average volume of traffic peaked between 10 – 11am with an average count of 790.1, while the lean period was observed between 6–7pm with an average count of 477.1 during the afternoon period.

Table 4.12: Weekly traffic volume on East-West highway by the new road junction (out)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	2879	2643	2924	2794	3228	2932	3270
Cat 2 (Car and Light Vans)	4166	2905	3767	3221	4281	4433	4642
Cat 3 (Lorries and Trucks)	1069	1218	1513	961	1008	995	944
Cat 4 (Buses and Coaches)	379	335	749	259	509	407	312
Total	**8493**	**7101**	**8953**	**7235**	**9026**	**8767**	**9168**

Figure 4.44b: Weekly average hourly traffic volume on East-West highway by the new road junction (out)

4.46.1.2 NPA DUAL CARRIAGE WAY FIRST ROUNDABOUT BY ONNE HEALTH CENTRE (IN)

Table 4 and figure 3 present traffic situation on the NPA Dual carriage way around the first roundabout leading to Onne Port as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 4 revealed the highest traffic volume of 9352 was recorded on Saturday, followed by Wednesday with a traffic volume of 7732, while the least traffic volume of 2995 was recorded on Sunday. The weekly based hourly average volume of traffic peaked between 2 – 3 pm in the afternoon hours with average count of 502.7, while the lean period was observed between 5- 6pm with average count of 383.1 in the evening hours.

Table 4.12a: Weekly traffic volume on NPA Dual carriage way around the first roundabout **(in)**

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	1704	3260	3319	1020	1805	2385	3053
Cat 2 (Car and Light Vans)	1519	1845	3142	1010	1740	1995	2451
Cat 3 (Lorries and Trucks)	228	1473	2088	735	1026	1015	1302
Cat 4 (Buses and Coaches)	157	478	803	230	565	600	926
Total	**3608**	**7056**	**9352**	**2995**	**5136**	**5995**	**7732**

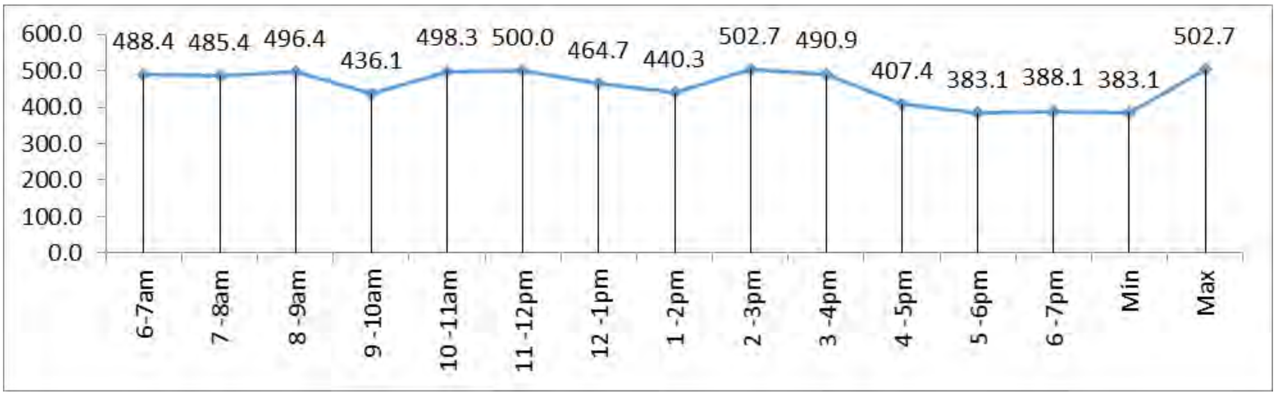


Figure 4.45a: Weekly average hourly traffic volume on NPA Dual carriage way around the first roundabout **(in)**

4.46.1.3 NPA DUAL CARRIAGE WAY FIRST ROUNDABOUT BY ONNE HEALTH CENTRE (OUT)

Table 5 and figure 4 present traffic situation on the NPA Dual carriage way around the first roundabout leading out of Onne Port as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 5 revealed the highest traffic volume of 10213 was recorded on Saturday, followed by Friday with a traffic volume of 8596, while the least traffic volume of 3210 was recorded on Sunday. The weekly based hourly average volume of traffic was peak between 3 – 4pm with average count of 553.7, while the lean period was observed between 7-8am with average count of 414.0 still in the morning.

Table 4.12b: weekly traffic volume on NPA Dual carriage way around the first roundabout (out)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	2159	3500	3638	1261	1570	2325	3055
Cat 2 (Car and Light Vans)	1825	2386	3273	819	1485	1730	2020
Cat 3 (Lorries and Trucks)	182	1617	2285	678	895	950	1340
Cat 4 (Buses and Coaches)	132	1093	1017	452	501	540	745
Total	**2159**	**3500**	**3638**	**1261**	**1570**	**2325**	**3055**

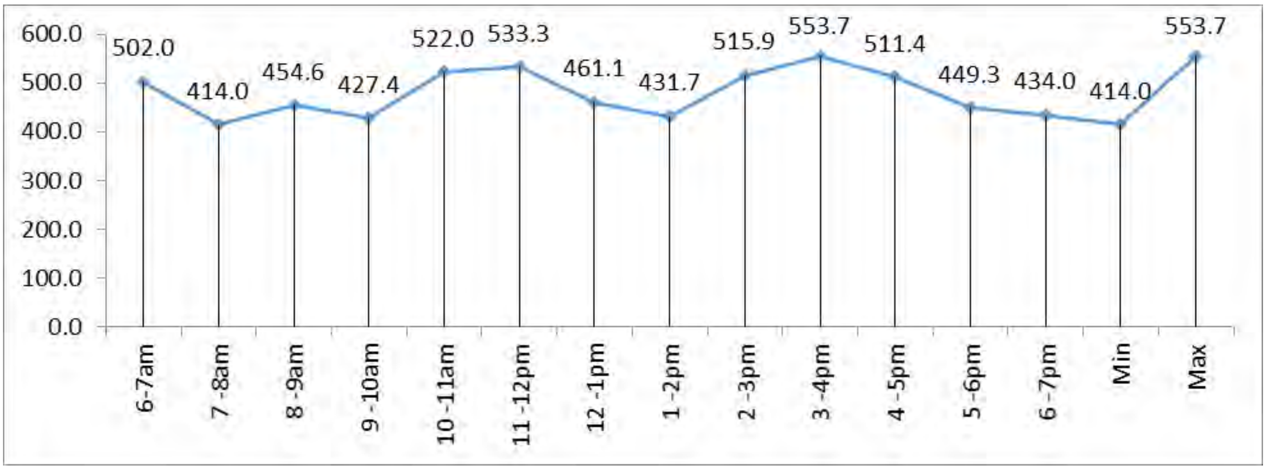


Figure 4.45b: Weekly average hourly traffic volume on NPA Dual carriage way around the first roundabout (out)

4.46.1.4 NPA DUAL CARRIAGE WAY SECOND ROUNDABOUT BY NAFCON JUNCTION (IN)

Table 6 and figure 5 present traffic situation on the NPA Dual carriage way around the second roundabout (NAFCON Junction) leading to Onne Port as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 6 revealed the highest traffic volume of 6648 was recorded on Thursday, followed by Friday with a traffic volume of 6602, while the least traffic volume of 3905 was recorded on Sunday. The weekly based hourly average volume of traffic peaked between 12 – 1pm with an average count of 539.6, while the lean period was observed between 6–7pm with an average count of 211.6 during the evening period.

Table 4.13a: Weekly traffic volume on NPA Dual carriage way around the second roundabout (in)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	2494	2829	1964	1669	2285	2075	1875
Cat 2 (Car and Light Vans)	2533	2192	1829	1356	1626	1763	1280
Cat 3 (Lorries and Trucks)	1041	1367	728	744	645	1079	728
Cat 4 (Buses and Coaches)	580	214	90	136	162	128	134
Total	**6648**	**6602**	**4611**	**3905**	**4718**	**5045**	**4017**

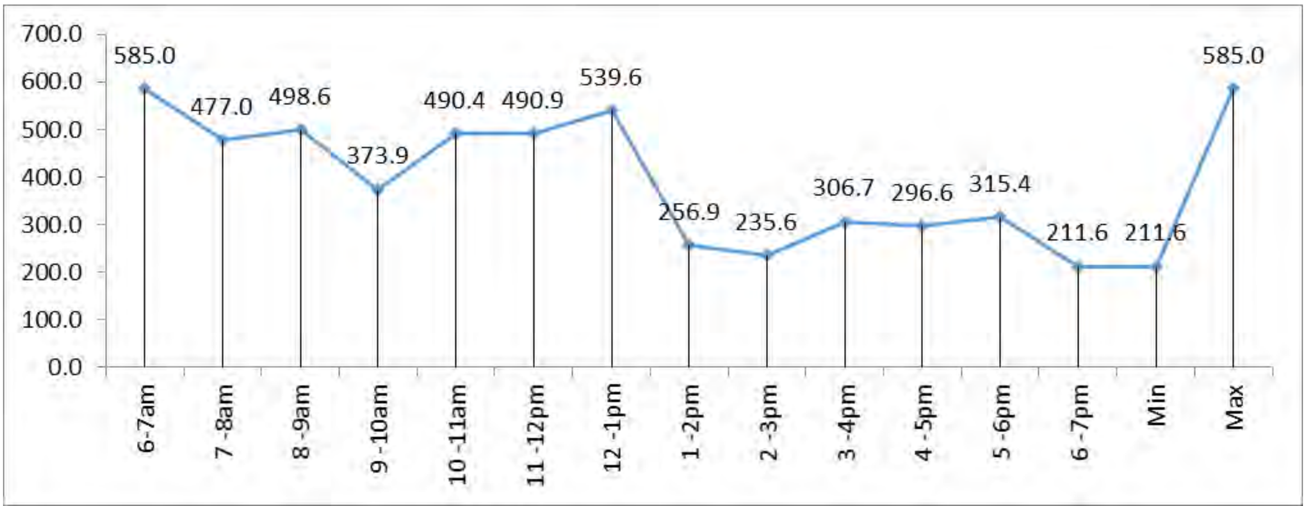


Figure 4.46a: Weekly average hourly traffic volume on NPA Dual carriage way around the second roundabout (In)

4.46.1.5. NPA DUAL CARRIAGE WAY SECOND ROUNDABOUT BY NAFCON JUNCTION (OUT)

Table 7 and figure 6 present traffic situation NPA Dual carriage way around the second roundabout (NAFCON Junction) leading out of Onne Port as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 7 revealed the highest traffic volume of 7046 was recorded on Wednesday, followed by Thursday with a traffic volume of 6898, while the least traffic volume of 5753 was recorded on Sunday. The weekly based hourly average volume of traffic was peak between 10 – 11am with an average count of 585.1, while the lean period was observed between 6–7pm with average count of 438.9 during the evening period.

Table 4.13b: Weekly traffic volume on NPA Dual carriage way around the second roundabout (out)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	3856	3752	3850	3835	3820	3741	3846
Cat 2 (Car and Light Vans)	2001	2123	2087	1550	2125	2053	2367
Cat 3 (Lorries and Trucks)	743	763	695	281	451	619	665
Cat 4 (Buses and Coaches)	298	177	172	87	141	167	168
Total	**6898**	**6815**	**6804**	**5753**	**6537**	**6580**	**7046**

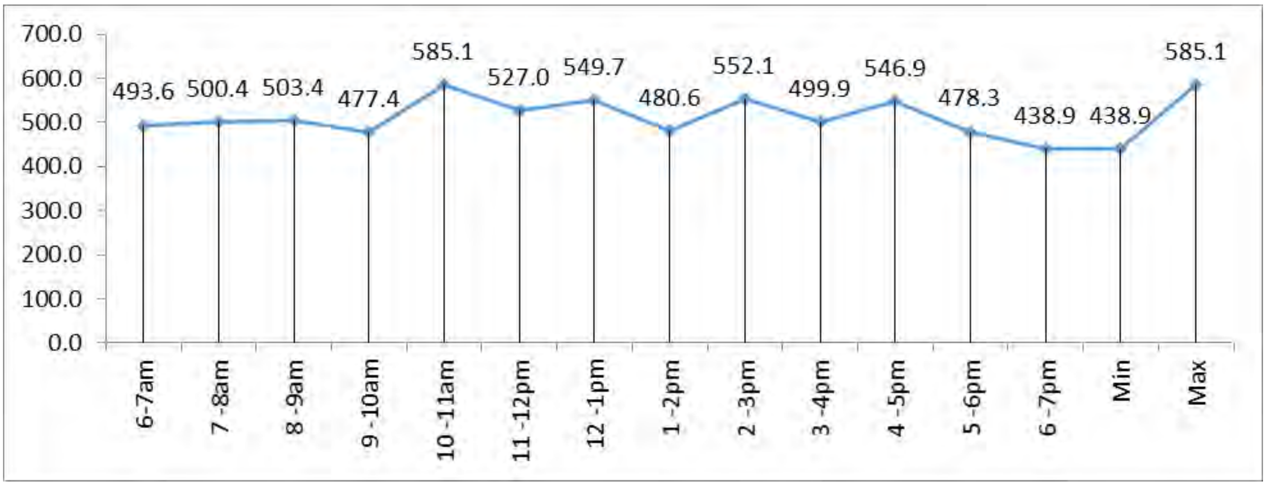


Figure 4.46b: Weekly average hourly traffic volume on NPA Dual carriage way around the second roundabout (out)

4.46.1.6. NPA MAIN ENTRANCE GATE (IN)

Table 8 and figure 7 present traffic situation of vehicles entering the Onne Port complex as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 8 revealed the highest traffic volume of 5363 was recorded on Monday, followed by Friday with a traffic volume of 3415, while the least traffic volume 1359 was recorded on Sunday. The weekly average hourly volume of traffic was highest between 11-12am, in the morning, while the lean period was observed between 9 – 10am in the afternoon. See fig 1. General observation revealed that the traffic volume was largely dominated by category 2 and 3.

Table 4.14a: Weekly traffic volume of vehicles entering NPA Main Entrance (In)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	145	162	142	164	104	156	166
Cat 2 (Car and Light Vans)	2027	2309	1143	824	3690	1698	1742
Cat 3 (Lorries and Trucks)	540	778	611	300	1296	721	735
Cat 4 (Buses and Coaches)	149	166	143	71	273	153	176
Total	2861	3415	2039	1359	5363	2728	2819

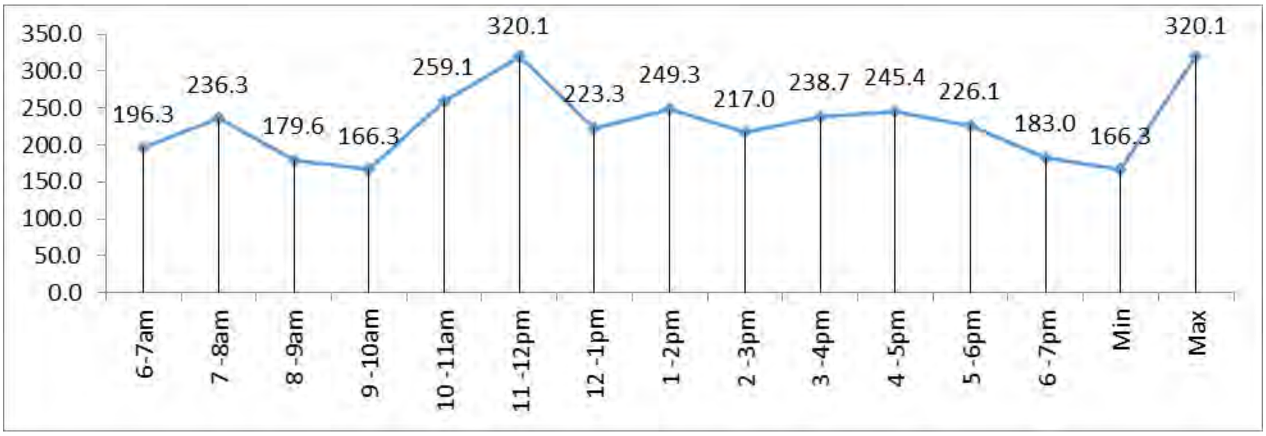


Figure 4.47a: weekly average hourly traffic volume of vehicles entering NPA Main Entrance (In)

4.46.1.7. NPA MAIN ENTRANCE GATE (OUT)

Table 9 and figure 8 present traffic situation vehicles leaving the Onne Port complex as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 9 revealed the highest traffic volume of 3540 was recorded on Friday, followed by Tuesday with a traffic volume of 3128 while the least traffic volume 1302 was recorded on Sunday. The weekly average hourly volume of traffic was highest between 4 –5pm (345.4), while the lean period was observed between 8 –9am (117.0), in the morning (see figure 2).

Table 4.13b: weekly traffic volume of vehicles leaving NPA Main Entrance (Out)

Category	**Thursday 13/7/23**	**Friday 14/7/23**	**Saturday 15/7/23**	**Sunday 16/7/23**	**Monday 17/7/23**	**Tuesday 18/7/23**	**Wednesday 19/7/23**
Cat 1 (Motorcycle/Keke)	292	338	302	184	227	251	341
Cat 2 (Car and Light Vans)	1460	2295	1129	771	1543	1908	1600
Cat 3 (Lorries and Trucks)	486	712	643	256	414	787	611
Cat 4 (Buses and Coaches)	172	195	104	91	78	182	233
Total	**2410**	**3540**	**2178**	**1302**	**2262**	**3128**	**2785**

Figure 4.47b: Weekly average hourly traffic volume of vehicles leaving NPA Main Entrance (Out)

4.46.1.8. WACT/OMT ENTRANCE GATE OFF FOT DUAL CARRIAGE ROAD (IN)

Table 10 and figure 9 present traffic situation from FOT Dual carriage road to WACT/OMT by the entrance gate as surveyed on 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 10 revealed the highest traffic volume of 1371 was recorded on Monday, followed by Friday with a traffic volume of 1327, while the least traffic volume of 341 was recorded on Sunday. The weekly based hourly average volume of traffic peaked between 7 – 8am with average count of 102.9, while the lean period was observed between 9–10am with average count of 75.6 during the evening period.

Table 4.14a: Weekly traffic volume from FOT Dual carriage road to WACT/OMT (in)

Category	**Thursday 13/7/23**	**Friday 14/7/23**	**Saturday 15/7/23**	**Sunday 16/7/23**	**Monday 17/7/23**	**Tuesday 18/7/23**	**Wednesday 19/7/23**
Cat 1 (Motorcycle/Keke)	147	178	104	80	234	129	147
Cat 2 (Car and Light Vans)	806	859	244	131	884	818	864
Cat 3 (Lorries and Trucks)	175	244	117	99	182	162	161
Cat 4 (Buses and Coaches)	46	46	46	31	71	89	53
Total	**1174**	**1327**	**511**	**341**	**1371**	**1198**	**1225**

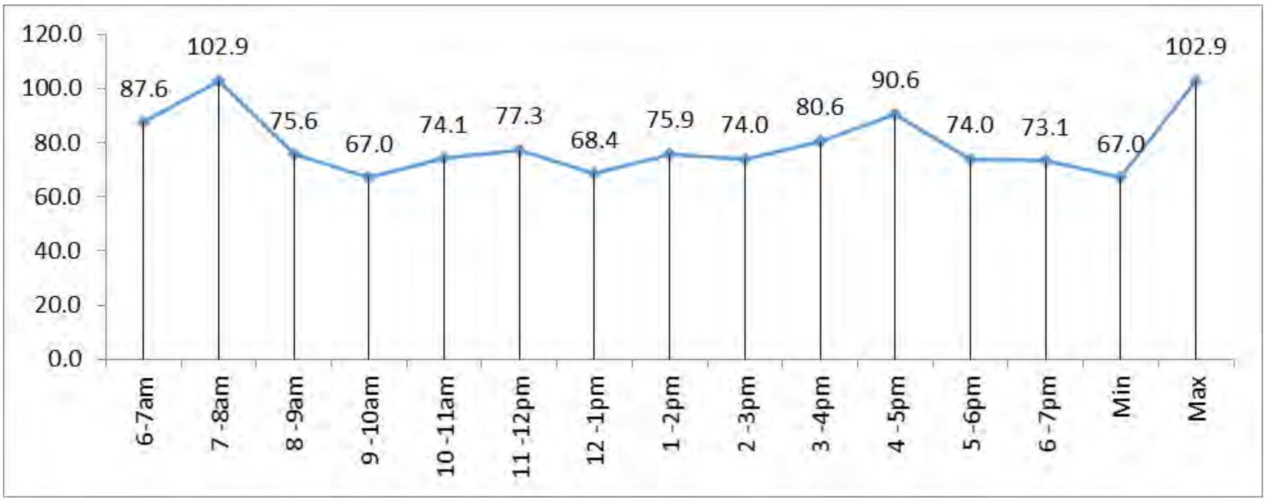


Figure 4.48a: Weekly average hourly traffic volume from FOT Dual carriage road to WACT/OMT (In)

4.46.1.9. WACT/OMT ENTRANCE GATE OFF FOT DUAL CARRIAGE ROAD (OUT)

Table 11 and figure 10 present traffic situation from WACT/OMT into the FOT Dual carriage way leading Main NPA gate as surveyed on 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 11 revealed the highest traffic volume of 1472 was recorded on Tuesday, followed by Monday with a traffic volume of 1447, while the least traffic volume of 383 was recorded on Sunday. The weekly based hourly average volume of traffic peaked between 2 – 3pm with an average count of 109.2, while the lean period was observed between 9–10am with average count of 60.7 during the morning period.

Table 4.14b: Weekly traffic volume from WACT/OMT into the FOT Dual carriage way (out)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	150	150	113	61	196	131	150
Cat 2 (Car and Light Vans)	854	507	289	166	778	861	732
Cat 3 (Lorries and Trucks)	339	197	251	145	432	404	391
Cat 4 (Buses and Coaches)	50	52	56	11	41	76	27
Total	**1393**	**906**	**709**	**383**	**1447**	**1472**	**1300**

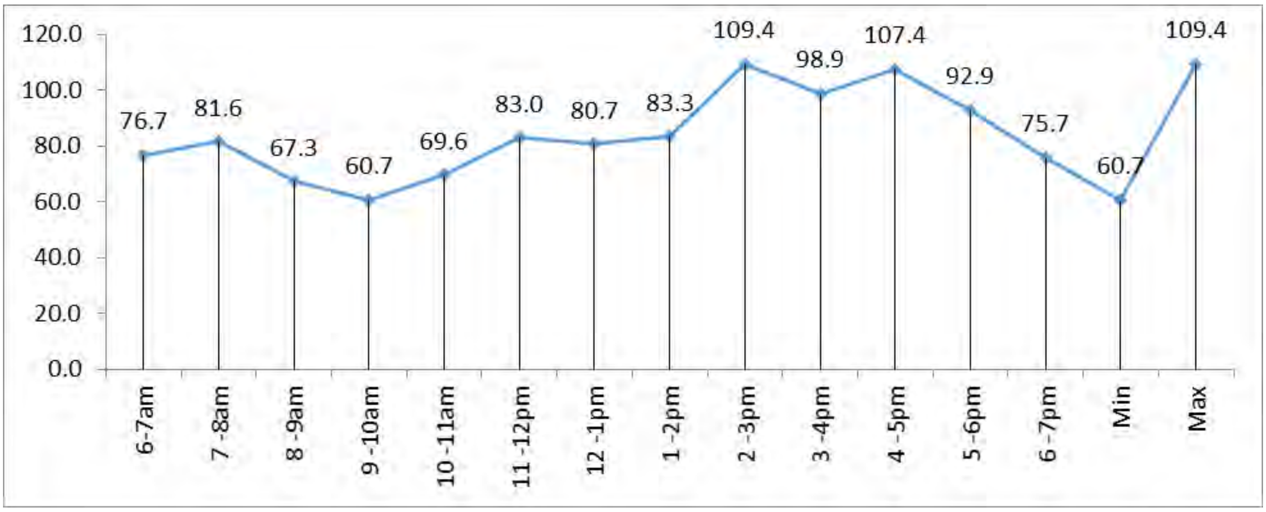


Figure 4.48b: Weekly average hourly traffic volume from WACT/OMT into the FOT Dual carriage way (out)

4.46.1.10. NEW WACT/OMT ROAD UNDER CONSTRUCTION (IN)

Table 12 and figure 11 present traffic situation on the New WACT/OMT (In) as surveyed on 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 11 revealed the highest traffic volume of 1125 was recorded on Monday, followed by Tuesday with a traffic volume of 1029, while the least traffic volume of 329 was recorded on Sunday. The weekly based hourly average volume of traffic was peak between 1 – 2pm with average count of 78.0, while the lean period was observed between 6–7am with average count of 32.6 during the morning period.

Table 4.15a: Weekly traffic volume on the New WACT/OMT (In)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	145	130	84	61	126	168	216
Cat 2 (Car and Light Vans)	459	476	132	87	486	464	431
Cat 3 (Lorries and Trucks)	333	343	180	172	316	379	447
Cat 4 (Buses and Coaches)	19	17	26	9	17	18	31
Total	**956**	**966**	**422**	**329**	**945**	**1029**	**1125**

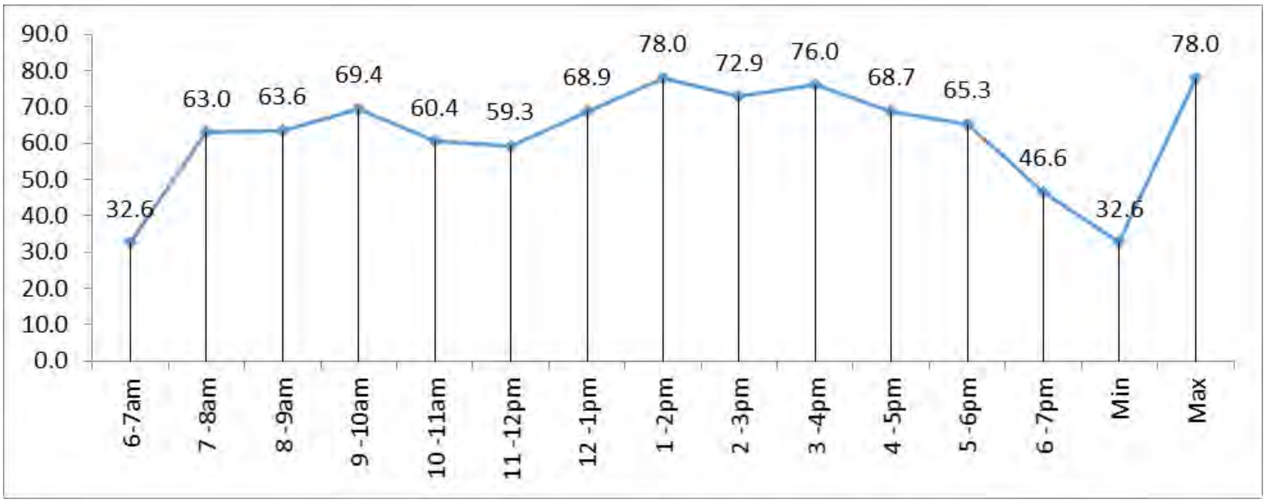


Figure 4.49a: Weekly average hourly traffic volume on the New WACT/OMT (In)

4.46.1.11. NEW WACT/OMT ROAD UNDER CONSTRUCTION (OUT)

Table 13 and figure 12 present traffic situation on the New WACT/OMT (Out) as surveyed on 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 13 revealed the highest traffic volume of 1232 was recorded on Wednesday, followed by Tuesday with a traffic volume of 1013, while the least traffic volume of 277 was recorded on Sunday. The weekly based hourly average volume of traffic was peak between 4 – 5pm with average count of 79.1, while the lean period was observed between 6–7am with average count of 29.7 during the morning period.

Table 4.15b: Weekly traffic volume on the New WACT/OMT (Out)

Category	**Thursday 13/7/23**	**Friday 14/7/23**	**Saturday 15/7/23**	**Sunday 16/7/23**	**Monday 17/7/23**	**Tuesday 18/7/23**	**Wednesday 19/7/23**
Cat 1 (Motorcycle/Keke)	143	140	77	61	159	194	241
Cat 2 (Car and Light Vans)	483	515	152	101	535	520	571
Cat 3 (Lorries and Trucks)	257	220	136	108	213	264	403
Cat 4 (Buses and Coaches)	18	9	18	7	39	35	17
Total	**901**	**884**	**383**	**277**	**946**	**1013**	**1232**

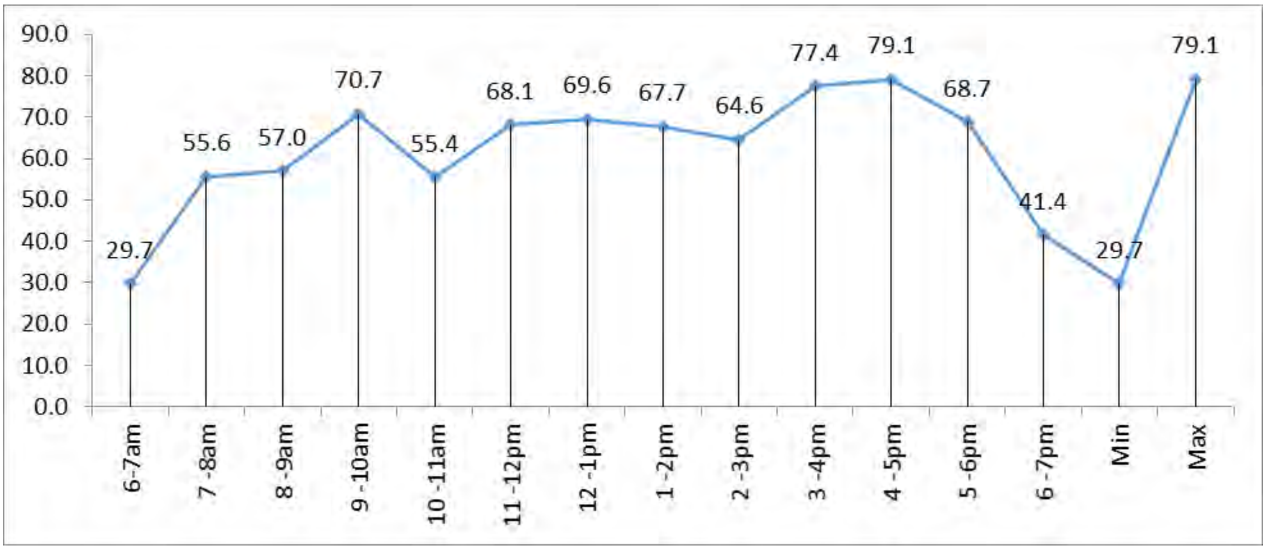


Figure 4.49b Weekly average hourly traffic volume on the New WACT/OMT (Out)

4.46.1.12. NEW WACT/OMT ROAD TO PROJECT SITE (IN)

Table 14 and figure 13 present traffic situation on the New WACT/OMT to MM Port Project site as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 14 revealed the highest traffic volume of 11 was recorded on Friday, followed by Tuesday with a traffic volume of 10, while the least traffic volume 1 was recorded on Saturday. The weekly based hourly average volume of traffic was peak between 4 – 5pm with average count of 1.0, while the lean period was observed between 12-1pm with average count of 0.0 in the afternoon.

Table 4.16a: weekly traffic volume on the New WACT/OMT to MM Port Project site (In)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	2	4	1	0	0	3	1
Cat 2 (Car and Light Vans)	1	4	0	4	5	7	3
Cat 3 (Lorries and Trucks)	1	3	0	1	1	0	0
Cat 4 (Buses and Coaches)	2	0	0	0	0	0	0
Total	**6**	**11**	**1**	**5**	**6**	**10**	**4**

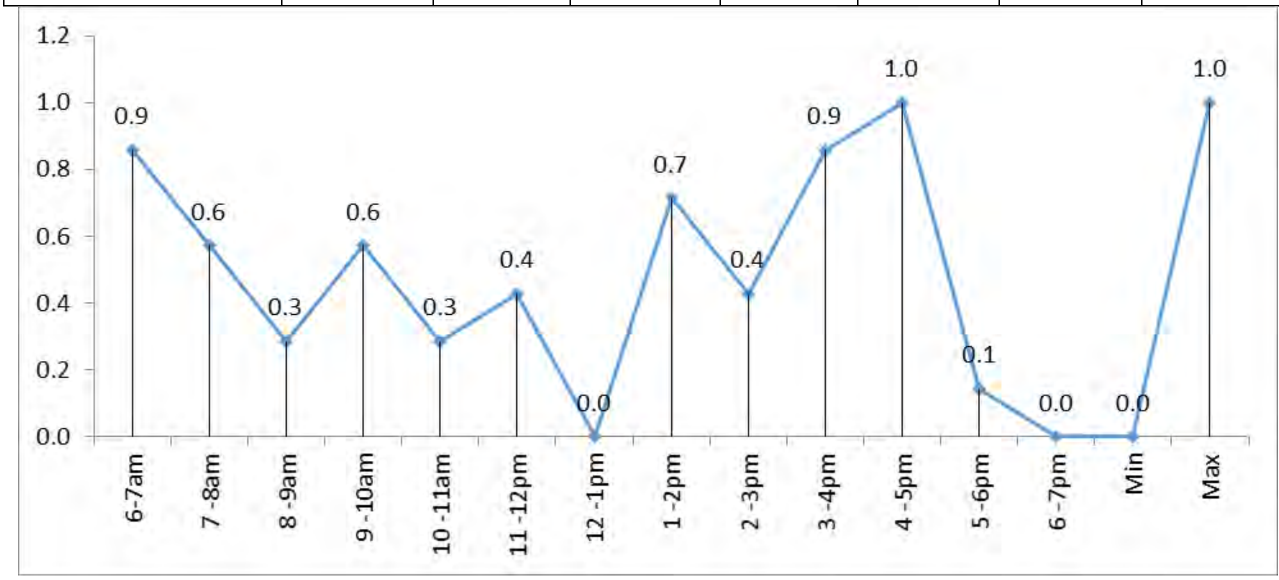


Figure 4.50a: Weekly average hourly traffic volume from WACT to Project Site

4.46.1.13. NEW WACT/OMT ROAD TO PROJECT SITE (OUT)

Table 15 and figure 14 present traffic situation leaving the Project site to the New WACT/OMT as surveyed 13th – 19th July 2023. The table presents the weekly traffic volume, while the figure presents the weekly based hourly average of traffic along the route. Table 15 revealed the highest traffic volume of 8 was recorded on Saturday, followed by Monday, Tuesday, and Friday, with a traffic volume of 8, while the least traffic volume of 4was recorded on Thursday. The weekly based hourly average volume of traffic peaked between 3 – 4pm in the evening with an average count of 1.1, while the lean period was observed between 10 – 11am with average count of 0.0 in the afternoon.

Table 4.16b: weekly traffic volume from Project site to the New WACT/OMT (Out)

Category	Thursday 13/7/23	Friday 14/7/23	Saturday 15/7/23	Sunday 16/7/23	Monday 17/7/23	Tuesday 18/7/23	Wednesday 19/7/23
Cat 1 (Motorcycle/Keke)	1	4	3	0	0	1	0
Cat 2 (Car and Light Vans)	2	2	4	4	5	6	3
Cat 3 (Lorries and Trucks)	1	1	1	1	2	0	2
Cat 4 (Buses and Coaches)	0	0	0	0	0	0	0
Total	**4**	**7**	**8**	**5**	**7**	**7**	**5**

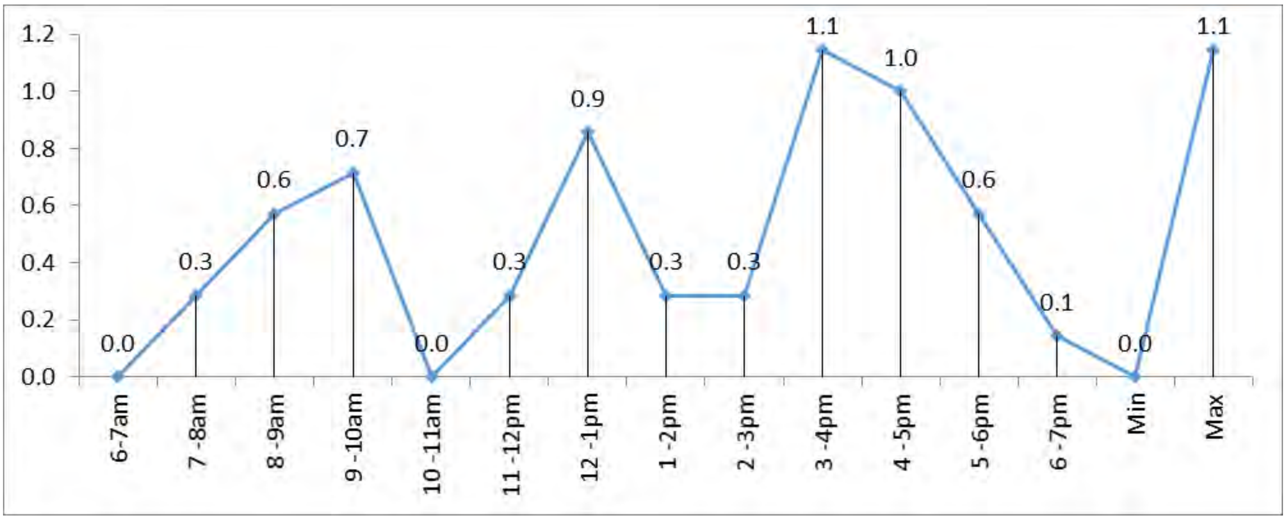


Figure 4.50b: weekly average hourly traffic volume from Project site to the New WACT/OMT (Out)

4.47. Impacts Assessment

Implementation of the proposed MM Port FZE may lead to the following impact both during construction and operation phase of the project.

- Reduction of access to road transport
- Increase in volume of traffic.
- Alteration to the composition of traffic.
- Reduction in road traffic flow.
- Increase in journey time.
- Decrease in road safety.

Moreso, these impacts are qualified to be Negative, Direct, Long-term, Reversible, and incremental as state in table 10 below:

4.47.1. Consequence of impacts

The potential consequence of an impact depends on two things:

- The magnitude of the potential changes to the environment, caused by a hazard; and
- The level of sensitivity of the receiving environment.

The potential consequences of social (traffic) impacts can be described in the following manner:

Table 4.17: Interaction Matrix of Receptor Sensitivity and Magnitude of Change, Showing Resultant Effects

Receptor Sensitivity	Level of Change		
	Low	Medium	High
Low	Trivial effect	Slight effect	Substantial effect
Medium	Slight effect	Substantial effect	Big effect
High	Substantial effect	Big effect	Massive effect

(Source: Shell (2005)

Table 4.18 Levels of Effect and Potential Consequences

Levels of Effect	Potential Consequences
Massive	Extreme
Big	Great
Substantial	Considerable
Slight	Little
Trivial	Hardly any

(Source: Shell (2005)

Hardly any – A trivial effect on the social environment is one which causes almost no nuisance or damage in the neighborhood. The local culture and lifestyle as well as the social infrastructure are somewhat negatively affected, but the effect is only temporary. The impact could result in some disagreement with stakeholder groups, but relationships are likely to remain strong.

Little – A slight effect on the social environment, which causes temporary changes in the way of 2life of the neighborhood. The local culture and societal structure are negatively affected. There is disagreement with stakeholder groups, but the relationship remains fairly strong.

Great - A big effect on the social environment. There is permanent disruption to communal lifestyle. The local culture and the societal structure suffer greatly. There now is a fundamental disagreement between the company and its stakeholders that destabilizes the company-stakeholder relationship. This may affect the speed and effectiveness of future decision-making processes.

Extreme - A massive effect on the social environment. There is sustained large disruption of, and changes to, the lifestyle of a neighborhood, leading to a reduction in quality of life. Impacts have become a concern for all stakeholder groups. There is irreversible damage to social structure, traditional culture, and infrastructure, as well as total breakdown of stakeholder relationships. The rating or risk assessment of potential impacts may be done numerically or qualitatively.

4.47.2. Qualitative Risk Assessment

Table 9 shows a qualitative risk assessment matrix. In this method a Risk Assessment Matrix (RAM) is employed with *likelihood* plotted on the y-axis and *consequence* on the x-axis. The cells of this matrix, representing possible combinations of *likelihood* and *consequence*, give the levels of impact significance as judged by experts. For instance, an impact judged to have a *low* likelihood of occurrence but of *great* potential consequence will have a *minor* significance rating.

Table 4.19 : Qualitative Impact Assessment Matrix

Likelihood	Potential consequences					
		Negative				
	Positive	Hardly any	Little	Considerable	Great	Extreme
High		Moderate	Moderate	Major	Major	Major
Medium high		Minor	Moderate	Moderate	Major	Major
Medium		Minor	Minor	Moderate	Moderate	Major
Medium low		Negligible	Minor	Minor	Moderate	Moderate
Low		Negligible	Negligible	Minor	Minor	Moderate

(Source: Shell (2005)

Table 4.20: Traffic Impacts Qualification and Rating for both construction & operation

Project Activity	Sensitivity	Impact Description	Qualification	Likelihood	Consequence	Impact Rating
Site preparation, Construction, and Operation	Access to road transport	1. Reduction of access to road transport	- Negative - Direct - Long term - Reversible - Incremental	Medium High	Considerable	Moderate
	Road traffic Volume	2. Increase in volume of road traffic	- Negative - Direct - Long term - Reversible - Incremental	Medium High	Considerable	Moderate
	Composition of road traffic	3. Alteration of the composition of traffic	- Negative - Direct - Long term - Reversible - Incremental	Medium	Little	Minor
	Road traffic flow	4. Reduction in road traffic flow	- Negative - Direct - Long term - Reversible - Incremental	Medium High	Little	Moderate
	Mean Journey time	5. Increase in mean journey time	- Negative - Direct - Long term - Reversible - Incremental	Medium High	Little	Moderate
	Road safety	6. Decrease in road safety	- Negative - Direct - Long term - Reversible - Incremental	Medium	Little	Minor

Table 4.21: **Traffic Impacts Mitigation Framework**

S/No.	Impact Description	Gross Rating	Mitigation /Enhancement	Net Rating	Responsible party
1.	Reduction of Access to Transport	Moderate	M.1 Schedule much of vehicular movement during observed off-peak periods. Make more use of Sundays as the survey has shown that there is relatively light traffic on that day.	Minor	EPC Contractor during construction MM FZE during operation
2.	Increase in Traffic Volumes	Moderate	M.2 Carry out major movements at night, possibly with armed escorts.	Minor	"
3.	Reduction in Traffic Flow	Moderate	M.3 Apply mitigations M1 and M2.	Minor	"
4	Increase in journey time	Moderate	M.4 Apply mitigations 1, 2, to reduce journey time.	Minor	"

5.0 Conclusion

Traffic survey of study area has been conducted in line with international best practice of using trained and experienced personnel, use of adequate data collection material and timing of 7days weekly and 14 hours' daily. The survey presents weekly traffic volume in four (4) vehicle categories and weekly based hourly average volume of traffic along all the surveyed routes. Thus, the findings of this survey are a veritable tool to understanding the baseline traffic situation along the surveyed route and also as for journey management purposes during construction and operation of the MM Port FZE Facility.

Table 5.0: Identified Impacts and Proposed Mitigation Measures - MM Port FZE Project

Project Phase	Project Activity	Description of Impact	Significance Rating Before Mitigation	Mitigation	Significance Rating After Mitigation (Residual Impact Rati
Mobilization	Movement of goods, equipment, and personnel	Potential increase in road traffic volume	Medium	▪ Heavy vehicles movement should be scheduled during off peak periods. ▪ Healthiness of road and use of alternative route ▪ Traffic wardens to guide heavy vehicle and COD movement	Low
		Potential increase in road traffic incidents	Medium	▪ Visible warning signs on roads and vehicles ▪ Speed breakers at strategic locations ▪ Defensive driving training to drivers ▪ Vehicle monitoring device / journey management procedure and alcohol policy shall be enforced	Low
Construction	Site preparation (Land clearing, excavation)	Increase in noise levels	Medium	▪ Limited vehicular movement in night hours ▪ Land clearing activities shall be limited to day hours. ▪ Use of minimum number of heavy earths moving vehicles.	Low
		Reduction in air quality (Dust, exhaust fumes)	Medium	▪ Water spray to wet surface ▪ Use of healthy vehicles	Low
		Loss of flora and fauna	Medium	▪ Site clearing limited to Project site. ▪ Clearing shall commence from one end of the plot. ▪ The project site is land filled site and hence limited vegetation clearing is required	Low

Project Phase	Project Activity	Description of Impact	Significance Rating Before Mitigation	Mitigation	Significance Rating After Mitigation (Residual Impact Rati
	Construction of the Jetty facilities	Increase in dust and noise	Medium	▪ The use of nose masks and earmuffs ▪ Water shall be sprayed on construction sites to reduce dust levels especially during dry season. ▪ Construction activities limited to day hours or minimal in night hours. ▪ Switch-off the equipment/vehicles when not in use	Low
Construction	Construction of Jetty facilities	Soil degradation	Medium	▪ Secondary containment for chemicals and liquid fuel storage ▪ Implementation of waste management plan ▪ Controlled fuelling of vehicles, ▪ Maintenance and servicing of construction machinery at designated area ▪ Availability of spill containment material	Low
		Water contamination and Loss of biodiversity	High	▪ Disposal of cleared vegetation at appropriate location far from riverbank ▪ Disposal of dredged spoils at designated disposal location identified by Nigerian Ports Authority ▪ The chemical and liquid fuel storage far from riverbank with secondary containment ▪ Training to construction workers on the sensitive nature of the biodiversity of the area and the need for conservation ▪ Periodical inspection of site drainage	Low

Project Phase	Project Activity	Description of Impact	Significance Rating Before Mitigation	Mitigation	Significance Rating After Mitigation (Residual Impact Rati
		Dredging	High	▪ Limited dredging to birth pocket ▪ The disposal of spoils at designated locations as identified by Nigerian Ports Authorities ▪ Engagement of highly experienced company having knowledge of the area for dredging activities ▪ Strict supervision of dredging and spoils disposal activities	Low
		Loss of habitat	Low	▪ Shall encourage the re-vegetation/landscaping of land cleared for temporary use where feasible	Low
		Threat to health of workers insect stings, injuries etc)	Medium	▪ Shall ensure usage of PPE by workers. ▪ Adequately numbers of first aiders and HSE Inspectors ▪ Shall ensure availability of anti-venom /antihistamine and regular fumigation. ▪ Site clinic and availability of Ambulance. ▪ Proper water drainage from the project site to avoid water accumulation	Low
Construction	Construction of Jetty facilities	Injury to workers	High	▪ Shall provide and enforce appropriate use of PPEs (e.g., coveralls, hard hats, eye goggles) ▪ Daily toolbox talk ▪ Implementation of work permit system	Medium
		Community concern	Medium	▪ Efforts to ensure that all host communities are represented in the employment. ▪ Efforts shall be made to provide contractors and supply orders considering the capabilities. ▪ Regular engagement	Non – existent

Project Phase	Project Activity	Description of Impact	Significance Rating Before Mitigation	Mitigation	Significance Rating After Mitigation (Residual Impact Rati
		Pressure on existing infrastructures and utilities	Medium	▪ Efforts shall be made to maximise employment of location population for construction activities. ▪ For highly skilled overseas manpower, the adequate accommodation will be arranged prior to mobilization to reduce pressure on local housing. ▪ As appropriate, shall support the development of the health facility and other infrastructure in the host communities.	Low
		Changes in local population	Medium	▪ Maximise the employment for local population and, hence reducing the influx. ▪ The availability of trained workers in the industrial zone, residing within the area ▪ Skill acquisition programs conduct by Indorama will support engagement of skilled & semi-skilled workers from the local residents.	Low
		Stress on existing security structures	Medium	▪ Dedicated security team for project site ▪ Surveillance around the project site by deployed security team ▪ Liaising with authorities like as NPA on security matters.	Low

Project Phase	Project Activity	Description of Impact	Significance Rating Before Mitigation	Mitigation	Significance Rating After Mitigation (Residual Impact Rati
		Increase in STIs / morbidity.	Medium	▪ Health awareness posters at site ▪ Immunization of workforce as appropriate ▪ Regular pest control ▪ Awareness campaign for construction workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution, and the need to sustain cultural values. ▪ Shall assist the activities of the state action committee on STIs/HIV/AIDS. ▪ Site clinic to take care of minor illnesses of construction workers	Low
	Waste generation and disposal	Increase in breeding ground for disease vectors. and other agents of diseases	Medium	▪ Implementation of waste management plan ▪ Disposal thru approved / accredited contractor at approved site ▪ Dedicated bins for collection and storage at site ▪ Segregation at generation point	Low
		Increase in nuisance	Medium	▪ IEPL CLOs will ensure there is continuous communication with the communities to allay/reduce fear of the unknown.	Low
		Contamination of the environment by domestic wastes	Medium	▪ Ensure regular collection and disposal of wastes in accordance with the project waste management plan. ▪ The availability to sufficient toilets at site	Low

Project Phase	Project Activity	Description of Impact	Significance Rating Before Mitigation	Mitigation	Significance Rating After Mitigation (Residual Impact Rati
		Disposal of scrap, packing material and empty containers	Medium	▪ Dedicated storage bins / area with appropriate facilities ▪ Disposal by accredited contractors ▪ Efforts shall be made to reuse the metal scrap and packing materials	Low
Operation and Maintenance	Operational activities	Increase in noise levels	Medium	▪ Shall ensure that appropriate maintenance programs are in place for all equipment. ▪ Switch-off the equipment/vehicles when not in use	Low
		Reduction in air quality	Medium	▪ Shall ensure that appropriate maintenance programs are in place for all equipment. ▪ Switch-off the equipment/vehicles when not in use ▪ Use of CNG driven power generating engines ▪ Use of CNG driven vehicles for transportation of Urea ▪ Installation and operation of de-dusting system at urea unloading facility	Low
		Degradation of soil and surface water from spills and leaks	Medium	▪ Shall provide secondary containment for chemicals and lube storage. ▪ Implementation of waste management plan ▪ Maintenance and servicing protocol for operation and maintenance of machinery is established and followed to minimise leaks and spills. ▪ Ensure availability of spill control materials ▪ Regular checks of storm water drainage system ▪ Regular housekeeping	Low

Project Phase	Project Activity	Description of Impact	Significance Rating Before Mitigation	Mitigation	Significance Rating After Mitigation (Residual Impact Rati
		Contamination of the environment by product (Urea), if spilled	Medium	▪ Shall ensure that products are properly managed/ stored in order to avoid spill. ▪ Unloading, storage and loading is within covered area with paved surface. ▪ Regular cleaning of conveyor gentries and recycling of swept urea at production site at Indorama Complex	Low
		Ammonia storage, release of ammonia vapours	Hight	▪ Dedicated flare for complete combustion of ammonia vapours released. ▪ Fire & Gas detection system, BOG system ▪ Double walled ammonia storage tank ▪ Fire water network	Low
		Discharge of treated sewage	Medium	▪ Functional sewage treatment plant ▪ The quality check of the treated sewage discharged. ▪ The periodical water quality monitoring of outfall area and at other locations of waterbody.	Low
		Traffic congestion (Marine & land)	Medium	▪ The use of new road for bulk urea truck movement ▪ Maximum movement during lean traffic ▪ Minimum movement during late night hours ▪ Liaising with NPA on navigations of marine vessels ▪ No ballast water discharge from vessels into the surface water.	Low

Project Phase	Project Activity	Description of Impact	Significance Rating Before Mitigation	Mitigation	Significance Rating After Mitigation (Residual Impact Rati
		Threat to health of workers (Snake bites, insect stings, injuries etc)	Medium	▪ Availability of first aid boxes and trained first aiders. ▪ Functional site clinic ▪ Use of appropriate PPEs ▪ Availability of anti-venom/antihistamine ▪ Regular fumigation/ pest control ▪ Proper drainage to avoid water accumulation	Low
		Potential community concern (employment, pollution and others)	High	▪ Shall ensure fair community representation in the employment of local labour, contract, and material supply. ▪ Regular engagement of Onne & Ogu communities ▪ Shall continue the existing engagement practices with host communities on CSR Projects, Skill acquisition programs, scholarship to students, micro-grant to women etc. ▪ Effective implementation of Stakeholder Engagement Plan & Grivence Management Procedure	Low