CHAPTER FOUR
DESCRIPTION OF THE ENVIRONMENT

4.1 GENERAL

The objective of the environmental baseline description is to establish the condition of the various environmental components that are likely to be affected by the proposed project against future occurrences as a result of the project activities. This would provide the basis for determining the impacts of the proposed project on the environment as well as the determination of mitigation measures. In this ESIA the environment is classified as biophysical, social and health. The baseline conditions of the biophysical environment (physical, chemical and biological) of the proposed field development project area, and the socio-economic and health conditions of the communities within the project area are described.

4.1.1 Baseline Data Acquisition Methods

The approach adopted was to obtain physical and biophysical baseline data from desktop, field and laboratory studies, interviews and consultations with individuals / representatives of the host communities of the proposed project area. For socio-economic & health studies, structured questionnaires were administered to a probability sample of households. This approach would provide adequate information for establishing the baseline status of the environment of the study area. The study consisted of a one-season field sampling campaign, which took place between 29 to 30th September, 2017 (Wet Season), while data collected from previous studies and compliance monitoring authored by Indorama during the dry season were used as secondary data (Appendix 1.3).

4.1.2 Description of Sampling Locations

The Sampling points were geo-referenced by means of Global Positioning System (GPS) on the field. Judgment sampling was applied in the selection of study stations, taking into account ecological features, geographical location of communities and control points in apparently undisturbed areas. The universe of households was obtained from listing by guides and assigned field assistants.

The map showing the study area with the sampling stations are shown in Appendix 4.1. The Local Government Area and communities (Table 4.1.1) were identified within the defined study boundary.

Table 4.1.1: Study Communities

STATE (1)	LOCAL GOVERNMENT AREA (2)	COMMUNITY (4)
Rivers State	Eleme	Aleto Agbonchia Akpajo
	Obio-Akpor	*Elelenwo*

4.1.3 Spatial Boundary for the Study

Data gathering for the baseline studies considered the following spatial boundaries:

- 2km radius for biophysical sampling
- 4km spatial boundary for socio-economic and health assessment
- 5km for Control samples
- Geo-referencing of all sample stations.

4.1.4 Environmental components of the Study

A comprehensive description of the baseline conditions of the proposed project area was undertaken. The scope covered:

- Meteorology
- Air Quality and Noise
- Soil, Land use and land cover
- Vegetation and Wildlife
- Geology/Hydrogeology
- Surface water and sediment quality
- Groundwater Quality
- Socio-economics
- Human Health

4.1.5 Study Design and Methodology

The study approach included

- Review of existing literature and secondary data
- Ecological baseline data gathering in line with the approved Terms of Reference (TOR) for the EIA

Biophysical Components

Field sampling and observations involved using standard methods such as:

- In-situ measurements with appropriate equipment having certified calibration;
- Laboratory analysis of samples using standard methods;
- Quality assurance and quality control management principles.

Socioeconomics and Health Components

Key methods have been used:

- Informant interviews;
- Focus Group Discussion (FGD);
- Direct observation;
- Administration of structured questionnaires and Collection of secondary data.

The field procedures adopted for data collection are summarized in Appendix 4.2 and the instruments used for sampling, measurement and analysis are summarized in Table 4.1.2 below.

Table 4.1.2: Environmental Components and Methods / Instruments used for sampling / measurement / analysis

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
METEOROLOGY	Temperature	Traceable Thermometer	°C
	Wind speed & Direction	Skye Master Anemometer & wind Vane	m/s,
	Humidity, Atmospheric Pressure	Skye Master Mini Weather Station	%

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
AIR QUALITY	Suspended Particulate Matter	Met One Instrument Aerosol Mass Monitor	mg/m^3
	Nitrogen Oxides	Testo 350 XL Gas Analyser	ppm
	Sulphur Oxides	Testo 350 XL Gas Analyser	ppm
	Carbon Monoxides	Testo 350 XL Gas Analyser	ppm
	VOC/HC	Testo 350 XL Gas Analyser	ppm
	Heavy Metals	Air metrics Minivol Sampler/ Atomic Absorption Spectrometry	ppm
NOISE	Sound level	Extech Sound Meter	dB(A)
SOIL	Sampling	Stainless steel auger	
	pH	Hannah pH meter	
	Electrical conductivity	Hannah conductivity meter.	µS/cm
	Soil Texture	Particle Size Matrix	
	Organic carbon	Wet combustion method	%
	Heavy metals	Digestion/Atomic Absorption Spectrophotometry	mg/kg
	Total Hydrocarbon Content	Extraction / IR Spectrophotometry	mg/kg
VEGETATION		Quadrant, Binoculars	
GROUNDWATER		Niskin water sampler & ISCO Borehole Sampler	
	Temperature	Eco Testr pH/temperature Meter	^oC
	pH	Eco Testr pH meter	
	Total, Dissolved and Suspended Solid	ExTech Conductivity/TDS Meter	mg/l
	Total Alkalinity	HACH Digital Titration method	mg/l
	Dissolved Oxygen	ExTech DO Meter	mg/l
	Biological oxygen Demand (BOD_5)	Winkler method	mg/l
	Total Hydrocarbon Content (THC)	Extraction / Spectrophotometer	mg/l

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
	Conductivity	Ex Tech Conductivity Meter.	
	Heavy metals	Flame Photometry / Atomic Absorption Spectrometry	mg/l
MICROBIOLOGY	Total heterotrophic bacteria, fungi, hydrocarbon Utilizing bacteria and fungi, total and faecal coliforms.	Composite samples for laboratory analysis	
WATER USE	Traditional use of rivers and water bodies (navigation, sand mining, food processing, aquaculture, domestic etc.)	Direct observation/ interviews	
WILDLIFE	Conservation status (rare, threatened and endangered species), conservation areas (forest reserves etc.), environmentally sensitive areas – wetlands and swamps), local conservation practices.	*In situ* observation, interviews, secondary data	
GEOLOGY	Profile, type and composition	*In situ* observation, drilling, laboratory analysis, reporting	
SOCIO-ECONOMIC STUDIES	Social Infrastructure Cultural Properties, Natural Resources and Land Use, Perception of the project, The role of women and children, Physically Challenged, Social Structure and Organization, Vehicular Traffic Analysis, Sex Trade	Key informant interviews, Focus Group Discussion (FGD), direct observation, Administration of structured questionnaires and Collection of secondary data.	
HEALTH STUDIES	Demographic profile of the Communities, Morbidity/Mortality Patterns, Healthcare facilities, Nutritional Status of Under-fives and the general population, Maternal	Key informant interviews, FGD, Administration of structured questionnaire and interviews, Physical examination of volunteers, Walk-through survey and	

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
	and Child Health, Knowledge, Attitude Practice and Behaviour (KAPB), Environmental health factors,	Collection of secondary data.	

4.1.6 Quality Assurance / Quality Control

The QA/QC programmes covered all aspects of the study, including sample collection and handling, laboratory analyses, generation of data and coding, data storage and treatment as well as report preparation. The quality assurance programme used in the fieldwork and laboratory analyses is in accordance with international and National regulatory recommendations such as:

- Ensuring that only experienced and qualified personnel are engaged in the study (see Appendix 4.3);
- Carrying out field calibrations of equipment and running distilled water blanks to reduce errors that could arise from field measurements;
- Ensuring that replicate samples are collected and used as checks on measurements;
- Carrying out field analytical operations in a defined sequence to avoid cross contamination of instruments.
- It is also be noted that the collected samples were submitted in due time to FMEnv approved laboratories, which are well equipped with latest sophisticated instruments and managed by well experienced professionals.

Parameters such as temperature, pH, turbidity, electrical conductivity and dissolved oxygen were determined *in situ* because of their rapid change due to deterioration of samples due to microbial degradation and transformation. They were therefore analysed at minimum time after collection.

4.2 METEOROLOGY

4.2.1 Site Specific Micro Meteorology

The Climate assessment for the study environment tends to highlight the atmospheric pattern of the study area. The assessment of climatic parameters such as rainfall, temperature, wind speed & direction, relative humidity and cloud cover are important baseline variables for any proposed or ongoing project activity in any place. According to Ayoade (2008), the weather condition of study environment is determined by the monsoon; a seasonal wind shift that brings rain (wet monsoon) via South-Westerly wind between March and early November and usher in dry season (dry monsoon) via North-Easterly wind between December and February. Rainfall is the main climatic variable and there is marked alternation of wet and dry seasons in the study area. Two air masses controls rainfall – moist Northward moving maritime air coming from the Atlantic Ocean and the dry continental air coming from the African Landmass. The climate of Niger delta is affected by ocean and atmospheric interactions both within and outside its environment, in which the Inter-Tropical Convergence Zone (ITCZ) plays a controlling factor. The movement of the ITCZ is associated with the warm humid maritime Tropical air mass with its South-Western winds and the hot and dry continental air mass with its dry North-Easterly winds.

To establish the microclimatic baseline of the study area, a weather station was set up in an open ground and allowed to run for 24 hours. The micro-meteorological data recorded are summarized in Table 4.2.1.

Table 4.2.1: A 24-hour Weather pattern recorded within study area.

Hours (GMT) Date: 29th, Sept' 2017	Air Temp. (°C)	R/H (%)	Wind		Pressure (mbar)	Cloud Cover (Oktas)	Weather
			Speed (m/sec)	Direction			
17:00	31.6	69	2.6	SE	1025.0	5	**S**
18:00	29.7	76	2.0	SW	1025.5	5	**PS**
19:00	28.0	83	1.5	SE	1025.7	NT	**Slight Wind**
20:00	27.0	86	1.0	SE	1026.2	NT	**Cool**
21:00	26.5	87	0.7	SW	1027.7	NT	**Cool**
22:00	26.0	92	0.5	SE	1027.5	NT	**Cool**
23:00	25.5	93	0.5	SW	1027.4	NT	**Cool**
00:00	25.0	93	Calm	Calm	1027.4	NT	**Calm**
01:00	24.5	94	Calm	Calm	1025.4	NT	**Calm**
02:00	24.0	94	1.0	SW	1025.4	NT	**Slight Rain**
03:00	23.0	95	1.4	SW	1025.2	NT	**Slight Rain**
04:00	23.0	95	1.3	SW	1025.2	NT	**Slight Rain**
05:00	22.5	96	1.5	SE	1025.3	NT	**Slight Wind**
06:00	22.5	96	1.6	SW	1025.3	6	**Slight Wind**
07:00	23.5	94	0.9	SE	1025.9	6	**PC**
08:00	25.5	87	1.0	SE	1026.0	6	**PC**
09:00	27.8	75	1.2	SW	1027.2	6	**PC**
10:00	29.5	65	1.5	SW	1027.8	5	**PS**
11:00	31.5	65	3.0	S	1027.8	5	**S**
12:00	33.4	60	3.5	SW	1027.4	4	**S**
13:00	32.8	63	3.3	SW	1027.3	5	**S**
14:00	33.1	61	3.2	SW	1026.7	5	**S**
15:00	33.3	61	3.1	SW	1026.9	5	**S**
16:00	33.2	61	3.2	SE	1026.7	5	**S**
Mean	**27.6**	**81**	**1.8**	**SW**	**1026**	**5**	

GPS Coordinates: Latitude N04° 48' 57.6" Longitude E007° 05' 52.8"

*S-Sunny, **PS- Partly sunny, ***PC- Partly cloudy, ****NT-Night time

Rainfall Pattern

The study area is situated within the tropical wet climatic belt. In this belt, rainfall variation is the most important parameter for the determination of season. In general, two seasons are characteristic of the climate in the region, namely the dry and wet seasons. In wet season, the annual distribution starts with the initial rains in March, which ceases in late November. Typically, there are two major seasons, sometimes, heavier rainfall than usual may occur and the rain is extended into the dry season and often the August break may not even occur. Rainfall is the most important element of climate change and water resources potential. It impacts almost all areas of human life such as agriculture, health, transportation etc. The amount and distribution of rainfall in the study area is such that it plays an important role in moving pollutants from the atmosphere to other spheres of the environment. The mean annual rainfall for the study environment is above 2300mm. The data retrieved from close meteorological station and shown in Table 4.2.2, present the mean monthly rainfall distribution for 30 years (1985-2015) in the study area. Average highest rainfall peaks were attained in September (370mm), July (364mm) and August (325mm). Lowest rainfall values were attained in January (15.3mm) and December (19.2mm). It should be noted that rainfall is very important in managing construction projects since it may cause erosion and erode soil particles from ground level surfaces.

Air Temperature

Maximum and minimum onsite temperature has been 33.4^{o}C measured at 12:00GMT and the minimum recorded was 22.5^{o}C at 05:00 & 0600 GMT (Table 4.2.1). Analysis from the macro data shows that the months of July-September recorded lower temperatures (28-29^{o}C) due to rainy periods while the months December to March recorded higher temperatures (32-34^{o}C) due to intense solar radiation prevalent in the dry season (Table 4.2.2). Uko and Tamunobereton-Ari, (2013) noted that the average maximum and minimum temperatures during the dry and wet seasons are within 31-33^{o}C and 21-23^{o}C as well as 25-33^{o}C and 18-23^{o}C respectively. The degree of air temperature is dependent on the amount of solar radiation received, atmospheric conditions, such as cloud cover and humidity, which trap heat and this impacts on the stability pattern of the atmosphere

in the area. Port Harcourt exhibit a very stable stability class F at nights that inhibits emission dispersion and slightly unstable/moderate stability classes C-B during the day periods that enhances emission dispersions (Edokpa and Nwagbara 2017). Air temperature also affects nearly all other weather parameters. For instance, air temperature affects: the rate of evaporation, wind speed and direction, precipitation patterns as well as the unstable, stable and neutral conditions of the atmospheric environment. Measuring air temperature is critical to the proper identification of the micro and macro environment of living organisms. It is especially critical for researchers in the animal and biological sciences since ambient temperature can influence their physiological, nutritional and behavioral status. The study environment is bounded heavily by open vegetation areas and this modifies ambient temperature. Ansari (2003) noted that the major parts of a healthy environment are vegetation associated with area. He emphasized that vegetation improves the environment by lowering the maximum temperature and increasing the minimum temperature most especially in locations of increased elevation. When air passes through vegetation it cools and obtains moisture which when mixed with the open environment reduces temperature thereby generating was is referred to as local precipitation (Ansari, 2003). Ayoade (2004) highlighted that the features which impact the distribution of temperature at any location include: the amount of insulation received, nature of the surface, distance from water bodies, relief, nature of prevailing winds and ocean currents. Figures 4.2.1 to 4.2.4 shows the processed satellite data for average surface temperature for 0000, 0600, 1200 and 1800 hours in the study environment for July 2017.

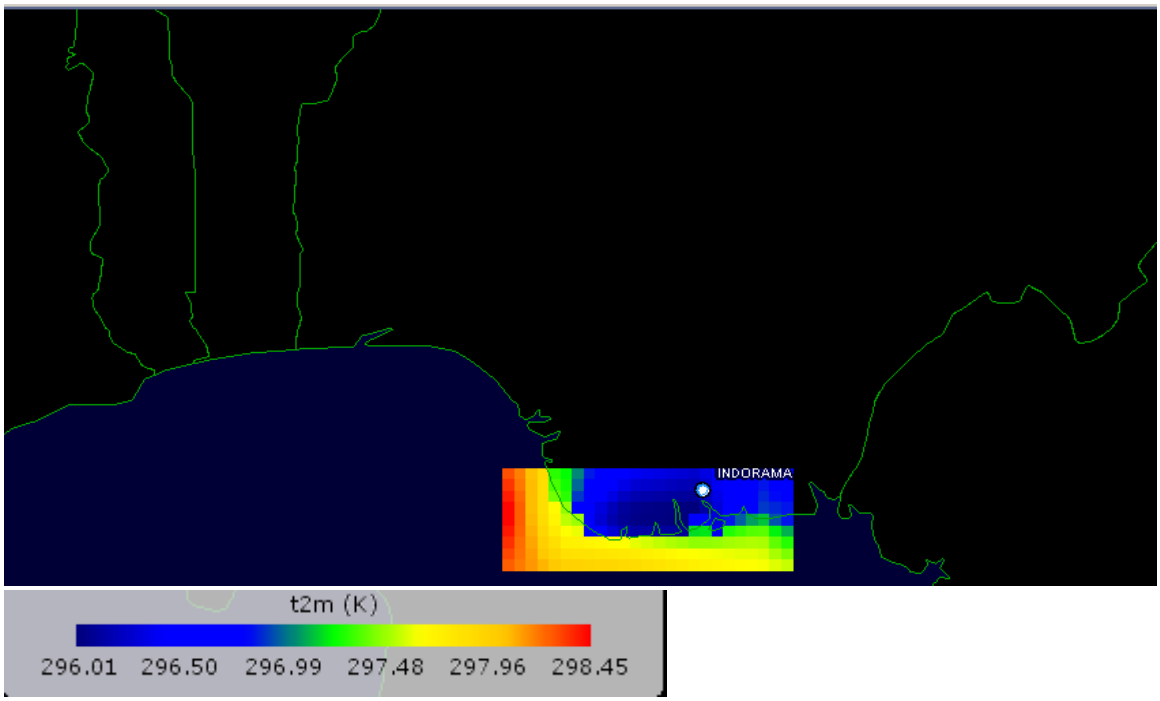

Figure 4.2.1: Average 0000Hr Air Temp. Pattern for Study Area in July 2017.

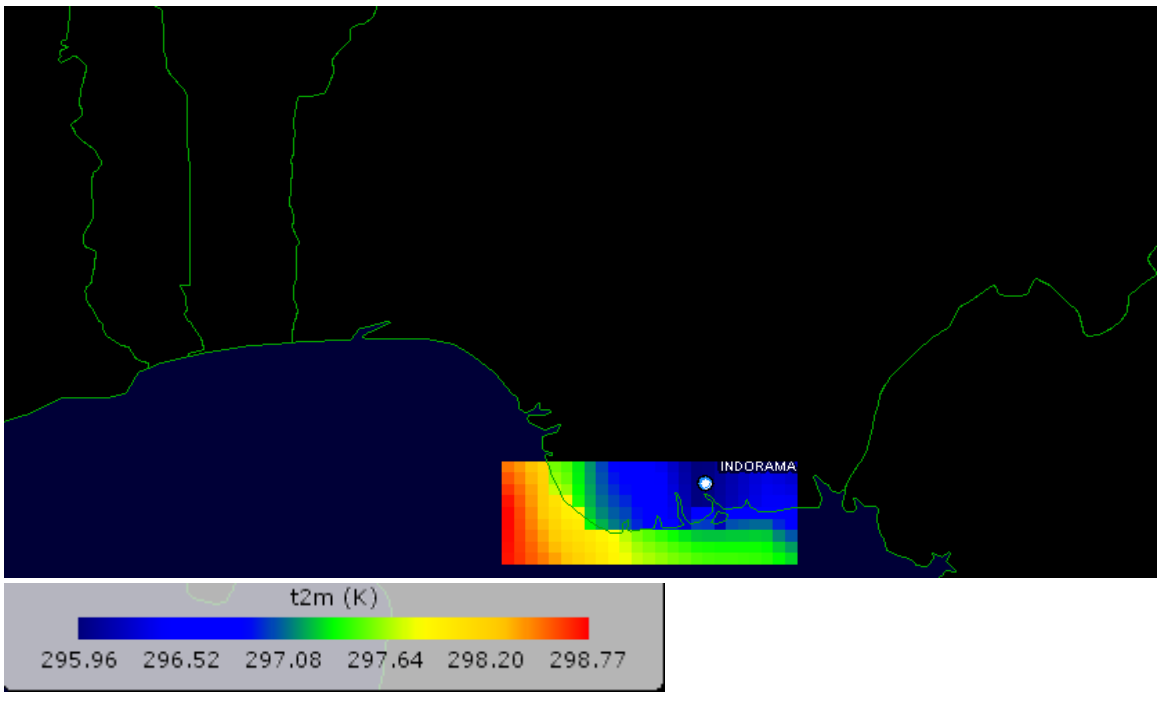

Figure 4.2.2: Average 0600Hr Air Temp. Pattern for Study Area in July 2017.

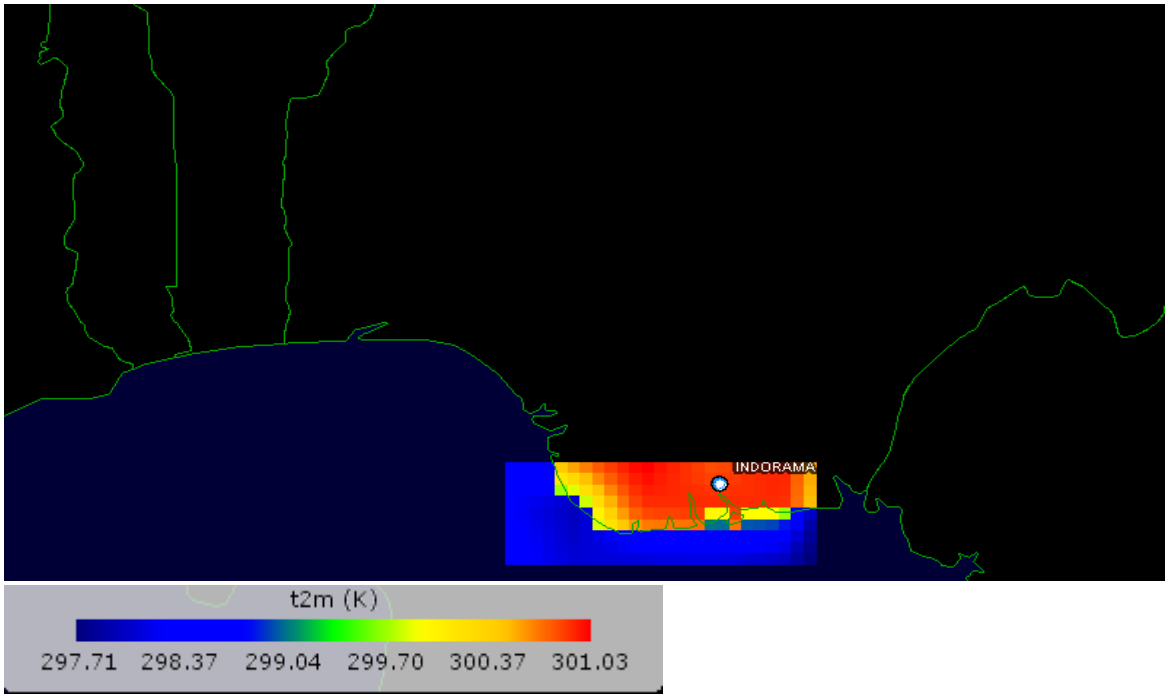

Figure 4.2.3: Average 1200Hr Air Temp. Pattern for Study Area in July 2017.

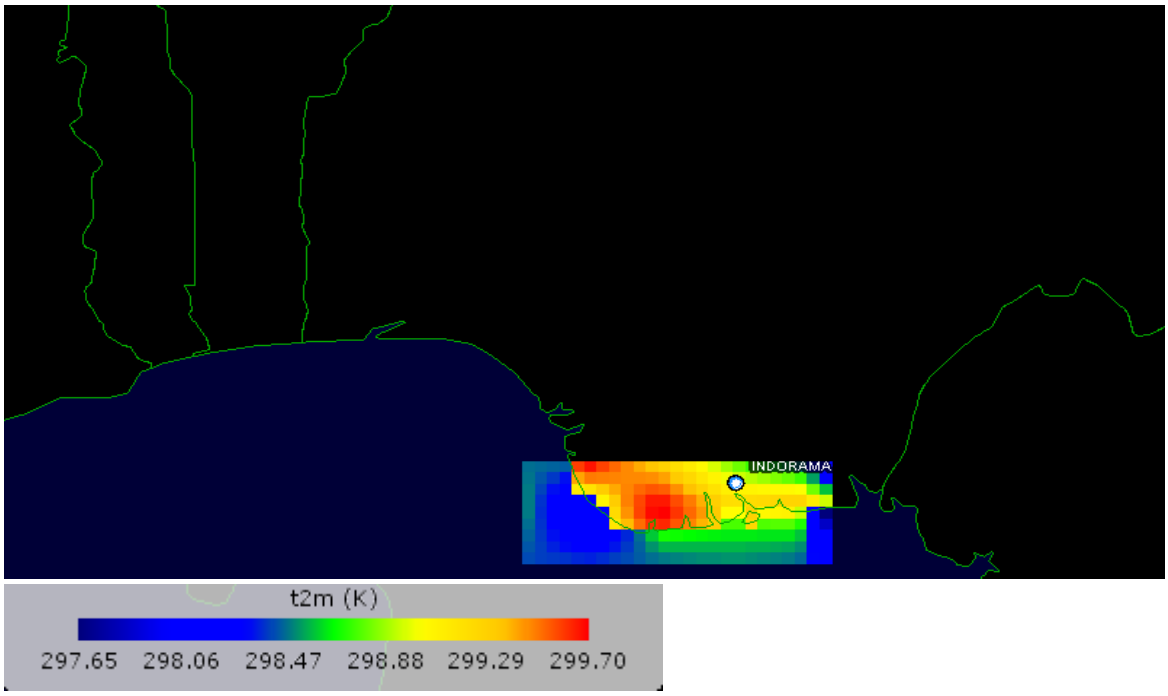

Figure 4.2.4: Average 1800Hr Air Temp. Pattern for Study Area in July 2017.

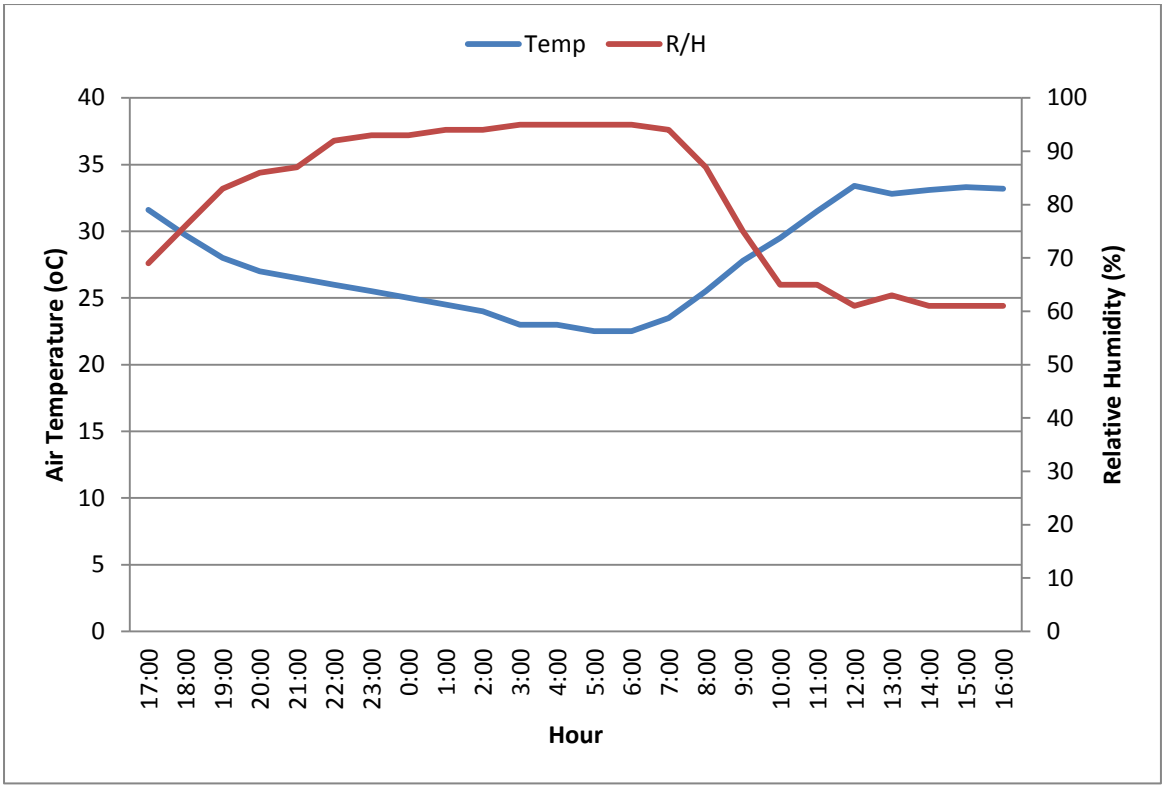

Figure 4.2.5: Diurnal temperature and relative humidity variations during fieldwork

Relative Humidity

The maximum relative humidity observed during fieldwork was 96%, recorded at 05:00-06:00GMT. The minimum recorded was 60% at 12:00 GMT (Table 4.2.1). As ambient temperature increases, percentage humidity decreases and vice-versa. Relative humidity which measures water vapour in the atmosphere is noted to be low during dry season and high during the peak of rainy season due to the influence of moisture laden South-Westerly winds as seen from the macro average monthly results. Also relative humidity was low during the afternoons and maximum at nights as indicated from the field data (Table 4.2.1). A 30-year mean monthly relative humidity analysis shows that the study environment has high relative humidity throughout the year with peaks during the wet season (Table 4.2.2). Oluyole et al., (2013) disclosed that average annual relative humidity for the area is above 80%. Figure 4.2.5 shows the observed diurnal relative humidity and temperature values moving in opposite directions. Due to the moist nature of the atmospheric environment in the study area, relative humidity is always high throughout the years.

Table 4.2.2: Average Weather Trend for Port Harcourt (1985-2015).

Sr. No.	Month	Average Temp (OC)	Rainfall (mm)	Cloud Cover (oktas)	Pressure (mbar)	R/H (%)	Wind Speed (m/s)	Wind Dir.
1	January	33.5	15.3	6.8	1006.5	72	2.8	NE
2	February	34.1	74	6.8	1005.8	77	2.5	SW
3	March	33.7	92.7	6.9	1005.6	81	3.6	SW
4	April	32.6	143	6.9	1005.7	83	3.6	SW
5	May	32.1	247.4	6.9	1007.4	87	3.7	SW
6	June	30.4	310	7	1008.4	89	3.8	SW
7	July	28.3	364	7	1009.7	91	4.2	SW
8	August	29.0	325	7	1009.6	91	4.1	SW
9	September	28.6	370	7	1008.9	91	4.3	SW
10	October	30.8	242	6.9	1007.7	88	3.5	SW
11	November	32.1	72.8	6.8	1006.8	84	2.6	SW
12	December	33.4	19.2	6.8	1006.7	73	2.4	NE

Source: NIMET, Port Harcourt.

Wind Speed/Direction

Average micro wind speed measurement during field survey was 1.8 m/sec (Table 4.2.1). Largely, wind speeds were moderate during the day and lesser at dawn. It was calm at the hour 00:00-01:00GMT of dawn. The prevailing wind direction was the South-Westerly winds as presented in the wind rose below (Figure 4.2.6). This implies that any released air emissions will be blown towards the North-East direction of the study environment. Figure 4.2.7 shows the direction in which the wind is heading to. Wind speed classification shows that range 0.5 -2.1m/s constituted 62.5% while the range 2.1-3.6m/s constituted 25% (Figure4.2.8). It is however the period of calm that is of importance in evaluating emissions (8.33%). If the air is calm, pollutants cannot disperse, and then the concentration of these pollutants will build up. On the other hand, when strong, turbulent winds blow, pollutants disperse quickly, resulting in lower pollutant concentrations. In pollution, meteorology calms are associated with inversions (temperature increasing with height). Inversion may result in fumigation; meaning that emissions are trapped at ground level close to their source as against other situations where it is dispersed and diluted much more easily. Inversion is widely known to be frequent during the early hours of the

day. A 30-year mean macro data shows that wind speed over the study environment is generally minimal and this signifies a low to moderate dispersive potential of the local atmosphere.

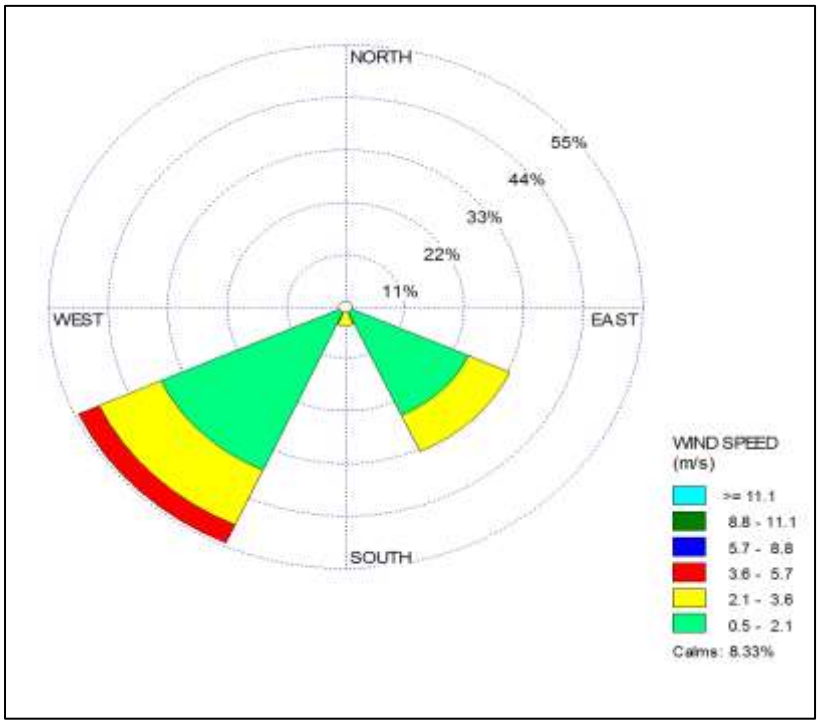

Figure 4.2.6: Diurnal Wind rose pattern of project area during fieldwork.

Figure 4.2.7: Study Area Wind Direction Coming from SW/SE.

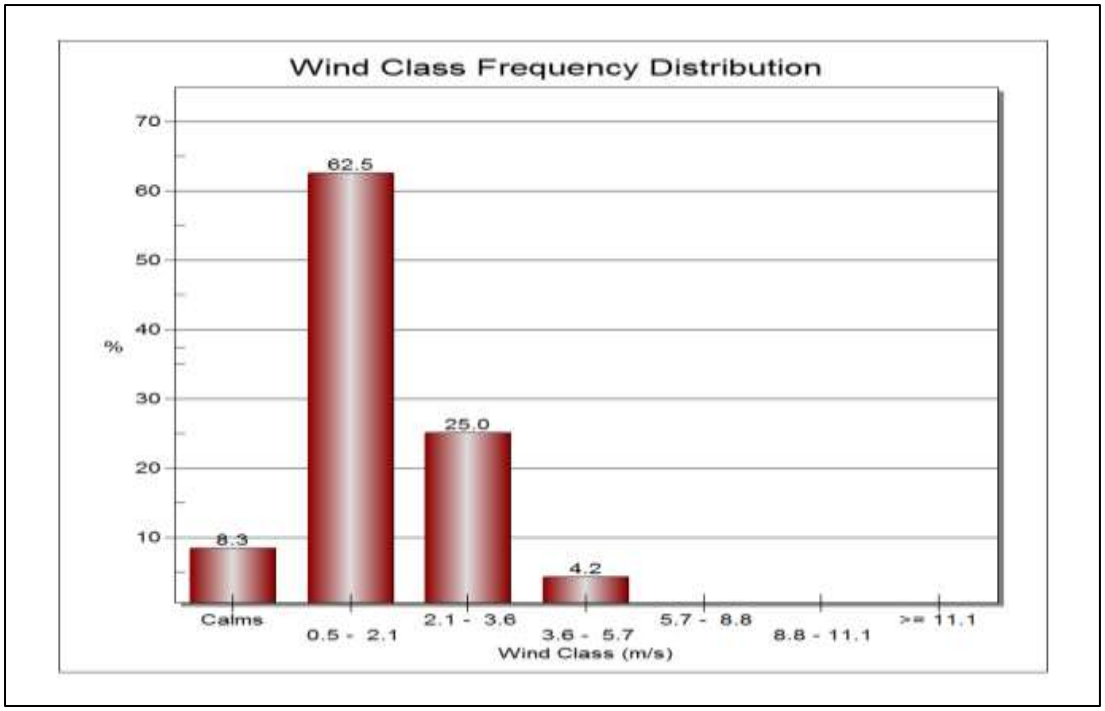

Figure 4.2.8: Diurnal wind speed record for project area during fieldwork

Cloud Cover

Mostly the weather condition during the period of field data collection was partly cloudy and the average cloud cover was 5oktas. Maximum cloud cover (6oktas) was observed during the morning period (06:00-09:00GMT). Average cloud cover for the area from 1985-2015 shown in Table 4.2.2, indicates values above 6 oktas throughout the year. This long term trend signifies the high rate of rising moist air mass due to the abundant water content in the study area which gives rise to convective clouds. It has been revealed (Edokpa, 2017) that the lapse rate pattern for the area under review tends towards the moist adiabatic lapse rate (MALR). High amounts of cloud inhibit instability that decreases the dispersion of plumes and lower amounts promote unstable conditions which enhances atmospheric dispersion of plumes. Cloud cover is prominent during rainy periods and minimal during dry seasons which allow the penetration of solar energy leading to increased heat during these periods.

Atmospheric Pressure

Atmospheric pressure at sea level measured during the period of field survey was between 1025-1027mbar. An important characteristic of the atmosphere is its pressure as it often determines wind and weather pattern across an area. The normal range of the

earth's air pressure is from 970mbar to 1050mbar. Air pressure differences across various locations are the results of unequal heating across surfaces. This leads to wind blowing from high pressure areas towards low pressure areas. High pressure areas are usually associated with clear weather while low pressure areas are associated with unstable weather conditions which generate precipitation.

4.3 AIR QUALITY AND NOISE

4.3.1 Air Quality

The ambient air quality monitored within Indorama complex and the surrounding communities represent baseline ambient air quality of the proposed project area. The low concentrations of gaseous pollutants obtained in the study area during this study may be due to the compliance level of industrial operation in the area and the wind direction & wind speed. Air quality expected after the realization of the IEFCL-Train2 project has been assessed by a dedicated study, called air dispersion modelling.

The baseline ambient air quality of the study area at selected locations during the field work is presented in table 4.3.1 and dry season data retrieved from previous reports is presented in table 4.3.2. The ambient air quality data and dispersion modelling output are summarized in Appendix 4.4.

Plate 4.3.1: Ambient Air Quality Monitoring in progress

Table 4.3.1: Wet Season Baseline Air Quality of Project Area

Location/Parameter		SO_2 (µg/m³)	NO_2 (µg/m³)	CO (µg/m³)	H_2S (µg/m³)	THC (µg/m³)	VOCs (µg/m³)	NH_3 (µg/m³)	TSPM (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
X1	Aleto Community	0.00	0.00	0.00	0.00	0.00	15.00	0.32	11.00	10.00	1.00
X2	Flare Area	0.00	0.00	0.00	0.00	20.00	9.00	0.20	27.00	18.00	9.00
X3	NG Receipt facility Area	0.00	2.00	1.30	0.00	0.00	25.00	0.30	15.00	10.00	5.00
X4	Urea bagging Plant	0.00	0.00	0.00	0.00	10.00	15.00	0.01	8.00	5.00	3.00
X5	Weigh Bridge	2.60	2.00	0.00	0.00	20.00	3.50	0.04	59.00	39.00	20.00
X6	Main Gate	0.00	0.00	2.60	0.00	10.00	10.00	0.03	47.00	31.00	16.00
X7	Akpajo Community	5.40	0.00	3.80	0.00	0.00	5.00	0.00	30.00	19.00	11.00
Control 1	Agbonchia Njuru	0.00	0.00	1.30	0.00	0.00	10.00	0.18	20.30	13.80	6.50
Control 2	Rumukrushi Town	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.00	15.00	8.00
	Range	**0.0-5.4**	**0.0-2.0**	**0.0-3.8**	**0.0**	**0.0-20.0**	**0.0-25.0**	**0.0-0.32**	**8.0-59.0**	**5.0-39.0**	**1.0-20.0**
	Mean	**0.9**	**0.4**	**1.0**	**0.0**	**6.7**	**10.3**	**0.1**	**26.7**	**17.9**	**8.8**
	Std. dev.	**1.90**	**0.88**	**1.40**	**0.00**	**8.66**	**7.44**	**0.13**	**16.79**	**10.81**	**6.09**
	FMEnv limit	**26**	**75-113**	**22.8**	**N/A**	**160**	**6000**	**0.5-1.0**	**250**	**N/A**	**N/A**
	IFC limit	**20**	**200**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**50**	**25**

Field Work 2017

Table 4.3.2: Dry season Baseline Air Quality of Project Area

Location / Parameter		SO_2 (µg/m³)	NO_2 (µg/m³)	CO (µg/m³)	H_2S (µg/m³)	THC (µg/m³)	NH_3 (µg/m³)	VOCs (µg/m³)	TSPM (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
X1	Aleto Community	5.58	2.89	3.51	1.17	13.98	0.19	10.83	74.90	39.30	18.90
X2	Flare Area	8.32	4.70	4.40	0.63	14.57	0.45	7.92	90.50	44.00	19.80
X3	NG Receipt facility Area	8.55	4.76	4.46	3.47	18.74	0.38	11.04	98.00	43.40	21.10
X4	Urea bagging Plant	7.49	6.18	4.15	2.33	16.96	0.44	10.83	90.70	37.90	18.40
X5	Weigh Bridge	7.95	5.17	5.42	2.30	18.75	0.19	8.54	106.60	43.50	19.50
X6	Main Gate	7.83	7.59	5.89	2.09	15.77	0.32	11.67	93.30	45.30	19.50
X7	Akpajo Community	4.37	4.28	4.04	0.70	13.68	0.35	4.80	78.20	41.80	16.50
Control 1	Agbonchia Njuru	6.30	4.08	5.24	0.48	10.70	0.16	7.94	61.50	33.70	13.50
	Range	**4.37-8.55**	**2.89-7.59**	**3.51-5.89**	**0.48-3.47**	**10.70-18.75**	**0.16-0.45**	**4.80-11.67**	**61.5-106.6**	**33.7-45.3**	**13.5-21.1**
	Mean	**7.0**	**5.0**	**4.6**	**1.6**	**15.4**	**0.3**	**9.2**	**86.7**	**41.1**	**18.4**
	Std. dev.	**1.48**	**1.42**	**0.80**	**1.06**	**2.74**	**0.12**	**2.33**	**14.37**	**3.88**	**2.39**
	FMEnv Limit	**26**	**75-113**	**22.8**	**N/A**	**3-160**	**6000**	**0.5-1.0**	**250**	**N/A**	**N/A**
	IFC limit	**20**	**200**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**50**	**25**

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Sulphur dioxide (SO_2)

SO_2 is an important oxide of sulphur as a primary pollutant, and is formed from the combustion of sulphur containing hydrocarbons in certain industrial processes. Fossil fuel combustion by electrical utilities, industries and automobiles are the primary sources of sulphur dioxides. Emissions of sulphur compounds are associated with industrial operations like combustion processes associated with the extraction, upgrading, and refining of oil, electricity and steam generation Kindzierski et al., (2009). A range of chronic and acute health impacts have been associated with human exposure to sulphur dioxide (WHO, 1999; Davis and Cornwell, 2008). SO_2 can irritate the respiratory system, cause shortness of breath, chest tightness and wheezing.

Results (shown in Tables 4.3.1) obtained in the wet season showed that concentrations of sulphur dioxides ranged from <0.01µg/m^3 to 5.4µg/m^3 with mean deviation of 0.9±1.90µg/m^3; while secondary data (shown in Table 4.3.2) obtained in the dry season showed that sulphur dioxide values ranged from 4.37µg/m^3 to 8.55µg/$m^3$with mean deviation of 7.0±1.48µg/m^3. The mean values are well below both FMEnv and IFC limits. The graphical presentation of wet and dry season data is shown in figure 4.3.1. These results represent the baseline sulphur dioxide concentration in ambient air of the proposed project area.

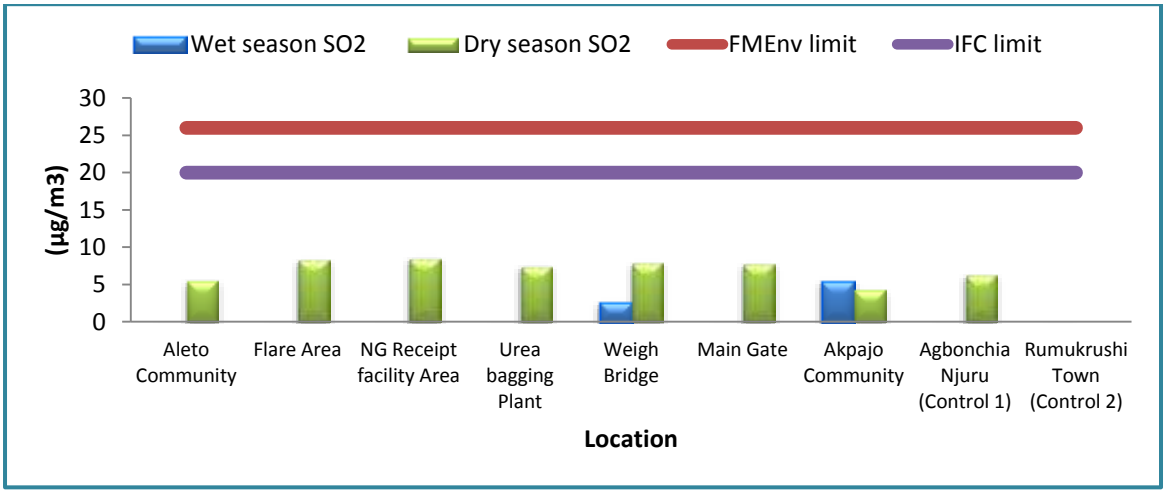


Figure 4.3.1: Sulphur Dioxide concentration in project area

Nitrogen Dioxide (NO_2)

Nitrogen dioxide is a product of high temperature combustion in vehicle engines, power plants, domestic fires and industrial facilities. Exposure to nitrogen dioxide has been associated with adverse health effects (WHO, 1999). At very high concentrations, NO_2 exposure can result in rapid and severe lung damage. It can also affect the liver, spleen and blood. It can also aggravate lung diseases leading to respiratory symptoms and increased susceptibility to respiratory infection. People with asthma or chronic obstructive pulmonary disease are more susceptible at lower concentrations. Based on the best available clinical evidence, a 1-hour guideline of 200µg/m^3 has been set by World Health Organization (WHO, 1999).

Field measurement shows that concentrations of NO_2 ranged from <0.01µg/m^3 to 2.0µg/m^3 with mean deviation of 0.4±0.88µg/m^3in the wet season (Table 4.3.1). The dry season data from previous studies conducted in the area (Table 4.3.2)) shows that NO_2 ranged from 2.89µg/m^3 to 7.59µg/m^3 with mean deviation of 5.0±1.42µg/m^3. The dry and wet season values are well within both FMEnv and IFC limits. Due to heavy downpour, the NO_2 concentration is quite low in wet season at most of sampling stations in comparison to the dry season. The graphical presentation of wet and dry season data is shown in figure 4.3.2. These values represent the baseline NO_2 concentration in ambient air of the proposed project area.

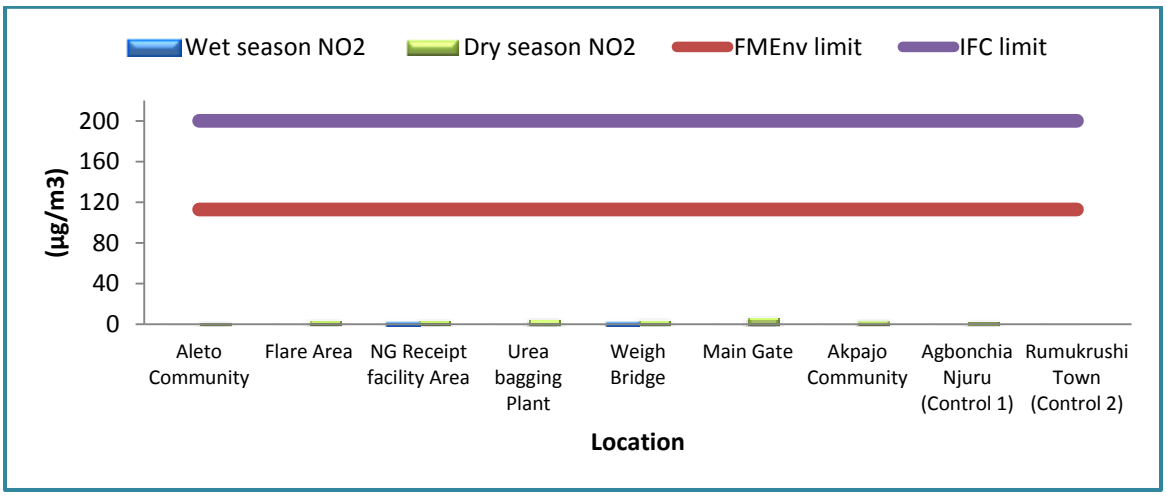


Figure 4.3.2: Nitrogen Dioxide concentration in project area

Carbon Monoxide (CO)

Carbon Monoxide is a product of incomplete combustion of fossil fuels or hydrocarbons. Main sources of CO in ambient air include road transport and industrial combustion (Kindzierski et al., 2009; EEA, 2013). The binding of carbon monoxide (CO) with hemoglobin to form carboxy-hemoglobin (COHb) reduces the capacity of blood to carry oxygen, and the binding with other haem proteins is directly related to changes in the functions of affected organs, such as the brain, cardiovascular system, and developing fetus. Very high CO concentrations causes death (WHO, 1999).

The wet season CO values ranged from <0.01µg/m^3 to 3.8µg/m^3 with mean deviation of 1.0±1.40µg/m^3 (Table 4.3.1); while the dry obtained from previous study (Table 4.3.2) ranged from 3.51µg/m^3 to 5.89µg/m^3 with a mean deviation of 4.6±0.80µg/m^3. These values are well below the FMEnv limit and represent baseline CO concentration. The wet and dry seasons CO concentrations in the proposed project area are shown in Figure 4.3.3.

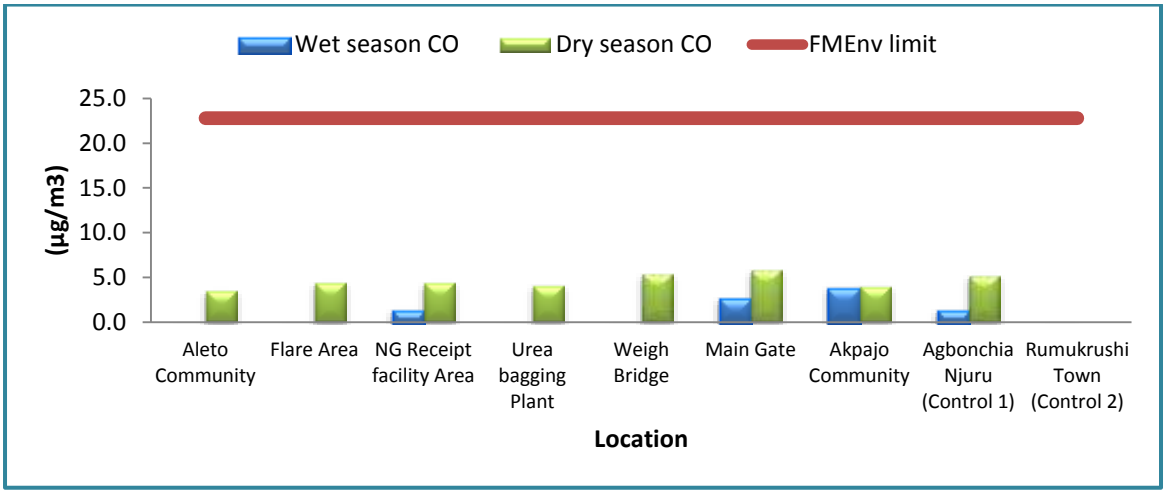


Figure 4.3.3: Carbon Monoxide concentration in project area

Hydrogen Sulphide (H_2S)

Hydrogen Sulphide is an extremely toxic, odorous, corrosive flammable gas. Anthropogenic sources of H_2S in ambient air include natural gas, petroleum refining, coke ovens exhaust gas and nylon & rayon manufacturing (Flagan and Seinfeld, 1988). The concentrations of H_2S in proposed project area is very low in wet seasons (<0.01µg/m^3). Similar results were obtained from previous studies conducted in the area in dry seasons (Table 4.3.2).

Ammonia (NH_3)

Ammonia is a colorless gas with pungent odor. Main sources of ammonia in ambient air include agricultural activities, manure storage, slurry spreading, and the use of synthetic nitrogenous fertilizers (Davis and Cornwell, 2008). Exposure to high levels of ammonia may irritate, eyes, throat, and lungs and cause coughing. People with asthma may be more sensitive to breathing ammonia than others. NH_3 may pose a serious threat to the health of the birds such as; increase risk of skin burns, high incidence of contact dermatitis: foot, hock and breast burns that can be a gateway for bacteria causing further health problems to the birds (Davis and Cornwell, 2008).

The concentrations of ammonia measured in the wet season ranged from <0.01µg/m^3 to 0.32µg/m^3 with a mean deviation of 0.1±0.13µg/m^3 (Table 4.3.1); while the dry season values obtained from previous study ranged from 0.16 to 0.45µg/m^3 with a mean deviation of 0.3±0.12µg/m^3 (Table 4.3.2). The wet and dry seasons concentrations of NH_3 measured in the project are shown in Figure 4.3.4. These results represent baseline NH_3 concentration in ambient air of the proposed project area.

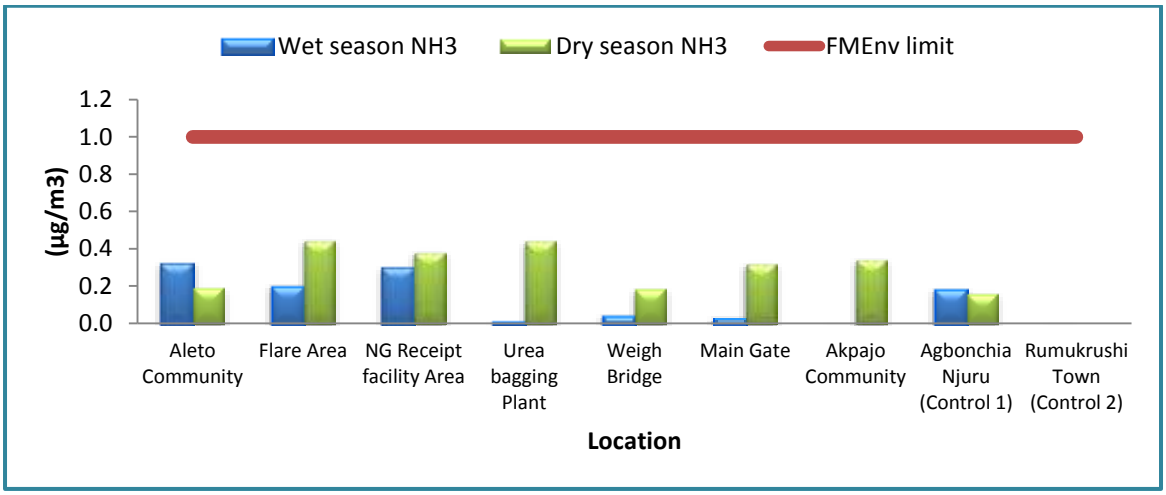


Figure 4.3.4: Ammonia concentration in project area

Total Hydrocarbon (THC)

Total hydrocarbon in ambient air comprises of aromatic hydrocarbons (benzene rings with carbon atoms) and aliphatic hydrocarbons (benzene rings with no carbon atoms). Methane (CH_4) constitutes by far the largest form (by mass) of total hydrocarbon in ambient air (Kindzierski et al., 2009). Background hydrocarbons are primarily composed of CH_4 with a

small contribution from non-methane hydrocarbons (NMHCs). THC is produced by both anthropogenic and biogenic (natural) sources. Major-anthropogenic sources include agricultural activities, road transportation and industrial processes. Methane is an important greenhouse gas, and also contributes to the formation of ground level ozone (Kindzierski et al., 2009).

Health effects associated with a single exposure to hydrocarbons are asphyxiation, narcosis (i.e. depression of the central nervous system; anesthesia), cardiac arrest and aspiration (WHO, 1999). The acute health effects of hydrocarbon mixtures are generally associated with exposure concentrations at thousands of ppm.

The wet season concentrations of total hydrocarbon monitored in proposed project area ranged from <0.01µg/m^3 to 20.00µg/m^3 with mean a deviation of 6.7±8.66µg/m^3 (Table 4.3.1); while the dry season values obtained from previous studies (Table 4.3.2) ranged from 10.70µg/m^3 to 18.75µg/m^3 with a mean deviation of 15.4±2.74µg/m^3. These measured well within the FMEnv specified limit.

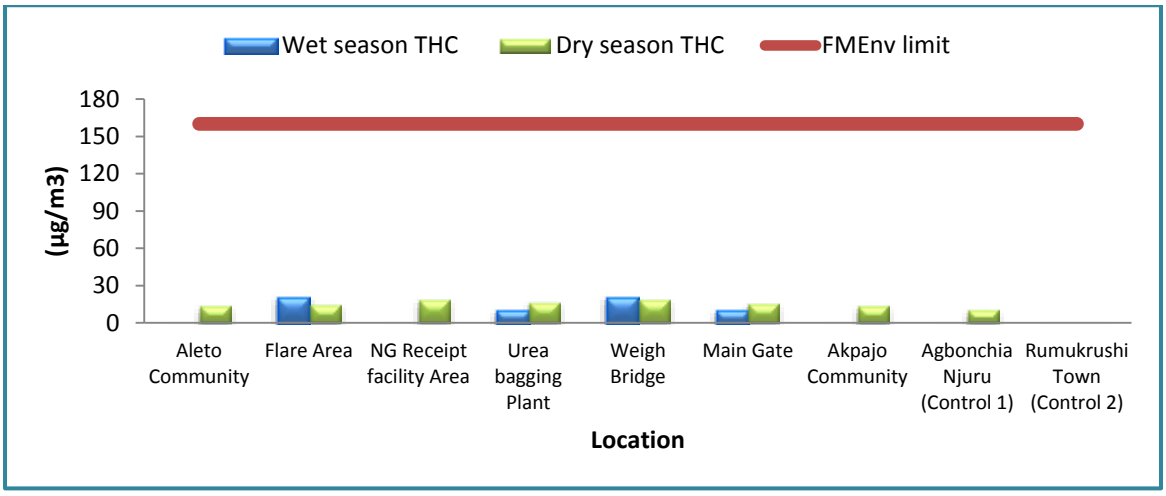


Figure 4.3.5: THC concentration in project area

Volatile Organic Compounds (VOC)

VOC are a large group of carbon-based chemicals that have a high vapour pressure and easily evaporate at room temperature conditions. They include Acetone, Benzene, Ethylene glycol, Formaldehyde, Methylene chloride, Toluene, Xylene, 1,3-butadiene etc. VOC are emitted as gases from certain solids or liquids. VOC include a variety of chemicals, some of which may have short- and long-term adverse health effects. VOC are emitted by

thousands of products including: paints and lacquers, paint strippers, cleaning agents, pesticides, furniture and furnishing items, office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues and adhesives, permanent markers, and photographic solutions.

VOC are known to cause Eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some organics can cause cancer in animals; some are suspected or known to cause cancer in humans (WHO, 1999). The principal harmful effects of VOC are toxicity, possible contribution to smog via photochemical reactions in the atmosphere, and possible contribution to the "greenhouse effect" and consequent global warming (Davis and Cornwell, 2008),

VOC concentrations measured in the project area in the wet season ranged from <0.01µg/$m^3$to 25.0µg/m^3 with a mean deviation of 10.3±7.44µg/m^3 (Table 4.3.1), while the dry season values obtained from previous studies (Table 4.3.2) ranged from 4.80µg/$m^3$to 11.67µg/m^3 with a mean deviation of 9.2±2.33µg/m^3. Concentration levels of VOC shown are well below limit and represent baseline VOC concentration of the proposed project area.

Total Suspended Particulate Matters (TSPM)

The term particulate matter (PM) describes materials that are suspended in the air. PM is a mixture of aerosol particles (solid and liquid) covering a wide range of sizes and chemical composition. These are light particles (Usually dust, fly ash) or other materials found suspended in the atmosphere and carried around by the wind. TSP is either directly emitted as primary particles or it is formed in the atmosphere from emissions of SO_2, NOx, NH_3 and Non methane volatile organic compounds (NMVOCs).

TSPM is emitted from many anthropogenic sources, including both combustion and non-combustion sources. Major sources of TSPM include transportation (diesel vehicles), combustion processes, refining of bitumen and coal-burning power plants (Kindzierski et al., 2009). Adverse health effects include aggravation of respiratory problems,

cardiovascular and lung diseases, heart attacks and arrhythmias. Prolong exposure to TSP can lead to premature death (WHO, 1999; Kindzierski et al., 2009).

Concentrations of TSPM obtained in the wet season ranged from 8.0µg/m^3 to 59.0µg/m^3 with a mean deviation of 26.7±16.79 µg/m^3 (Table 4.3.1), while the dry season values obtained from previous studies (Table 4.3.2) ranged from 61.50µg/m^3 to 106.60µg/m^3 with a mean deviation of 46.7±14.37µg/m^3. Concentrations of TSPM measured in project area are well below FMEnv limit and represent baseline TSPM concentration of the project area. The wet and dry seasons TSPM concentrations in the proposed project area are shown in Figure 4.3.6.

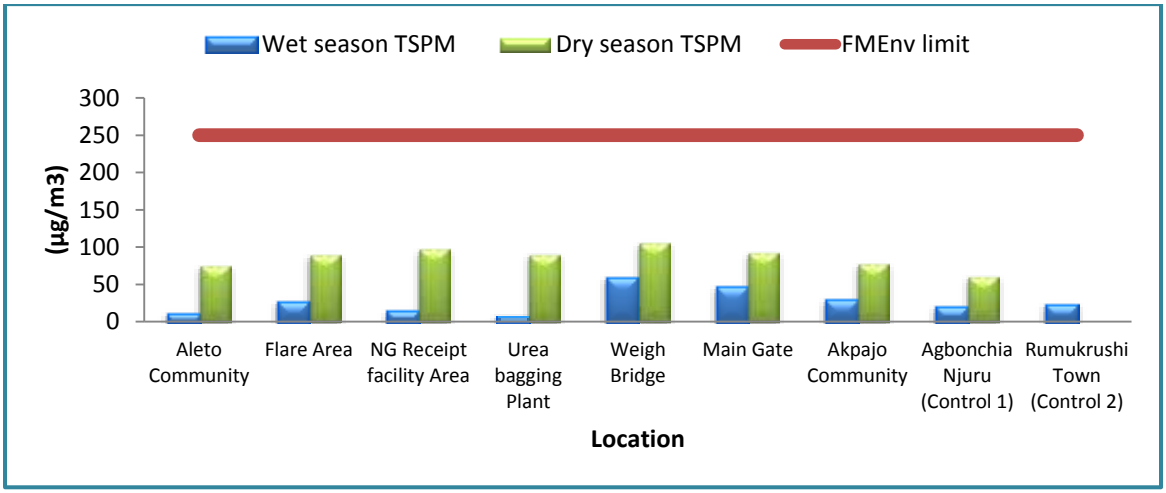


Figure 4.3.6: TSPM concentration in project area

PM_{10}Particulate Matter (Respirable Suspended Particulate matter, RSPM)

PM_{10} refers to particulate of size less than 10 microns (≤10 µm) in aerodynamic diameter. PM_{10} particulate matter is also known as respirable suspended particulate matter because it is breathe out by human beings. It has the same sources and effects as TSPM.

Concentrations of PM_{10} obtained in the wet season ranged from 5.0µg/m^3 to 39.0µg/m^3 with a mean deviation of 17.9±10.81µg/m^3 (Table 4.3.1), while the dry season values obtained from previous studies (Table 4.3.2) ranged from 33.7µg/m^3 to 45.3µg/m^3 with a mean deviation of 41.1±3.88µg/m^3 (Table 4.3.2). Concentrations of PM_{10} measured in the proposed project area are well below the IFC limit of 50µg/m^{3}as shown in Figure 4.3.7 and these values represents the baseline concentration of PM_{10} in the project area.

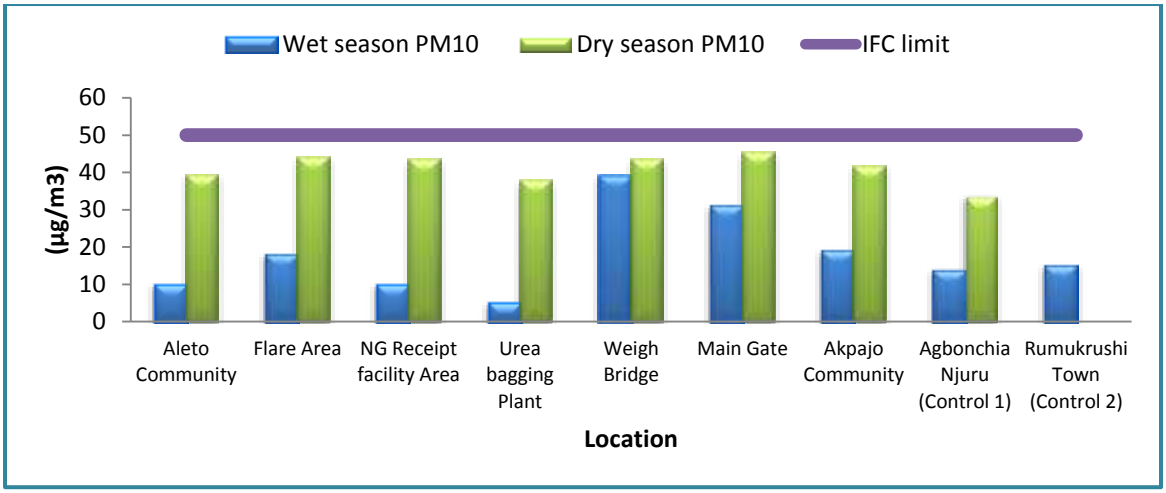


Figure 4.3.7: PM_{10} concentration in project area

$PM_{2.5}$ Particulate Matter (Inhalable Suspended Particulate matter, ISPM)

$PM_{2.5}$ refers to particulate matter with size less than 2.5 microns (≤2.5 µm) in aerodynamic diameter. It also called inhalable suspended particulate matter because it can penetrate through the upper respiratory track into the lungs. It has the same sources and effects as TSPM.

The wet season concentrations of $PM_{2.5}$ obtained in the project area ranged from 1.0µg/m^3 to 20.0µg/m^3 with a mean deviation of 8.8±6.09µg/m^3 (Table 4.3.1), while the dry season values obtained from previous studies (Table 4.3.2) ranged from 13.5µg/m^3 to 21.1µg/m^3 with a mean deviation of 18.4±2.39µg/m^3. The mean concentrations of $PM_{2.5}$ measured in project area is well below the IFC limit of 25µg/m^3as shown in Figure 4.3.8. These values represents baseline $PM_{2.5}$ concentration in ambient air of project area.

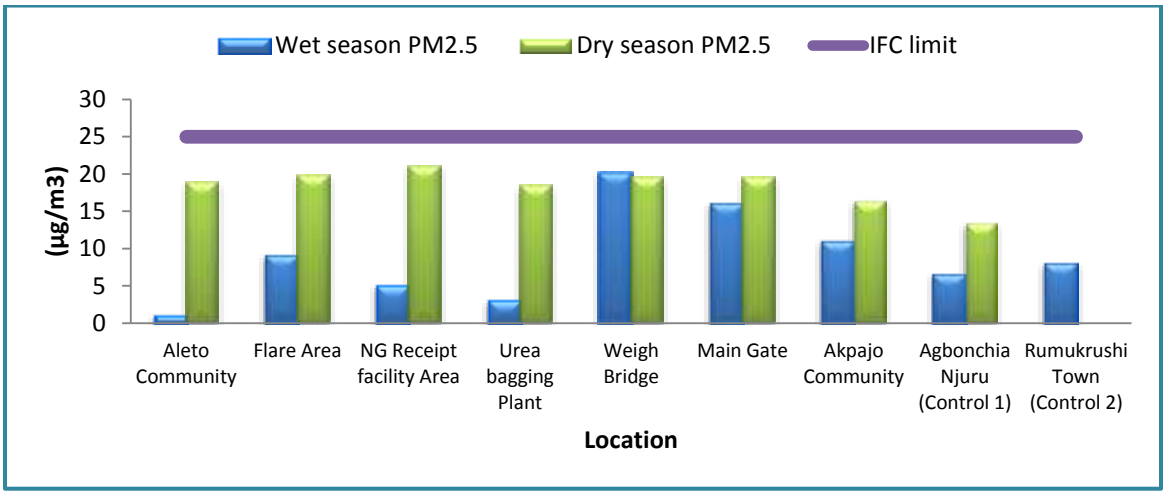


Figure 4.3.8: $PM_{2.5}$ concentration in project area

Odour in Relation to Air Quality

An odour is caused by one or more volatile chemical compounds, generally at a very low concentration, that is perceive by the sense of olfaction. It is the smell that we are able to detect from substances, usually carried by air into our nostrils. The ability of odours to be carried long distances in the air means that odour have the ability to affect a large number of people. The degree to which people are affected will however depend on the sensitivity of their sense of smell and their tolerance of the odour in question. The any sense of odour was not observed during filed work.

4.3.2 Noise Survey

Noise measurement was carried out with ambient air quality monitoring at all the sampling stations in line with the FMEnv approved scope of work (Table 4.3.3).

Table 4.3.3: Wet and Dry season Baseline Noise Level in Project Area

	Location	Wet season Noise Level (dB A)	Dry season Noise Level (dB A)
X1	Aleto Community	43.9	52.0
X2	Flare Area	45.9	48.6
X3	NG Receipt facility Area	65.0	74.4
X4	Urea bagging Plant	59.4	56.0
X5	Weigh Bridge	45.9	62.5
X6	Main Gate	52.6	65.2
X7	Akpajo Community	61.8	49.3
Control 1	Agbonchia Njuru	47.3	48.6
Control 2	Rumukrushi Town	46.8	--
	Range	**43.9-65.0**	**47.9-74.4**
	Lavg dB (A)	**55.5**	**61.4**
	L_{Aeq} dB (A)	**58.70**	**66.2**
	L_1 dB (A)	**68.7**	**75.9**
	L_{10} dB (A)	**65.2**	**71.7**
	L_{50} dB (A)	**51.8**	**55.7**
	L_{90} dB (A)	**41.1**	**43.3**
	Standard deviation	**7.98**	**9.42**
	FMEnv limit dB(A)	**90**	**90**
	NESREA limit dB(A)	**85**	**85**
	NESREA limit (Industrial outside perimeter) L_{Aeq} dB(A)	**70**	**70**
	IFC limit L_{Aeq} dB(A)	**70**	**70**

Dry season data: IEPL & IEFCL Compliance monitoring'2017

The FMEnv permissible noise limit for an 8-hour exposure is 90dB (A). The National Environmental Standards and Regulatory Agency (NESREA, 2009) has stipulated permissible noise level limit 85 dB (A) from a factory/workshop and a noise equivalent (L_Aeq) limit of 70dB (A) for industrial outside perimeter fence in Nigeria. IFC specified noise equivalent (L_Aeq) limit of 70dB (A) at receptors. Noise levels measured within the project area in the wet season ranged from 43.9 dB(A) to 65.0 dB(A) with a mean deviation of 55.5±7.98dB (A), while mean noise levels in the dry season (Table 4.3.3) ranged from 47.9 dB(A) to 74.4 dB(A) with a mean deviation of 61.4±9.42 dB(A) The measured noise levels recorded in the area during field exercise are within FMEnv limit of 90dB (A) on a weighted scale A as shown in Figure 4.3.9 and Lavg and Leq are shown in Figure 4.3.10. These results show baseline noise condition of the proposed project area.

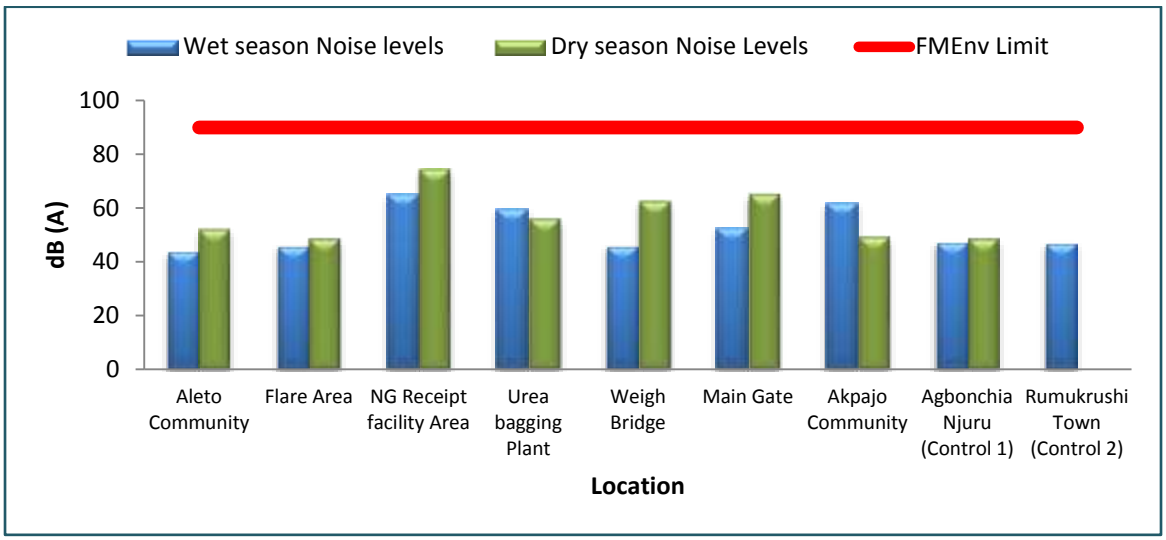


Figure 4.3.9: Wet and dry season Noise level in project area

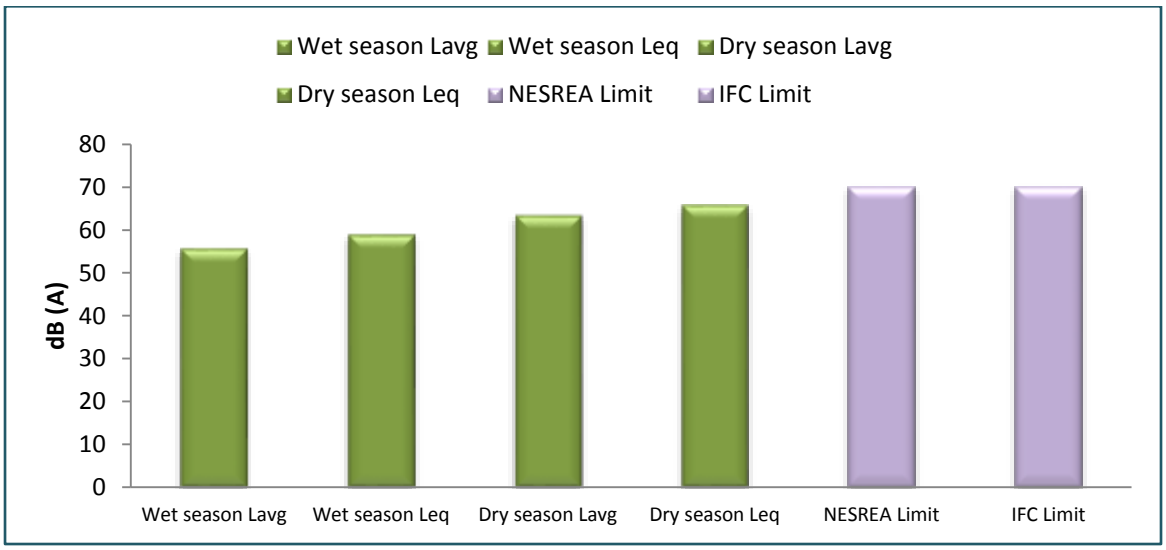


Figure 4.3.10: Noise Lavg and Leq in project area

More recently, research has focused on noise as an auditory stressor that can produce both direct and indirect health effects (Sheela, 2000). The direct health effect known to be attributable to noise is hearing loss (resulting from damage to the inner hair cells of the organ of corti) with noise exposure higher than 90 decibels. There are several non-auditory physiological effects of noise exposure including a possible increase in cardiovascular disease from elevated blood pressure and physiological reactions involving the cardiovascular endocrine system (Talbott, 1995). In addition, community noise has been shown to adversely affect sleep, communication, performance and behavior, reading and memory acquisition, and mental health (Talbott, 1995).

4.3.2.1 Day and Night measurement

For a proper understanding of possible cumulative effect, a comprehensive noise survey for day (07:00 – 22:00) and night (22:00 – 07:00) period covering both internal and external receptors was carried out and presented as Appendix 4.5. The result indicated that noise levels within the complex for day and night were 75.3 and 72.2dB (A) respectively. While noise levels recorded at the closest external receptor were 68.1 and 65.7dB (A) for day and night respectively.

4.3.3 Stack Emission

Flue/ Stack Gas monitoring was carried out in accordance with the FMEnv approved term of reference (ToR) and scope of work for the proposed IEFCL-Train2 project in the existing Indorama complex. The flue gas monitoring was carried using Testo 350 XL flue gas analyzer. A total of nine readings were taken for each stack at 10 minutes intervals. The mean values were calculated and then converted from ppm to mg/Nm^3 as presented in the table 4.3.4 below. The result revealed low concentration of priority parameters measured when compared to the FMEnv limit.

For monitoring of PM and ammonia in granulator stack flue gas, isokinetic sampling method was adopted, where the gas was sucked isokinetically and particulate matter collected in thimble. This collected mass is divided by normalized volume to get PM emissions in mg/Nm^3. To analyze ammonia, standard acid is used as absorbent and then concentration was determined through a back titration with 0.2N-NaOH. The gas volume

is normalized by temperature and pressure correction, and ammonia calculated in mg/Nm3. The granulator stack monitoring results are represented in table 4.3.5.

Table 4.3.4: Summary of stack emission results from existing stack in the facility

Stacks	SO_2 (mg/Nm^3)	NO_2 (mg/Nm^3)	CO (mg/Nm^3)	H_2S (mg/Nm^3)	CH_4 (mg/Nm^3)	VOCs (mg/Nm^3)	CO_2 (%)
Polymer Incinerator	1.25	18.53	3.63	0.00	1.34	1.61	2.00
Sludge Incinerator	2.28	17.38	4.25	0.00	0.54	1.47	2.55
Olefin Furnace A	0.86	22.67	1.00	0.00	0.00	0.00	10.41
GT 02	0.57	28.35	0.00	0.00	0.00	0.00	2.45
GT 03	0.86	29.58	0.00	0.00	0.00	0.00	3.19
Boiler A	1.14	24.68	0.00	0.00	0.00	0.00	9.61
Boiler B	1.03	25.95	0.00	0.00	0.00	0.00	9.53
Reformer	0.00	71.62	0.00	0.00	0.00	0.00	4.88
FMEnv Limit mg/Nm3	**30 -3000**	**350 -1000**	**-**	**-**	**50.00**	**0.00**	**-**
IFC Limit mg/Nm3	**500**	**300**	**-**	**-**	**-**	**-**	**-**

Table 4.3.5: Summary of Granulator stack monitoring results

Stack	Ammonia	PM
Urea Granulator	36.2 mg/Nm^3	8.7 mg/Nm^3
IFC Limit	50 mg/Nm^3	50 mg/Nm^3

4.3.4 Emission Modeling

The mathematical simulation of the dispersion of air pollutants emissions from the new ammonia/urea plant is presented and discussed in this section. Two modelling approaches were employed in the modelling - Level 1 assessment and Level 2 assessment. A screen view model was applied for first level assessment, while ISC-AERMOD View model was used for second level assessment. Both models are approved by the United States Environmental Protection Agency (USEPA) for air pollutants dispersion modelling.

A screening model was applied for first level assessment to provide the worst-case pollutant concentrations, while ISC- AERMOD was used for second assessment to provide an in-depth modeling approach to determine long-range (24-hour) scenarios.

Screen view version 4.0 is a screening-level air quality model approved by the United States Environmental Protection Agency (USEPA) for the **estimates of worst-case ground level concentrations** for a single source as well as concentrations in the cavity zone, and concentrations due to inversion break-up and shoreline fumigation (Lake Environmental, 2011). The screen view model has a built-in, meteorological data matrix that represents a spectrum of different combinations of meteorological conditions that could possibly occur in the area. It calculates concentrations under these different combinations of meteorological conditions. From this output, the highest (worst-case) concentration is selected. Screening models are generally limited to providing the worst-case one-hour concentrations at a receptor. Screening models are considered to provide conservative concentration estimates, and as such are used as a flagging device that indicates the potential for unacceptable air quality (British Columbia Ministry of Environment, 2008).

Although Level 1 assessments are useful in many situations, often the complete distribution of concentrations in time and space are of interest. This distribution provides the spatial pattern of maximum concentrations at different time averages surrounding the source area, and/or the identification of areas where certain specified concentration thresholds are exceeded as well as their exceedance frequencies (British Columbia Ministry of Environment, 2008).

The **ISC-AERMOD** View model was used at the second level modelling assessment to determine long range air pollutants transport and their impacts on surrounding receptors. Mathematical simulations of emissions air dispersion from new stationary sources on long term basis was achieved by the modelling code AERMOD using the graphical user interface (GUI) AERMOD View. AERMOD View is a steady-state Gaussian Plume Air Dispersion Model developed by the Atmospheric Studies Group (ASG) scientists. The model incorporates Industrial Source Complex Model (ISCST3), AERMOD model and Plume Rise Enhancements (ISC-PRIME).

ISC-AERMOD View is a USEPA Regulatory, refined, steady-state, multiple source, Gaussian plume air Dispersion Model. ISC- AERMOD View is widely accepted as the preferred model to use for industrial sources in air quality analysis. The model was used to simulate pollutant concentrations emitted from the proposed ammonia/urea plant. Therefore, using ISC- AERMOD View for cumulative impacts modelling gives conservatively high impacts from a distance point source**.** Results are compared with Federal Ministry of Environment (FMEnv) and International Finance Corporation (IFC) standards and guidelines.

Point source Emission data

It is indicated the summary of emission factors, and stack characteristics, adopted in the model for plant's stacks

Table 4.3.6: Summary of Stack emission rate

Stack	Emission Rate
Boiler stack emission	124,938 Nm3/hr.
Reformer stack emission	295,326 Nm3/hr.
Granulator 1	11, 86, 000 Nm3/hr.
Granulator 2	180,900 Nm3/hr.

Table 4.3.7: Summary input data

Stack	No of Stack	Stack height (m)	Exit Temp (oC)	Exit Temp (ok)	Stack Dia. (m)	Maximum Concentration (mg/Nm3)			
						NOx	SOx	PM	NH3
Ammonia Reformer	1	35	120	413	3.65	150	2.90	50	N/A
Boiler Stack	1	40.6	160	433	2.2	@100% 150	@100% 30	@100% 50	N/A
Urea Granulation 1	1	55	50	323	5.5	N/A	N/A	50	50
Urea Granulator 2	1	55	50	323	2.1	N/A	N/A	50	50

4.3.4.1 Results of First Level Assessment

Results of level 1 assessment are shown in Table 4.3.8. The Table shows the 1-hour maximum concentrations of NO_X, SO_X, NH_3 and particulate matter (PM) from the proposed ammonia/urea plant, and the location of the maximum impacts on the air

quality of study area. In worst-case scenario the predicted values are well below FMEnv regulatory/IFC guidelines

Table 4.3.8: Level-1 assessment results

Plant	Stack ID	Parameter	Maximum 1-hour conc. (µg/m³)	Distance of maximum concentration (km)	FMEnv (µg/m³)	IFC (µg/m³)
Ammonia Reformer Stack	1	NOx	23.04	0.980		200 (guideline)
		SOx	0.4459	0.980	260	
		PM	9.434	0.780	600	
Boiler Stack	2	NOx	16.56	0.758		200 (guideline)
		SOx	3.312	0.758	260	
		PM	4.228	1.022	600	
Urea Granulation 1 stack	3	NH_3	0.409	0.560		
		PM	0.409	0.560	600	
Urea Granulation 2 stack	4	NH_3	0.103	0.943		
		PM	0.103	0.943	600	

Proposed New Plants

Ammonia Reformer Stack

Maximum concentrations of NO_x and SO_x are predicted to occur in the modeling in the cavity zone at 980 meters from the Ammonia reformer stack, while particulate matter, PM is predicted to occur at 780 meters from the source.

Boiler Stack

Maximum concentrations of NO_x and SO_x are predicted to occur in the modeling in the cavity zone at 758 meters from the boiler stack, while particulate matter, PM is predicted to occur at 1022 meters (1.022km) from the source.

Urea Granulation stacks

Maximum concentrations NH_3 and PM are predicted to occur at 979 meters from the stack in the cavity region.

However, these results were further subjected to second level advance modeling using AERMOD View model.

4.3.4.2 Results of Second Level Assessment

Prediction of Pollutants Emissions

Air quality impact of the proposed ammonia/urea plant has been predicted based on the physical details of stacks and emission rates of SO_X, NO_X, NH_3 and PM. The simulation isopleths for the 24-hour modeling period are shown in Figures 4.3.11 to 4.3.14. All the figures reported the maximum expected values comparable with the Air Quality Standards as point of the model domain which refers to areas outside the Indorama complex.

The maximum 24 hourly average concentration of SO_2 is predicted to be 0.23µg/m^3 (Table 4.3.9 and Figure 4.3.11). This maximum ground level concentration of SO_2 occurred adjacent to the Indorama complex as shown in Figure 4.3.11. The effective cumulative prediction is made by superimposing the maximum predicted concentration on the measured background average SO_2 concentration level. This is computed to be 1.13µg/m^3 in the wet season and 7.23µg/m^3 in the dry season. These values are well below the FMEnv limit.

The maximum 24 hourly average concentration of NO_2 is predicted to be 15.95µg/m^3 (Table 4.3.9 and Figure 4.3.12). This maximum ground level concentration of NO_2 also occurred adjacent to the Indorama complex as shown in Figure 4.3.12. The effective cumulative concentration of NO_2 is forecasted by superimposing the predicted concentration on the observed background average concentration of NO_2. This is computed to be 15.99 µg/m^3 in the wet season and 20.95 µg/m^3 in the dry season. These values are well below FMEnv limit.

The maximum 24 hourly average concentration of NH_3 is predicted to be 0.27µg/m^3 (Table 4.3.9). This maximum ground level concentration of NH_3 also occurred adjacent to the Indorama complex as shown in Figure 4.3.13. The effective cumulative concentration of NH_3 is forecasted by superimposing the predicted concentration on the observed background average concentration of NH_3. This is computed to be 0.37 µg/m^3 in the wet season and 0.57 µg/m^3 in the dry season.

The maximum 24 hourly average concentration of particulate matter (PM) is predicted to be 10.89µg/m^3 (Table 4.3.9). This maximum ground level concentration of PM also occurred adjacent to the Indorama complex as shown in Figure 4.3.14. The effective cumulative concentration of PM is forecasted by superimposing the predicted concentration on the observed background average concentration of PM. This is computed to be 37.59µg/m^3 in the wet season and 97.59µg/m^3 in the dry season. These values are well below the FMEnv limits.

Predicted ground level concentrations of SOx, NO_X, NH_3 and PM are shown in Table 4.3.9.

Table 4.3.9: Level-2 assessment results

Parameter	Maximum Predicted 24hr value (µg/m3)	Dry season cumulative (µg/m3)	Wet season cumulative (µg/m3)	FMEnv Limits (µg/m3)	IFC Guidelines (µg/m3)
SO_X	0.23	7.23	1.13	26	20 (guideline)
NO_X	15.95	20.95	15.99	75-113	~
NH_3	0.27	0.57	0.37	~	~
PM	10.89	97.59	37.59	250	~

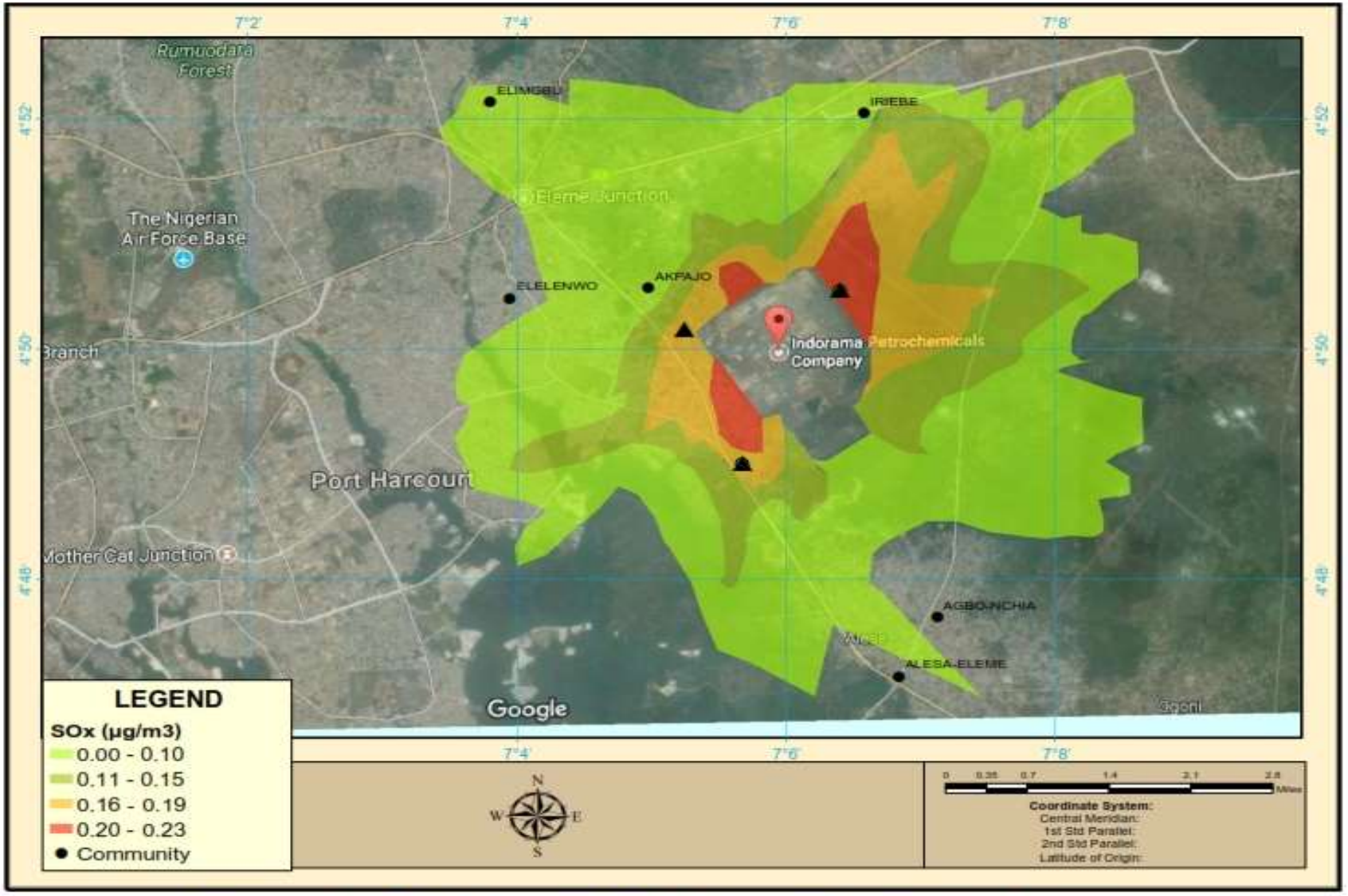
The Figure 4.3.11 represents the isopleths for 24-hour SOx concentrations for the project area and environs. The model output of SO_X prediction showed that maximum concentrations of SO_X emission (0.20µg/m^3- 0.23µg/m^3) from the proposed plant will occur within the proximity of the Indorama facility up to 2.0km away from the facility. The model also indicated that the proposed plant will contribute only about 0.82µg/m^3 to its background values of SOx. The SOx Model affirms the meteorological influence on dispersion pattern with a dominant trend along South-West, North-East direction.

The Figure 4.3.12 above represents the isopleths for 24-hour NOx concentration for the project area and environs. The model output of NO_X prediction showed that maximum concentrations of NO_X emission (11.0µg/m^3– 15.95µg/m^3) from the proposed plant will occur within the proximity of the Indorama facility up to 1.0km away from the facility. The model further indicated concentration of 2.33µg/m^3 to its background values. NOx Model

affirms the meteorological influence on dispersion pattern with a dominant trend along South-West, North-East direction.

The Figure 4.3.13 represents the isopleths for 24-hour NH_3 concentrations for the project area and environs. The model output of NH_3 prediction indicated that maximum concentrations of NH_3 (0.20µg/m^3– 0.27µg/m^3) will occur within the proximity of the Indorama facility up to 1.0km away from the facility. It is predicted that the proposed plant will contribute about 0.18µg/m^3 to its background values. NH_3 model showing that the receptors are at SW/NE position affirms the meteorological influence on dispersion pattern. Dominant wind direction is trending at South-West, North-East direction.

The Figure 4.3.14 represents the isopleths for 24-hour Particular Matter (PM) concentrations for the project area and environs. The model output of PM prediction showed that maximum concentrations of PM (7.70µg/m^3- 10.89µg/m^3) from the plant will occur within the Indorama facility up to about 0.8km away from the facility. It is predicted that the proposed plant will contribute about 2.75µg/m^3 to its background values. PM model affirms the meteorological influence on dispersion pattern with a dominant trend along South-West, North-East direction.



SOx AIR DISPERSION MODEL OF STUDY AREA

Figure 4.3.11: Isopleths for 24-hour Maximum Concentration of SO_X

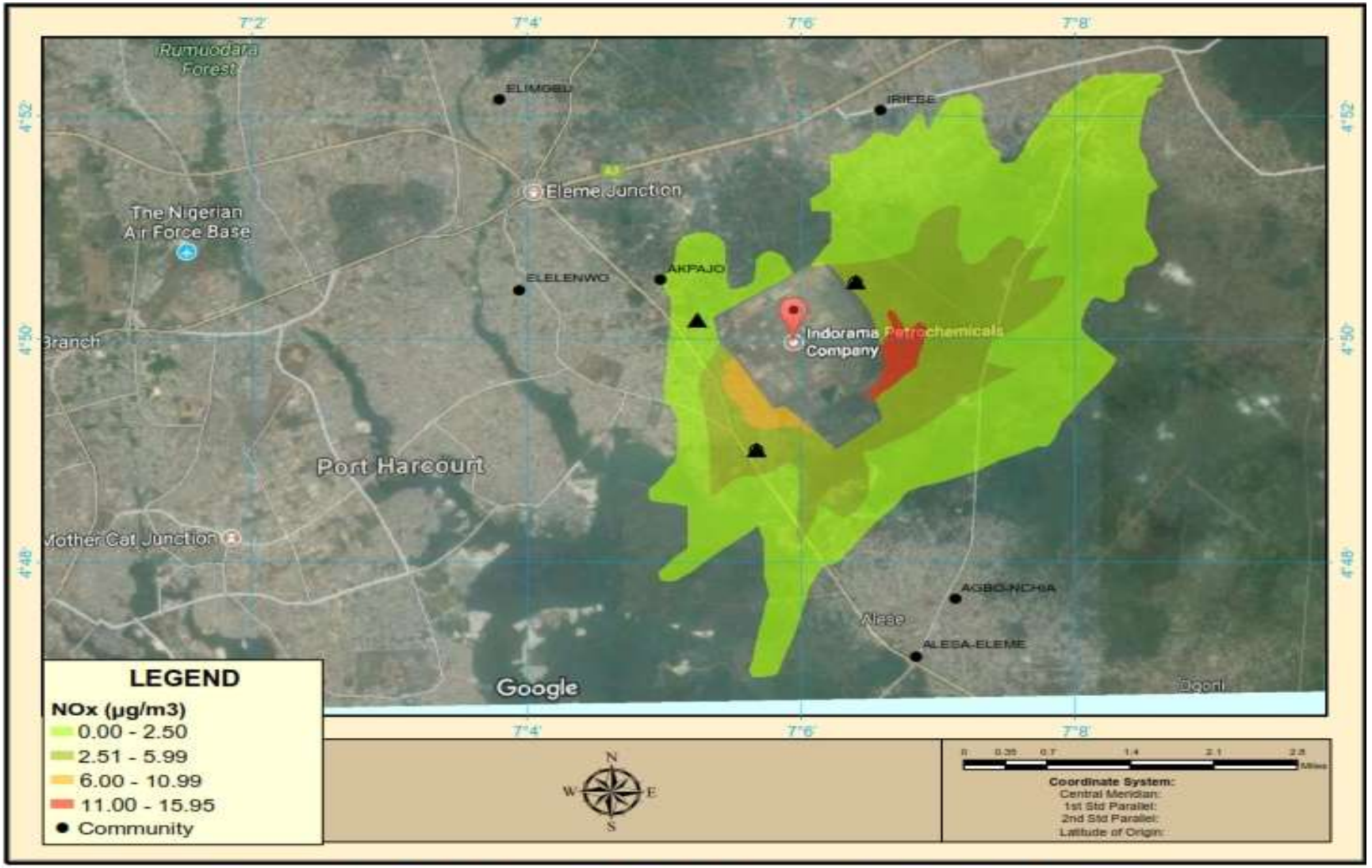


Figure 4.3.12: Isopleths for 24-hour Maximum Concentration of NOx

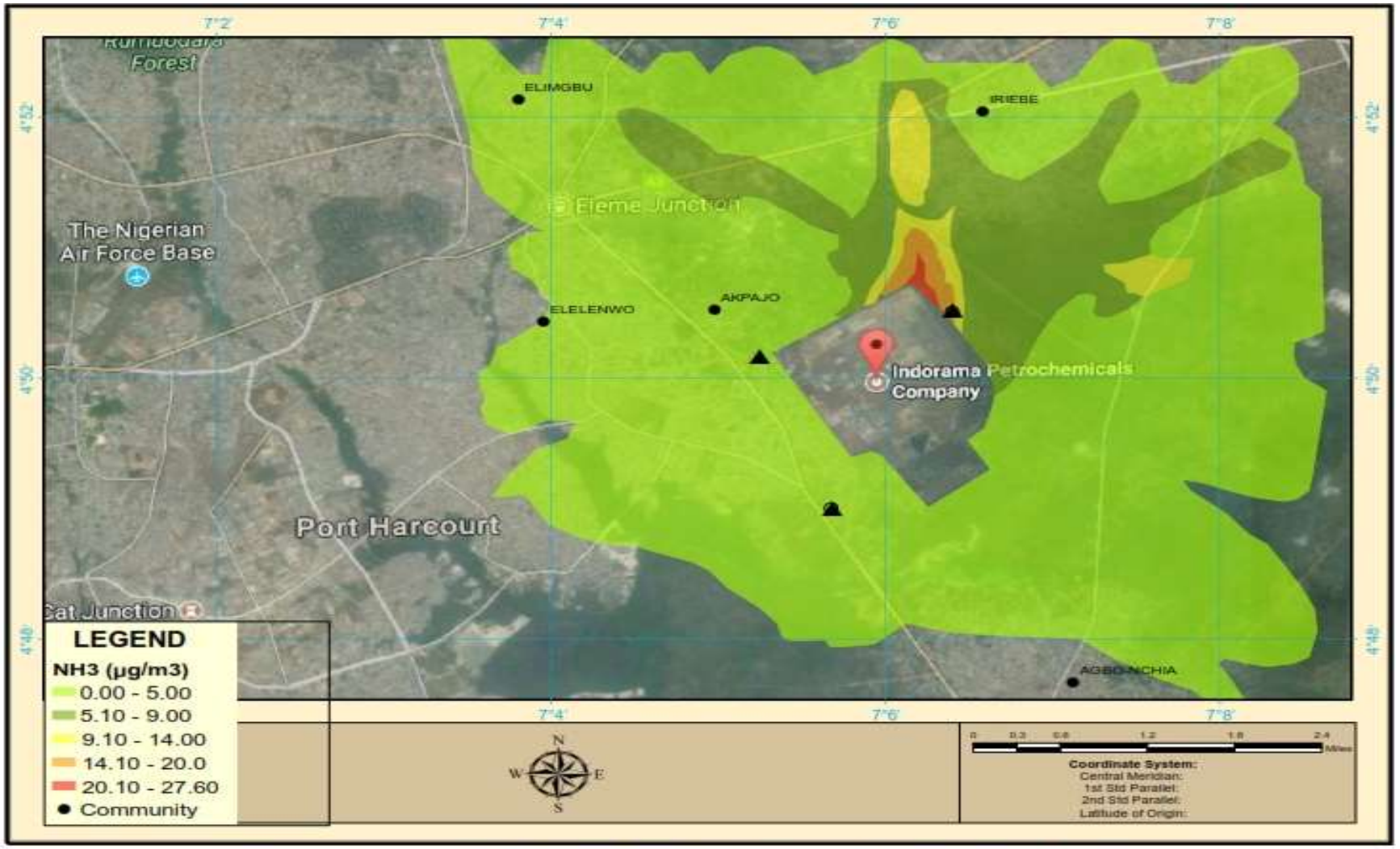


Figure 4.3.13: Isopleths for 24-hour Maximum Concentrations of NH_3

PM AIR DISPERSION MODEL OF STUDY AREA

Figure 4.3.14: Isopleths for 24-hour Maximum Concentration of Particulate Matter (PM)

METEOROLOGY

The meteorology of the proposed project area will play a significant role in the dispersion of air pollutants in the area. Historical meteorological data (PSU/NCAR Mesoscale Model MM5), secondary data meteorological data and field observed data were used to investigate and simulate pollutants dispersion pattern in the dry season and wet season period. The measured data and MM5 data have been used to build pollution roses centered on site (see Figures 4.3.17 and 4.3.18).

The dry season and the wet season polar plots of pollutants dispersion from the new plants are shown in Figures 4.3.15 and 4.3.16 respectively. The simulated polar plots showed that highest pollutant concentrations are related with high wind speed from the North-East and North-West directions. In addition, at a wind speed of about 4.0m/s pollutant concentrations will spread to the South-East and South-West. The pollution roses showed that North-East wind blowing towards the South in the dry season will contribute most to the overall mean concentrations of pollutants (Figure 4.3.17). Similarly, the South-West wind blowing towards the North in the wet season will contribute most to the overall mean concentrations of pollutants (Figure 4.3.18). This clearly showed the dominance of South-Westerly winds controlling the overall mean pollutants concentrations at the proposed facility site in the wet season and the dominance of North-Easterly winds controlling the overall mean pollutants concentrations at the proposed facility site in the dry season. Pollution roses conditioned by wind speed and direction are presented in Figures 4.3.17 and 4.3.18.

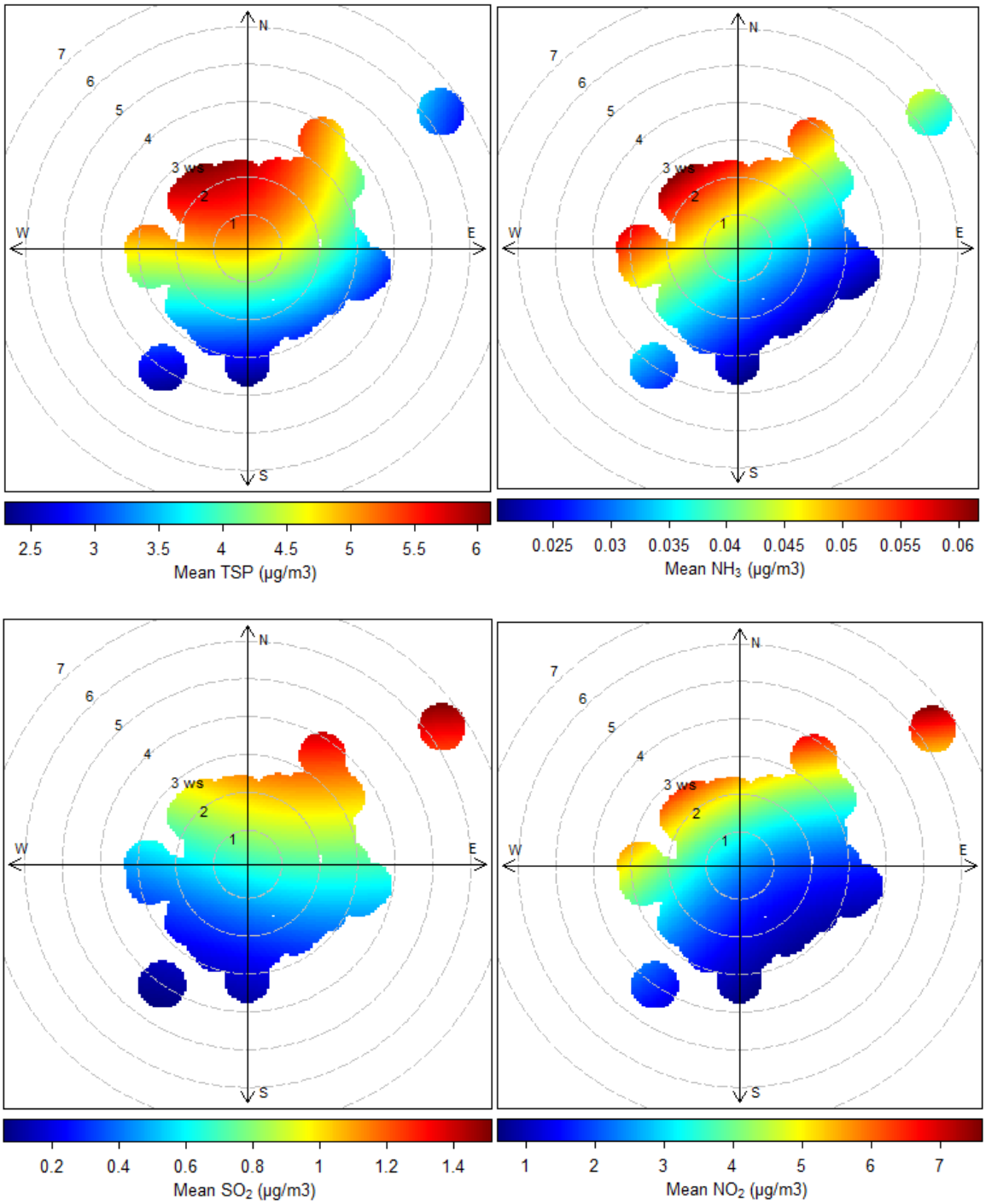


Figure 4.3.15: Dry Season Polar plot of Pollutants Concentrations near the Ammonia/urea

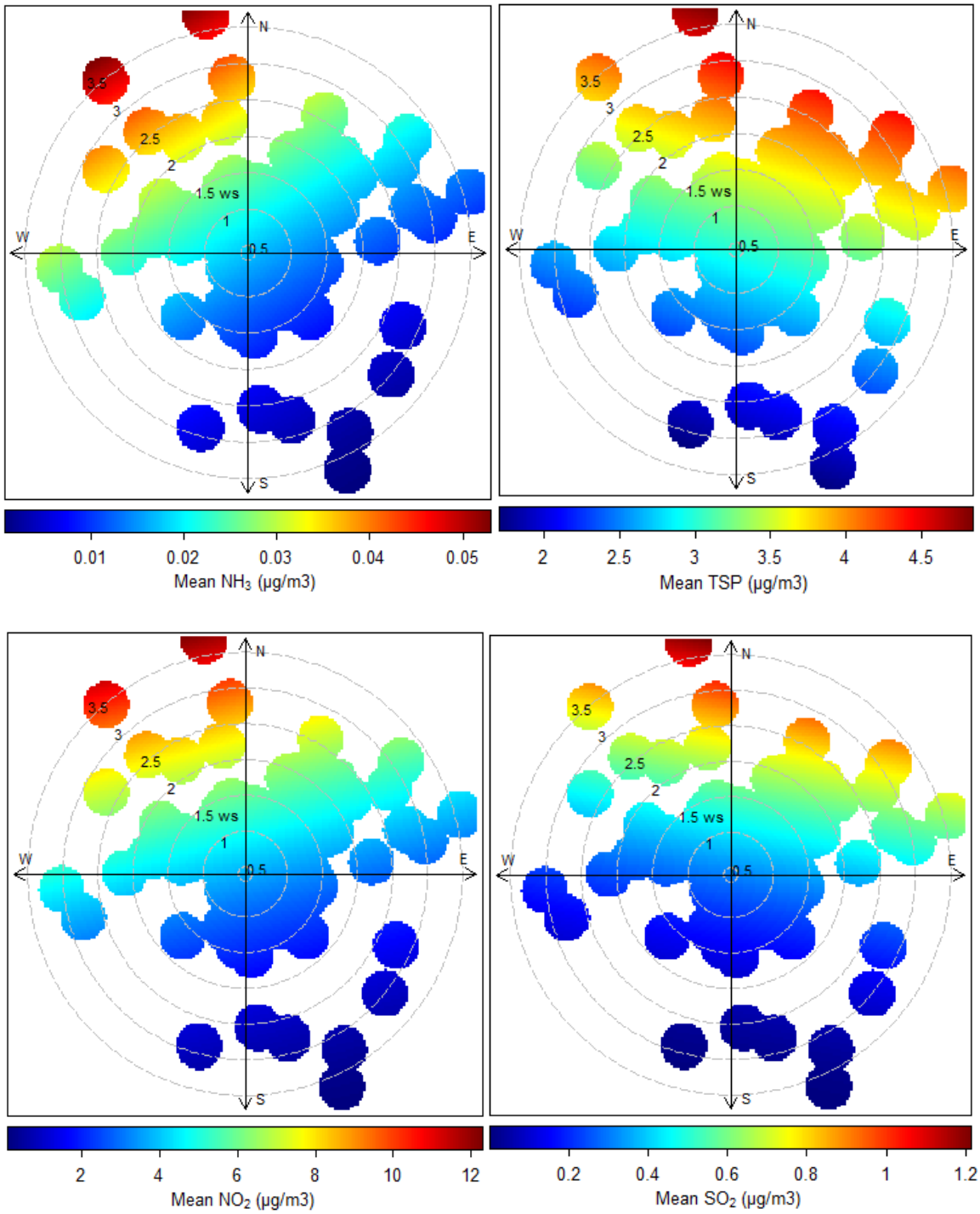


Figure 4.3.16: Wet Season Polar plot of Pollutants Concentrations near the Ammonia/urea

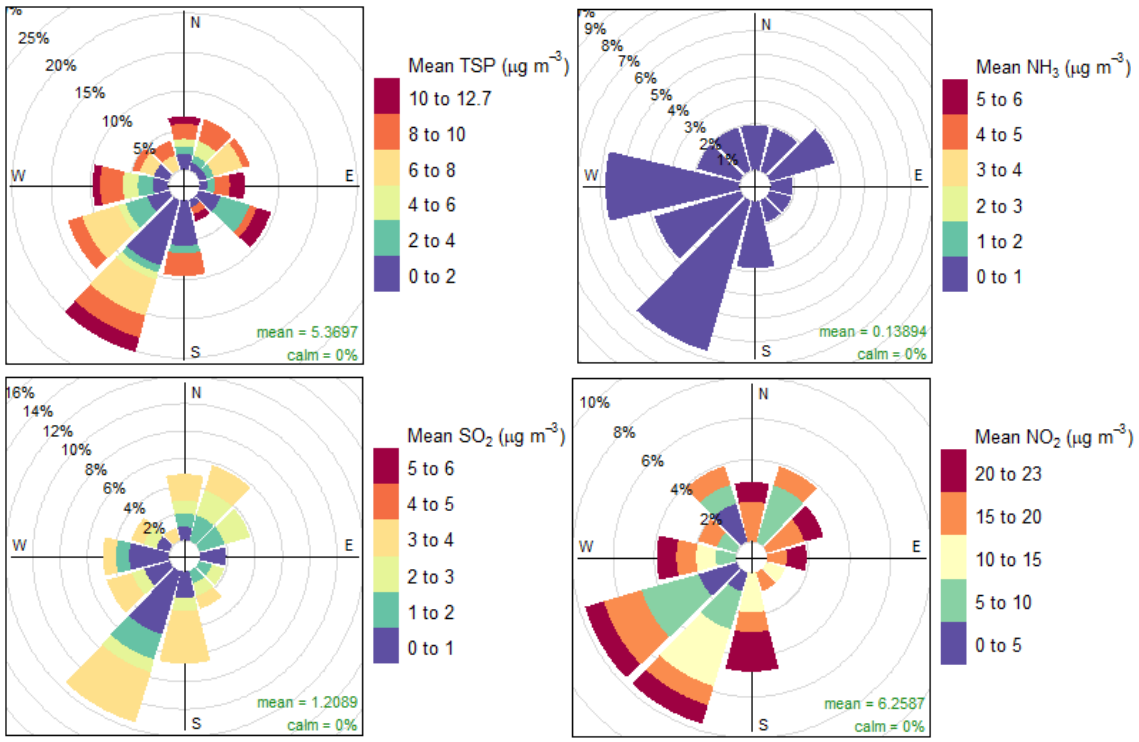


Figure 4.3.17: Dry season Pollution Roses

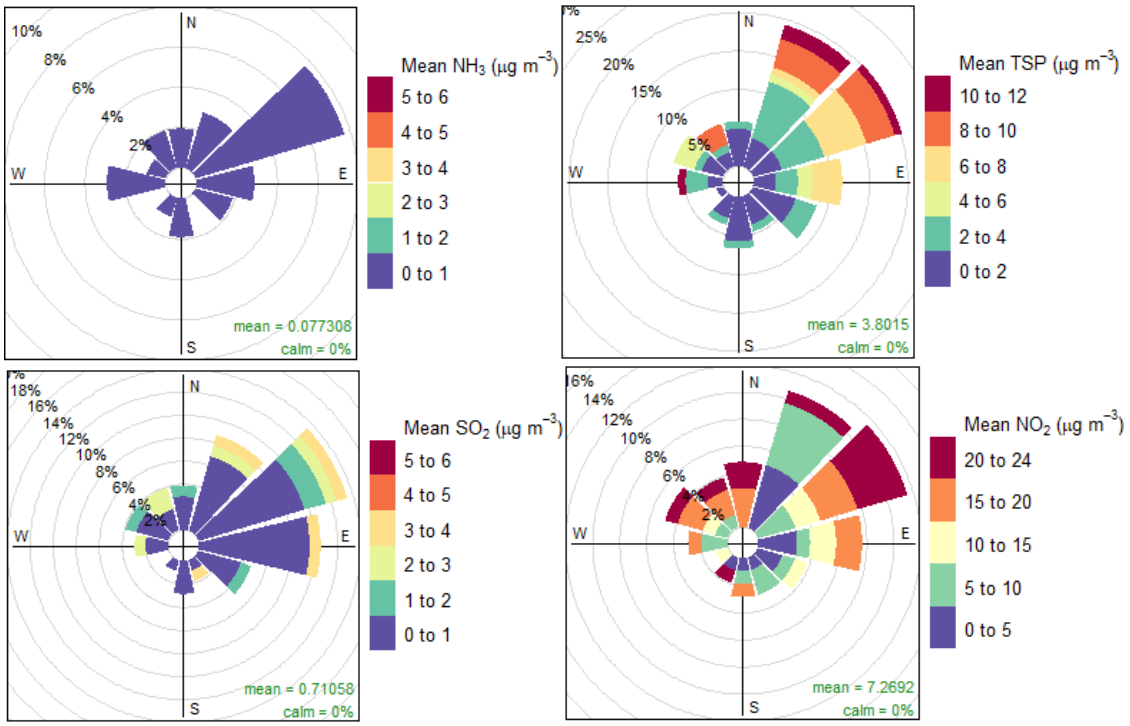


Figure 4.3.18: Wet season Pollution Roses

The analysis carried out highlighted the compliance of air quality in the Ante Operam scenario according to the values monitored. The modeling of emissions carried out in this report was able to provide an insight to what emissions are expected and how they would be dispersed from the proposed facility. All the Ante/post operam scenarios showed that pollutants concentrations from the new plants are well below the FMEnv regulatory/IFC guidelines standards. Hence, the impacts of the proposed ammonia/urea facility are well below the allowable prevention of significant deterioration (PSD) increment.

Second level modeling results (Table 4.3.9) indicated that pollutants concentrations from the proposed ammonia/urea plant are well below FMEnv and IFC permissible limits. Results also revealed that maximum ground-level concentrations are expected to occur up to 2.0km away from the proposed plants. The dispersion of air pollutants from the proposed plant have a minor influence on the background concentration levels of NOx, SOx, PM and NH_3.

Modeling simulations indicated that all concentrations outside the plant are expected to be within the concentration limits/regulation standards. Base on this, it is possible to assume that:

- Minor increments are expected in pollutant concentrations at ground level after the operation of the new Fertilizer Plant;
- Ground level concentrations of all pollutant emissions during the operation of the proposed plant project are well below air quality regulatory standards.
- All the values will be in compliance with the applicable occupational exposure standards.

4.4 SOIL QUALITY

4.4.1 Sampling Methodology

Soil samples were randomly collected using the vegetation, slope and elevation as the factor determining the point for each sampling. A GPS reading was taken at each point of sampling to establish the coordinates and the elevation. Composite soil samples were collected at two depths: 0-15cm (Topsoil) and 15 – 30cm (Subsoil) with the aid of Dutch stainless steel hand auger (Plate 4.4.1) from Seven (7) sites at different locations within the proposed project area and two control sites outside the project area. A total number of Eighteen (18) soil samples were collected. The soil samples were collected in duplicate; those for physical and chemical analysis were packed in Ziploc polythene bags, and those for microbial and oil & grease analysis wrapped in aluminum foil. The samples were neatly labeled, preserved and taken to FMEnv accredited laboratory - Earthquest International laboratory Warri, Delta State for analysis. All in-situ observations were recorded in a field notebook.

Plate 4.4.1: Soil sampling in progress

4.4.2 Morphological properties

The soils of the study area is part of the coastal plain sands some times called Ogoni Sands of South Eastern Nigeria. Anderson (1966) had earlier stated that Ogoni soils were composed of sandy deposits originally laid down at or near sea level in Oligocene to

Pleistocene times. The soils of the study area are coarse grained, gravelly, locally fine-grained, poorly sorted, subangular to well rounded (Assez,1975). Ojanuga et al (1981) stated that the genesis of these soils have resulted from cycles of soil formation which alternated with cycles of erosion in the mid tertiary to Holocene era in Nigeria. Soil consistency as observed during the field exercise were between wet (slightly sticky and non sticky) and moist (friable), while soil colour were between black (10YR2/1), Dark red (2.5/YR3/6), Brown (10YR5/3) and Strong brown (7.5YR4/6). The topography of the study area were relatively flat with some gentle slope as observsed around station one (SS1-Okulu Aleto).

Soils of the area with the exception of some localized variations are characterized as very good physical features, poor inherent fertility status, low degree of acidity, low cation exchange capacity (FAO, 1990) and predominant sandy texture.

4.4.3 Soil Physico-chemical Characteristics

The summary of results of the soil physico-chemical analysis is presented in Tables 4.4.1 and 4.4.2 for the topsoil (0 – 15 cm) and subsoil (15 – 30 cm) respectively, while detailed results for all the sample locations are presented in Appendix 4.6. The textural classification of the two soil depths within the study area and control site was predominantly fine-grained fairly consolidated Loamy Sand, Sandy Loam and Sandy Clay Loam soil (using the soil particle size matrix), with considerably low clay content. The sand, silt and clay contents of the topsoil ranged between 64.50 – 77.00%, 5.80 – 1.10% and 13.80 – 27.00% respectively, while the subsoil recorded 58.80 – 72.20% sand, 6.10-7.90% silt and 20.80 – 34.40% clay. The mean values obtained from the control sample locations were not significantly different from that of the project influence zone. Similar textural characteristics have been reported for the study area from previous studies of IEFCL-Train1 EIA 2010. The texture of a soil determines the water absorption/infiltration rate, the water holding capacity and migration of pollutant down the soil strata (Agede 2009). It also determines the amount of soil aeration, ease of tilling, and soil fertility (Udoh 1986). High sand percentage observed on the soil result is indicative of porous nature of the soil, which may encourage easy percolation of nutrients and pollutants to the groundwater table in the event of chemical spillage, while the moderate clay content of the soil is

suggestive of greater cohesion, plasticity and aggregation of the soil particles for a better soil structure and possible soil stability especially under high engineering activity.

Other parameters that determine the dynamics of pollutants in soil include bulk density and porosity. The bulk density in particular gives a rough estimation of the aeration and permeability of a soil. The lower the bulk density, the higher the soil permeability to encourage free movement of liquid substance across the soil horizon (Nwachukwu 2016). Bulk density varies with structural conditions of the soil. Therefore, it is related to packing and often used as a measure for soil structure. The results obtained in this study revealed porosity range of 43.80 – 53.20% and bulk density 0.15 – 0.28 for topsoil, while the respective values for subsoil ranged from 44.00 – 56.08 % and 0.18 – 0.33 g/cm^3, with no significantly different ($p>0.05$) when compared to the control values. The low soil bulk density result revealed that no form of soil compaction is in progress within and outside the project influence zone (Nwachukwu 2016).

The strength of soil changes with respect to soil water content. Thus, the soil moisture content ranged from 0.24 – 1.15% and 0.26 – 0.51% for topsoil and subsoil respectively. Both the moisture content and bulk density recorded in the cause of this study depict strong soil with respect to compressibility. Brady and Weil, (1999) remarked that soil moisture, plasticity and particle size of soils determine stability of soils in response to loading forces from traffic, tillage and building foundations. Clay content, nature of clay, nature of exchangeable cations and organic matter content of soils vary, and these influence the plasticity and general activity levels of soils.

The soil reaction falls within acidic pH range of 4.70 – 5.60 (5.22 ± 0.39) for topsoil and 4.30 – 6.80 (5.37 ± 1.03) for subsoil indicating that the soil is slightly acidic, which is typical of a Niger Delta soil (Isirimah 1987). pH is often considered in terms of the soil capability and suitability to support plants growth. This is because the value of the free H^+ concentration in a soil influences the availability of nutrient elements and biochemical reactions in the soil (Bohn *et al*., 1984). Agriculturally, soil pH has so far been proven to influence nutrient absorption and plant growth through the availability of plant nutrient and presence of toxic element harmful to plants. Therefore soil pH is like an index

parameter to estimate concentration of other parameters in the soil, just like low pH increases heavy metal concentration in the soil (Itanna 1998); pH <6.5 affect the availability of Phosphorus (Brady, 1974). Consequently, the present pH condition of the soil may enhance the solubility and mobility of heavy metals and their subsequent percolation to the groundwater table but may slow down microbial degradation. The optimum pH values for pollutant-degrading microorganisms range from 6.5 to 7.5 (Margesin and Schinner, 2005).

The Organic matter content of the soil ranged from 0.09 – 0.21% at the topsoil, while the subsoil ranged from 0.08 – 0.16% indicating low organic matter content of both topsoil and subsoil according to FAO (1990) classification, which also reflected in the Total Organic Carbon results recorded during this studied. Spatial variation in the measured TOM values across the sampling stations was not too high with coefficient of variation less than 25%. Soil organic matter contributes to soil aggregation and reduces susceptibility to erosion (Brady and Weil, 1996). As such many important soil properties are dependent on the quality of organic matter present in soil. These properties include the absorption and retention of water, reserves of exchanged bases, the capacity to supply nitrogen, phosphorus and other elements to growing crops, stability of soil structure, adequacy of aeration and pollutants bioavailability (Margesin and Schinner, 2005). In fact pollutant concentrations in soil are normalized with the organic matter in conjunction with clay content (DPR, 2002).

Table 4.4.1: Summary of Physiochemical properties of soil within the project area (0-15cm)

PARAMETERS	Min	Max	STD	Ave	CV %	Control 1	Control 2
Sand (%)	64.50	77.00	4.32	69.05	6.25	76.50	66.70
Silt (%)	5.80	10.10	1.70	8.05	21.18	1.30	21.40
Clay (%)	13.80	27.00	4.75	22.90	20.75	22.20	11.9
Porosity (% Pore space)	43.80	53.20	3.38	50.07	6.75	42.80	50.90
Permeability (k-4cm/hr)	1.70	2.10	0.22	1.90	11.53	1.90	1.60
Bulk Density (g/cm)	0.15	0.28	0.05	0.23	20.39	0.22	0.20
Moisture Content (%)	0.24	1.15	0.31	0.60	51.60	0.72	0.42
pH	4.70	5.60	0.39	5.22	7.51	4.80	5.30
Electrical Conductivity (us/cm)	48.20	172.20	42.07	108.42	38.81	124.60	39.40
Phosphorous (%)	0.13	0.28	0.05	0.18	28.59	0.14	0.12
Total Nitrogen (%)	0.08	0.39	0.11	0.19	58.01	0.17	0.16
CEC (cmol/kg)	0.81	1.32	0.18	1.04	17.76	1.21	1.04
SO_4^{2-} (mg/kg)	2.70	7.25	1.67	4.47	37.34	8.66	2.76
NO_3 - N (mg/kg)	0.05	0.18	0.06	0.12	48.78	0.07	0.05
NH_4 - N (mg/kg)	0.16	0.52	0.16	0.37	42.38	0.18	0.19
O & G (mg/kg)	1.28	6.16	1.93	2.22	86.93	2.31	0.68
TOC (%)	0.04	0.13	0.03	0.10	33.68	0.25	0.26
OM (%)	0.09	0.21	0.04	0.17	24.76	0.39	0.33
Exc. Acidity (meq/100g)	0.70	1.20	0.19	0.95	19.69	1.10	1.00
Base Saturation (%)	3.85	13.79	3.90	9.07	42.99	9.40	3.44
CATIONS							
Ca ($cmolkg^{-1}$)	0.63	1.30	0.25	0.90	28.27	0.86	0.72
Mg ($cmolkg^{-1}$)	0.36	3.61	1.36	1.97	68.89	1.63	0.12
Na ($cmolkg^{-1}$)	4.61	22.51	6.76	14.74	45.88	21.26	6.31
K ($cmolkg^{-1}$)	0.95	4.15	1.37	2.83	48.27	1.50	1.40

Field work 2017

Table 4.4.2: Summary of Physiochemical properties of soil within the project area (15-30cm)

PARAMETERS	Min	Max	STD	Ave	CV %	Control 1	Control 2
Sand (%)	58.80	72.20	5.43	65.15	8.34	71.1	75.9
Silt (%)	6.10	7.90	0.63	7.07	8.93	5.40	5.70
Clay (%)	20.80	34.40	5.18	27.78	18.63	23.5	18.4
Porosity (% Pore space)	44.00	56.08	4.35	50.70	8.58	52.30	57.40
Permeability (k-4cm/hr)	1.60	2.00	0.15	1.82	8.10	2.00	1.90
Bulk Density (g/cm)	0.18	0.33	0.07	0.25	27.08	0.28	0.26
Moisture Content (%)	0.26	0.51	0.09	0.41	22.31	0.16	0.15
pH	4.30	6.80	1.03	5.37	19.14	5.50	5.50
Electrical Conductivity (us/cm)	41.10	121.70	39.44	78.47	50.26	38.30	34.50
Phosphorous (%)	0.14	0.32	0.07	0.21	33.37	0.22	0.19
Total Nitrogen (%)	0.08	0.27	0.07	0.17	38.37	0.07	0.12
CEC (cmol/kg)	0.70	1.49	0.33	1.03	31.85	1.04	0.93
SO_4^{2-} (mg/kg)	2.92	7.31	1.51	5.66	26.72	1.65	2.43
NO_3 - N (mg/kg)	0.04	0.22	0.06	0.10	64.98	0.06	0.09
NH_4 - N (mg/kg)	0.12	0.47	0.13	0.33	38.66	0.18	0.27
O & G (mg/kg)	0.92	1.52	0.33	1.14	28.99	<0.01	<0.01
TOC (%)	0.03	0.09	0.02	0.06	36.51	0.04	0.07
OM (%)	0.08	0.16	0.03	0.12	26.95	0.07	0.12
Exc. Acidity (meq/100g)	0.60	1.40	0.34	0.97	35.03	1.00	0.90
Base Saturation (%)	2.64	13.85	4.67	7.14	65.43	3.39	2.88
CATIONS							
Ca ($cmolkg^{-1}$)	0.50	1.21	0.25	0.72	35.44	0.88	0.53
Mg ($cmolkg^{-1}$)	0.34	2.27	0.76	1.13	66.77	0.59	0.17
Na ($cmolkg^{-1}$)	4.46	18.06	6.56	11.13	58.97	5.06	4.66
K ($cmolkg^{-1}$)	0.80	2.90	0.85	1.63	52.25	1.45	0.93

Field work 2017

Total Nitrogen levels ranged between 0.08 – 0.39% and 0.08 – 0.27% for both the top and sub soil respectively indicating that Medium to high soil fertility according to FAO (1990) classification of soil. Soil nitrogen of more than 0.15% is considered optimal for most crops (Sobulo and Osiname, 1986). Nitrogen concentrations in soils generally fall sharply with depth, with most of the nitrogen being in the top one meter layer of soils. Over 90%, of the nitrogen in the surface layers (A-horizon, plow-depth zone) of soil is in organic matter (Bremmer, 1965; Stevenson, 1982). Total phosphorus levels in the topsoil and subsoil also fall within low soil fertility classification (FAO, 1990), with a value range between 0.13 – 0.28% for topsoil and 0.14 – 0.32% for subsoil, this can be a result of slight acidic nature of the soil which must have fixed the phosphorus content of the soil (Brady, 1974). Phosphorus in soils is present in the soil solution (plant-available); as labile phosphate precipitates and adsorbed to soil particles, mainly clay minerals (potentially available to plants); as non-labile phosphate in the form of calcium, iron, and aluminum phosphate (not plant-available); in organic form, including P in soil organic matter (released after mineralization); and in living soil biomass. Phosphorus is utilized in the fully oxidized and hydrated form as orthophosphate. Deficiency of phosphorus may limit the growth of plants and the microbial decomposition of pollutants in soil. Phosphorus is likely to be deficient in hydrocarbon-impacted soils and sub-soils.

The exchangeable cations (Ca, Mg, K and Na) are positively charged ions usually absorbed by electrostatic or columbic attraction to soil surface colloids. Plants absorbed it in exchangeable form (Donahue, 1990). The exchangeable cations for the surface soils were as follows: Ca (range, 0.61 – 1.30cmolkg^{-1}); Mg (range, 0.36 – 5.61cmolkg^{-1}); K (range; 0.95 – 4.15cmolkg^{-1}) and Na (range, 4.61 – 22.51cmolkg^{-1}) for topsoil. While, the following values were recorded for the subsurface soils; Ca (range, 0.50 to 1.21); Mg (range, 0.34 – 2.27 cmolkg^{-1}); K (range, 0.80 - 2.90 cmolkg^{-1}) and Na (range 4.46 – 18.06 cmolkg^{-}1) for subsoil. The exchangeable acidity ranged between 0.70 – 1.20 cmolkg^{-1} for topsoil and 0.60 – 1.40 cmolkg^{-1} for subsoil; cation exchange capacity (CEC) (0.81 – 1.32cmolkg^{-1}) for topsoil and between 0.70 – 1.49cmolkg^{-1}for subsoil, while base saturation ranged between (3.85 – 13.79%) for topsoil and between (2.64 – 13.85%) for subsoil with no significant ($p>0.05$) mean variation of project zone influence and the control station.

Oil and grease content of the soil ranged from 1.28 to 6.16mg/kg topsoil and 0.92 to 1.52mg/kg subsoil. The oil and grease concentration were more on the topsoil and lower on the subsoil. However the oil and grease content of the soil were generally low indicating no form of oil spillage within the study area, this is further corroborate by the low presence/count of HUB recorded in the cause of this study.

4.4.4 Soil microbiology

Soil represents a very favorable habitat for microorganisms and is inhabited by a wide range of microorganisms, including bacteria, fungi, algae, viruses and protozoa. Microorganisms are found in large numbers in the soil (usually between one and ten million microorganisms are present per gram of soil) with bacteria and fungi being the most prevalent. However the availability of nutrients is often limiting for microbial growth in soil and may increase soil fertility and plant growth.

Consequently, an investigation to determine existence of heterotrophic as well as hydrocarbon Utilizing bacteria and fungi in the study area was carried out and presented in (Table 4.4.3.).

Table 4.4.3: Summary of Soil microbes within the project area

PARAMETERS	Min	Max	STD	Ave	CV %	Control 1	Control 2
Topsoil							
THB (cfu/g X 10^4)	0.52	4.50	1.47	2.64	55.77	1.00	1.61
THF (cfu/g X 10^4)	0.15	1.59	0.55	0.86	64.25	0.45	0.23
HUB (cfu/g X 10^4)	0.25	1.96	0.63	0.74	84.35	0.20	1.45
HUF (cfu/g X 10^4)	0.64	3.00	0.84	1.50	55.96	2.00	0.38
T.Col. (cfu/g X 10^4)	0.85	1.31	0.17	1.13	15.00	1.34	1.26
Subsoil							
THB (cfu/g X 10^4)	1.50	3.95	1.09	2.65	41.29	2.03	0.85
THF (cfu/g X 10^4)	0.45	2.00	0.56	0.99	55.87	0.94	0.12
HUB (cfu/g X 10^4)	0.37	1.99	0.60	1.11	53.75	0.27	NIL
HUF (cfu/g X 10^4)	0.22	3.50	1.29	1.62	79.66	1.21	0.5
T.Col. (cfu/g X 10^4)	0.31	0.45	0.06	0.41	15.12	0.41	0.46

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The total population of total heterotrophic bacteria (THB) ranged from $0.52x10^4$ to $4.50x10^4$(cfu/g) for topsoil and $1.50x10^4$– $3.95x10^4$(cfu/g) for subsoil; total heterotrophic fungi (THF) ranged from $0.15x10^4$ – $1.59x10^4$(cfu/g) for topsoil and $0.45x10^4$– $2.00x10^4$(cfu/g) for subsoil. The population of total hydrocarbon utilizing bacteria (THUB) ranged from $0.25x10^4$– $1.96x10^4$(cfu/g) for topsoil and $0.37x10^4$– $1.99x10^4$(cfu/g) for subsoil, and the total hydrocarbon utilizing fungi (THUF) ranged from $0.64x10^4$ – $3.00x10^4$(cfu/g) for topsoil and $0.22x10^4$– $3.50x10^4$(cfu/g) for subsoil. Comparatively, the hydrocarbon utilizers were the least in population. Therefore, it can be said that there is no significant hydrocarbon pollution around the study area to encourage the significant presence of this bacteria, this is further justified by low concentration of oil and grease content in the soil samples.

4.4.5 Soil Fauna

The soil macro-fauna identified through visual observation in the study area include various arthropods (*Myricarid striata*, *Dorylus fimbriatus, Glomens marginata*), Annelids (Earthworms) and Nematodes (*Acanthamoeba polyphaga, Acrobeloides sp, Porcellia scraber*). These organisms are primary consumers; decomposers, mixers and utilizers of energy stored in plants and plant residues, and contribute to the recycling of nutrients. They also help in soil particle aggregation to encourage soil stability. Others are secondary consumers such as centipedes and spiders. These animals consume smaller sized animals and they, also may serve as food for organisms occupying higher levels of the food chain. Soil fauna are notable and are critical in the biological turnover and nutrients release of plant residues by fragmenting the plant residues, resulting in enhanced microorganism activities and grazing of micro flora by fauna. Anderson and Fletcher (1988) noted a symbiotic interaction between earthworm and microorganism in the breakdown and fragmentation of organic matter.

4.4.6 Heavy metals

Heavy metals analysis in the soil samples revealed Iron (Fe) having the highest concentration (Mean 6847.25mg/kg topsoil and 6685.20mg/kg subsoil), while mercury (Hg) and Vanadium (v) recorded the lowest concentration <0.05mg/kg, Lead concentration ranged from 38.14 to 51.16 topsoil and 31.03 to 48.74mg/kg in subsoil.

Similar values were recorded at the control stations. High concentration of iron in soil is common within the Niger Delta environment Aiyesanmi, 2005). Agriculturally, Iron concentration above 360 mg/kg is considered high and can adversely affect crop yield (FAO, 1990).

Table 4.4.4 Summary of heavy metal composition in soil within the project area

PARAMETERS	Min	Max	STD	Ave	CV %	Control 1	Control 2
Topsoil							
V (mg/kg)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ni (mg/kg)	7.81	17.32	3.19	13.27	24.00	13.57	13.38
Fe (mg/kg)	5931.95	8592.83	989.02	6847.25	14.44	3709.22	4468.47
Pb (mg/kg)	38.14	51.16	4.84	43.43	11.15	38.92	38.17
Cu (mg/kg)	7.06	11.31	1.52	8.84	17.23	5.91	5.81
Zn (mg/kg)	60.66	80.38	7.63	69.67	10.95	72.28	70.97
Cd (mg/kg)	5.31	8.90	1.37	7.88	17.37	8.93	2.68
Cr (mg/kg)	0.40	1.25	0.35	0.78	45.42	0.12	0.62
Hg (mg/kg)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Subsoil							
V (mg/kg)	<0.05	<0.05	0.00	0.00	0.00	<0.05	<0.05
Ni (mg/kg)	10.92	17.27	2.07	14.01	14.80	17.28	15.62
Fe (mg/kg)	4003.32	8401.76	1583.27	6685.20	23.68	2915.96	2023.67
Pb (mg/kg)	31.03	48.74	7.70	41.31	18.65	40.59	38.28
Cu (mg/kg)	5.16	10.41	1.71	7.89	21.65	3.95	5.01
Zn (mg/kg)	52.96	78.58	9.23	64.02	14.43	52.25	62.77
Cd (mg/kg)	6.28	8.60	0.92	8.15	11.30	4.84	2.83
Cr (mg/kg)	0.12	3.78	1.32	1.41	93.51	0.19	0.56
Hg (mg/kg)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

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4.4.7 Land use

Land use within the study area is largely affected by large extent of human activities such as industrilisation, municipal and agricultural activities. High industrialization, which is at its peak within the area has resulted to visible reduction in agricutural activity of the study area. The notable landuse within the study area included Indorama complex (which is playing host to the proposed IEFCL-Train2 fertilizer project), NNPC estate adjcent to Indorama complex, Onura shrine, Port Harcourt Refinery, fuel stations and road infrastucture network. Comparatively, Port Harcourt Refinery, Indorama complex and NNPC Estate occupies prominent space in the land use of the study area.

4.5 VEGETATION AND WILDLIFE

The ecological study covered flora and fauna species compositions, in terms of species that are abundant, common, occasional and rare. The tables and figures below are used to explain prevailing situations in the study area. In addition the study area lies within the riparian lowland forest with a two-layer canopy characteristic and a low lying flat terrain that experiences seasonal flooding. The soils of the IEFCL Train2 which is sandy-loam, clayey-loam, clayey and poorly drained. The soil of the study area is wet and moist in the wet season but dry and friable during the dry season. However, the proposed IEFCL Train2 site had little vegetation components which are mainly herbaceous in nature as compared to the surroundings of the Train1 facility. No endangered and endemic species were encountered in the study area. Hence, the project will not affect any form of wildlife or plant in the IEFCL Train2 project environs as well as in the study area.

4.5.1 Vegetation

4.5.1.1 Tree/Shrub species composition

Within the study area, a total of thirteen tree/ shrub species occurred and out of which no specie (tree/shrub) was abundant but rather, one specie was found to be common and that specie was *Elaeis guinensis*. In the same vein, four species were occasional and they include; *Anthonota macrophylla, Alchornea cordifolia, Alstonia boonei and Harungana madascariensis*. However, eight species were found to be rare and they are; *Ficus exasperate, Psidium guajava, Anthocleista vogelii, Musanga cecropioides, Anacardium occidentalis, Bambusa vulgaris, Baphia nitida and Persea Americana.*

Table 4.5.1: Tree/Shrub Species Composition

Sr. No.	Tree shrub composition	Common name	Family	A	C	O	R
1	*Ficus exasperate*	Forest sand paper	*Moraceae*				X
2	*Elaeis guinensis*	Oil palm	*Arecaceae*		x		
3	*Psidium guajava*	guava	*Mytraceae*				X
4	*Anthonota macrophylla*	African rose wood	*Mimosaceae*			x	
5	*Anthocleista vogelii*	English cabbage tree	*Potaliceae*				X
6	*Musanga cecropioides*	Umbrella tree	*Urticaceae*				X
7	*Alchornea cordifolia*	Christmas bush	*Apocynaceae*			x	
8	*Alstonia boonei*	African nut tree	*Apocynaceae*			x	
9	*Anarcadium occidentalis*	Cashew tree	*Anacardiaceae*				X
10	*Harungana madascariensis*	Dragon blood tree	*Hypericaceae*			x	
11	*Bambusa vulgaris*	Bamboo	*Bambusae*				X
12	*Baphia nitida*	Cam wood	*Fabaceae*				X
13	*Persea Americana*	Avocado	*Lauraceae*				X

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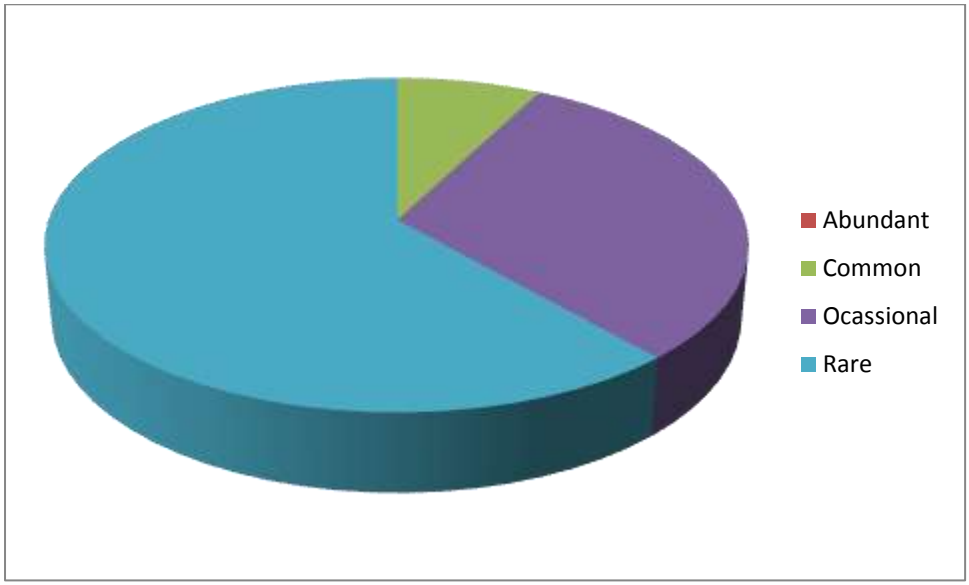

Figure 4.5.1: Tree/Shrub Species Composition in the Study Area

4.5.1.2 Tree/Shrub family composition

Twelve families were seen to occur within the thirteen tree/shrub species. From the occurrence, it was observed that a total of eleven families based on their ecological status were found to be rare and they include; *Moraceae, Arecaceae, Mytraceae, Mimosaceae, Potaliceae, Urticaceae, Anacardiaceae, Hypericaceae, Bambuseae, Fabaceae and Lauraceae* while *Apocynaceae* was the only occasionally occurring family.

Table 4.5.2: Tree/Shrub family composition

Sr. No.	Family	Frequency	A	C	O	R
1	*Moraceae*	1				X
2	*Arecaceae*	1				X
3	*Mytraceae*	1				X
4	*Mimosaceae*	1				X
5	*Potaliceae*	1				X
6	*Urticaceae*	1				X
7	*Apocynaceae*	2			x	
8	*Anacardiaceae*	1				X
9	*Hypericaceae*	1				X
10	*Bambusae*	1				X
11	*Fabaceae*	1				X
12	*Lauraceae*	1				X
	TOTAL	**13**				

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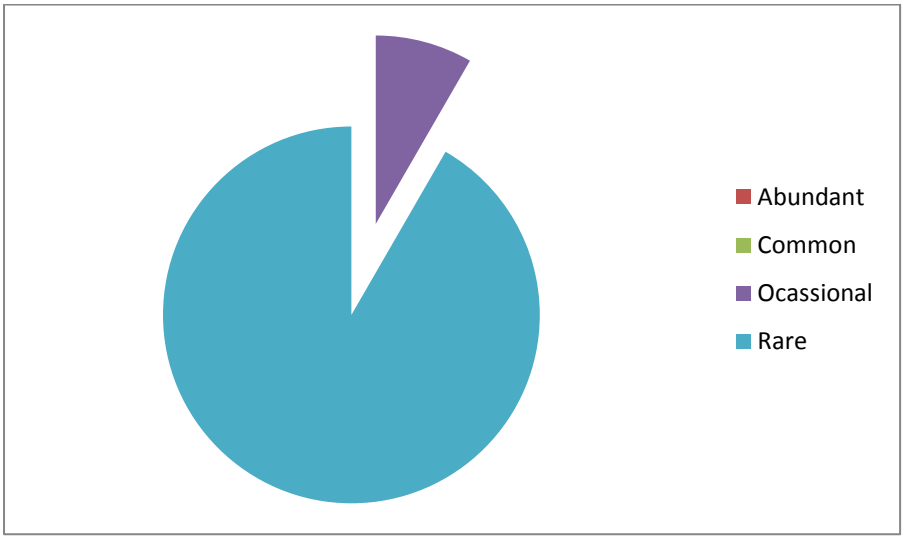

Figure 4.5.2: Tree/shrub Species Family Composition in the Study Area

4.5.1.3 Herbaceous species composition

A total of eighteen (18) herbaceous species were found to occur within the study area and from the occurrences, it was observed that *Panicum maximum* was the only abundant occurring family while *Ipomoea involucrate* was the only common family. Occasionally speaking, six herbaceous species were found to be in that range and such species include; *chromoleana odorata, pennisetum purpureum, cyperus spp, costus afer, kyllinga erecta* and *sida acuta.* Moreover, nine (9) species were rare and they were; *Aspilia Africana,*

Elusine indica, Spermacoce venticullata, Mimosa pudica, Calopogonium mucunioides, Senna occidentalis, Amaranthus spinosus, Imperata cylindrical and *Emilia sonchifolia*

Table 4.5.3: Herbaceous species composition

Sr. No.	Herbaceous species	Common name	Family	A	C	O	R
1	*Panicum maximum*	Guinea grass	*Poaceae*	x			
2	*Aspilia africana*	Haemorrhage plant	*Asteraceae*				X
3	*Elusine indica*	Wire grass	*Poaceae*				X
4	*Centrosema pubescens*	Butterfly pea	*Fabaceae*		x		
5	*Spermacoce venticullata*	Shrubby false buttonweed	*Rubiaceae*				X
6	*Mimosa pudiica*	Shame weed	*Fabaceae*				X
7	*Chromoleana odorata*	Siam weed	*Asteraceae*			x	
8	*Calopogonium mucunoides*	Wild groundnut	*Fabaceae*				X
9	*Senna occidentalis*	Coffee weed	*Fabaceae*				X
10	*Amaranthus spinosus*	Spiny pigweed	*Amaranthaceae*				X
11	*Pennisetum purpureum*	Elephant grass	*Poaceae*			x	
12	*Imperata cylindrical*	Cogon grass	*Poaceae*				X
13	*Cyperus spp*	Nutsedges	*Cyperaceae*			x	
14	*Emilia sonchifolia*	Tassel flower	*Asteraceae*				X
15	*Costus afer*	Spiral ginger	*Costaceae*			x	
16	*Ipomoea involucrate*	Morning glory	*Convolvulaceae*		x		
17	*Kyllinga erecta*	Spikesedges	*Cyperaceae*			x	
18	*Sida acuta*	Broomweed	*Malvaceae*			x	

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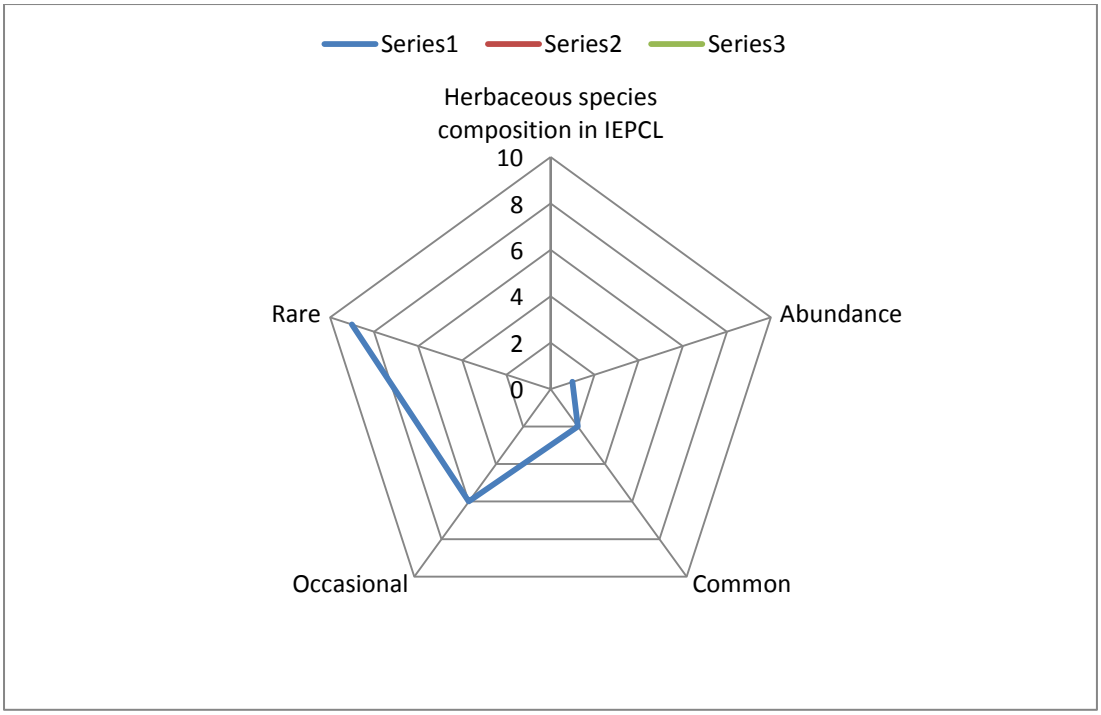

Figure 4.5.3: Herbaceous Species Composition in the Study Area

Figure 4.5.3 explains in graphical form the information provided in Table 4.5.3 which was the herbaceous species composition in the area. Also, this showed the species that were abundant, common, occasional and or rare in the area.

4.5.1.4 Herbaceous family composition

In consideration of the herbaceous family composition within the study area, it was observed that a total of nine families occurred within the eighteen (18) herbaceous species. Further, two families namely *Poaceae* and *Fabaceae* were in abundance while *Asteraceae* was the only commonly occurring family. In the same vein, *cyperaceae* was found to be the only occasionally occurring family. However, five species were found to be rare and they include *Rubiaceae, Amaranthaceae, Costaceae, Convolvulaceae* and *Malvaceae.*

Table 4.5.4: Herbaceous Family

Sr. No.	Family	Frequency	A	C	O	R
1	*Poaceae*	4	x			
2	*Asteraceae*	3		x		
3	*Fabaceae*	4	x			
4	*Rubiaceae*	1				X
5	*Amaranthaceae*	1				X
6	*Cyperaceae*	2			x	
7	*Costaceae*	1				X
8	*Convolvulaceae*	1				X
9	*Malvaceae*	1				X
	TOTAL	**17**				

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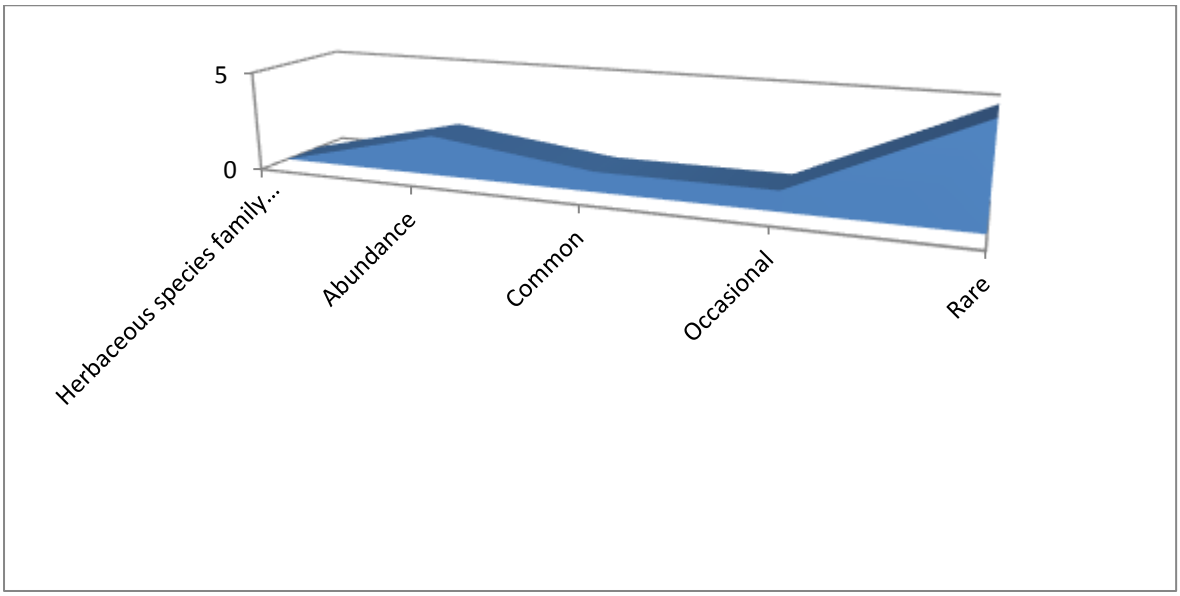

Figure 4.5.4: Herbaceous Family Species Composition in the Study Area

4.5.2 Wild Life species composition in the study area

A total of twenty-one (21) wildlife species occurred within the study area and it was observed that no wildlife species was found to be abundant but however, three wildlife species were common namely *Rattus rattus, Streptopelia senegalensis* and *Corvus albus*. Occasionally, eleven (11) wildlife species were found in this range and they include

Cricetomys emini, Lemniscomys striatus, Dendroaspis viridis, Pycinonothus barbatus, Nectarinia chloropygia, Anthreptes gabonicus, Nectarinia fuliginosa, Streptopelia semitorqota, Milvus migrans, Ploceus cucullatus and *Apus affinus*. Nevertheless, seven (7) wildlife species were found to be rare and such species include; *Thryonomys swinderianus, Varanus niloticus, Python sabae, Agama agama, Vidua macroura, Ploceus nigerimus* and *Ploceus inelanocephala.*

Table 4.5 5: Wild Life Species in the study area

Sr. No.	Common names	Scientific names	A	C	O	R
1	Greater cane rat	*Thryonomys swinderiamus*				X
2	Emins giant rat	*Cricetomys emini*			X	
3	Black house rat	*Rattus rattus*		x		
4	Spotted grass mouse	*Lemniscomys striatus*			X	
5	Nile monitor lizard	*Varanus niloticus*				X
6	Rock python	*Python sabae*				X
7	Agama lizard	*Agama agama*				X
8	Green mamba	*Dendroaspis viridis*			X	
9	Common garden bulbul	*Pycinonothus barbatus*			X	
10	Pintailed whydah	*Vidua macroura*				X
11	Olive bellied sunbird	*Nectarinia chloropygia*			X	
12	Mouse brown sunbird	*Anthreptes gabonicus*			X	
13	Carmelite sumbird	*Nectarinia fuliginosa*			X	
14	Red eye dove	*Streptopelia semitorqota*			X	
15	Laughing dove	*Streptopelia senegalensis*		x		
16	Black kite	*Milvus nigrams*			X	
17	Pied crow	*Corvus albus*		x		
18	Village weaver	*Ploceus cucullatus*			X	
19	Viellot's black weaver	*Ploceus nigerimus*				x
20	Black-headed weaver	*Ploceus inelanocephala*				x
21	Little African swift	*Apus affinis*			X	

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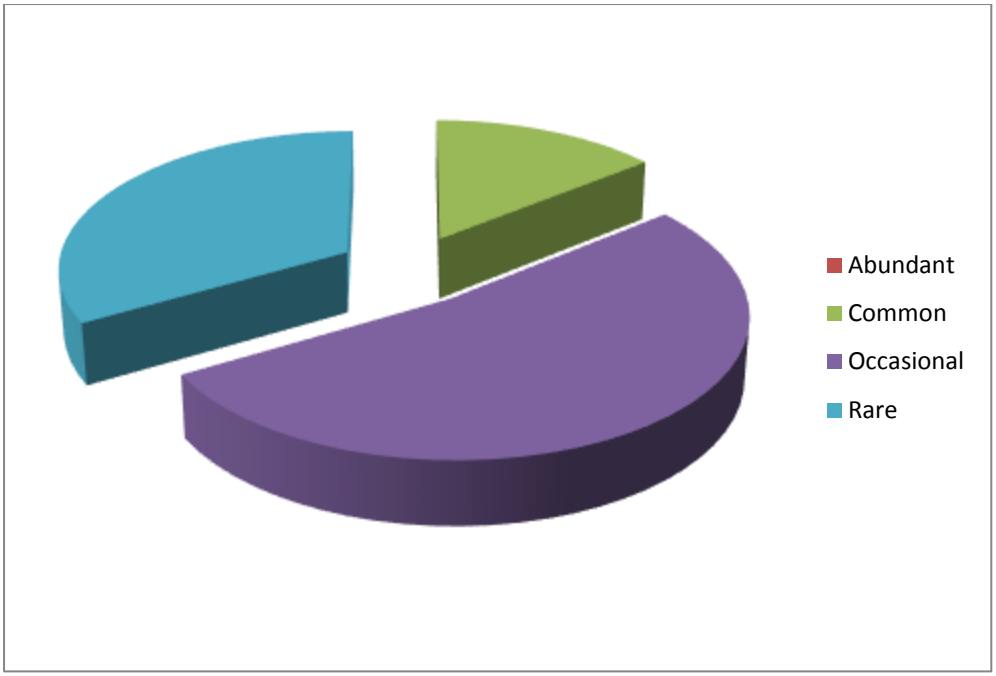

Figure 4.5.5: Wildlife Species Composition in the Study Area

4.5.2.1 Plant Diseases Symptoms and Isolated Pathogens

In the study area, plant disease symptoms and isolated pathogens of some plants were observed and asserted. Tissue analysis from the herbarium, showed that four plants species were sampled namely *Chromoleana odorata, Costus afer,Anthocleista vogelii* and *Calapogonium mucunoides* had one form of disease symptoms and so on. From the foregoing, it was observed *Chromoleana odorata* had common symptoms like leaf spot, mold and blight and necrotic lesions which were caused by *Botrylis linerea*, while *Costus afer* had dead streaks, black colorations and wilting of leafs which was believed to be caused by *Oedecephallum spp*. *Thielaviopsis mosaic/ Curvuleria Spp* was the pathogen that caused by yellow molting and wilting of leaves on *Anthocleista vogelii* and *Calapogonium mucunoides*. Summarily, four isolated pathogens were the major causes of disease in the study area.

Also, in spite of the few observed disease and symptoms on plants species this was not a serious issue as the disease range and impacts were minor. Therefore, the general plant health and conditions was in shape. Hence, the vegetation of the area was healthy.

Table 4.5.6: Plant diseases symptoms and isolated pathogens

Sr. No.	Plant Species	Disease Symptoms	Isolated Pathogens
1	*Chromoleana odorata*	Leaf spot, mold and blight, necrotic lesions	*Botrylis linereae*
2	*Costus afer*	Dead streaks. Black colouration and wilting	*Oedecephallum spp*
3	*Anthocleista vogelii and Calapogonium mucunoides*	Soty molds, yellow wilting and molting	*Thieleviopsis mosaic/ Curvuleria Spp*

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4.6. HYDROGEOLOGY

Geologically, the site is underlain by the coastal plain sands, which in this area is overlain by firm – stiff clay/sandy clay sediments belonging to the pleistocenic formation.

The general geology of the area essentially reflects the influence of movements of rivers in the Niger Delta and their search for lines of flow to the sea with consequent deposition of transported sediments. In broad terms, the area may be considered flat. The site is accessible from East-West Road – Onne – (from Eleme Junction to Alsea-Eleme Community) via Eleme refinery axis.

Environmental/Geophysical and Geotechnical/Groundwater data of the underlying soils are needed for the study of the subsurface conditions. Consequently, Environmental, Geophysical survey (VES), were performed at the existing environmental Geotechnical boreholes/monitoring boreholes perimeter to conduct a limited subsoil investigation at the site.

4.6.1 Geomorphology

The geomorphology of the study area Indorama Complex and Alesa Eleme corresponds with that of Niger Delta. The area forms part of Niger Delta, which extends from the Forcados in the West to Calabar River in the East and covers a distance of about 350km. The Delta has a narrow coastal strip varying in width from a few meters to about 16m, it makes up more than half of the Southern Nigeria basin, which includes all the sedimentary sequences, bounded by Benin hinge line in the West and the Calabar hinge line on the East. The Delta is tropical one, being composed mainly of fine grained deltaic sediments.

The area is tectonically stable and is situated in the equatorial rain forest belt. The Niger Delta is characterized into five (5) major inter gradational geomorphologic units (Allen, 1965; short and stumble, 1975, and Wigwe, 1975). These units occur from land to sea as.

- Dry flatland and plain
- Dry deltaic plain with rare fresh water swamps
- Extensive fresh water swamps and meander belts
- Saltwater mangrove swamps, estuaries, creeks and lagoons
- Abandoned and active coastal Islands and beaches

The study area falls under dry flat land plain. There is dense rain forest vegetation in area.

4.6.2 Geology

4.6.2.1 Geology (General Geology of Niger Delta)

The geology of the Niger Delta has been described by various authors including Allen, 1965 and short and stumble, 1975. The formation of the Niger Delta began in the early Palaeocene times and was as a result of the buildup of fine – grained sediment eroded and transported by the River Niger and its tributaries. The Niger Delta is composed of three subsurface lithostratigraphic units (Akata, Agbada and Benin formations overlain by various deposits of Quaternary Age. The Benin formation (2100m thick) is the most prolific aquifer in the region and constitutes over ninety percent (90%) massive, porous sands with localized clay/shale interbeds. The quaternary deposits (40 – 150m thick) generally consist of rapidly alternating sequences of sand and silt/clay, with the latter becoming increasing more prominent seawards.

The Agbada formation underlies the Benin formation and was deposited under transitional environment, with an almost equicom positional makeup of sands and shales. However increasing clay may occur with depth.

Underlying the Agbada formation is the Akata formation, which was deposited, in marine environment. It consists of marine clays, silts and shales with occasional turbidite sand lenses. The formation is rich in organic matter and is the source rock of oil in the Niger Delta. It has a relative thickness of 20,000ft (5882m).

Table 4.6.1: Geologic Unit of the Niger Delta (Allen, 1965)

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

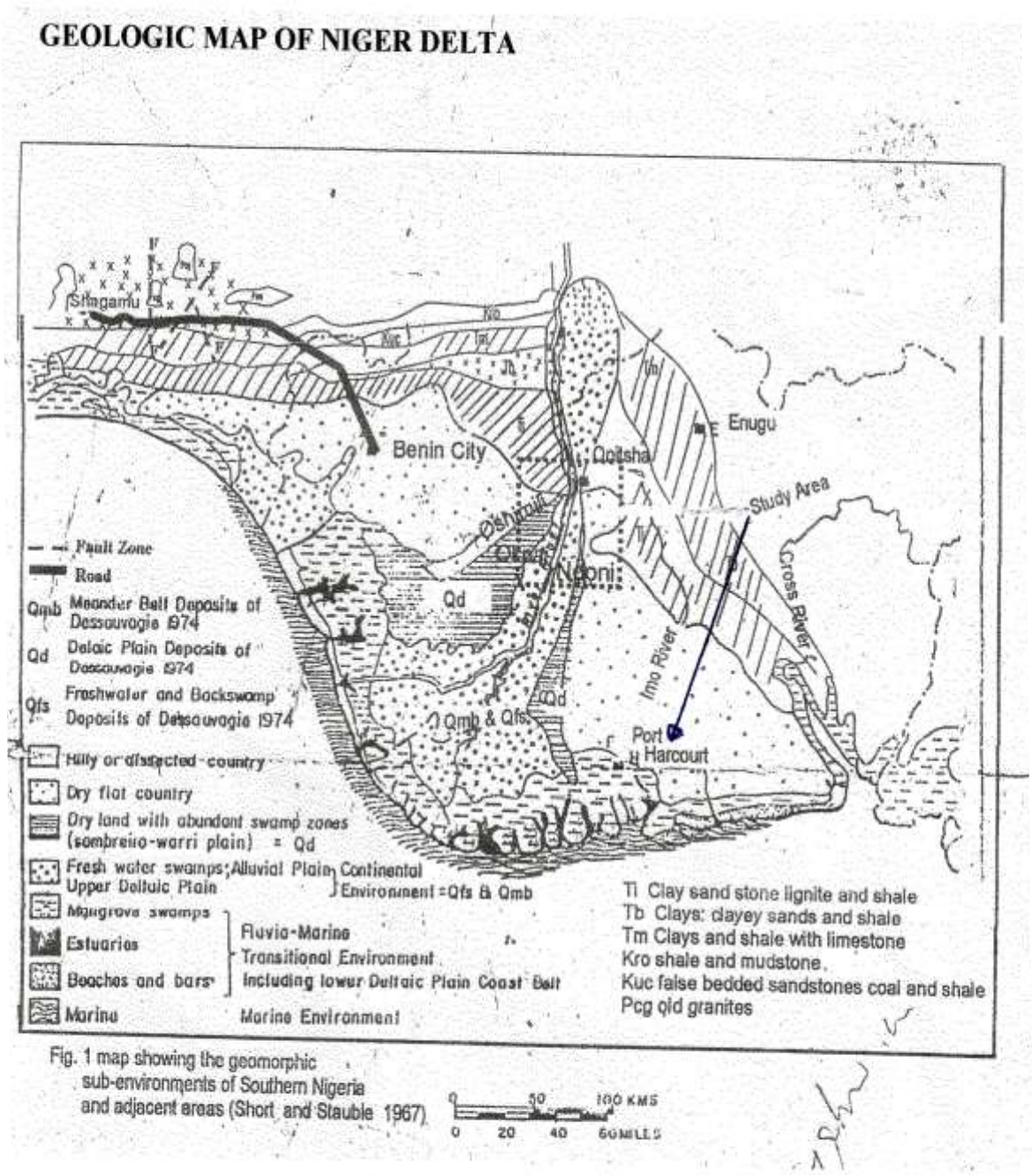

Figure 4.6.1: geologic characteristics of the study area

Local geology

The geology of the catchment area consists of alluvia and fluvia sediment deposits of peat, clay and sands within the depth probed.

Terrain

The terrain within the local study area originally consists of mud flats with slight slope and swamps with dry sand ridges (sand fill) on which the facilities and settlements are found. A number of creeks and streams that empty into Okulu Stream that empties into Okirika Channel which empties into Bonny River also exist.

4.6.3 Hydrology

The hydrologic system in the catchment area can be conceptualized by series of flat and dipping topography towards Okulu Stream flow direction and other valleys (wetland).

To assess the hydrology of ground water in area three (3) existing boreholes were considered borehole 1-3 in triangular array. This is to capture ground water flow direction and the heterogeneity of the subsurface across the area. The position and the slope of the water table (potentiometric surface in confined aquifer) is determined by measuring the position of the water level in wells from a fixed measuring point. The direction of slope of the water table is also important because it indicates the direction of ground water flow. However, if the depth to water in a non-flowing well (hw) is subtracted from the altitude of the measuring point (z) the result is the total head (ht)

$$Z - hw = ht$$

Using the above relation to determine the slope of water table i.e. direction of ground water movement. The respective total head (ht) of the borehole wells are determined relative to a common datum plane. In summary, the direction of ground water movement and the hydraulic gradient can be determined if the following data are available for at least 3 wells located in any triangular arrangement.

- Relative geographical position of the wells
- Distance between the wells
- Total head at each well

The ground water flow direction was determined following the graphical constructional approach of R.C Health (U.S Geological Survey Water supply Paper 2220). The triangular plot indicating the direction(s) of ground water flow is presented below while the respective parameters of boreholes are stated below.

Borehole 1
Altitude, (z2=20.5m (asl)
Depth water level, (hw) 6.5m
Total head, (ht)=14m (asl)

Borehole 2
Altitude, Z=18m (asl)
Depth to water level, hw= 6.1m
Total head (ht) =11.9 (asl)

Borehole 3
Altitude z=24.6m (asl)
Depth to water level, hw=7.6m
Total head (ht)=17m (asl)

As indicated in figure 4.6.2 below (flow direction chart) the general flow direction in the vicinity of the catchment area is to the South-East.

This is supported by the regional factors such as SSE trending pattern of Affluent River, topographic conditions as well as buried stream channels (surface outflow) in the study area.

Precipitation infiltrates the over burden vadose zone (clay and sand), surface impoundments before recharging the sand and gravel shallow aquifer and very slowly discharges naturally into the stream/rivers. Also within the study area water leaves the shallow aquifer through ground water withdrawal by pumping from the existing water boreholes supplies and evapo-transpiration by capillarity rise, surface run-off from the built-up areas and plant areas into the drainage. There are good network open drainage system all over with man-hol in places where the run-off entered and empties into the stream water body in the area. Following Darcy's law (velocity is proportional to both the hydraulic conductivity of the formation and the hydraulic gradient) more of in the horizontal flow. Also vertical flow of ground water and contaminants by gravity causes the leakage from the aquifer into adjacent strata.

Also, the overland out flow from surface water impoundment (dump pits, well pit etc.) can contribute to the distribution of chemicals in the overburden vadose zone and farm lands in the area.

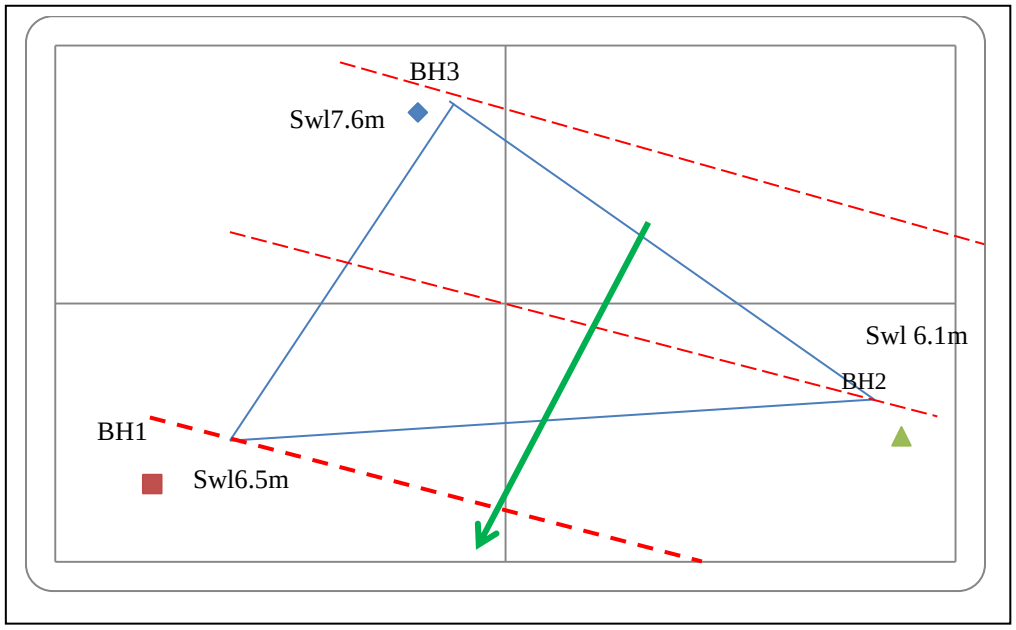

Figure 4.6.2: Ground water flow direction at Urea, Train 2 proposed site in Indorama Complex, Rivers State

4.6.4 Groundwater quality of Boreholes

The physiochemical properties of ground water are presented in Table 4.6.2. The result reveals that the ground water quality is slightly acidic to moderately alkaline which is typical to Niger Delta groundwater quality. Nutrient content result were very low across all stations indicating that the ground water is not under any form of organic stress, this is further justified by the low concentration of BOD result. Heavy metal were almost <0.001 except for iron with a maximum concentration below 5.0mg/l. Bacterial count were low and does not have any influence to the ground water quality of the area. The seasonal variations of both seasons ground water quality within Indorama complex are very marginal and as such will not influence the process water quality to the plant.

Table 4.6.2: Physiochemical properties of ground water within Indorama complex and control stations

PARAMETER	Wet season			Dry season		
	BH1	BH2	BHC	BH1	BH2	BHC
	Flare Area	Water treatment plant	Akpajo	Flare Area	Water treatment plant	Akpajo
pH	5.31	5.98	6.59	5.08	5.82	6.61
Temperature	28.7	28.2	26.9	26.4	24.2	27.2
Color	Clear	Clear	Clear	Clear	Clear	Clear
Dissolved Oxygen	1.52	2.96	2.92	1.28	3.22	2.43
Turbidity (NTU)	4.8	4.2	3.8	33.2	2.2	3.3
Conductivity (µs/cm)	19.9	24.6	182	22.2	36.8	393
Total Dissolved Solids (mg/l)	10.3	12.3	91.0	13.3	18.2	195
Total Suspended Solids (mg/l)	2.6	2.9	2.2	9.0	3.0	2.4
Total Hardness (mg/l)	4.0	14.0	24.0	5.0	24.0	40.1
Biological Oxygen Demand(mg/l)	1.20	1.40	2.80	1.98	0.98	1.98
Chemical Oxygen Demand (mg/l)	1.80	2.60	3.60	12.40	1.26	2.98
Nitrate (NO_3^-) (mg/l)	1.08	1.48	1.82	0.98	2.60	1.60
Sulphate (SO_4^{2-})(mg/l)	8.4	13.6	19.8	11.4	18.0	13.0
Phosphate $P04^{3-}$ (mg/l)	<0.10	0.11	0.13	0.12	0.16	0.24
Oil and Grease (mg/l)	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Cyanide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper Cu (mg/l)	0.029	0.018	0.046	0.025	0.011	0.085
Lead Pb (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc Zn (mg/l)	0.096	0.082	0.078	0.071	0.129	0.120
Iron Fe (mg/l)	0.414	0.196	0.142	0.337	0.121	0.096
Cadmium Cd (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel Ni (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As) (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium Cr (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	0.0001
THB (cfu/ml)	$1.3x10^3$	$1.0x10^3$	$2.0x10^3$	$1.2x10^3$	$1.3x10^3$	$2.4x10^3$
HUB (cfu/ml)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
THF (cfu/ml)	$1.2x10^2$	$4.1x10^2$	$1.2x10^2$	$1.4x10^2$	$1.7x10^2$	$1.1x10^2$
HUF (cfu/ml)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total coliform (MPN/100 ml)	<3.00	6.00	11.0	<3.00	11.00	21.00

Fieldwork 2017 (wet) and 2015 (dry)

4.6.5 Water Budget

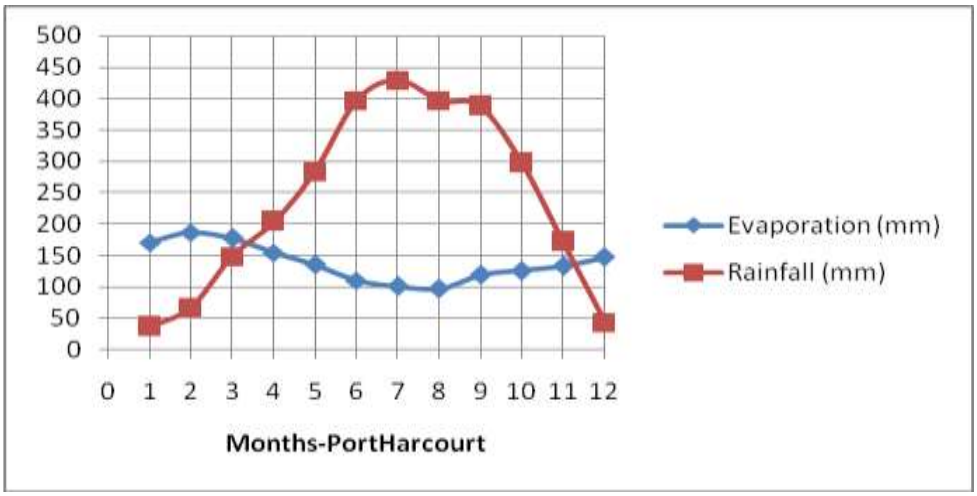

Figure 4.6.3: Rainfall and concurrent evaporation at Indorama Complex Port Harcourt area

The components of water budget equation:

Precipitation = Evaporation + Infiltration + Runoff + differential Storage

Were analyzed for the proposed urea IEFCL-Train2 Project.

Infiltration was assessed using a simplified version of Darcy's law. In this model the ponded water is assumed to be equal to h_0 and the head of dry soil that exists below the depth of the wetting front soil suction head is assumed to be equal to $-\psi - L$.

$$F = k \frac{(h_o - (-\psi - L))}{L}$$

Where

h_0 is the depth of ponded water above the ground surface;

K is the hydraulic conductivity;

L is the total depth of subsurface ground in question.

In summary, all of these equations should provide a relatively accurate assessment of the infiltration characteristics of the soil in question.

The water budget implications for the soils were evaluated in relation to the geological formations. Results show that there is very reasonable infiltration and that 60% of total rainfall is translated into runoff.

The project area is in a geological formation of high potential of groundwater recharge because of

- Favourable sub surface geology falling within the Benin formation
- Abundant recharge potential from
    i. Rainfall of above 2,280mm/year average
    ii. Natural groundwater flow from North Southwards
- Evapo-transpiration does not adversely affect infiltration of water from ground into the aquifer.

Based on above, total recharge potential of the area was found as 1 mega cubic meter (mcm) per square kilometer. (Rivers State Ministry of Water Resources, 2000). This recharge potential has effectively ensured that users of groundwater in Eleme Local Government Area and the study area are not starved of water.

4.6.6 Geophysical investigation

Resistivity was measured by passing a current of known value into the ground by means of two electrodes (C_1, C_2) and measuring potential difference between two intermediate points in the ground using another two electrodes (P_1, P_2). The ground whose mean resistivity is measured is that comprised between the voltage electrodes (P_1, P_2) up to a depth (ID) equal to about 1/3 of the distance between C_1 and C_2 (total electrode spread) and a width equal to about 2/3 of the distance C_1 and C_2.. As the electrode spread (C_1, C_2) increases, depth of the probe increases, thereby, giving a vertical electrical sounding. VES also referred to as electrical drilling. The potential – drop – ratio method is a variation on this procedure used for determining resistivity. All resistivity techniques in general use require the measurement of apparent resistivity $\boldsymbol{\rho_a}$, which is obtained from the electrode configuration.

$\boldsymbol{\rho_a} = \pi.R.a\ (b/a + b^2 / a^2)$

Where R = resistance value read on the resistivity meter (Ω)
a = distance between both inner electrodes (m)
b = distance between inner and outer electrodes (m)

$\boldsymbol{\rho_a}$ = avearage resistivity (Ωm) of an equivalent soil layer which is equal to 75% of the distance between the inner and outer electrodes (0.756)

4.6.6.1 Instrumentation

The measuring field equipment used include: SR-2 Soil Resistivity Meter with a liquid crystal digital readout containing three main units; all housed in a single casing; the transmitter, the receiver and the micro-processor. The electrically isolated transmitter sends out well-defined and regulated signal currents. The receiver discriminates wise and measure voltage correlated with transmitted signal current (resistivity surveying mode), the microprocessor monitors and controls operations and calculates ground resistance.
A pair of current electrodes and pair of potential electrodes all made of stainless steel. Rolls of copper cables with connecting cables, plugs and clips.

4.6.6.2 Data Processing

Raw field data was transferred to computer on completion of each day and the data was checked to verify accuracy and that the equipments was fully functional and to identify and measurement which may require immediate resurvey. Data was finally analyzed by mathematical methods using appropriate constants and are presented in a tabular form by an appropriate computer programme.
The VES data are then presented as sounding curves, which are obtained by plotting graph of apparent resistivity versus depth on the logarithmic graph sheets.

4.6.6.3 Results

The results are displayed in the table and graphics is presented in Appendix 4.7. The computer-modeled curve (Apparent resistivity graphics and sections) is generated from the field data displayed on the table. The geo-electric model summarizes the probable subsurface geology and information on subsurface condition in the survey site.

As resistivity is a fundamental electrical property of rock material closely related to their lithology, thus the determination of the subsurface distribution of resistivity from measurements on the surface can yield useful information on the structure or composition of buried formation.

From the result of the 3 geo-electric resistivity measurement certain deductions could be made:

VES 1.

The area could be characterized with 3 major geo-electric resistivity zones within a shallow subsurface sounded depth of 30m. The upper subsurface geo-electric zone; 211-2760m, thickness about 5.0m, with Lateritic, Silty clay material. Middle geo-electric zone 500-10000m, thickness about 20.0m, silty clay material. Lower geo-electric zone; 1000-5000m, with sand – gravel sand material.

VES 2.

The area could be characterized with 3 major geo-electric resistivity zones within a shallow subsurface sounded depth of 30m. The upper subsurface geo-electric zone; 10000m, thickness about 5.0m, with lateritic silty sand material. Middle geo-electric zone; 6000 – 8000m, thickness about 21.0m, with lateritic sand material. Lower geo-electric zone; 900 – 10000m, with sand – silty sand material.

VES 3.

The area could be characterized with 3 major geo-electric resistivity zones within a shallow subsurface sounded depth of 30m. The upper subsurface geo-electric zone; 10000m, thickness about 3.0m, with lateritic silty clay material. Middle geo-electric zone; 300 – 8000m, thickness about 23.0m, with lateritic sand material. Lower geo-electric zone; 900 – 12000m, with sand – gravel/sand material.

VES 1 &3. First and second layers are made up of impervious unit with low porosity and poor permeability while the third layers are made of aquifer layers of high porosity and permeability. The ground water movement is most viable in third layer.

In VES 2. First – third layers ranged from sand to silty sand layers with appreciable porosity and permeability thus must of the infiltration that reaches the ground water discharge to the surface streams/ creek thus enhancing soil flush. Any pollutant can percolate down through the silty soil, then moves rapidly as interflow to the estuarine system. This is a peculiar case with the coastal drainage of unconsolidated top sediment (U.S EPA, 1995).

Also VES 1-3 resistivity values, there is one indication of any anomaly as values above 90000Ωm that depicts faults, crack, loose sand or sink holes and fractures etc. are not witnessed.

Table 4.6.3: Summary of geo-electric model in VES 1-3:

VES No	Geo-electric Resistivity (Ωm)	Location	Approximate thickness (m)	Lithology
1	211 - 276 500 - 1000 1000 – 527	BH 1	5.0 20.0 13	Lateritic Silt Sand Lateritic Sand Sand
2	439 - 414 600 - 800 900 – 1000	BH 2	5.0 21.0 16	Lateritic Silty Sand Lateritic Sand Sand
3	1000 300 – 800 900 - 1200	BH 3	3.0 23.0 10	Silty Sand Lateritic Sand Sand

Field work 2017

Soil Corrosivity property in the area is minimal (slightly corrosive) with apparent geo – electric resistivity of over 100Ωm. The geo-electric resistivity observed at the VES point 3 showed negligible contaminant impact with values close natural conditions.

4.7. SURFACE WATER SYSTEM

The impact of industrial toxics and hazardous wastes on aquatic life including microorganisms cannot be over-stressed. Consequently, upon the industrial revolution, many production and manufacturing companies have due to improper waste management techniques, added toxic and hazardous wastes including synthetic compounds into the aquatic environment. These wastes are also discharged into water without any treatment as a result of improper or deliberate channeling of the wastes into aquatic environment. The presence of these wastes in the environment causes extensive damage to the water quality characteristics and the ecology of the environment, especially when microbial degradation activities fail to remove these pollutants fast enough to prevent environmental degradation. The environmental consequences of marine pollution include creating a harsh marine environment which adversely affects activities of marine micro-flora as well as fish and other marine lives. Okulu stream takes its course form Ogale meandering through Agbonchia and serves as the Indorama complex treated effluent and rain water surface run-off discharge receiving water body. It flows from the East towards the West and changes direction South West towards the downstream. The Indorama complex treated effluent and rain water surface run-off is held in a retention pond and flows through a 1.10 km earth channel before emptying into the Okulu Aleto wetland.

4.7.1 Physico-chemical properties of Surface water (Okulu Stream)

The summary of the Physico-chemical characteristics of surface water collected during field work (wet season) are presented in Table 4.7.1 and the secondary data for dry season retrieved from IEFCL and IEFCL-compliance monitoring reports are presented in table 4.7.2.

Table 4.7.1: Physico-chemical properties of Surface water (Okulu Stream) in Wet season

Parameters	Up stream	Mid stream	Down Stream	Agbonchia River Control	Rumukrushi Control	FMEnv Limits Aquatic Life	IFC LIMITS
pH	6.80	6.90	6.95	6.60	6.55	**6.0-9.0**	**6-9**
EC us/cm	42	226	63	35	140	-	-
Temperature ^{o}C	26.1	25.8	25.8	24.8	28.0	**20-33**	-
TDS (mg/l)	23	115	32	18	72	-	-
Turbidity NTU	2	15	5	2	8	-	
D.O (mg/l)	5.8	5.31	6.93	5.68	4.56	**6.8**	-
TSS (mg/l)	5.1	4.3	4.8	5.3	6.2	**NS**	-
COD (mg/l)	28.80	37.60	26.40	28.80	25.20	**40**	**150**
BOD_5 (mg/l)	2.78	3.69	2.10	1.17	3.42	**4.0**	**30**
Total Hardness (mg/l)	10	12	10	12	12	NS	
Nitrate (mg/l)	1.31	1.29	0.96	2.16	1.58	**NS**	-
Sulphate (mg/l)	32.5	17.7	13.8	372.3	17.7	**NS**	-
Phosphate (mg/l)	0.08	0.06	0.19	0.20	<0.01	**NS**	-
Ammonia (mg/l)	<0.10	<0.10	<0.10	<0.10	<0.10		**5.0**
Chloride Cl- (mg/l)	30.0	12.0	15.0	6.0	10.0	-	-
Alkalinity(mg/l)	76.0	54.6	66.8	69.0	88.0	-	-
Cyanide (mg/l)	<0.10	<0.10	<0.10	<0.10	<0.10	-	-
Magnesium (mg/l)	0.26	0.18	0.13	0.14	0.12	-	-
Calcium (mg/l)	0.39	0.02	0.01	0.03	0.01	-	-
Nickel (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
Iron (mg/l)	0.43	0.26	0.12	0.22	0.01	**1.0**	-
Lead (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	**0.05**	-
Zinc (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	**50**	-
Cadmium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	**<0.1**
Manganese (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	NA	
Vanadium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	
Chromium, (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	**0.03**	**<0.1**
Mercury (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**	-
Arsenic (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	0.5	-
Silver (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	-
Copper (mg/l)	0.013	0.11	0.09	0.12	0.06	1.0	
Oil and grease (mg/l)	<1.0	<1.0	<1.0	<1.0	2.5	**NS**	**10**
Total Coliform (MPN 100ml^{-1})	93	240	23	75	1100	0	0
THB (x10^{4}cfu ml^{-1})	2.4X10^3	6.2X10^3	1.7X10^3	2.1 X 10^3	4.2X 10^4	N/A	-
THF (x10^{3}cfu ml^{-1})	1.0X10^3	3.0X10^3	1.0X10^3	1.0X10^3	2.6 X 10^4	N/A	-

Field work 2017

Table 4.7.2: Physico-chemical properties of Surface water (Okulu Stream) in Dry season

Parameters	Up stream	Mid-stream	Down Stream	Agbonchia River Control (Mar'17)	FMEnv LIMITS Aquatic Life	IFC LIMITS
pH	6.73	8.24	6.74	7.10	**6.0-9.0**	**6-9**
EC us/cm	592.0	298.1	171.7	538.7	-	-
Temperature °C	25.7	25.7	25.6	24.3	**20-33**	**-**
TDS (mg/l)	298.0	149	85.7	270.3	**-**	**-**
Turbidity NTU	21.7	20.3	28.8	22.7	-	-
D.O (mg/l)	6.30	6.36	6.22	5.95	**6.8**	**-**
TSS (mg/l)	10.4	11.5	8.9	11.4	**NS**	-
COD (mg/l)	17.33	13.67	16.67	20.07	**40**	**150**
BOD_5 (mg/l)	2.40	2.23	2.30	2.47	**4.0**	**30**
Total Hardness (mg/l)	3.3	4.0	3.3	4.7	NS	-
Nitrate (mg/l)	0.46	1.43	3.14	0.91	**NS**	**-**
Sulphate (mg/l)	11.24	11.02	8.17	14.07	**NS**	**-**
Phosphate (mg/l)	0.68	<0.001	<0.001	0.59	**NS**	**-**
Ammonia (mg/l)	<0.10	<0.10	<0.10	0.14	**-**	**-**
Chloride Cl- (mg/l)	24.71	19.07	18.97	21.10	-	-
Alkalinity (mg/l)	66.7	76.7	76.7	66.0	-	-
Calcium (mg/l)	10.47	8.11	12.05	8.82	-	-
Iron (mg/l)	1.20	1.21	1.89	1.07	**1.0**	**-**
Lead (mg/l)	0.054	0.053	0.757	0.057	**0.05**	**-**
Zinc (mg/l)	0.637	0.236	0.581	0.463	**50**	**-**
Cadmium (mg/l)	<0.001	<0.001	<0.001	<0.001	**0.002**	**<0.1**
Manganese (mg/l)	0.036	0.010	0.035	0.080	-	-
Chromium, (mg/l)	0.147	0.041	0.080	0.123	**0.03**	**<0.1**
Mercury (mg/l)	<0.001	<0.001	<0.001	<0.001	**0.001**	**-**
Silver (mg/l)	<0.001	<0.001	<0.001	<0.001	**0.1**	**-**
Copper (mg/l)	0.008	<0.001	0.012	0.011	**1.0**	**-**
Oil and grease (mg/l)	<1.00	<1.00	<1.00	<1.00	**NS**	**10**

EIPL & IEFCL Compliance monitoring'2017

pH

The water body is a fresh water body with pH slightly acidic at the upstream which is typical of the Niger delta surface water bodies. The pH during the rainy season fieldwork (2017) ranged from 6.80 to 6.95 and 6.55 – 6.60 at the Okulu River and control stations compared to 6.73 to 8.24 and 7.10 for control station for dry season sampling. The values recorded complied to regulatory limit of 6.50 to 8.50. The trend analysis showed the recipient water pH values were more alkaline in the wet season than values obtained in the dry season. This could be as a result of run off of agricultural fertilizers applied to farms into the surface water and sand mining activities on the water body. However the observed pH values are normal for the Niger Delta (Ideriah *et al*. 2010) and within the recommended range of pH for natural surface waters. The change in pH was not significant and the various industrial activities around the study area (industrial treated wastewater discharge, mechanical and manual sand mining) have not significantly altered the pH of the water body.

Temperature

Temperature of a water body is influenced by the condition of the weather, ambient atmosphere and temperature of runoff or effluent discharged into it. The temperature of the sampling stations during the dry season ranged from 25.6 to 25.7^{o}C and 24.3^{0}C at control station against 25.8 to 26.1 ^{0}C and 24.8 to 28.0^{0}C at the control stations in wet season. The fluctuation in temperature could also be attributed to the time of sampling, velocity and turbulence mixture of the sample.

Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. Turbidity is considered as a good measure of the quality of water. The suspended particles scatter the light, thus decreasing the photosynthetic activity of plants and algae, which contributes to lowering of dissolved oxygen concentration The turbidity values ranged from 20.3 to 28.8NTU and 22.7 for Okulu Stream and control station respectively during the dry season against 2.0 to 15.0 NTU and Control stations of 2.0 to 8.0 NTU in rainy season (September 2017). Sand mining activity is carried out on all sides and directions of the stream which serves as a major

contributor to the high turbidity values of the water body. This statement agrees with past similar studies that streams are vulnerable to land use activities and accompanying run-offs which interfere with the stream characteristics. (Kiel 1997). The trend analysis indicated the turbidity was higher during the dry season compared to the wet season probably due to less volume of water which resulted to higher presence of particles and muddiness of water body.

Plate 4.7.1: Turbid water around sand mining area

Plate 4.7.2: Cattle within the Okulu river bank feed lot

Plate 4.7.3: Collapsed bank of Okulu stream due to sand mining

Plate 4.7.4: Sampling on the Okulu river

Total Dissolved Solids (TDS)

Total Dissolved Solids are of concern due to their potential for causing unfavorable physiological reactions in both human and marine life. It is indicative of the amount of

loads on a water body the higher the concentrations the more the loads. The TDS concentrations range from 85.7 to 298.0mg/l and 270.3 mg/l at the control in dry season as against the wet season of 23.0 to 115.0 mg/l and 18.0 to 72.0 mg/l at the control stations.

Total Suspended Solids (TSS)

Suspended solids consist of an inorganic fraction (silts, clays, calcium, potassium, bicarbonates, chlorides, etc.) and an organic fraction (algae, zooplankton, bacteria and detritus) that are within the water column (GEMS, 1992). The TSS concentrations in dry season ranged from 8.9 to 11.5mg/l and 11.4 mg/l at control station as against the wet season (September 2017) concentration of 4.3 to 5.1 mg/l at sampling stations and 5.3 to 6.2 at control stations. The trend analysis indicated the TSS was higher during the dry season compared to the wet season probably due to less volume of water which resulted to higher presence of particles and muddiness of water body.

Oxygen Demand

The dissolved oxygen level during the dry season was ranged from 6.22 to 6.36mg/l and 5.95 mg/l at the control station. The concentration recorded during fieldwork September 2017 was 5.31 to 6.93 mg/l, while at the control station it ranged from 4.56 to 5.68mg/l. This result clearly shows the intense anthropogenic activities at the control stations (car washings, storm run-off and waste disposal) which may have influence on the result recorded within these stations. This implies that the Okulu stream has more carrying capacity than the control stations located in Eleme and Obi-Akpor LGAs. The Chemical Oxygen Demand level for the study area in rainy season (September 2017) ranged from 26.40 to 37.60 mg/l and 25.20 to 28.80 mg/l at control stations against dry season results of 13.67 to 17.33 mg/l and 20.07 mg/l at the control station. BOD concentration recorded indicate that the water body is not in any form of organic stress, as such have sufficient oxygen to handle organic load intrusion into the water body.

Heavy Metals

The values of heavy metals determined were generally low and within their respective regulatory acceptable limits. The results showed concentration of the heavy metal such

as Pb and Zn were moderately low, while vanadium, Chromium, Arsenic, Cadmium, Lead and Zinc were less than detectable limit of the instrument used. Some metal levels exhibited significant seasonal variation. The concentration levels might be attributed to anthropogenic enrichment arising from sand mining, abattoir, excavation activities as well as surface runoff from dumpsite in the area.

On the whole water quality data obtained in the area showed that the water bodies have low level alkaline earth metals and some heavy metals. The concentration levels of hydrocarbons was within the acceptable limits. The values of heavy metals determined were generally low and within their respective regulatory acceptable limits. Surface water in the Niger Delta has been recorded to contain high iron concentrations attributed to the metals being bound to the soil and sediment matrix. The intense manual sand mining observed during study is a confirmed contributing factor to high iron concentration. The physicochemical characteristics of the surface water indicate slight contamination of the recipient environment due to the ongoing sand mining activity on the water body. However the carrying capacity of the water body evaluated, is good.

4.7.2 Surface water microbiology

Coliforms commonly referred to as indicators of recent contamination (bio monitors) of water were present in the surface water samples. The total coliforms ranged from 23 to 240 MPN/100ml for rainy season. The low prevalence of total coliforms, especially those of vegetative origins maybe attributed to the absence of several autochthonous species and supported by the prevailing environmental conditions and physicochemical characteristics of the surface water. Similarly, the total coliform counts in the control stations did not show any significant difference.

4.7.3 Sediment

In aquatic ecosystem, the sediments act as sink and therefore preserve or retain the quality of the environment. The heavy particles or the insoluble fractions settle down on the bed as sediments. The nature and quality of sediment could also be determined from information on the status of the physico-chemical properties. Such information is also

vital in determining the parameters that would also be responsible for specific changes and effects in this environment.

Table 4.7.3: Physico-chemical properties of Sediment

PARAMETERS	Up stream	Mid stream	Down Stream	Agbonchia River Control	Rumukrushi Control
Sulphide, (mg/kg)	<0.01	<0.01	<0.01	<0.01	<0.01
Sulphate (SO_4^{2-}), mg/kg	434.10	51.83	483.46	362.73	185.73
Nitrate (NO_3^-), mg/kg	2.64	19.23	16.91	10.42	8.22
Phosphate (PO_4^{3-}), mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
Total Organic Carbon (TOC),%	0.72	1.08	0.88	0.68	0.56
Total Petroleum Hydrocarbon (TPH),mg/kg	18.22	9.62	11.69	4.76	2.90
Total Coliform (MPN/100ml)	>1100	>1100	160	460	>1100
Total Heterotrophic Fungi (cfu/ml)	$5.10X10^4$	$8.70X10^4$	$4.60X10^4$	$5.20X10^4$	$1.47X10^5$
Total heterotrophic Bacteria (cfu/ml)	$9.6X10^4$	$1.01X10^5$	$6.50X10^4$	$8.40X10^4$	$3.60X10^5$
Total Plate Count (cfu/ml)	$1.17X10^5$	$1.42X10^5$	$1.00X10^5$	$1.10X10^5$	$4.40X10^5$
Total Iron, mg/l	5.01	4.02	2.07	4.22	3.90
Sodium (Na),mg/l	0.55	0.63	0.22	0.45	0.56
Calcium (Ca) mg/l	22.05	19.77	22.77	24.05	21.65
Magnesium (Mg), mg/l,	10.88	9.88	12.05	10.76	9.42
Zinc (Zn), mg/l	39.7	19.03	22.65	20.05	17.44
Copper (Cu) mg/l	7.03	5.03	6.03	2.05	3.76
Manganese (Mn) mg/l	2.90	42.03	1.04	0.44	1.43
Total Chromium (Cr) mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel (Ni), mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Lead {Pb} mg/l	0.32	0.33	0.21	<0.001	<0.001
Mercury {Hg} mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium {Cd} mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As),mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium (V),mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt (Co),mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001
Silver (Ag),mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001

Field work 2017

4.7.3.1 Sediment Physico-chemistry

The color of the sediment samples ranged from black to dark grey coloration. The silt fraction was higher than the sand and clay content making the sediment Silty in texture. Nutrients are adequate to support the healthy growth of benthic population. The concentrations of nutrients in sediment around the study area are indicated below; Sulphate concentrations varied from 51.8 to 483.5 mg/kg and 185.7 to 362.7 mg/kg for rainy season (September 2017) nitrate content ranged from 2.64 to 19.23 mg/kg and 8.22 to 10.42 mg/l at control stations for rainy season. Total Petroleum Hydrocarbon was low for all samples taken 9.62 to 18.22 mg/kg and at control stations with 2.90 to 4.76 mg/l for rainy season. This implies that the sediment along the study area is slightly contaminated with petroleum hydrocarbons resulting from the mechanical dragger on the water body. The heavy metal concentrations are low in the sediment samples and there is no indication of their accumulation in the samples. Mercury and Arsenic were very low and below detection limit in the sediment samples.

4.7.3.2 Sediment Microbiology

The microbiological data obtained from the analysis of the sediment samples. The hydrocarbonoclastis (Hydrocarbon Utilizing Bacteria and Fungi) were not detected in the sediment, showing the low hydrocarbon burden and thus corroborating with the absence of hydrocarbon contamination in the sediment sample. The low hydrocarbonoclastic counts in the study area and control station further lends credence to the sediment physicochemical results as also described by Atlas (1981). Furthermore, the bacterial genera isolated in the sediment include *Pseudomonas, Klebsiella, Proteus, Bacillus, Staphylococcus, Serratia, Micrococcus, Flavobacterium, Enterobacter, Achromobacter* and *Arthrobacter.* The fungal isolate mainly belonged to the genera *Fusarium, Aspergillus, Candida, Mucor* and *Penicllium.*

4.7.4 Treated Effluent Water Quality

The monthly treated effluent water sample collected from Indorama complex discharged point by third party and analysed by FMEnv approved laboratory, is presented in table 4.7.4 (wet season) and table 4.7.5 (dry season). The data revels that the treated effluent quality is in compliance with regulatory limits/IFC guidelines.

Table 4.7.4: Physico-chemical properties of Treated effluent water quality (Wet Season)

Parameters	July	Aug	Sept	Ave.	FMEnv LIMITS	IFC LIMITS
pH	8.10	6.98	6.78	7.29	**6.0-9.0**	**6.0-9.0**
Temperature ^{o}C	22	26.1	26.4	24.8	**<35**	-
EC us/cm	232	450	500	394	-	-
TDS (mg/l)	117	225	250	197	**2000**	-
Turbidity NTU	18.5	16.6	14.2	16.43	-	-
TSS (mg/l)	9.4	10.0	28.1	15.83	**30**	**30**
Total Hardness (mg/l)	9.0	11.0	8.0	9.33	-	
Alkalinity (mg/l)	43.0	60.0	50.0	51.00	-	-
Chloride Cl- (mg/l)	18.1	13.4	9.5	13.67	**600**	-
Sulphate (mg/l)	16.2	17.39	9.78	14.46	**500**	-
Nitrate (mg/l)	2.12	0.23	1.22	1.19	**20**	-
Phosphate (mg/l)	0.17	2.32	1.14	1.21	**5.0**	-
Ammonia, (mg/l)	<0.10	<0.10	<0.10	<0.10	-	**5.0**
DO (mg/l)	5.10	5.63	5.42	5.38	-	-
BOD_5 (mg/l)	2.04	3.66	4.26	3.32	**30**	**30**
COD (mg/l)	25.74	18.50	19.26	21.17	**40***	**150**
Oil and grease (mg/l)	<1.00	<1.00	<1.00	<0.10	**10**	**10**
Total Iron (mg/l)	0.28	0.69	0.38	0.45	**5.0**	**3.0**
Calcium (mg/l)	0.83	0.36	0.28	0.49	**200**	-
Magnesium (mg/l)	0.28	0.25	0.19	0.24	**200**	-
Zinc (mg/l)	0.23	0.13	0.13	0.16	**1.0**	-
Copper (mg/l)	0.10	0.04	<0.01	0.07	**1.0**	**0.5**
Manganese (mg/l)	0.05	0.03	<0.01	0.04	**5.0**	-
Total Chromium (mg/l)	0.04	<0.01	<0.001	0.04	**1.0**	**0.5**
Silver (mg/l)	<0.001	<0.001	<0.001	<0.001	**0.1**	-
Lead (mg/l)	<0.001	<0.001	<0.001	<0.001	**1.0**	**0.1**
Mercury (mg/l)	<0.001	<0.001	<0.001	<0.001	**0.05**	**0.02**
Cadmium (mg/l)	<0.001	<0.001	<0.001	<0.001	**0.1**	**0.1**

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Table 4.7.5: Physico-chemical properties of Treated effluent water quality (Dry Season)

Parameters	Jan	Feb	March	Ave.	FMEnv LIMITS	IFC LIMITS
pH	7.26	7.30	6.65	7.07	**6.0-9.0**	**6.0-9.0**
Temperature ^{o}C	23.8	27.2	28.7	26.6	**<35**	-
EC us/cm	335.3	526.0	764.0	541.8	-	-
TDS (mg/l)	169.0	263.0	383.0	271.7	**2000**	-
Turbidity NTU	5.6	29.4	16.9	17.3	-	-
TSS (mg/l)	14.3	14.2	14.5	14.3	**30**	**30**
Total Hardness (mg/l)	4.0	4.0	4.0	4.0	-	
Alkalinity (mg/l)	90.0	200.0	180.0	156.7	-	-
Chloride Cl- (mg/l)	19.85	22.18	19.08	20.37	**600**	-
Sulphate (mg/l)	2.16	19.50	14.73	12.13	**500**	-
Nitrate (mg/l)	0.91	1.46	1.28	1.22	**20**	-
Phosphate (mg/l)	1.05	<0.10	<0.10	0.35	**5.0**	-
Ammonia, (mg/l)	<0.10	<0.10	<0.10	<0.10	-	**5.0**
DO (mg/l)	5.60	5.20	5.04	5.28	-	-
BOD_5 (mg/l)	2.60	2.40	2.20	2.40	**30**	**30**
COD (mg/l)	17.00	15.00	13.01	15.00	**40***	**150**
Oil and grease (mg/l)	<1.00	<1.00	<1.00	<1.00	**10**	**10**
Total Iron (mg/l)	1.84	0.59	0.401	0.944	**5.0**	**3.0**
Calcium (mg/l)	10.03	10.13	3.55	7.90	**200**	-
Zinc (mg/l)	0.08	0.11	0.11	0.10	**1.0**	-
Copper (mg/l)	<0.01	<0.01	<0.01	<0.01	**1.0**	**0.5**
Manganese (mg/l)	0.03	0.03	0.03	0.03	**5.0**	-
Total Chromium (mg/l)	0.010	0.020	0.021	0.017	**1.0**	**0.5**
Silver (mg/l)	<0.001	<0.001	<0.001	<0.001	**0.1**	-
Lead (mg/l)	0.020	0.090	0.042	0.051	**1.0**	**0.1**
Mercury (mg/l)	<0.001	<0.001	<0.001	<0.001	**0.05**	**0.02**
Cadmium (mg/l)	<0.001	<0.001	<0.001	<0.001	**0.1**	**0.1**

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4.8 HYDROBILOGY

4.8.1 Phytoplankton

A total of forty-eight (48) phytoplankton species representing four (4) major classes were identified in the study area in both climatic regimes (dry and wet seasons). The four classes include: Bacillariophyceae (diatoms), Chlorophyceae (green algae), Cyanophyceae (blue green algae) and Euglenophyceae. Bacillariophyceae formed the most dominant group of phytoplankton in the wet season with a percentage composition of 42.27%. Similarly, in the dry season the percentage composition was 29.83% which is about 1 fold decrease. The seasonal changes in the species composition and population density may be attributed to the changing environmental conditions, increase in nutrients from surface runoff during the dry season and deposition of organic matter. However, the surge in the population of Bacillariophyceae may be attributed to their ability to grow under relatively low temperatures which are less suitable for other algae (Wanganeo and Wanganeo, 1991). The findings compare favourably with Davies *et al*, 2009; Allison and Otene, 2012; Lund, 1965 and Munawar, 1974 for similar ecosystems. The population density ranged from 2 to 43 cells/1000L in the dry season and 12 to 24 cells/1000L in the wet season. Well represented taxa in the wet and dry season include: *Cyclotella*spp, *Naviculas*pp, *Melosira*spp (Dry season); *Navicula cuspidate, Nitzschiaclosterium, Amphora ovalis, Nitzschia frigida, tabellaria fenestrate* (wet season). The Bacillariophyceae depicted bimodal growth in the wet season especially in the upstream of the Okulu stream. This may be attributed to the deposition of nutrients during these peak periods (Kaul, *et al*, 1978).

The Chlorophyceae formed the second most dominant group of phytoplankton in the wet season (34.02%) with a population density of 6 to 20 cells/1000L and 0 to 12 cells/1000L in the dry season (12.41%). Peak values in the wet season may be attributed to change in environmental conditions. Bimodal wet season peaks were also observed in the upstream and downstream of the Okulu stream which may be attributed to influx of nutrients into the Okulu stream. Generally due to runoffs slight sessional variations were observed across the sampling stations. Well represented taxa include: *Closterium lineatum, Micrasterias radiata* (wet season) and *Rhizocloniums*pp, *Chlorella* spp (dry season).

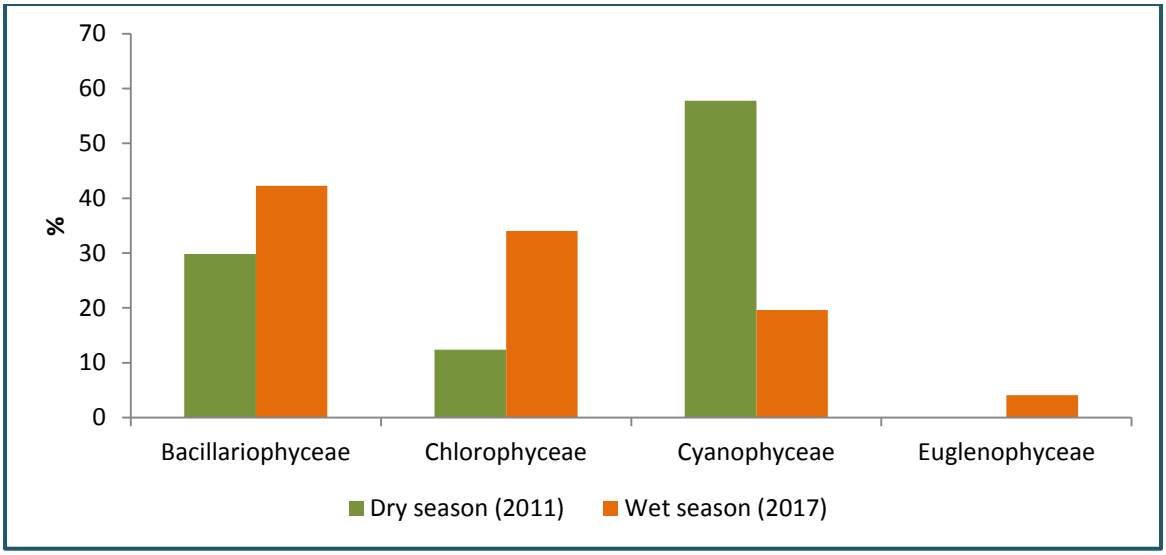

Figure 4.8.1: Percentage composition of phytoplankton groups in the wet and dry season

The Cyanophyceae maintained a population density of 0 to 172 cells/1000L in the dry season and 6 to 9 cells/1000L. *Coelosphyaerium*spp, *Oscillatoria*spp and *Anabaena limnetica*were well represented in the dry and wet seasons and contributed significantly to the cynophyta population. The Cynophyceae depicted unimodal peak growths downstream in the wet and dry season. This may be attributed to increase nutrients levels and temperature variations in the downstream. High temperatures have been known to act as a principal factor causing blooms of Cyanophyceae (George, 1960).The order of dominance was: Bacillariophyceae >> Chlorophyceae >> Cyanophyceae >> Euglenophyceae (Wet season); Cyanophyceae >> Bacillariophyceae >> Chlorophyceae (Dry season).

Diversity indices

In the dry season, the Shannon-Weiner index ranged from 0.06 in the downstream to 1.44 around the outfall area of Okulu stream, while during the wet season it ranged from 2.67 to 3.01 in upstream and control station respectively. The ecological indices suggest low dominance of these aquatic organism probably due to disturbed habitat as a result of sand mining through their eggs, thus hampering their reproduction capacity.

Furthermore, the evenness values reflect poor distribution of species especially in the dry season. The population density of Bacillariophyceae, Chlorophyceae and Cyanophyceae in dry season supports the poor distribution of phytoplankton, as during this period there

are no water influx into water body with nutrient to attract these organism to increasing their presence/dominance during this period.

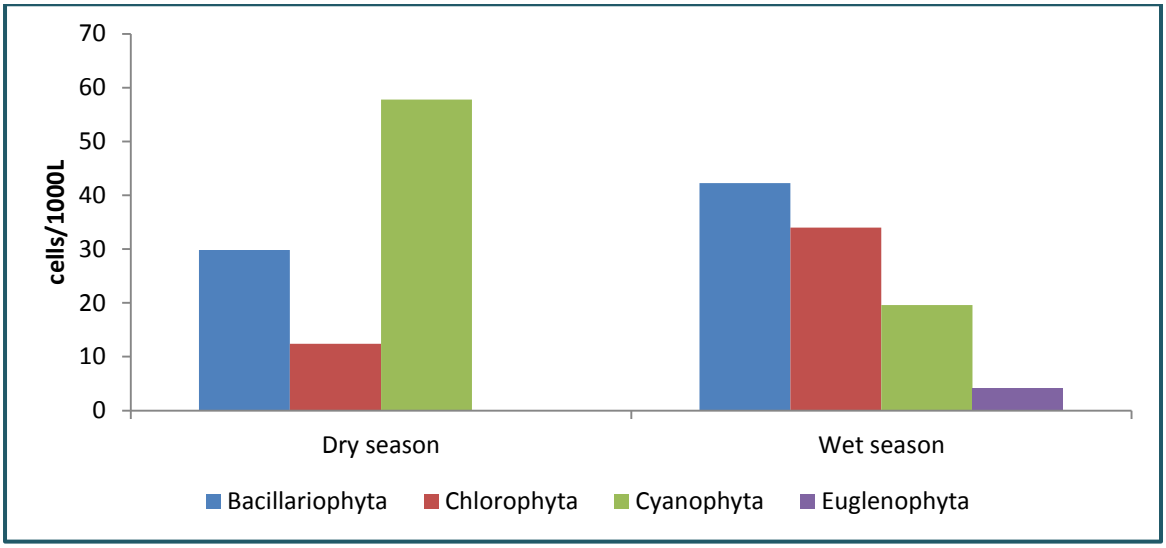

Figure 4.8.2: Population density of phytoplankton in the wet and dry season

Table 4.8.1: Phytoplankton species composition & distribution in the study area (Dry season)

Taxa	Up stream	Mid stream	Down Stream	Agbonchia River Control	Rumukrushi Control	Total	%Total
Bacillariophyta							
*Naviculas*pp	0	0	0	0	13	13	
*Nitzschias*pp	1	0	0	0	7	8	
Fragilaria crotonensis	0	0	0	0	4	4	
*Cyclotella*spp	0	2	75	2	2	81	
*Melosira*spp	0	0	0	0	17	17	
*Synedra*spp	1	1	0	0	0	2	
Subtotal	**2**	**3**	**75**	**2**	**43**	**125**	**29.83**
Chlorophyta							
Chlorella spp	0	3	12	0	0	15	
*Rhizocloniums*pp	0	0	0	0	37	37	
Subtotal	**0**	**3**	**12**	**0**	**37**	**52**	**12.41**
Cyanophyta							
Coelosphyaerium spp	0	22	48	172	0	242	
Subtotal	**0**	**22**	**48**	**172**	**0**	**242**	**57.76**
Taxa_S	2	4	3	2	6		
Individual (cells/1000L)	2	28	135	174	80		
Shannon_H	0.69	0.74	0.91	0.06	1.44		
Evenness_e^H/S	1	0.50	0.82	0.08	0.80		
Margalef	1.44	0.90	0.41	0.19	1.14		
Dominance_D	1	0.38	0.56	0.02	0.71		

Field survey, 2011

Table 4.8.2: Phytoplankton species composition and distribution in the study area (Wet season)

Taxa	Up stream	Mid stream	Down Stream	Agbonchia River Control	Rumukrushi Control	Total	%Total
Class: Bacillariophyceae							
Amphora ovalis	1	5	1	0	1	**8**	
Amphora spiroides	0	0	0	1	0	**1**	
Nitzschia frigida	5	0	1	0	1	**7**	
Nitzschiagracilis	0	1	5	1	1	**8**	
Nitzschiaclausii	1	0	0	1	1	**3**	
Nitzschia closterium	0	7	1	1	0	**9**	
Cyclotella stigmata	0	1	0	0	5	**6**	
C. operculata	1	0	1	0	1	**3**	
C. centralis	0	1	0	1	0	**2**	
Melosiravarians	1	0	1	0	1	**3**	
Naviculagracilis	1	5	0	0	0	**6**	
N. cuspidate	3	1	1	5	1	**11**	
N. ovalis	1	0	0	0	1	**2**	
Synedra ulna	2	0	0	0	3	**5**	
Tabellariafenestrata	1	3	1	2	1	**8**	
SUBTOTAL	**17**	**24**	**12**	**12**	**17**	**82**	**42.27**
Class: Cyanophyceae							
Oscillatoriaindica	3	0	1	0	1	**5**	
O. limnosa	0	1	1	2	1	**5**	
O. major	1	0	3	1	0	**5**	
O. obscura	0	1	0	0	1	**2**	
O. miniata	1	1	1	2	0	**5**	
Anabaena affinis	0	1	0	0	1	**2**	
A. flos-aquae	1	0	1	0	0	**2**	
A. laxa	1	1	0	1	1	**4**	
A. limnetica	0	3	1	0	1	**5**	
A. affinis	1	0	1	1	0	**3**	
SUBTOTAL	**8**	**8**	**9**	**7**	**6**	**38**	**19.59**
Class: Chlorophyceae							
Closterium gracile	0	2	0	2	2	**6**	
C. littorale	6	0	0	0	0	**6**	
C. navicula	0	3	0	0	3	**6**	
C.lineatum	3	0	6	1	1	**11**	
C. parvulum	0	6	0	0	0	**6**	
C. kuetzingii	4	0	0	2	0	**6**	
Eudorinaelegans	0	1	0	0	1	**2**	
E. cylindrica	0	0	3	1	0	**4**	

Taxa	Up stream	Mid stream	Down Stream	Agbonchia River Control	Rumukrushi Control	Total	%Total
Scenedesmusacuminatus	0	0	0	0	0	**0**	
S. quadricauda	3	1	0	0	0	**4**	
Cosmariumsp	1	3	0	0	0	**4**	
Micrasteriasapiculata	0	1	0	0	1	**2**	
Micrasterias radiata	3	2	2	0	2	**9**	
SUBTOTAL	**20**	**19**	**11**	**6**	**10**	**66**	**34.02**
Class: Euglenophyceae							
Euglena caudata	1	0	5	1	1	**8**	
SUBTOTAL	**1**	**0**	**5**	**1**	**1**	**8**	**4.12**
SUMMARY							
Taxa_S	23	22	19	17	24		
Individuals (cells/1000L)	46	51	37	26	34		
Shannon_H	2.91	2.83	2.67	2.68	3.01		
Evenness_e^H/S	0.93	0.92	0.91	0.96	0.97		
Margalef	5.75	5.34	4.98	4.91	6.52		
Dominance_D	0.95	0.95	0.94	0.95	0.97		

Field work, 2017

4.8.2 Zooplankton

The zooplankton community in the project area comprises Copepoda, Rotifera, Tintinidae, Cladocera and Cichlidae in the wet and dry season. A total of 4 species were identified in the dry season and 15 species in the wet season. In both climatic regimes, the Rotifers were the most dominant zooplankton taxonomic group representing about 72.14% and 42.86% in the dry and wet season. The population density ranged from 0 to 11 cells/100L in the dry season and 3 to 10 cells/100L in the wet season. The most abundant species in both climatic regimes were *Keratella cochlearis* and *Lecane sp.* The dominance of the Rotifers is not uncommon as it has been reported in other fresh water bodies (Verma*et.al*, 2013; Kar and Kar, 2016). The dominance of Rotifers may be attributed to the presence of sediments in suspension in the surface water bodies (Kirk and Gilbert, 1990). Several species of rotifers are known to tolerate high concentration of water pollution as they are tolerant to different types of suspended materials in the water bodies.

Furthermore, the Copepoda and Cladocera are classified as the most important component of the zooplankton community. The copepods consist of 1 species in the dry season and 4 species in the wet season with a percentage composition of 20.69% and 27.14% in the dry and wet seasons. The low taxa number in both climatic regimes maybe attributed to the sand mining activities in the water body which constantly disturb the habitat of these organisms there by preventing them from reproducing through destruction of their eggs. The copepoda population in the dry season ranged from 0 cells/100L in the upstream and downstream of Okulu stream to 4 cells/100L around the outfall area. In the wet season, the population density ranged from 1 cells/100L to 10 cells/100L around the downstream. The most abundant species in the wet and dry season include: *Copepod nauplius, Diaptomussp*and *Metacyclops sp*. The Cladocera were relatively absent in the dry season. In increasing order, the dominance pattern of the zooplankton community were Rotifera >> Copepoda >> Tintinidae (Dry season); Rotifera >> Copepoda>>Cladocera>>Cichlidae (Wet season).

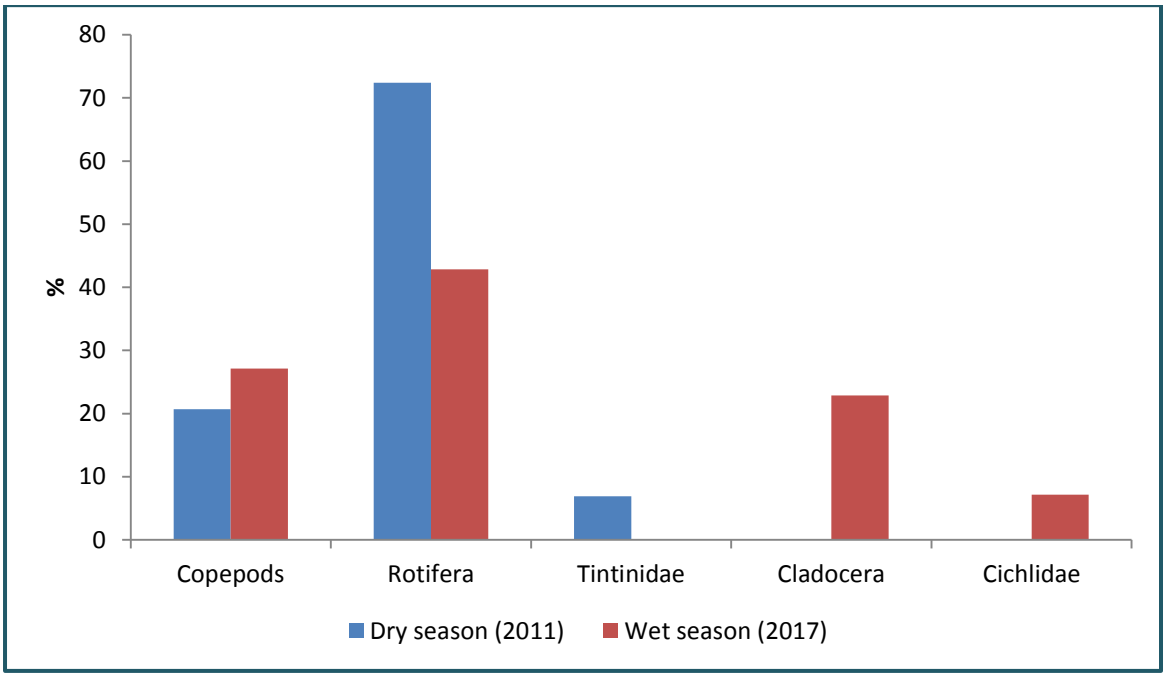

Fig 4.8.3: Percentage composition of zooplankton groups in the wet and dry season

Table 4.8.3: Zooplankton species composition and distribution in the study area (Dry season)

Taxa	Up stream	Mid stream	Down Stream	Agbonchia River Control	Rumukrushi Control	Total	%Total
Order: Copepoda							
Copepod nauplius	0	0	0	2	4	6	
Subtotal	**0**	**0**	**0**	**2**	**4**	**6**	**20.69**
Rotifera							
Keratella cochlearis	0	0	0	9	11	20	
***Kellicotia*spp**	0	0	0	1	0	1	
Subtotal	**0**	**0**	**0**	**10**	**11**	**21**	**72.41**
Tintinidae							
Tintinid larva	0	0	0	0	2	2	
Subtotal	**0**	**0**	**0**	**0**	**2**	**2**	**6.90**
Taxa_S	0	0	0	3	3		
Individuals (cells/100L)	0	0	0	12	17		
Shannon_H	0	0	0	0.72	0.87		
Evenness_e^H/S	0	0	0	0.62	0.78		
Margalef	0	0	0	0.80	0.71		
Dominance_D	0	0	0	0.44	0.54		

Field survey, 2011

Table 4.8.4: Zooplankton species composition and distribution in the study area (Wet season)

Taxa	Up stream	Mid stream	Down Stream	Agbonchia River Control	Rumukrushi Control	Total	%Total
Order: Cladocera							
Alonasp	0	0	0	1	0	1	
Bosminaaffinis	1	0	1	0	1	3	
Bosminadiaphana	1	1	0	1	0	3	
Polyphemus sp	5	0	1	0	1	7	
Moinasp	1	0	0	1	0	2	
SUB TOTAL	**8**	**1**	**2**	**3**	**2**	16	**22.86**
Order: Copepoda							
Mesocyclopssp	1	0	0	0	3	4	
Diaptomussp	1	5	1	0	0	7	
Eucyclopssp	0	0	0	1	0	1	
Metacyclopssp	1	5	0	0	1	7	
SUB TOTAL	**3**	**10**	**1**	**1**	**4**	**19**	**27.14**
Order: Rotifera							
Lecanesp	0	5	1	1	1	8	
Euchlanissp	0	4	1	0	1	6	
Collothecasp	5	0	0	1	0	6	
Keratellasp	1	0	1	1	1	4	
Asplanchnasp	3	1	0	1	1	6	
SUB TOTAL	**9**	**10**	**3**	**4**	**4**	**30**	**42.86**
Cichlidae							
Tilapia sp (fry)	0	1	3	0	1	5	
SUB TOTAL	**0**	**1**	**3**	**0**	**1**	**5**	**7.14**
Taxa_S	10	7	7	8	9		
Individuals (cells/100L)	20	22	9	8	11		
Shannon_H	2.03	1.74	1.83	2.08	2.10		
Evenness_e^H/S	0.87	0.90	0.96	1	0.97		
Margalef	3.00	1.94	2.73	3.37	3.34		
Dominance_D	0.88	0.84	0.92	1	0.95		

Field work, 2017

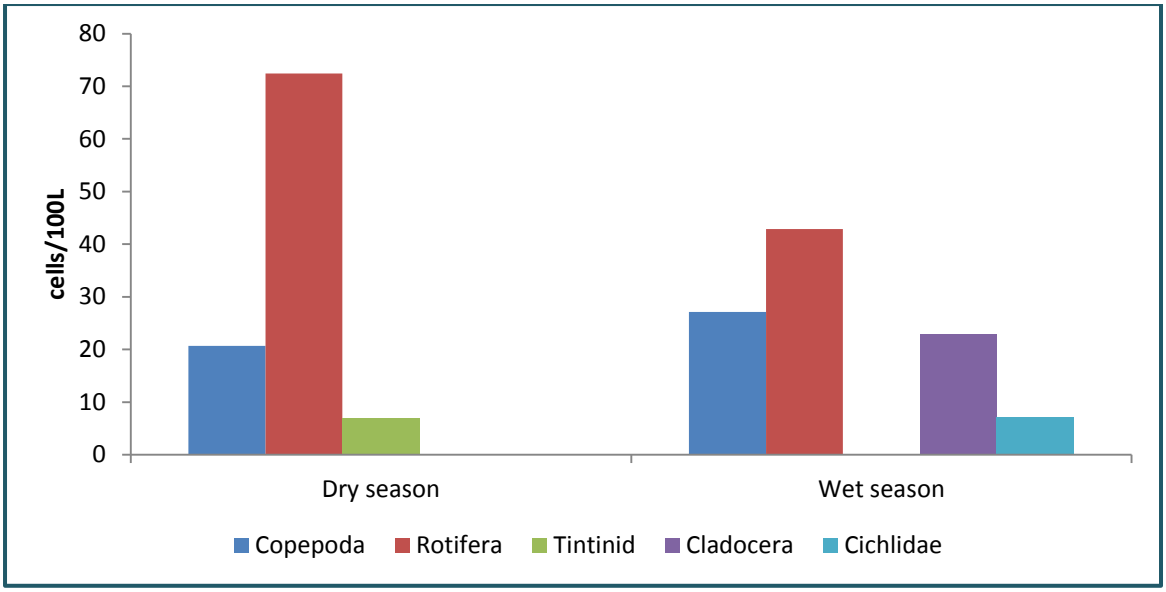

Fig 4.8.4: Population density of zooplankton in the wet and dry season

Diversity indices

The Shannon-Weiner diversity index for the zooplankton taxonomic group in the surface water bodies ranged from 0 to 0.87 in the dry season and 1.83 to 2.10 in the wet season. This variation is envisaged in any surface water body owing to the fact that during the wet season surface water body received influx of water, which are made up of different sources ranging from animal/human waste, as such have the capacity increase the diversity of aquatic organism.

The species evenness showed a poor distribution across the sampling stations in the dry and wet season, which is as a result of intense mechanical and manual sand mining ongoing in the Okulu stream, thus disturbing the habitat of these aquatic organism. The maximum evenness in the dry season was 0.78 around the outfall area of the Okulu stream and 0.97 around the control stations in the dry season. The results indicate a consistently low zooplankton population with poor identical values.

4.8.3 Benthic fauna

The Benthic invertebrates were represented by three taxonomic groups in the wet and dry season. The taxonomic groups are Oligochaeta, Insecta and *Nauplii* comprising of 4 taxa in the dry season and 10 taxa in the wet season. The insect dominated the benthic fauna community with a percentage composition of 75% in the dry season and 52.38% in

the wet season. The dominance of Insecta is not uncommon in freshwater ecosystems as it has been reported to tolerate extreme conditions and high competitive capacity (Di Giovanni *et al.,* 1996). The dominance of this taxonomic group of organisms suggests enrichment by organic matter in the sediments (Dévai, 1990). This agrees with the analytical results of the sediments in the study area.

Furthermore, the Oligochaetes were the second most dominant benthic invertebrates in the study area comprising about 25% composition in the dry season and 38.10% in the wet season. The population ranged from 0 to 3 cells/m^2 in the dry season and 1 to 3 cells/m^2 in the wet season. In increasing order, the dominance pattern of the benthic fauna were Insecta >>Oligochaeta (Dry season); Insecta>>Oligochaeta>>Nauplii (Wet season).

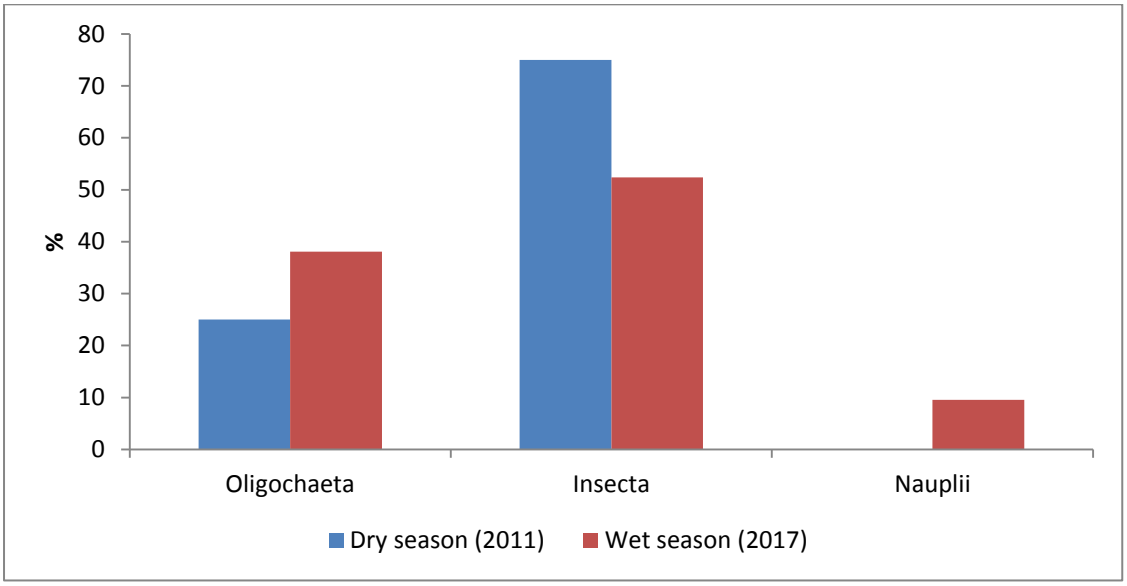

Fig 4.8.5: Percentage composition of benthic invertebrates in the wet and dry season

Diversity

The Shannon-Weiner diversity index for the benthic invertebrates in the dry season ranged from 0 to 0.85 and 0.69 to 1.79 in the wet season. The sharp variation noticed in wet season is possibly due to erosional process of water influx into the water body from animal feed lot and agricultural farm land within the water body which may has increase the dominance of Benthic invertebrates during the wet season as observed in the diversity index. This may be responsible for the sparse population of benthic fauna across the sampling stations. The results of the evenness index were low in both climatic regimes.

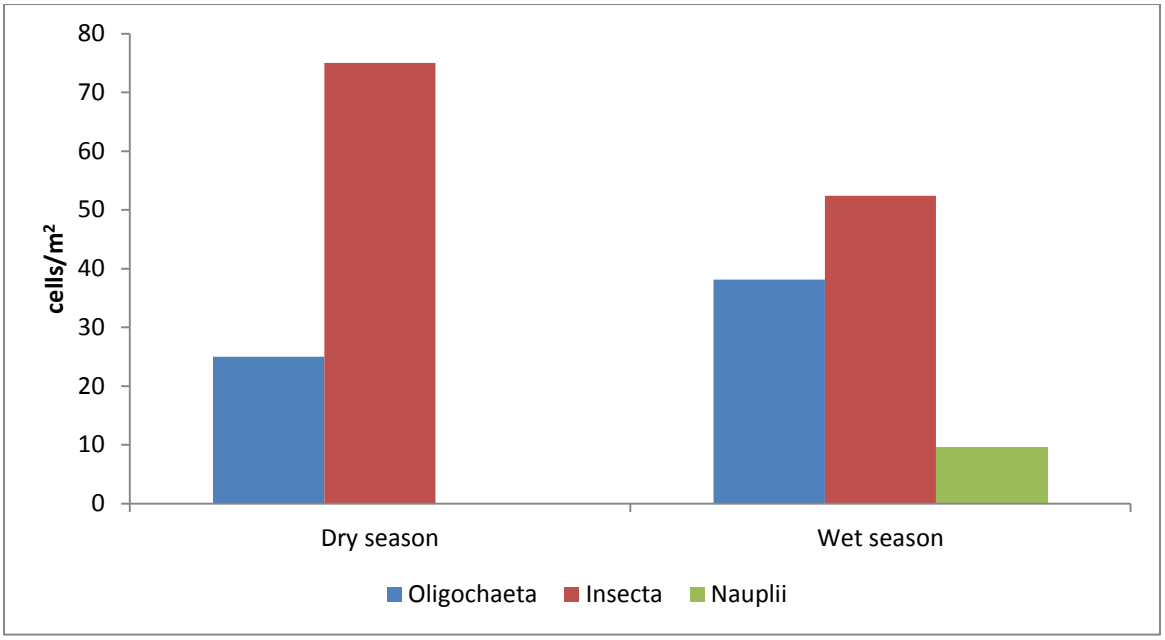

Figure 4.8.6: Population density of benthic invertebrates in the wet and dry season

Table 4.8.5: Benthic invertebrates' composition and distribution in the study area (Dry season)

Taxa	Up stream	Mid stream	Down Stream	Agbonchia River Control	Rumukrushi Control	Total	%Total
CLASS: OLIGOCHAETA							
***Oligochaete* worm**	0	0	0	3	0	3	
SUB TOTAL	0	0	0	3	0	3	25
CLASS: INSECTA							
***Chaoborus*larvae**	0	0	0	0	2	2	
***Chironomus* larvae**	0	0	0	0	6	6	
***Simulium* larvae**	0	0	0	0	1	1	
SUB TOTAL	0	0	0	0	9	9	75
Taxa_S	0	0	0	1	3		
Individuals (cells/m²)	0	0	0	3	9		
Shannon_H	0	0	0	0	0.85		
Evenness_e^H/S	0	0	0	0	0.74		
Margalef	0	0	0	0	0.91		
Dominance_D	0	0	0	0	0.56		

Field survey, 2011

Table 4.8.6: Benthic invertebrates' composition and distribution in the study area (Wet season)

Taxa	Up stream	Mid stream	Down Stream	Agbonchia River Control	Rumukrushi Control	Total	%Total
CLASS: OLIGOCHAETA							
Deroobtusa	2	0	0	0	1	3	
Ophidoniassp	0	0	1	0	0	1	
Dugesiapolychroa	1	0	0	0	1	2	
Lumbricussp	1	0	1	0	0	2	
SUB TOTAL	4	0	2	0	2	8	**38.10**
CLASS: INSECTA							
Chironomoussp	0	1	0	0	1	2	
Corduliasp	0	2	0	0	0	2	
Donaciasp	1	0	0	1	1	3	
Dytiscussp	0	0	1	0	0	1	
Poissoniasp	1	0	0	1	1	3	
SUB TOTAL	2	3	1	2	3	11	**52.38**
Nauplii	0	1	0	0	1	2	
SUB TOTAL	0	1	0	0	1	2	**9.52**
Taxa_S	5	3	3	2	6		
Individuals (cells/m^2)	6	4	3	2	6		
Shannon_H	1.56	1.04	1.10	0.69	1.79		
Evenness_e^H/S	1	1	1	1	1		
Margalef	2.23	1.44	1.82	1.44	2.79		
Dominance_D	0.93	0.83	1	1	1		

Field work, 2017

4.8.4 Fisheries

4.8.4.1 Fishery Composition of the Study Area

Fishing activities in the surface water bodies around the project area are generally subsistent and nearly absent in the last few years. The fishery resources in these lentic systems have been severely threatened with increasing manual and mechanical sand-mining activities. During the field data gathering exercise, there was no presence of artisanal fishing activities in the Okulu stream.

The analytical result of the aquatic ecosystem in both climatic regimes (Surface water quality, Sediment quality and Hydrobiology) which are far below threshold limits set by regulatory agency indicate sufficient carrying capacity of the Okulu stream.

4.9 WASTE MANAGEMENT

The solid waste generation during construction and operation phase and their disposal summarized as below:

During construction generated waste will includes metal scraps, wood, glasses, paper, cements bags, empty containers, spent oil from vehicles and heavy earth movers. Construction wastes will be segregated, collected and disposed in accordance with statutory guidelines. Comprehensive list of expected waste during the construction is presented in table 4.9.1 with their respective management strategy.

Table 4.9.1: Expected Waste Types/management strategy during the Construction Phase

Waste Type	Management Strategy
Soil cuttings	Clean fill, levelling and landscaping.
Wood	Reuse,
Empty Cement Bags	Reuse, incineration
Empty container	Decontamination and sale
Metal scraps, Cables	Sale
Spent Oil	Sale/ Incineration
Food waste	Composting at approved dump site by accredited waste vendor
Paper waste	Recycling
Plastic bottles and sachets	Recycling/Incineration

Plate 4.9.1: Waste segregation within Indorama Complex

Operation Phase: Domestic solid wastes will be collected, segregated and disposed of in the approved manner by accredited waste vendors and to the satisfaction of the Nigerian environmental and waste management regulations.

Table 4.9.2: Expected Solid waste/management strategy during Operation Phase

Solid Waste	Source	Management Strategy
Metals	Maintenance	*Collection in the scrap yard for reuse or sale*
Battery	Control room, Forklifts etc.	Supplier of new battery takes the old battery; disposal by used battery accredited third party vendor.
Biomedical	Clinic	Incineration
Electric bulbs and E-waste	Plant, offices, clinic, control room	Collection in dedicated receptacles; disposal by accredited third party vendor.
Food waste	Offices and plant	Collection in dedicated receptacles; disposal by accredited third party vendor.
Oil soaked cotton	Plant, maintenance	Incineration
Paper, plastic	Offices and plant	Recycling; incineration.
Polymer Waste	Waste chemical stack, water treatment plant	Incineration

Waste management Strategy

Generally, the existing waste management strategy in Indorama complex includes waste reduction, waste reuse, waste recycling, and final disposal by an accredited waste management vendor. This strategy emphasizes on prevention of waste, followed by reduction, reuse before recycling, recovery and lastly disposal to an approved dumpsite using an accredited waste vendor manifested to ensure cradle to grave. The philosophy behind this 4Rs is to cut down waste generation to a manageable volume for final disposal. Wastes contribution from the proposed new plants will add to the existing waste stream in the Indorama Complex will be handle by the existing waste management facility.

4.10 SOCIO – ECONOMIC ASSESSMENT

4.10.1 Study Settlements

The area considered for the Socio Economic Impact Assessment (SEIA) covers a radius of 5km from the Indorama Complex (area of study for the project EIA report). In the area under consideration, there are four (4) main settlements namely Agbonchia, Aleto, Akpajo, in the Eleme Local Government Area and Elelenwo in Obio/Akpor. Elelenwo is of Ikwerre origin. Among Aleto and Agbonchia settlements, there are three family units, respectively Okerewa, Njuru and Akpankpan, whose creations were to ensure adequate community welfare packages to the host communities by the Indorama management. Okerewa is studied under Aleto, while Njuru and Akpakpan are covered under Agbonchia. These settlements have been considered for the study because of their proximity to the Project site, in which the major social impacts related to the project are expected. The people of Eleme claim a common ancestry, language and ethnicity while the Elelenwo community is of the Ikwerre ethnic group.

4.10.2 The Eleme Communities

Eleme is a kingdom and the current traditional head king Oluka Ejire, the Onne-eh Eleme is a government recognized 1st class chief. Although Ogale is the traditional headquarters of Eleme kingdom, the present ruler hails from Agbonchia. Eleme shares boundary with other ethnic groups in Rivers State like Ikwerre, Okrika, Oyigbo and Ogonis. The language of Eleme also borrows from these neighbours and shares strong similarities with Ogoni. There are two clans in Eleme: Odido and Nchia; the study communities belong to the Nchia clan.

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

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

4.10.3 Elelenwo Community

The people of Elelenwo are descended from Obio after whom Obio/Akpor local government area of Rivers state is named. Obio had two sons namely Evo and Apara. Under Evo, there are three clans EvoKpotoma and Esara. Kpotoma has six communities namely Rumuluku, Rumuenyeron, Rumueziolu, Rumuoduwere, Rumueheleze and Rumuodani. Elelenwo comprises sections of the last three communities. Rumuodani is the community whose land is part of the territory that was acquired by the Federal government to build the then Eleme Petrochemical complex. Elelenwo traditional leadership has a committee of the three clans whose chairman is the paramount ruler of Elelenwo. The headship is rotated so that every clan at some time have the chance of leading the community. For Elelenwo as a whole, there is a community development committee, youth council, women group and Owhor holders (Ikwerre traditional priesthood). These various groups are like arms that govern Elelenwo community.

4.10.4 Socio-economic Survey

In this survey, respondents weighed the relative degree of influence among the categories described above. In community governance; chiefs were rated highest, followed by the youths, elders, women and age grade.

Settlement Pattern

Settlement pattern in the study area is nucleated. All the settlement layouts are densely built and occupied with streets and lengthy roads. It is likely that they all began as linear settlements along the old Bori road, but the evidence now is of settlements with internal structures that spread deep from the main thoroughfare. The internal structures of the

settlements have not matured to a point where they acquire distinctive functional properties like commercial, residential or public uses. These settlements are all struggling to integrate with the sprawl at the fringe of Port Harcourt; therefore they may take some time to develop unique identities.

Demography

The total population of the four settlements surveyed in this study was 66,614 in 2010. The data was generated by tabulating their respective 1991 census and the projections for 1996 as published by the National Population Commission (1996) at settlement level. The Federal Government of Nigeria (2007) estimates the growth rate of population in Rivers State as 3.4% annually, although Nigeria grows at 3.2%. The growth rate for Rivers State is used to project the population of the study settlements from the 2010 to the present. By the estimate, Agbonchia has 25,876 people, Elelenwo 24,491, Akpajo 14,404 and Aleto 17,678 people in 2017. The population of the communities was derived from 2006 NPC figure projected to 2011 at 3.4%, the national growth rate. There are more male population (57%) than female (43%) among the households surveyed in this study. The study settlements are in the outskirts of Port Harcourt and influenced by companies operating outside Indorama complex but within the thematic region of the study area.

Table 4.10.1: Demography

Community	Population 2010	Population 2016 @ 3.5 growth rate	% change
Agbonchia	20,829	25,876	19.5
Elelenwo	19,954	24,491	18.5
Akpajo	11,597	14,404	19.5
Aleto	14,234	17,678	19.5
Total	**66,614**	**82,449**	**19.3**

Source: National Population Commission & National Bureau of Statistics 2016

Occupation, Employment and Income

The distribution of occupation among the respondents is 48 percent for the self-employed, 21 percent for those who work in government offices, 12 percent for company

workers and 19 percent unemployed (See Figure 4.10.1). The self-employed are more in Agbonchia and Elelenwo than in Aleto and Akpajo. Likewise too, Aleto and Akpajo have more government and company employees than the other settlements. The highest rate of unemployment was reported in Agbonchia and the least in Akpajo. The occupation of the self-employed are business (small scale business and contractors to EPC) (56%), farming (29%), trading (12%) other (3%). Those categorised as other include, clergy and church workers, artisans, transport workers, etc. Majority of the businessmen are suppliers to the large companies in the area. Only 2 percent of the respondents claim they fish.

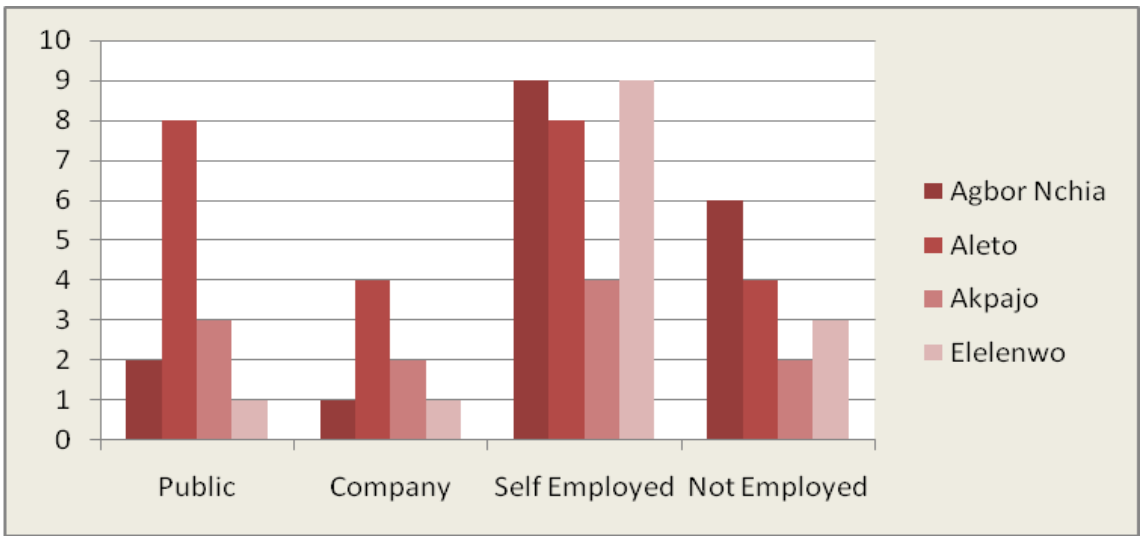

Figure 4.10.1: Employment Distribution in the Study Settlements

The mean daily income of people in the study area is ₦700. This is slightly above the national minimum wage of ₦18, 000/month. It should be noted that the national minimum wage is paid to individuals who may be heads of households and its overall impact will be significantly below what a household require for its sustenance.

Commerce and Industry

In the Port Harcourt Master Plan 75 the settlements surveyed in this study are located in the North Eastern axis designated for heavy duty industries. The state-of-affairs is that the large industrial complexes have not attracted medium manufacturing industries to utilize their products. This lack of backward integration permeates to the low level of small aspiring entrepreneurs. There are no signs of industrial activities at the community

level in the study settlements. As reflected in the occupation structure, people either farm, work for government or they are businessmen. Being a businessman simply means as a vendor to many of the large industrial complexes in the area. What remains of industries that community members can relate to are small time welding and fabrication, sand mining in all the rivers in the area, traditional food processing like fish smoking and cassava flour production, as depicted in Plate 4.10.1.

Plate 4.10.1: Cassava Processing in Eleme

The presence of the large industries, the local government headquarters of Eleme and a large population means that there are commercial activities. In the formal sectors are many commercial bank branches, retail outlets, small hotels, and asphalt plants. In the informal sector there are many small trading activities, automobile mechanics, local transport business, eateries and building construction. The informal commercial sector is the most numerous business activities in the area. Every community own a market; some are periodic while others are daily. The Nchia market (Plate 4.10.2) is the largest of the daily markets. Two periodic markets are famous in the area: the Nim market (also called Ikwurugba) trades every fifth day in Elelenwo and the Echietaejie market of Agbonchia which trades only on Sunday. These two markets have patrons from across Rivers State and beyond.

Plate 4.10.2: Nchia Main Market in Eleme

Agriculture and Land Practices

Land ownership and the rules of transfer are strict and contentions in the settlements. Distant lands from the community are devoted to subsistent farming. The crops cultivated in their order of importance are cassava, maize, yam, plantain, green vegetables, cocoyam and fruits. The farming system is a limited form of shifting cultivation whereby land is cleared and cultivated for several years until productivity diminishes; it is then abandoned until natural processes regenerate the soil. The fallow period was up to 7 years about 30 years ago. Presently fallow period is reduced to a year or two. Consequently agriculture in the study area as a main stay of the people's income has reduced to very low level of subsistence farming.

Water Supply and Sanitation

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

A more comprehensive study of domestic water supply in the study areas by NDDC (2008) (see Table 4.10.2) shows that majority of households in the study area rely on outdoor taps (usually boreholes) for their water supply. Another proportion sinks the boreholes in their premises, and then pipes the water to their houses. Others use land dug wells and streams as their source of water supply.

Table 4.10.2: Percentage Distribution of Household Water Sources

LGA	Piped	Outdoor tap	Well	River	Vendor	Other
Eleme	8.1	41.4	16.2	24.2	6.1	4.0
Obio/Akpor	27.2	54.4	17.8	0.0	0.6	0.0

Source: NDDC (2008)

The study settlements are covered by the activities of the state sanitation authority, responsible for the evacuation of refuse in Port Harcourt and its immediate neighborhoods. Most respondents, especially in Akpajo and Elelenwo attribute the management of waste in their domain to the sanitation authority. They however complain about paucity of collection sites which prompt people to also use nearby bushes, vacant plots and their backyard as dumping grounds. These methods of disposal are common in the host communities. The picture in Plate 4.10.2 was taken at the vicinity of the Nchia Ultramodern market, while Plate 4.10.3 is a dump near the water body in Aleto. Dumps like this litter the host communities and proves the inadequacy of waste segregation, storage, collection and disposal. Depending on the type of refuse and the season, burning is used by the citizenry to minimize the nuisance and unhealthy situation rounding waste management in the area.

Plate 4.10.3: Refuse Dump adjoining to water body in Aleto

The flushing of toilets into septic tanks and soak away are the commonest means of excreta management. Ideally, the septic tank should be evacuated when due but not later than six months; however that is not the case in the study area. Another observation with the use of septic tank as retainer for sewage is that the owners are oblivious of the fact that boreholes for domestic water supply are often sited close to these septic tanks. There are no clear cut regulations on this in Nigeria but, the practice elsewhere is that boreholes cannot be sited less than 200m from a septic tank (Ede and Edokpa, 2010). This calls to question the quality of water sourced from boreholes as practiced in the study area. The other important means of excreta disposal in the study area is covered pit latrine and it is nearly as prevalent as the water closet system. People also use surrounding bushes, water channels and the pail system to manage their excreta in the study area.

Transportation

The four settlements in the study area are traversed by two major highways: the East-West Road that begins from Warri and end in Eket and the Port-Harcourt-Aba Expressway. The two roads are in fairly good condition and are always busy. It is from these major roads that the internal road arteries emanate. Most of the internal roads are not paved. In Aleto and Agbonchia, NDDC paved some roads, but most of them have failed and are

un-useable at some points. The problems with the NDDC roads are that they have very poor foundation and no proper base before the asphalts were laid. Sometimes they do not have drainages and where drainage exists, they channel water to nowhere, which contributes to the road failure.

Movement from one place to another is by road in the study settlements. All the study settlements are big enough to require some sort of transport and it is met through the use of tricycles and motorcycles. Motorcycles stand on left of the plate 4.10.4 on Agbonchia –Oyibo road.

Plate 4.10.4: Motorcycles are Important Means of Transportation in Eleme

Education

Every community in this study has a model primary school, recently constructed or under construction, as in Plate 4.10.6, that is publicity funded. All the settlements except Akpajo also have a secondary school owned by the government. All the communities have benefited from the new primary schools project by the state government, who have vowed to equip them with modern facilities like computers, laboratories and well trained teachers. Privately run schools from primary to secondary levels are present in all the settlements. These private schools sometimes may offer teaching standard that are higher than those in government schools, but their fees are usually exorbitant. They nevertheless provide opportunity and choices to parents and pupils.

Plate 4.10.5: Comprehensive Secondary School in Alesa – Eleme LGA

Energy and Electricity

Energy demand in the study area is for lighting, cooking, maintenance workshop and driving machines, (including automobile). Vehicles are driven with gasoline and diesel, electricity and kerosene are used in lighting, while wood, kerosene and liquefied petroleum gas (LPG) are used in cooking. Our experience during the field work is that all these energy types are in short supply. Electric light is epileptic and there are occasions when they receive only a few hours of power in a week. The petroleum based types are scarce and expensive, for instance, one liter of kerosene costs ₦350 as against the advertised and regulated price of ₦50. A modest bundle of wood cost ₦1,200 because the bushes from where they are sourced have been significantly depleted. It is true to say that residents of host communities are facing difficulties in acquiring adequate energy for various household uses (fuel for generator; fuel for motorbikes; kerosene for house lamps, cooking and house lighting, and wood).

Housing and Household Possessions

Most respondents live in owner occupier houses. Majority of the houses are constructed with concrete blocks and roofed with corrugated iron sheets, earth block and iron sheets and the traditional wattle and mud houses roofed with thatch or iron sheets. The crowding index is 1.2, that is, a room is available to every 1.2 persons in the study area.

Household assets indicated by the respondents include bicycles, motor car, van, television, power generator, motor cycle, radio refrigerator and air conditioner. The most widely owned household possessions are television, generators, and radio sets. Half of the households surveyed in this study owned refrigerators and a third owned car and motor cycle. The frequency of ownership of household assets is presented in Figure 4.10.2.

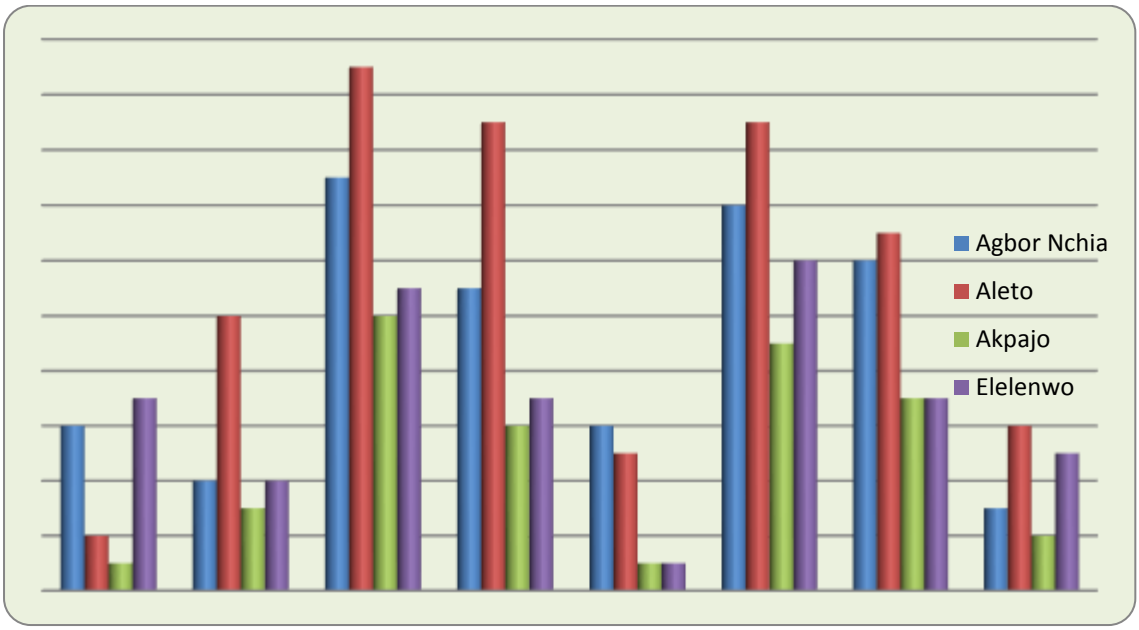

Figure 4.10.2: Ownership of Household assets in the Study Area

Cultural Calendar and Social Affiliations

Four activities dominate the cultural calendar of communities in the study area namely; wrestling, traditional marriages, new yam festival and dances. Wrestling takes place during and after harvest, usually in the months of September, October and November. Wrestling is invitational that is one community goes to another community, showcases their prowess and engages their host wrestlers in a duel. A winner emerges between two wrestlers when an opponent is dusted on the ground. A visiting community becomes a host to their previous host another.

Marriage is like a rite of passage in the communities. Every adult (males in particular) must marry sometime in their life to signify that they are now men. Marriage ceremonies are however conducted according to the woman's (bride's) culture. Traditional marriages in Eleme and Ikwerre are elaborate systems that include hosting the family and

community in feasts. As a result, the drinks and foods are the key expenditures the groom has to prepare for. Marriage in these cultures is also not a onetime event among the Ikwerres, this may include a minimum of four occasions and each of those occasions is embellished with food and drinks. In Eleme a woman may be sponsored in what is called Mgbete that takes a year of preparation before her outing to the public and suitors.

The decline in yam production in the area has affected new yam festivals also. New yam festival used to hold in August and it is practiced in all the study settlements. The principle is that nobody in a community eats of their yam harvest unless it is first offered to the gods and ancestors, whom it is believed made the harvest possible. Some respondents who do not grow yam of their own even purchase newly harvested yam in order to partake in the ceremony. Again the new yam festival which was highly regarded as Christmas today is fading into obscurity due to urbanization and modernity.

Traditional dances are found in every African culture. The dances may be for members' only, free and open participation with or without masquerades. The dances may be mixed or gender restrictive sometimes too; Esomba dance in Aleto is for women only. Similarly, Ndudu is a form of dance for women in Ikwerre culture.

Social Affiliation in the societies involves being a member of groups where people share things in common. The categories posed to the respondents include politics, co-operatives, social clubs, education, religion and cultural associations. Across the study communities, affiliation to a religious body was the greatest indicated by the respondents. The implication is that almost all the respondents are religious, usually of the Christian faiths. Affiliation to one or more (mainly foreign) football clubs came second. There is no doubt that most adolescents and young adults in the community have their favourite football clubs, and that watching their club play on television is perhaps their preferred pastime. Other social affiliations include membership of political parties, social clubs, educational associations, co-operatives and cultural clubs. We observed a tendency among respondents to see specialized training in trades like fitting, iron bending, welding and mechanics which are required in striving petroleum industries around the area. Some even enroll for higher education as reasons for citing education as a social affiliation.

Taboos and Sacred Places

All human activities in traditional Eleme or Ikwerre setting has a spiritual side to it that is effected through rituals and sacrifices and the places designated to perform these rituals are sacred places. The basic structure of traditional religion in the study areas begins with the family alters. In Agbonchia the study team were shown spots where the family alters are. The Elelenwo people also have their rukannis that approximates the same thing in Ikwerre land.

At the community level there are shrines dedicated to so many causes. Adooka and Onura shrine in Aleto protects the community and in Elelenwo Mini Achara will be the equivalent. Seseiokulu in Agbonchia is a shrine to which sacrifices are made before planting, soil fertility and harvest. When things considered abomination (e.g., the death of a woman under pregnancy, drowning) occur, the chief priest Onnenkike in Eleme is invited to cleanse the land through sacrifice, so that such bad event do not happen again. In Elelenwo, an infant who is afflicted may be taken to the shrine of Mini Achara vows made to the deity. If reprieve is granted the parents are expected to redeem their pledge through sacrifice. In Ikwerre calendar as used in Elelenwo there are five days in a week namely Riabo, Sarabo, Namake, Okwa and Nim. Riabo is the sacred day in which most traditional religious rites are performed and Nim is the market day. In Eleme there are five (5) days a week namely Obo (big market day), Nma, Ojua, Ochun (small market day), Okor. Obon is the traditional market day that no farming is allowed.

Religion

In spite of the traditional observances in the study communities most respondents profess themselves to be Christians. The religious learning of the people include all possible denomination, whether Orthodox or unorthodox. Among the orthodox churches cited are Anglican, Catholic, Lutheran, Baptist, Jehovah's Witness, and Cherubim. The Anglican Church was however described as the community church. It is usually the oldest Christian denomination in the communities, built through community effort and it will have a mission school attached which is to the congregations' commitment. Every community surveyed in this study had several Anglican churches for instance Agbonchia had 4, Aleto 3 and Elelenwo 4. The new (Pentecostals) churches are also gaining

acceptance in the communities and their membership is growing even more rapidly. Some of the Pentecostals in the communities include Redeemed, Deeper life, Assemblies, Church of God, Commonwealth and Greater. The attraction of the Pentecostals is in their use of music and rigorous preaching. The congregations are often smaller and the pastors appear to be more likely to be rigid in the interpretation of the doctrines as with Deeper Life, but some are also lax in the area of dressing by not requiring women to cover their head like Winners.90% of the population are Christians, 6% traditional worshiper and 4% Muslims

Conflict Resolution in Communities

Dispute over land boundary and ownership is the primary cause of intra and inter communal conflicts in the study settlements. The respondents affirm that there is a rise in conflict over land and who benefits from the proceeds of land in all the study settlements. In relation to the period when the area was acquired by NNPC for the Eleme petrochemical complex, certain landlords resulted resorted to the court to resolve ownership of their respective portions of the land acquired for Eleme Petrochemicals Complex. This approach was at variance with the traditional ways of settling land disputes. It is pertinent to mention again that there is no land dispute on the sitting of IEFCL-Train2 project with any stakeholder. Settlements like Akpajo with large water front also have disputes over the ownership of water bodies. Politics have become an important source of dispute in the study area. Who represents the people at the various levels of government and legislative bodies are becoming contentious because there appear to be a lot to be gained in holding political office. The sources of conflicts among respondents in the study communities are presented in Figure 4.10.3.

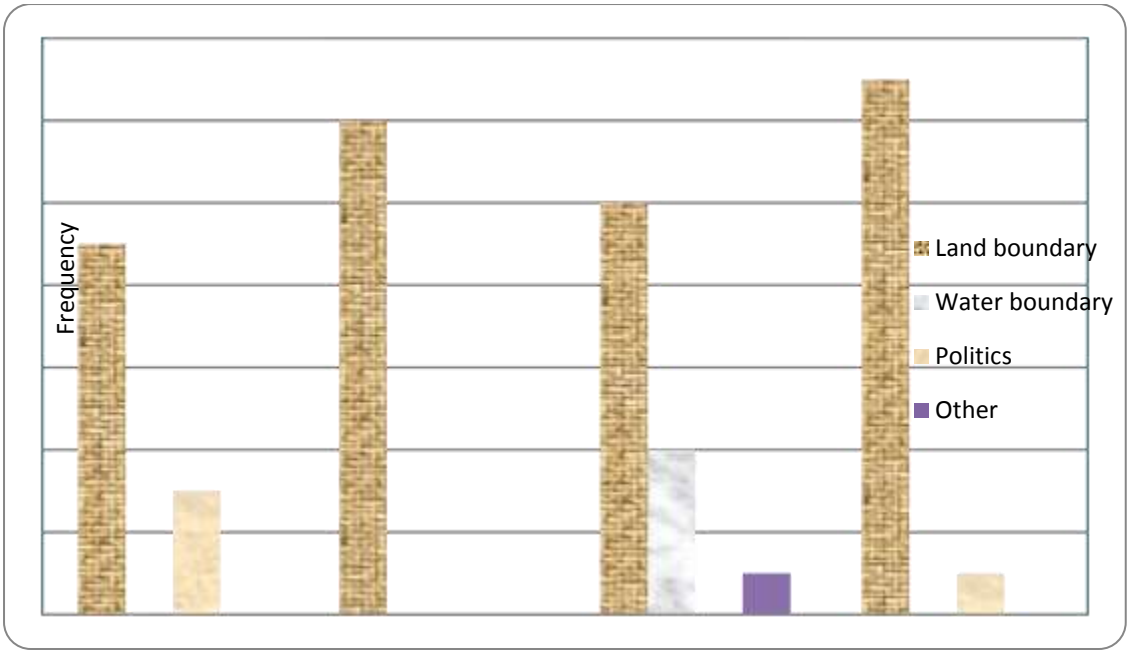

Figure 4.10.3: Sources of Conflict in the Study Area

Traditional dispute resolution takes the form arbitration of chiefs acting individually or in a group (in-council). Resort to courts is very popular and was rated by respondents as the principal mode of dispute resolution. The opening of courts at local government levels has made this option attractive among litigants. In the past it was also usual for people to be summoned before shrines.

4.10.5 DISCUSSION OF FINDINGS

1. Economic features of Host Communities and effect of the IEFCL-Train2 Project

The area to be directly affected by the IEFCL-Train2 Project consists of the six communities named Agbonchia, Aleto, Njuru, Okerewa, Akpakpan, Akpajo and Elelenwo and the indirect influence areas are Eleme Local Government and Obio/Akpor Local Government, all in Rivers State.

The residents of the area where IEFCL project is located are local people whose primary and traditional occupations are agriculture (farming, fishing and hunting). However, with the influx of industries into the area and modernization due to education and urbanization, the residents of these host communities are now involved in other forms of paid employments. The distribution of occupation among the respondents indicates that

48 percent for those who are self-employed, 21 percent for those who work in government offices, 12 percent for company workers and 22 percent unemployed.

Prevalence of poverty is high in Nigeria just like most developing economies. The survey reveals that the mean daily income of people in the study area is ₦700 per head per day, this amount being slightly above the United Nations Development Program (UNDP) poverty line of $1.25 per day and the national minimum wage of N18, 000/month.

The views on economic lives of the residents of the host communities were sought and analysed using key economic gauges like increase in business competition, increase in employment opportunities, improvements in volumes of economic activities, improved income level and increase in disposable income. The survey reveals that the IEFCL- Train2 project will cumulatively create positive impact on business competition, improved economic activities and improved general income level. To the residents of the area, the entire Indorama facility had increased their chances of gaining employment and improving the take home pay. Such opportunities are expected from the IEFCL-Train2 project. The 49.91% of the respondents agreed strongly to the issues of job creation and 41.98% to improve personal income.

The respondents reported that during IEFCL-Train1 construction, appreciable employment opportunities were given to host communities. This information was corroborated by Community Relations Department of Indorama which gave the employment status approximately 4000 equally distributed among the host communities. Respondents expected the same opportunities with the addition of IEFCL-Train2 Project. The respondents from vendor/contractor segment reported that Indorama gives priority to host community contractors for general service contract, which is providing indirect employment to host communities. Similarly responses from youth groups expressed positive perception of Indorama's performances so far and are expecting even better relationship in employment opportunities in IEFCL-Train2 Project.

To some respondents, the up-coming project may create concerns in their communities due to unfair distribution of the benefits accruing to them from the company. This they

wished that Community Relations Department should play same active role, as they played in Train1 project. They also desire that company should help them in setting up of skill development initiatives, which will help them to develop skills that enhances their employability, even outside Indorama. Some respondents even though expressing concerns about the increase in cost of living were in agreement that economic development will affect positively on general wellbeing of the people of the host communities.

2. Social Characteristics of Host Communities and effects of the IEFCL-Train2 Project

Given an annual population growth rate of 3.46% in Rivers State (see NBS, 2016), the increase in population of the host communities is expected and due to industrialization it is expected to increase much more than estimated annual growth rate. For instance, in 2010, the total population of the four host communities was 66,614. By 2016 the population of the four communities increased to 82,449. This represents a 19.3% rate of population change. This rise in population of studied communities could be attributed to the movement of persons and businesses to these communities in order to maximize the positive externalities.

One major implication of the high population growth in this area is (mounting) pressure on existing facilities and a high demand for additional housing and landed property. Both informal and formal housing areas have expanded in density. The pressure on road, electricity supply, health care and other infrastructure may also increase.

The survey report of ESIA on the Phase1 fertilizer plant shows that the host communities have high population dependency burden. According to the report children between 0-4 years and the aged represent 41% of the total population, while the working age form 59% of the population. Given that most persons graduate from tertiary institutions at 21 – 25years, there is the tendency that the population dependency burden may increase. A high dependency ratio implies that poverty level will rise since few working individuals have to care for more persons in the family.

Table 4.10.3. Population Distribution in the Host Communities

Community	Population 2010	Population 2016 @ 3.5 growth rate	% change
Agbonchia	20,829	25,876	19.5
Elelenwo	19,954	24,491	18.5
Akpajo	11,597	14,404	19.5
Aleto	14,234	17,678	19.5
Total	**66,614**	**82,449**	**19.3**

Source: National Population Commission & National Bureau of Statistics 2016

According to NDDC (2008), adult literacy rate in Eleme is 82.3 percent while in Obio/Akpor it is 85.5 percent which is relatively high compared to the average adult literacy rate in the South-South of Nigeria which is 68.6 percent for women and 80.2 percent for men. The first EIA report attributed this high adult literacy rate to proximity of the residents of Eleme to schools, institutions and industries.

Table 4.10.4. Educational Level in the Host communities of Indorama IEFCL

		Educational Attainment by Household Members.	
Categories	**Obio- Akpor**	**Eleme**	**%**
No formal Education	**375**	**457**	**13.3**
Pre-primary Education	**213**	**162**	**6.8**
Primary Comp.	**341**	**231**	**12.3**
Secondary Uncompleted	**238**	**216**	**11.6**
Secondary completed	**312**	**478**	**13.5**
Tertiary Uncompleted	**98**	**104**	**4.9**
Tertiary Completed	**476**	**337**	**13.3**
Teachers Grade2	**236**	**176**	**9.5**
Trade test cert.	**128**	**118**	**5.9**
City and Guild Cert.	**287**	**101**	**8.9**
TOTAL	**2704**	**2380**	***100***

Sources: Adapted from Field survey, 2012 and LGAs publications (various editions)

The sitting and activities of the Indorama may have positive and adverse effects on the social lives of the host communities. On the positive contributions of the activities to their social lives, the people agreed strongly that the presence of the company will lead to improvement in quality of housing and bring affordable houses to the host communities. This is a product of the general increase in income level in the area. The respondents also expressed less worries about the company's activities on pressure in schools, hospitals and family unity. The increase in social investments like private schools and health care facilities as a result of the presence and activities of the company may have improved these social variables. Improved income level also contributes to family unity and stability since most families' needs could be met due to additional income earned from the company's activities.

According to respondents, through the holding of six host communities in IEPL, the communities have proportionate holding commensurate to IEPL's equity shares in the Fertilizer operations as well. This gives them feeling of ownership. Almost all respondents wish that the company should grow and bring more projects to utilize available resources within the region. The other respondents said that Indorama's sharing philosophy has make company a successful example of private - public partnership.

According the IEFCL SEIA Phase 1 report, most respondents in the host communities live in owner occupier houses. The majority of the houses are constructed with concrete blocks and roofed with corrugated iron sheets, earth block and iron sheets, and the traditional wattle and mud houses roofed with thatch or iron sheets. Though the study reported a crowding index of 1.2, that is, a room is available to every 1.2 persons in the study area, the structure/pattern of shelter and availability have improved due to the activities of Indorama in the area.

According to respondents, that traffic and road safety in and around the host communities have created some concerns to road management due to the presence and activities of numerous trucks in area, in general in state. This they believe may deteriorate further with the proposed fertilizer Phase II plant. These traffic and road safety deterioration are consequences of additional workforce which will use the road to the company on a daily

basis, increased subsidiary investments like restaurants and hotels, upsurge of people residing in the host communities and additional vendors and heavy duty vehicles that are involved in the movement of the products of the company to either the wharf or to other parts of the country. There is also a concern about social friction among the various ethnic groups living around the host communities. It should be noted that people from other parts of the country also would migrate into Eleme LG area as a result of booming industrial activities in the area and consequently also contribute to security of the area. The people of the host communities also have concern that their social identities, value and traditional recreational activities may affect due to the influx of persons into their communities. The people further expressed the desire that the coming of new projects in the area will afford the youths some vocational skills and empowerment.

3. Cultural Characteristics of Host communities and the effect of IEFCL-Train2 Project

The following activities dominate the cultural calendar of communities in the study area, namely: wrestling, traditional marriages, new yam festival and dances. Marriage is like a rite of passage in the communities. Every adult (males in particular) must marry sometime in their life to signify that they are now men. Marriage ceremonies are, however, conducted according to the woman's (bride's) culture. Traditional marriages in the host communities are elaborate and are done by hosting the families of the bride and groom, and the community in feasts.

The host communities are mostly Christians and affiliations to religious and political bodies are stronger among the people than other social clubs like age grade and other cultural clubs.

The host communities have very strong traditional institutions headed by a Chief or family head. According to the Phase I EIA report, all human activities in traditional Eleme or Ikwerre setting have a spiritual side to it that is effected through rituals and sacrifices and the places designated to perform these rituals are sacred places. The designated places for rituals are usually decorated with the artefacts and instruments which depict the ancestry or origin of the community. The communities also have high moral values which tend to promote hard work, discipline and respect. Certain activities or events like; the

death of a woman under pregnancy, drowning in a river/stream are considered taboos in Eleme and Ikwerre kingdoms.

The opinion of the people in the host communities was sought and analysed based on the cultural parameters such as marriage ceremonies, dressing, language and religion. The reactions of the respondents showed that the effect of the location of the project and the fact that expatriate staff live within Indorama facility reduces the contact with the residence of host communities. Secondly, the response gathered from questionnaires also showed that greater number of the peoples that will be employed, directly or indirectly will come from host communities and as such the respondents agreed that effect on the above stated cultural parameters will be minimally affected.

4.11 HEALTH IMPACT ASSESSMENT

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. Data obtained from these facilities were subsequently compared with state and National data and averages that are available.

4.11.1 Health services

From the result of the analysis of questionnaire responses, focus group discussion, interviews and personal observations, it is apparent that the primary health care delivery service in these communities was inadequate. Healthcare delivery services lack infrastructural facilities, adequate funding for drug procurement, adequate health personnel and financial resources to sustain and upgrade the entire health system.

Health-care facilities

The communities of Agbonchia, Aleto, Akpajo and Elelenwo are blessed with primary Healthcare Service Centers, newly built by the Rivers state Government. It is believed that when they are fully equipped, people in the host communities would have a better opportunity to assess primary health care services. There are however a lot of private clinics, maternities, medical laboratories and pharmaceutical/chemist shops. Some of these health facilities include:

- Primary Health Care Centers
- Private medical clinics and Maternities.

In the communities the medical team identified many traditional medicine practitioners, few Traditional Birth attendants who in their limited capacity still assist and compliment orthodox Healthcare delivery. These people lack adequate training in Hygienic procedures. There is urgent need to train them in the area of hygiene to make their contributions more meaningful. There were many patent medicine stores that stock both fake and adulterated drugs, surprisingly at prices beyond the reach of the people. Facilities for prompt/emergency responses were absent, only available in few of the hospitals such as the General hospital Eleme etc. Poor economic and financial resources, problem of

trained personnel, lack of infrastructural facilities limiting the quality and type of Healthcare delivery in these private Health institutions. In these places all the private Healthcare Centers were lacking in essential equipment and drugs. Laboratory equipment's were lacking and, where present, were both obsolete and non-functional.

Facilities Available in Communities

Table 4.11.1: Health facilities available in the different communities.

Communities	G Hospital	Primary Health Centre	Private clinic	Traditional
Aleto	x	√	√	√
Akpajo	x	√	√	√
Agbonchia	x	√	√	√
Elelenwo	x	√	√	√

√ Presence; X Absence

Plate 4.11.1: Health Center at Nchia - Eleme

Utilization of Primary Health Services.

The table on illustration in percentage is the attendance at health facilities in Eleme

Table 4.11.2: Treatment Facility Utilization in Eleme (Agbonchia)

Sr. No.	Facility	Utilization (%)
1.	Hospital/Health center	55%
2.	Chemists/Pharmacy	20%
3.	Traditional/Herbal home	10%
4	Healing Home/church	15%

Field work 2017

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

- High cost of hospital treatment
- Some hospitals are not user-friendly
- Massive, aggressive and vigorous campaigns by the Pentecostal sect that their members will deliver like Hebrew women of the Old Testament without recourse to caesarean section/assisted delivery.

The patients come back to the hospital when there are problems/complications such as prolonged/traumatic labour, 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 labour/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 labour 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.

4.11.2 Nutritional Status

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 farming 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.

- Anthropometry measures, or assessment – height, weight, skin fold thickness, arm muscle circumference and other parameters.
- Biochemical (laboratory) assessment of blood and urine, enzyme activities, levels of nutrient or the bye-products.
- Clinical assessment (physical examination): general appearance of skin, eyes and tongue, rapid hair loss, sense of touch, ability to walk.
- Diet History: usual intake or record of previous day's meal.

For the purpose of this study anthropometric assessment was done on children from the different communities i.e. Height, Weight and Mid arm circumference measurements were taken in addition to physical examination, appearance of skin, eyes and tongue were done. The result of these assessments indicates that the nutritional status was good. There were a few of the children in some of the communities and pregnant women that showed slight evidence of malnutrition, the rest were nutritionally healthy.

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. The Abattoir/slaughter along the East-West highway at Aleto Bridge (Plate 4.11.2) and the one in Elelenwo are both dirty. 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 contaminations can be removed by good rural marketing practice and improved personal hygiene.

Sanitation of the Living Environment

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

Plate 4.11.2: Abattoir opposite the Aleto (Okulu) River Bridge

Housing Conditions

Housing is a fundamental component of quality of life influencing health, sanitation, social environment and community wellbeing. Few of the houses are still roofed with thatches while most of the inhabitants live in a standard block houses as.

Plate 4.11.3: Residential Houses at Aleto

Housing is a key component in the protection and promotion of health which carries equal priority with nutrition, water supply, sanitation and health care. House needs to be sited properly and constructed in such a way as to provide the physical and social needs of those housed. House needs to protect people from adverse effects of the climate as well as provide fresh air, security and privacy to ensure, dignity, health and wellbeing. All these qualities and attributes depict a good housing in most of these communities.

4.11.3 Reproductive Health

Reproductive sexual health services: Reproduction and sexual health as a concept encompasses a set of health problems or diseases associated with the physical and social risks of human sexuality and reproduction.

Common Reproductive and Sexual Health problems in the Communities includes:

- Lack of access to good quality contraceptive family planning
- Hazardous birthing environment
- Infertility
- Maternal and child malnutrition and infection
- Human immune deficiency syndrome (HIV) & sexually transmitted diseases (STIs)

During the sampling, it was found that these health problems exert an enormously heavy illness burden on adults, young people and children, often with long term physical and social consequences. About 50-100 pregnancy related deaths cases occurs each year and each of these perhaps one-quarter to one-third are due to lack of access to safe abortion services. This information cannot be authenticated, because the source could not back it with records. It is estimated that for every pregnancy related death, some may have suffered significant complications. In other words many women suffer serious morbidity each year. Of the prenatal deaths among children in the community, about half are associated with low birth weight (under 2500gm) due predominantly to maternal protein-calorie malnutrition and anemia and in some cases STIs.

HIV and STIs constitute another major cluster of reproductive health problem, which cannot be statistically reported because of lack of records in the area. Again the State Governments policy/programme in health care may bring succor to this important global issue when the health centers become functional and operational.

4.11.4 Disease Prevalence

The information provided in these sections is based on hospital records and responses from questionnaires, focus group discussion, on the spot observation and key informants

on the nature and pattern of diseases in the communities in the study area in the last 12 months. There were a few fragmented data from hospital records in the area.

The prevalence rate (i.e. the number of cases of the condition at a particular time or period divided by the size of the population exposed) has been used in the assessment of disease prevalence. It has enabled a fair interpretation of data about the disease prevalence in the community and it's comparison with the ill health in other areas in subsequent studies. A reliable prevalence rate could not be determined because of insufficient data In addition a lot of people carried out self-medication while some are treated by traditional medical practitioners and traditional birth attendants without records.

Summary of prevalence of communicable diseases in the community in the project area

Malaria

Malaria was the most prevalent and occurring disease in the communities hosting the project. It was characterized by periodic chills and fever, its presence is confirmed by examination of blood smear for the parasite. Its prevalent rate was high in the communities in the project area. The high prevalence rate of malaria is sustained by a number of factors:

- The abundance of mosquitoes (the insect vector of the causative agent which consists of plasmodium falciparum and less of plasmodium vivax and plasmodium malariae),
- Presence of stagnant water,
- Absence of pest control,
- Inadequate prophylactic drugs supply and inadequate diagnostic facility and personal indifference to health care.

It affected both male and female of all ages but least in children under one year old. The prevalence rate was high between April and June when the presence of numerous water holding ponds favoured the breeding of mosquito vector. Severity of malaria varies from weakening effect or fever to death particularly in children.

Diarrhoea

Diarrhoea was the second most prevalent disease. Its symptom includes unusually frequent passage of loose watery stool and occasional presence of blood pus and mucus in the stool.

Protozoa, entamoebe histolytic organisms or parasitic bacteria Escherichia coli cause it. It resulted in severe dehydration and weakness and was prevalent in all the communities of the project area. Its prevalent rate could not be determined due to absence of record. Its high prevalence was attributed to poor sanitation, consumption of facially contaminated water in the community.

It affected male and female of all ages but least in children under one year of age; probably as a result of improved maternal care of babies through breast feeding and sterilization of baby food and materials (proper hygiene).

Upper Respiratory Tract Infections

This includes any of the several diseases of the respiratory tracts characterized by inflammation of the lungs and caused by bacteria, viruses or chemical irritant. It was prevalent in the communities of the project area. Its severity varies from mild respiratory discomfort to death. It affected both male and females.

Skin Rashes

The condition includes measles, chicken pox, ring worm, eczema, different agents caused these. They were generally of medium to high prevalence.

Sexually Transmitted Infections (STIs)

They include gonorrhoea, acquired immune deficiency syndrome (AIDS). Syphilis and tuberculosis.

STIs are important because of the high morbidity and complication, for example infertility, congenital infection and pelvic inflammatory disease (PID), AIDS is now a pandemic health outcome especially in developing countries. Its incidence was high and recorded in the hospitals and health centers but are referred to UPTH, BMH and other specialized hospitals probably because of absence and low health facilities and usage. The presence of many seamen and sailors that arrive Onne port regularly and many workers working in

the over 100 companies in and around Eleme and Elelenwo contribute to the problem of sexually transmitted diseases.

HIV/AIDS and STIs Control:

- Forcing prostitutes to get regular examination and treatment
- Better treatment to prevent the spread of resistant organism
- Good prophylactic drugs.
- Immunization against gonorrhoea, it is still at the trial stage.
- Examination and treatment of bar girls and other high risk groups.
- Utilization of special of STI health visitors or assistants based on wards in towns.
- Use of posters.
- Telling people to get contacts treated or giving contact slip
- Radio announcement about high prevalence
- Advising people on early symptoms and having more clinics which are more private and confidential in their management of the diseases.
- NGO's may be required to enhance Health education for secondary schools, youth groups, the communities, and other risk groups.

Schistosomiasis

The incidence of Schistosomiasis was very low being lower than 10/10,000 in the area. However whenever it occurred it is usually mistaken for signs of puberty and in some cases witchcraft.

Filariasis

The condition was of high prevalence. Many cases were sighted and this was in agreement with official hospital records.

Tuberculosis

The incidence of Tuberculosis was noted in two communities (Agbonchia and Elelenwo). The people involved were physically and clinically examined and there were overt signs of Tuberculosis. In one particular case the sputum of the patient contained blood in it, and the patient looking weak and wasted. Co-infection with HIV/AIDS was suspected

because the symptoms of both diseases are similar. During the FGD, the people also complained that TB which was hitherto unknown in their communities is now rampant. It was also noted that in some place, people lived in over-crowed houses which certainly predispose people to Tuberculosis as the diseases is airborne.

Tetanus

This is caused by mycobacterium tetani. This results from untreated wounds caused by fishing gears and stumps from the farm.

Non-Communicable Diseases

Food Poisoning

This was recorded only sporadically in the area as resulting from consumption of contaminated food. It caused vomiting, dehydration and body weakness.

Malnutrition

It is due to inadequate food intake or micro nutrient deficiency. Only in some parts of the community where the cases were recorded recently and where some children and few pregnant mothers presented with malnutrition. The pregnant mothers equally presented with oedema.

Injury

Occupational injuries occurred at the farms and while fishing and from fishing gears. Injuries are also sustained during fetching of fire wood, cutting of wood in the forest, building of boats, boat mishap and fire incident caused by fuel stored in the boats. Some other people get injuries from working in the numerous companies in Eleme e.g. during Tank cleaning and loading and offloading of scrap metals and demolition wastes.

Mental Disorder

There were few cases of mental disorder probably caused by substance abuse. Substance abuse is gradually becoming so much of problem in the communities that laws banning the use of substance in the public should be enacted. Substance abuse involves the use of marijuana, heroin and inhalation of poisonous chemicals.

Muscular - Skeletal Disorder

This condition described as rheumatism was common in the communities. Its prevalence rate was high in the community especially in adult over 50years of age. It manifested as rheumatic pains. It could be as a result of long standing during fishing and other manual works.

Hypertension

The blood pressures of the people in the project were determined using the blood pressure monitor (Sphygmomanometer). The prevalent rate of hypertension (blood pressure which exceeded 140/100mmttg) was high. The data showed that many people had blood pressures higher than 140/100. The people were randomly selected from the communities. The specific prevalent rate could not be determined due to insufficient data or records. It occurred more in adult men over 50 years of age. The hypertensive individuals complained of stress from economic hardship and family responsibilities. Hypertensive cases were more among adult males than in adult females of the same age. Juvenile hypertension was not recorded in any of the communities assessed.

4.11.5 Environmental Health Conditions

The entries in this section were compiled from field observation, questionnaire and interviews.

The noise and vibration levels from trucks traffics and aerial one are still within acceptable limits.

Treated municipal water was not observed in the communities. Water for drinking and domestic services are from streams, hand dug wells, mono pumps, rain harvesting, small pools and ponds. Water samples obtained from these ponds, pools had high coliforms counts higher than values recommended by Word Health Organization (WHO), Federal Ministry of Environment (FMEnv) for drinking water.

Refuse Disposal

There was no organized and managed waste management system. In the study area each household provides containers to collect the wastes mainly household/organic wastes.

Commercial wastes (papers, cartons, nylon bags) and canteen wastes (left-over foods yams and cassava peelings, cans, plastic containers) are usually taken to waste dumps scattered all over the place in Agbonchia, Aleto, Akpajo and Elelenwo.

The problem of waste management in the project area as in the case of Nigeria in general is a long term challenge that has become a huge concern for Nigerian cities and rural areas alike (Longe, E.O et a.l.2009).

Plate 4.11.4: Garbage observed near Nichia Super market

Waste management which is constitutionally the responsibility of local governments has been taken over by the state government. This is understandably so because as the local governments have proved their inability to handle the overwhelming challenge of waste management in all areas of the country.

Sewage Disposal

In the communities, there are generally little control over the disposal of both liquid and solid waste from industrial, dwellings, villages, factories, towns and cities. The control of the disposal of wastes of all kinds is necessary in order to improve and safeguard public health and to protect water resources.

Disease vectors

The vectors identified in the area include:

- Mosquito (particularly anopheles species and culex species) were abundant in the area especially in stagnant waters, drains, and in swamps where they breed. They transmit plasmodium which causes malaria.
- Tsetse fly (glossino species) transmits trypanosome which causes sleeping sickness in humans.
- House Fly (Muscadomestica) and latrine fly (fanniacanicularis) were common in refuse dump. They transmitted a wild array of disease agents including those of diarrhoea and dysentery.
- Snails occurred in the swamps and are host of shistosoma (s.haematobium and s.mansoni), that causes shistosomiasis characterised by frequent painful and bloody urination and blood in the stool respectively.

Water Supply

There is no functional Municipal treatment scheme sighted anywhere in the study area. Source of water supply included shallow hand-dug well, rivers, streams, ponds, rain harvesting, and a few sometimes non-functional bore holes. Some of these non-functional boreholes were provided by SPDC and Indorama and others by families/personal efforts. They are used for all domestic purposes including drinking and bathing, the water is not usually treated before use. Samples of water taken from such sources analysed in the laboratory showed high coliform count higher than the values recommended by WHO and Federal Ministry of Environment. The WHO has estimated that 80% of all sicknesses and diseases in the world are attributed to unhygienic water.

Water–borne diseases are among the leading causes of death in many developing countries today, Nigeria being a typical example. In addition to the alarming mortality rates, it is estimated that people in Nigeria and other developing nations lose 10% of their productive time because of diseases related to poor and contaminated water. Improvements in health are generally considered to be one of the most important benefits of water programmes.

Water Pollution; The pollution of natural waters in the project area by waste matter resulting from the industrial and human activities such as slaughter slabs by rivers, dredging and illegal sand mining are fingered as sources of river water pollution in the area

- Domestic sewage with high concentration of microorganisms, BOD, organic and inorganic and floatable matter.
- Pesticides and fungicides
- Oil & grease and oil dispersants from thousands of tanker trucks in the area.

Water Supply Needs of the Project Areas; Agbonchia, Aleto, Elelenwo, Akpajo need adequate safe, potable water supply, easy access is a major factor in raising the health standard of the people and its beneficial effect in the reduction of morbidity especially among children and infants have been established.

Provision of potable water supply represents in the final analysis a challenging worthwhile and lasting investment which benefits all by improving hygiene and reducing the incidence of water borne and water associated diseases. Majority of households in the study area rely on outdoor taps (usually from boreholes) for their water supply. Another proportion sinks the boreholes in their premises, and then pipes the water to their houses. Others use hand dug wells and rain harvesting as their source of water supply.

Plate 4.11.5: Water taps at Agbonchia

Cooking Practices

The most commonly used fuels for cooking in the area are firewood and kerosene. Wood is the most common fuel used for cooking, reported by 66 % of households. Indoor

cooking is also commonly practiced. Indoor cooking is prevalent in most of the locations. About, 45% and 43% in Eleme and Akpajo respectively all cook indoors.

Smoke generated from this practice may serve the additional purpose of preserving the wood and other ephemeral materials from which some make-shift houses are constructed, against insects and termites.

Cooking with firewood indoors exposes individuals to toxic air pollutants and can contribute to or aggravate respiratory infections, asthma, chronic bronchitis, and other health problems. The indoor cooking practice is common across Nigeria. According to the National Demographic and Health Survey (2008) about 40% of household cook inside their houses, while about one-quarter (25%) cook outdoors.

These mosquito species are major disease vectors. *Anopheles* transmits malaria parasites (*Plasmodium sp.*) and also known to transmit the filarial parasite: *Wuchereriabancrofti. Culex* species also transmit *Wuchereriabancrofti* while *Aedes* are the main vector of yellow fever. PCR analysis revealed *Anopheles gambiaesensustricto:* the most efficient African malaria vector as the only *Anopheles* species in the three clusters.

Mosquito Breeding Sites

Standing water are typical breeding sites for mosquitoes. Over 50% of the mosquito breeding sites identified in the surveyed area were anthropogenic due to the daily activities engaged in by members of the community. More of the breeding sites were also as a result of heavy rainfall and flooding coupled with poor drainages that lead to stagnant waters that support larval growth days after the rains, most of these sites were identified at Akpajo and Elelenwo.

Mosquito Control in Households

Almost every household surveyed uses at least one type of mosquito control method. The most common method is the use of bed nets, followed by mosquito coils and insecticide sprays. Other less common methods found in the surveyed area are insecticide treated nets, window netting, and nocturnal leaf burning.

Insecticide Susceptibility Status of Mosquitoes

The three mosquito species: *Anopheles, Culex and Aedes* are susceptible to the pyrethroid insecticide (Deltamethrin). This insecticide is commonly used for treating bed nets/ Long Lasting Nets and also employed for Indoor Residual insecticide Spray. However, the three species of mosquitoes identified in the area are resistant to DDT.

Source of Health Information in the study area

A significant proportion of respondents indicated electronic media (radio/Television) as their most important source of health information. The second most important health information sources are community health workers, whom they consider as doctors and nurses (Table 4.11.3). Other sources identified are friends, print media, and family. These sources of health information remain/ are consistent with results obtained in a 2012 HIA

Table 4.11.3 : Most Important Health Information Source

Location	Doctors/ Nurses	Friends	Print media	Electronic media	Family/ Relatives
Eleme community	36%	2%	9%	49%	4%
Akpajo	30%	4%	5%	57%	4%
Elelenwo	28%	5%	5%	60%	2%

Field study (EIA, 2012)

Access to Health Care Services

The health status of the local people range from good, fair and poor according to their own assessments. The main reasons given for poor health are poor social and health infrastructure, lack of potable water, poor education and the lack of good medical care. There are quite a number of medical facilities in the area but many are poorly staffed and underequipped especially at Akpajo and Elelenwo. The ones that are well equipped and well- staffed are not affordable by most families especially during this period of recession. This generally supports the findings on the ranking of development needs at Akpajo Elelenwo, which identified medical facilities as one of the first three needs in terms of priority.

Previous health survey indicates that about 10-15% of the respondents in the surveyed communities manage their health problems through herbal remedy and/or self-medication. The others visit/patronize one type of health facility or the other and still others patronize prayer houses or churches.

4.11.6 Indorama Medical center

Indorama operates a comprehensive medical center with the state of the art equipments, drugs supply, aesthetic and clean environment, adequate number of medical professionals, like Medical doctors, Pharmacist, Nurses and Laboratory scientists. It also has good occupational and health and safety professionals. Health conditions ranging from minor injuries like cuts, laceration and bruises to malaria, diarrhea, body pains, skin rashes, hypertension, respiratory distress and a number of other cases are handled at the medical center, complex and more difficult cases are referred to bigger hospitals such as BMH and UPTH etc.

Occupational health and safety department complements the effort of the medical center by emphasizing occupational health and safety issues reducing hazards, injuries and accidents. Management is completely committed to occupational health and safety issues. There is a general duty on employers to protect the health of the employee under the health and safety at work 1974 (HSWA) section 2 (1). There is emphasis on the prevention of risk to health of workers arising and where prevention is not possible however employers must control this risk/exposure to this risk.

This duty ensures the implementation of the number of strategies which must be related to the degree of risk. Other strategies are available as support strategies. Support strategies such as PPE (Personal Protective Equipment), health surveillance and provision of appropriate welfare amenities, provide extra protections if there are used correctly and on a regular basis. This occupational health and safety approach is strongly adopted and adhered to by the management of Indorama. This approach has drastically reduced accident and injuries, lost man hours and absenteeism due to ill health and incapacitation arising from injuries and accidents

4.11.7 Discussion of Findings

Many of the residents in the project area are quick to point out that there are health facilities without adequate personnel, equipment, adequate prophylactic drugs and drug revolving scheme in their communities. According to them, "People in the community have no option than to resort to unorthodox treatment/herbal healers for their health care needs". The nearest general hospital is located at Ogale in Eleme. For those at the communities of Akpajo and Elelenwo they have no other general hospital, they go to the one at Ogale when the need arises.

They further assert that the lack of finance, doctor/patient contact time and the attitude of health workers discourage the use of the only hospital in the study area by community members. Although largely improved due to improved facilities and good paved road network, as compared to earlier studies (Anyanwu 2012), but the regular traffic jam/chaos along the East/West road remain a major challenge in situations of emergency that would require an immediate evacuation.

In-depth interviews with the Traditional Birth Attendants (TBAs) suggest that the government should provide a functional health facility for the communities which could serve as a referral point and collaboration for orthodox and traditional medicine as these would go a long way in improving the health status of people within the environment. In most cases people who need medical attention in the community resort to patent medical store owners for advice or to alternative medicine which is diverse in the study area. In Elelenwo for instance, there is specialization in this form of healing. There are practitioners specializing in orthopaedic (Nbadiwe Amadi and Mgbualu Ehoro), ear and eye (Chief Ihianyi), paediatrics (Ebuchi Mgbamosu) remedies against snake bites (Ejekwu James) and epilepsy (ChikweleNjo). Similar specialization was cited by the panel on focus group in Agbonchia, for instance Chinwi Okparaji and Ada Wachi are bone healers in that community.

Africans attribute most illness to the supernatural and the prayers of their detractors. Some churches believe they can tackle such problems, so it is not unusual for churches to serve as spiritual healing homes, with the promise of cure as sure as orthodox medicine.

Healing homes appeal to the mindset of the common man, and the other attraction is that it is cheap and almost free. They nevertheless provide the succor patients crave for. There are healers whose talents are not entirely predicated on beliefs. They use herbs and psychology in their approach, an example is Inapow in Aleto (One of the host community). Traditional birth attendants are also well patronized in the study area. Recently NGOs and government outreach have been educating practitioners on how to improve on their knowledge of general hygiene and make referrals if faced with cases that are beyond their competence.

The choice of a health facility was also surveyed and convenient access was the most common reason for the respondents' choice. The reasons for the choice of place of last treatment ranged from 8.2% for considerate/courteous services to 35.7% for convenient access (Figure 4.11.1).

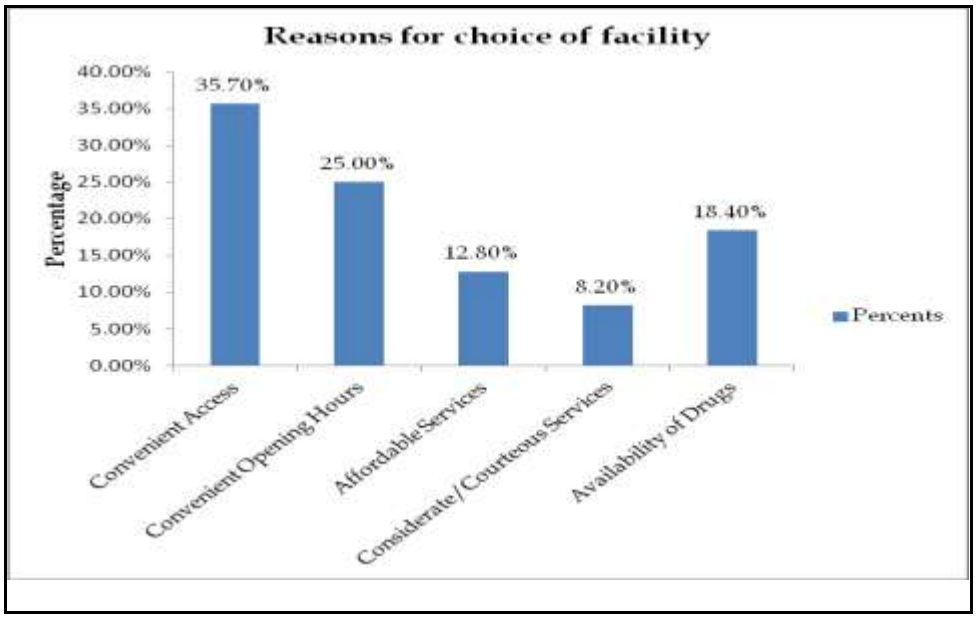

Figure 4.11.1 Reason for Choice of Health Facility in the Project Area

i. Health Programmes Supported by the Communities

Health-related activities embarked upon by the communities include environmental sanitation, community mobilization in support of National Immunization Day (NID) and financial contributions. Community associations involved in this practice are identified in the study area. Roles of these associations in health care include support for sick members through financial contributions, environmental sanitation and community mobilization

for major health programs. These organizations serve as informational vehicles for special health programmes.

ii. Traditional Health Care Providers

Traditional healers confirm that sometimes they are the first point of treatment for many people in the community and while some report health cases early, others come late. According to healers, those who delay do so because of apparent high costs of treatment, shame or ignorance.

Traditional health care providers also claim that they refer patients to the nearest orthodox medical facilities such as the General Hospital at *Ogale*, private clinics which involves movement of people from Elelenwo and Akpajo to Ogale and to the private clinics located outside their domain.

The healers do not only refer the patients but they also assist in getting the patients to the facility as reported by a group of key informants.

"We follow the patient to the PHC and we accompany the nurse at the center to travel with the patient. Usually the family of the patient finances this trip. Transporters usually assist the family in such emergency by asking the family to pay for fuel cost. Later the rest of the money is paid to the transporter".

Traditional healers also indicate that transportation is one of the major challenges to the practice of their trade. It limits access to places where they can purchase herbs for prompt treatment of their patients. Also some patients cannot afford their services.

iii. Overall Use of Health Care Options

Patronage of health facilities among respondents in stakeholder communities is commendable.

About 50% of the respondents visit Primary Health Centers (PHC) when they are ill.

However, the figures are higher at Agbonchia relative to Akpajo and Elelenwo. About 15% and 2% use self-medication and spiritual homes respectively.

Table 4.11.4: Distribution of Respondents by Sex According to the Type of Medical Facility they Visit for Treatment

Location	Sex	PHC	General hospital	Private hospital	Traditional clinic	Home remedies	Spiritual home
Ogale	Female	60%	7%	6%	13%	13%	2%
	Male	58%	9%	7%	10%	14%	2%
Akpajo	Female	45%	5%	7%	21%	21%	0%
	Male	47%	8%	9%	8%	28%	3%
Elelenwo	Female	46%	4%	6%	8%	35%	0%
	Male	40%	5%	10%	14%	28%	3%
PHC = Primary Health Care							

Pregnant women in the stakeholder communities are aware of the importance of ante natal classes during pregnancy. About 65% of respondents receive ante natal classes during pregnancy while about 36% do not attend ante natal classes. The figures are similar across the three communities. Despite the predisposition of pregnant women to ante natal classes, the women think that the quality of care during gestation is below minimum standard in some of the private clinics.

iv. Personal Assessment of Health

Generally, most (86.5%) of the respondents gave a positive appraisal of their health status. Only a small proportion (0.5%) rated their health as fair or poor.

v. Health Insurance Coverage

Health insurance improves access to health care, thus promoting good health. Reasonable access to health care encourages individuals to seek health maintenance services more regularly than they otherwise would, thereby prevent potentially serious illnesses. Focal group discussion revealed that taking health insurance to improve health condition was a utopian idea at this stage of the economy in the study area.

vi. Health Conditions

The assessment of health conditions of the community members was based on survey and hospital records. From the survey, majority of the respondents in all the communities surveyed (96%) reported that their perceived health condition was good, 3% reported a

bad health status while the remaining 1% said that their health status is undecided as they cannot give an affirmative response as to whether or not their perceived health status is good or bad. Malaria was reported by majority (88.5%) as the most prevalent health problem followed by Musco-skeletal disorders (3.3%) and rheumatism (3.5%). Reported cases of Typhoid fever was low (0.8%) while the remaining 1.7% reported other conditions such as headache, backache, hypertension, diabetes, peptic ulcer, rheumatoid arthritis, infertility, general muscle ache and bone ache as their common health problem.

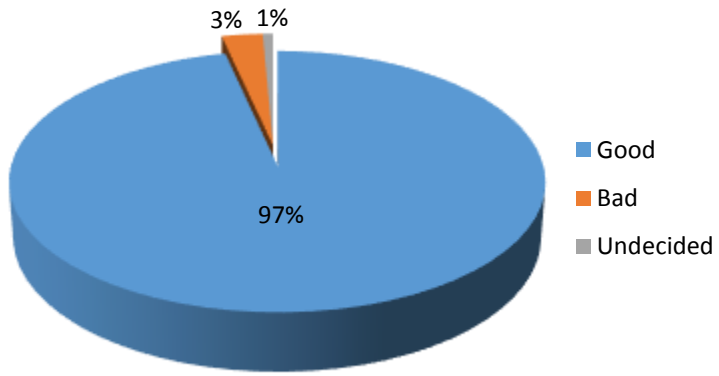

Figure 4.11.2: Perceived Health Condition in Surveyed Communities (2017)

vii. Common illness treated by Traditional Health Care Provisions

The table below summarizes the findings

Table No. 4.11.5: Most Common Illnesses/Disorders Treated by Traditional Health Care Providers for Children, Adults and Pregnant Women

Types of Illnesses/Disorders	Group Affected
Measles, malnutrition, convulsion, worms, new born tetanus, ear infection, teething problem, boils, headache, jaundice, cough, malaria	Children
Oedema, hernia, anemia, insomnia, weakness, lack of appetite vomiting, jaundice, miscarriage, spitting of blood, worms, haemorrhage, sepsis, poor development of foetus, malaria	Pregnant women
Hydrocele, prostate cancer, diabetes, stroke, malaria, rheumatism, eye problems, backache "peppering feeling in the feet ", STIs, impotence, worms, breast problems, ulcer, prolapsed of the womb	Adult men and women

Field Survey 2017

viii. Immunization Status of Children Under-Five

According to the World Health Organization (2007), a child is considered fully vaccinated if he or she has received a BCG vaccination against tuberculosis; three doses of DPT vaccine to prevent diphtheria, pertussis, and tetanus (DPT); at least three doses of polio vaccine; and one dose of measles vaccine. These vaccinations should be received during the first year of life. In Nigeria, BCG and Polio vaccine should be given at birth, DPT and polio vaccines should be given at approximately 6, 10, and 14 weeks of age. Measles vaccine should be given at or soon after the child reaches nine months of age. It is also recommended that children receive the complete schedule of vaccinations before their first birthday and that the vaccinations be recorded on a health card given to the parents or guardians.

The health survey on children immunization is presented in table 4.11.6. The table below shows the doses of each vaccine received by the children either by history or card and represent the improvement need for children immunization. More health education and enlightenment campaign programme is required to improve immunization awareness and levels.

Table 4.11.6: Immunization status of under-five children in the Community

Vaccines	Immunized		Not Immunized
	By History	By Card	
BCG	50.%	25.1%	14.9%
*OPV	36.3%	31%	36.2%
*DPT	48.6%	33.7%	17.3%
MEASLES	25.3%	40.7%	8.5%
*HEPATITIS B	47.6%	8.8%	17.3%

*At least a dose of the vaccine received by the child
(Field Survey 2017)

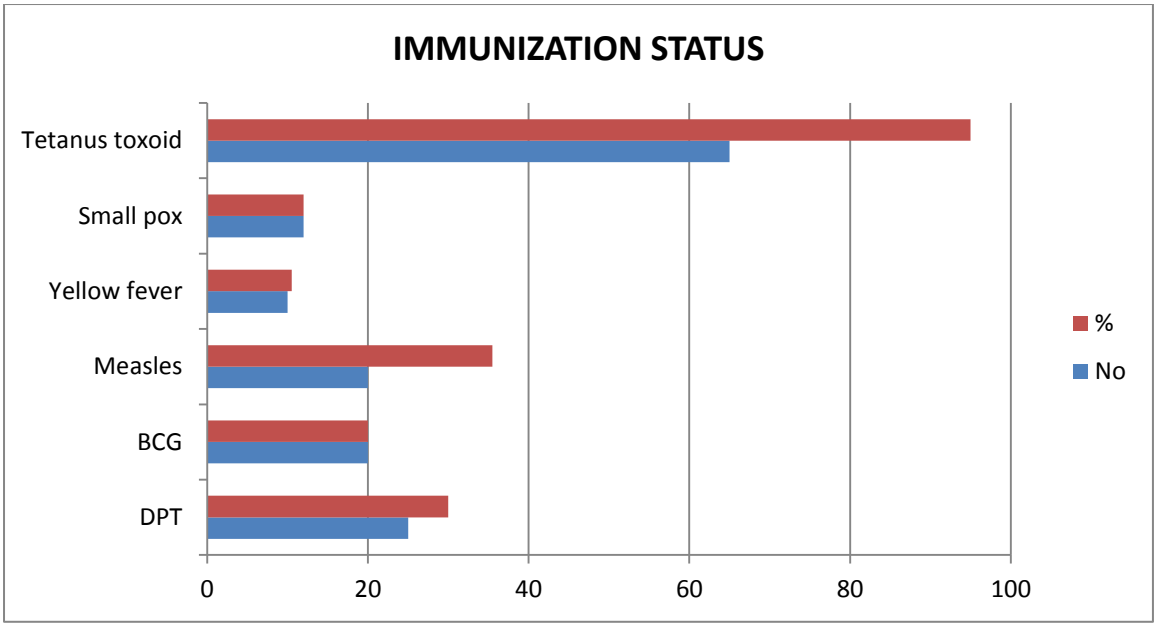

Figure 4.11.3: Immunization status of the area

4.11.8 Morbidity and Mortality Rates

Estimates for mortality rates obtained from medical records could not be relied upon completely in determining mortality rate in the host communities due to the inadequate health facilities and poor record keeping.

Infant Mortality Rate

Given the inadequacies of health care facilities in the project area, including the problem of under-reporting, it would be inaccurate to base the calculation of population mortality rates on the number of cases presented and recorded at health facilities. An estimate can be obtained by using the number of children reported to have died before their first birthday in the household surveys. This number is then divided by the total number of births in the preceding year as reported by respondents. A total of 128 births and 3 infant deaths were obtained thus giving an Infant Mortality Rate of: *Infant Mortality Rate (IMR) = 3 X 1000/128 = 23/1000.*

Infant and child mortality rates are basic indicators of a country's socio-economic situation and quality of life (UNDP, 2007). The rates are important for identifying population groups at risk; planning, monitoring, and evaluating population and health programmes and

policies; and monitoring progress towards the Millennium Development Goal to reduce child mortality by two-thirds by the year 2015.

Data from the 2008 NDHS indicate that the national infant mortality rate is 75 deaths per 1,000 live births, while the under-five mortality rate is 157 per 1,000 live births.

The national neonatal mortality rate is 40 per 1,000 births. Thus, almost half of childhood deaths occurred during infancy, with one-quarter taking place during the first month of life. Child mortality is consistently lower in urban areas than in rural areas (CDC, 2005). There is also variation in the mortality level across zones. The infant mortality and under-five mortality rates are highest in the North East, and lowest in the South West (CDC, 2005).

Maternal Mortality Ratio

A total of 2 maternal deaths are reported in relation to 128 births during the preceding year (Akpajo community). This would give the maternal mortality ratio as follows:
Maternal Mortality Ratio = 2 X 1000/128 = 16/1000

Crude Mortality Rate

Crude mortality rate was estimated in a similar manner as the infant mortality rate by using the estimated total population of the sampled households and the total number of deaths reported by the respondents during the survey. Out of a sampled population of 2729, in an early study, a total of 22 deaths were reported in the preceding year giving a Crude Mortality Rate of: Crude Mortality Rate (CMR) = 22 X 1000/2729 = 8/1000.

It should be noted that this estimate is based on deaths reported by respondents, and could not be verified due to the lack of mortality records. Respondents may have reported fewer deaths than actually occurred. This would explain why the crude mortality rate estimated is much lower than the national crude mortality rate of 14/1000 (NPC, 1991).

In 2016, the prevalence of reported deaths among households in the last one year from available records indicate that mortality ratio was highest at Elelenwo and least at Akpajo.

Birth Rate

Based on the findings of the household survey, a total of 128 births are reported in the preceding year. Given the estimated total population of the sampled households which is 2729, the birth rate for the project area is estimated as:

Birth Rate = 128 X 1000 / 2729 = 47/1000.

This is slightly higher than the value of 42/1000 reported for the entire country but closer to the value of 45/1000 reported for rural areas (NDHS 2003).

Reported Causes of Death

The leading cause of death in the area is malaria fever followed by typhoid fever, respiratory problems, and child birth

Table 4.11.7: Reported Causes of Death in the Project Area

Reported Cause	Percent
Asthma/Cough	11%
Convulsion	5%
Body Pains and Spots	5%
During Child Birth	11%
Loss of Blood	5%
Malaria/Fever	26%
Typhoid	16%
Premature	5%
Other Sickness	11%

Field Survey 2017

4.11.9 Social issues affecting Health

The WHO (2011) reports that the harmful use of alcohol is a worldwide problem resulting in millions of deaths, including hundreds of thousands of young lives lost. It is not only a causal factor in many diseases, but also a precursor to injury and violence. Furthermore, its negative impacts can spread throughout a community or a country, and beyond, by influencing levels and patterns of alcohol consumption across borders. Indeed, people who drink alcohol excessively (over two drinks per day) have a one and a half to two times increase in the prevalence of hypertension. The association between alcohol and high

blood pressure is particularly noticeable when the alcohol intake exceeds 5 drinks per day. Moreover, the connection is a dose-related phenomenon (WHO, 2010).

Smoking on the other hand increases the risk of vascular complications (for example, heart disease and stroke) in people who already have hypertension, it is not associated with an increase in the development of hypertension (CDC 2006).[8]

The health surveys in the host communities suggests that more than a tenth (12%) of the households have someone who smokes, while more than a quarter (29.8%) of the households have one or more persons who drinks alcohol. Beer is the most commonly consumed, followed by gins. Other forms of alcohol reported to be consumed are spirits and other wines. Marijuana use was reported in less than 1% of households, and no other drug substance use was reported

HIV/AIDs

HIV/AIDS is a global crisis, a challenge to human life and dignity with ability to erode social and economic development. It has great influence on stability, life expectancy and economic development. It is a major public health problem with Sub-Saharan Africa severely affected by the epidemic.

UNAIDS in its 2008 global report stated that although HIV prevalence is much lower in Nigeria than in many other African countries such as South Africa and Zambia, the large size of Nigeria's population meant that by the end of 2007, there were an estimated 2,600,000 people infected with HIV in Nigeria and approximately 170,000 people died from AIDS in 2007 alone. In recent years, life expectancy in Nigeria has declined partially as a result of the effects of HIV and AIDS.

Table 4.11.8: Family History of Tobacco Smoking

Smoking	Frequency	Percent
No	18	85.7
Yes	3	14.3
Total	21	100.0

Field Survey 2017

Table 4.11.9: History of alcohol Consumption

Alcohol	Frequency	Percent
No	15	71.4
Yes	6	28.6
Total	21	100.0

Field Survey 2017

In 1991, the average life expectancy was 53.8 years for women and 52.6 years for men (UNFPA, 2005). The 2007 estimate had fallen to 50 years for women and 48 years for men. Poverty, low literacy levels, high rates of casual and transactional unprotected sex in the general population, particularly among youth between the ages of 15 and 24, low levels of male and female condom use, cultural and religious factors, as well as stigma and discrimination are reported to be major factors in the transmission of HIV in Nigeria (study community).

HIV has the potential of hindering the realization of the Millennium Development Goals and its spread promotes poverty, and has unleashed immense suffering on different countries and communities worldwide.

There is a declining trend in the prevalence of HIV / AIDS in Nigeria, after it peaked in 2002 from 5.9% to 4.6% in 2008. This decline is due to the several national and international intervention programmes (UNAIDS, 2008).

HIV/AIDS Prevalence in the Project Area

There are no available records on HIV/AIDS prevalence in the project area. However, a general prevalence can be discerned from regional and national studies on HIV/AIDs. According to the national sentinel study on HIV/AIDs (2005), Rivers State, where the surveyed communities as well as the project site are situated, has a prevalence of 2.1-4.0% (MDHS-1986). This figure is less than the national average (4.4%) and corresponds to the lower tier of prevalence in Nigeria.

The awareness on HIV/AIDS is generally high in Nigeria, although attitudes to preventive measures are not commensurate. This awareness is also reflected in the

study area. However, cases of HIV /AIDS among residents in the surveyed households are only skeletally reported.

4.11.10 Health Needs of the Community

The needs of the community as gathered from the questionnaire, focal group discussions and informal discussions include:

- Uninterrupted sources of potable water as well as improved and accessible health care facilities;
- Training of health manpower (i.e. community health workers (CHEW),nurses, doctors, medical lab scientist, occupational health therapies radiographer and radiologist);
- Training of traditional birth attendants and traditional medical practitioner on hygienic procedures;
- Regular Immunization Programs, provision of facility for prompt/emergency response such as ambulance, mobile clinics;
- Monitoring and surveillance for early detection of epidemics;
- Health insurance schemes to make health care accessible and affordable to the people.
- Regular Town Hall talks on Environmental Health.

4.12 STAKEHOLDER ENGAGEMENT / CONSULTATION

Meaningful public and stakeholder participation and engagement is the cornerstone of any successful environmental assessment of a project. Not only the public and stakeholder consultation required as part of Nigerian environmental impact assessment (EIA) legislation and IFC Environmental Guideline, an open and meaningful public engagement program undertaken as part of the EIA of a project contributes to building positive community relations, and generally assists in the acceptance of, or co-existence with, a development proposal.

In Nigeria all EIA legislations require that the proponent of a project demonstrate that the potentially affected public and other stakeholders have been given a meaningful opportunity to provide comment and raise any concerns they may have about the project, as part of the EIA process. In addition, the proponent must incorporate the relevant feedback received from such stakeholders into the EIA report, and must demonstrate how it has considered or addressed (or how it intends to consider or address), as appropriate, the issues raised by the public into the EIA and subsequent development of the project.

The primary objectives of the consultation were to:

- Identify stakeholders for the proposed IEFCL-Train2 project;
- Explain to host communities and other stakeholders about the proposed project activities/operations and ensure exchange of information that will facilitate good working relations; see public engagement briefing document Appendix 4.12
- Identify and address issues and concerns of stakeholders early;
- Incorporate the relevant feedback obtained from the public, stakeholders, and regulatory agencies into the EIA Report for the Project, as well as in the business decision-making process for the Project;
- Meet statutory requirement.

The project team held series of stakeholder consultation sessions. Initial discussions and consultation were initiated with the stakeholders, including the business community, government, community groups and neighbours, to obtain information on any initial

concerns that these and other stakeholders may have about the Project. The consultation sessions culminated in a scoping workshop. The stakeholders identified for the project and who participated in the various consultation sessions included communities within the project area and the regulators, and where adequately engaged through:

- scoping workshop,
- baseline data gathering,
- focal group discussion,
- questionnaire administration
- Public forum etc.

Communities concerns that were apparent in the community stakeholder engagement are summarized below:

- Can two fertilizer plants be sited in a particular place?
- Traffic congestion and pollution as a result of heavy traffic.
- Environmental impact of proposed project to human health
- The capacity of Okulu stream to handle effluent from the proposed Train2 project
- How will the project consider women.
- Will the project give employment to Eleme people
- The benefit of the project to host community
- Migrants from other regions may take most jobs and dominate most of the business as it is already visible in the area.
- The other major concern of the host communities is the lack of good potable water, basic social amenities like road infrastructure, and steady electricity in the area.
- Another important concern of the communities was the dilapidated nature of some schools in the area and prayed that Indorama through corporate social responsibility should continue to give support in this area.
- Most people mention the possibility that migrant workers might bring diseases that are not common in the area.
- Safety problems from the increasing numbers of big trucks to be used during construction work and operation in form of product lifting.

- Transportation of finished products from the factory will cause congestion on the already stretched public road.

Community expectations

Views on expectation of what the proposed project should bring to the people were unanimous and the people ranked them in the following order of priority.

- Employment/scholarship and contract opportunity to host communities
- Improved basic social amenities such as good boreholes in each community
- Improved health care facility.
- Build a training center to enable new skill development
- Consider host community first in terms of employment opportunities

The complete proceedings of stakeholder's engagement carried on the 17th November 2017 is attached as Appendix 4.12

4.13 CORPORATE HEALTH AND SOCIAL RESPONSIVENESS

The present report also reviewed how the proponent had responded to the social and health needs of the host communities.

The Company's Philosophy of Corporate Social Responsibility (CSR)

- Indorama-Nigeria Group strongly believes in being socially responsible and responsive, especially as it related to health, safety and environment, as well as community development and empowerment.
- The Company firmly believes in the concept of Corporate Social Responsibility (CSR) or Corporate Social Investment (CSI) as a major integral part of business operations.
- In this regard, the company makes conscious or deliberate effort to include public interest and sustainability in corporate decisions involving people, plant and profit.
- Consequently, the Company considers the welfare, wellbeing, healthcare and socio-cultural issues of the host communities, surrounding or neighboring communities and the larger society.
- The Company firmly believes in giving back to society part of its fortunes in appreciation of good neighborliness and good corporate citizenship.
- Areas of community interventions include providing employment opportunities, youth empowerment programs, micro-credit for vulnerable groups such as widows, construction of roads, and providing social amenities such as building of schools, rural electrification, water supply, healthcare; etc.
- The Company strongly believes in the sustainability of its CSR programmes through needs analysis and community participation in all corporate interventions and executions.

Sustainable CSR Programmes for Host Communities

In the past ten years, the companies have executed many community development programmes such as building of schools, construction of roads and drainages, rehabilitation of hospitals and supply of medical equipment and electrification projects.

Others includes award of scholarships to indigent undergraduates from Eleme and Elelenwo, employment opportunities for indigenes, sponsorship of worthy events, donation of drugs and food items to some charity organizations in the area and youth empowerment programmes.

In specific terms, the companies have achieved the following CSR millstones in the following areas:

Socio-economic Financial Empowerment

- The biggest of Indorama's CSR programmes is the allotment of 7.5% shares of the company to six host communities of Akpajo, Aleto, Agbonchia, Elelenwo, Njuru and Okerewa as a successful example of private - public partnership.
- This has created tremendous value and engendered significant economic activities in the communities. More than N20 Billion has accrued to the host communities through this intervention since 2012.
- The company has created over 3,500 direct and indirect employment opportunities to indigenes of the six host communities, the pipeline communities and neighboring communities. This has significantly increased their socio-economic wellbeing of the workers and their families and other dependents.
- The company's micro-credit scheme has been able to empower many widows and other vulnerable groups in the six host communities who are into micro businesses.
- Indorama has created a pool of entrepreneurs from the host communities. Capacity of a people to earn income and generate employment has been developed.
- Lots of contract jobs have been given to host community contractors ranging from civil, electrical, logistics, labour supplies, car hire, equipment leasing, asphalting of roads in the complex, security on the company pipelines, etc.

Education:

- Building of a massive secondary school complex (boys and girls) for Aleto community (one of the host communities). The school comprising 12 classrooms, Principal's office, staff offices, science laboratories, sick bay, etc. was commissioned and handed over to the community leaders on 11th January 2017.
- Donation of 79 sets of solid high quality seat-fitted tables to the Nigerian Navy Basic Training School, Onne, Rivers State;
- Has awarded scholarships to 30 indigent students of Eleme/Elelenwo extraction doing engineering and other science related courses in universities and polytechnics. For Engineering Courses are for five years while others are for four 4 years.
- In 2008, the company organized a graduate training program for host community engineering students with zero experience and later absorbed them as staff. The company shall consider it again as personnel requirement improves.
- Purchased a plot of land in Aleto community and constructed ICT and Skill Acquisition Center, which is operational and functional now.
- Indorama donated N10 million to the University of Port Harcourt Centre of Gas, Refining & Petrochemicals to sponsor an international conference to add value to the education and knowledge sharing for national development.

Healthcare:

- Indorama carried out a full renovation of the Nchia General Hospital Eleme and donated drugs and medical equipment worth Eighty Million Naira (N80,000,000) to the hospital.
- To make the hospital fully functional, Indorama embarked on building of doctors' and nurses' quarters, and building of a major emergency entrance/exit road in the hospital. All these have been commissioned.
- As a follow up to the hospital renovation, Indorama organized a two-day Free Eye Camp in which about 500 persons with eye diseases were diagnosed and treated free of charge.

- At various times, Indorama has donated drugs and food items to Daughters of Charity, a Catholic charity organization, which takes care of the poor and needy in the Eleme and environs.
- Indorama healthcare interventions also are extended to the larger society. In March 2013, the company donated various sets of medical equipment to the University of Port Harcourt Teaching Hospital.
- Another donation of medical equipment worth millions of naira was also made to the Braithwaite Specialists Memorial Hospital (BSMH), Port Harcourt (owned by the Rivers state Government) in August 2017.

Infrastructure

- In July 2015, Indorama donated N530 million in an initiative of the Rivers state Government to rehabilitate the Eleme – Onne axis of the Federal highway which had become impassable and causing terrible hardship for motorists and workers.
- The company has done quite enormous number of developmental projects in the host communities including
  (a) Building of roads in Elelenwo and Agbonchia communities,
  (b) Electrification project in Njuru and Akpajo communities,
  (c) Building of modern secondary school in Aleto community.
  (d) In each Community the company has expended N26M (N52M for 2 Communities).
  (e) Each community has 600 MTR road and Electrification project consisting of erection of 36 High Tension Poles, 22 Low Tension Poles to cover 1KM, Installation of 1KM long HT and LT Cables and procurement & installation of 500KVA Transformer to power the HT/LT Cables.
- Indorama Eleme Petrochemicals Ltd and its sister companies have made lives better to its host and transit community as well as the larger society through its numerous corporate social responsibility (CRS) initiatives.

Conclusively, Appendix 4.13 has been attached to show full details and status of CSR projects to the host community.