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ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE AJAOKUTA – OBAJANA GAS PIPELINE PROJECT

(FINAL REPORT)

FEBRUARY 2004

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LIST OF ABBREVIATIONS AND ACRONYMS

APHA	-	American Public Health Association
ASTM	-	American Standard Testing on Materials
AG	-	Associated Gas
AGG	-	Associated Gas Gathering
BH	-	Borehole
BOD	-	Biochemical Oxygen Demand
CA	-	Community Assistance
C	-	Carbon
CAP	-	Chapter
Ca	-	Calcium
$CaCO_3$	-	Calcium Carbonate
cfu	-	Colony forming unit
Cl	-	Chloride
cm	-	Centimeter
CO	-	Carbon monoxide
COD	-	Chemical Oxygen Demand
Cr	-	Chromium
Cu	-	Copper
dB	-	Decibel
DEP	-	Design and Engineering Practice
DO	-	Dissolved Oxygen
DPR	-	Department of Petroleum Resources
DS	-	Dissolved Solids
EA	-	Exchangeable Acidity
EC	-	Electrical Conductivity
ECEC	-	Effective Cation Exchange Capacity
ELO	-	Environmental Laison Officer
EIA	-	Environmental Impact Assessment
EMP	-	Environmental Management Plan
ESD	-	Emergency Shut Down
E&P	-	Exploration and Production
Fe	-	Iron
FEPA	-	Federal Environmental Protection Agency
FMENV	-	Federal Ministry of Environment
g	-	gramme
ha	-	hectare
HAZOP	-	Hazard in Operation
HAZID	-	hazard identification
hr	-	Hour
H	-	Hydrogen
HHWS	-	Highest High Water Spring
HSE	-	Health Safety and Environment
HCO_3	-	Bicarbonate
h^1	-	level at time t^1, (m)
H_2O	-	Water
H_2S	-	Hydrogen sulphide
ITCZ	-	Inter tropical Convergence Zone
ITF	-	Inter tropical Front
ITD	-	Inter tropical Discontinuity

IUCN	-	International Union for the Conservation of Nature and Natural Resources
K	-	Potassium
kg	-	Kilogramme
m	-	metre
meq	-	milli equivalent
Mg	-	Magnesium
Mn	-	Manganese
mg	-	milligramme
MJR	-	Maintenance Job Routines
ml	-	millilitre
LNG	-	Liquified Natural Gas
mm	-	millimetre; million
mmscfd	-	million standard cubic feet per day
Mn	-	Manganese
mS	-	milli-siemen
MT	-	Tropical Maritime
N	-	Nitrogen
Na	-	Sodium
NGO	-	Non-Governmental Organisation
NTU	-	Nephelometric Turbidity Unit
NH_4	-	Ammonium ion
NIFOR	-	Nigeria Institute for Oil Palm Research
NNPC	-	Nigerian National Petroleum Corporation
nm	-	nanometre
No.	-	Number
NO_2	-	Nitrogen (IV) oxide
NO_x	-	Nitrogen oxides
NPC	-	National Population Commission
%	-	Percentage
O_2	-	Oxygen
OPEX	-	Operational Expenditure
OSD	-	Operational Shut Down
P	-	Phosphorus
Pb	-	Lead
pH	-	Hydrogen ion concentration
PII	-	Pipeline Integrity International
PO_4	-	Phosphate
ppm	-	parts per million
PPE	-	Personal Protection Equipment
PTS	-	Permit to Survey
PtCo	-	Platinum cobaltnitrate
QA/QC	-	Quality Assurance/ Quality Control
RH	-	Relative humidity
ROW	-	Right of Way
SAFAN	-	Safety Analysis
SD	-	Standard Deviation
SPM	-	Suspended particulate Matter
SO_2	-	Sulphur dioxide
SO_4^{-2}	-	Sulphate ion
SPDC	-	Shell Petroleum Development Company of Nigeria Limited
SS	-	Suspended Solids

SYSOP	-	System and Operability
t	-	time
TDS	-	Total Dissolved Solids
THC	-	Total hydrocarbon
T^oC	-	Temperature in degree Celsius
TOR	-	Terms of Reference
TS	-	Total Solids
TSS	-	Total Suspended Solids
µ	-	Micron
V	-	Vanadium
VOC	-	Volatile Organic Carbon
WHO	-	World Health Organization
WS	-	Water Sampling Station
µs	-	micron siemen
µg	-	microgramme
µm	-	micrometre
Zn	-	Zinc

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ACKNOWLEDGEMENT

Dangote Industries Limited wishes to acknowledge the Federal Government of Nigeria for the opportunity given to her through its agencies to conduct this Environmental Impact Assessment (EIA), in support of the Ajaokuta-Obajana Gas Pipeline Project.

We are grateful to the Federal Government and Kogi State Government for their support for the project. We also acknowledge the support of Paramount Chiefs, Emirs and Community Elders during the consultation process. We particularly give our thanks to the Paramount Chiefs and Emir for attending to us promptly, even without prior booking.

The contributions of the Environmental Consultant –Ambah Project International Limited commissioned to execute this EIA is also acknowledged and commended.

We acknowledge the wonderful support of private, public organizations and individuals too numerous to mention by name-they allowed us uninhibited access to their database for the success of the EIA process.

Lastly, the contribution of Dangote Industries Limited Environment Matters Unit towards the success of the project is also acknowledged.

EXECUTIVE SUMMARY

INTRODUCTION

Background

This report represents the EIA of Ajaokuta-Obajana Gas Pipeline Project. Dangote Industries Limited in conjunction with Kogi State and the Federal Government of Nigeria proposed to build a modern cement factory at Obajana in Kogi State. The factory shall be equipped with a 75 MW – 100 MW Gas/Steam turbines to generate its own electric power for use by the cement kilns and other production processes. The natural Gas supply will originate from a suitable tie-in point on the NGC Oben - Ajaokuta gas supply line. The envisaged gas volume requirement is 62.40 Mmscfd.

The proposed gas pipeline will be hooked to and existing NGC gas line at Ajaokuta and will run along the edge of the (Okene-Ajokuta) dual carriage road for over 32 km to Eganyin village. The pipeline will then join an existing ROW belonging to NNPC/PPMC from Eganyin to Lokoja/Kabba junction about 37km. The pipeline will continue from Lokoja/Kabba junction to Obajana for a distance of about 21km, where a metering station will be built for final gas treatment. Over 53km ROW is envisaged to be acquired for the pipeline route. The project in a long run will enhance power supply to the cement factory and boost cement production in the country.

Nigeria

Nigeria is the largest and most populous country in sub-Saharan Africa. It lies between latitudes 4^o and 14^o North of the Equator and longitudes 3^o and 14^o East of the Greenwich Meridian. It has a geographical area of 923,768km^2 and a population of approximately 88.5 million by the November, 1991 Census. It is bordered by Chad and Niger Republics to the north, Cameroon to the East; Republics of Benin and Togo to the west and the Atlantic Ocean to the south. It is made up of several ethnic groups, the major ones being Hausa, Fulani, Igbo, Yoruba, Edo, Efik Ijaw and Kanuri.

The Applicant

Dangote Industries Limited is a member of the Dangote Group, which is a leading and corporate responsible organization in Nigeria with its operational headquarters in the bustling metropolis of Lagos. The group is a collection of companys involved in various activities such as manufacturing, packaging and distribution of consumer and industrial food products. Some of the manufactured products include cement, building materials, and textiles. It is one of Nigeria's foremost-diversified business conglomerates, with a hard-earned reputation for excellent business practices.

Administrative & Legal Framework

Specific statutes guiding the project include:

- The petroleum act of 1969.
- Environmental Guidelines and Standards for the Petroleum Industry in Nigeria, DPR, 1991.
- The National Environmental Impact Assessment Decree No. 86 of 1992 (FEPA).
- IUCN and World bank regulations on environmental assessment

Declaration
Dangote Industries Limited in its capacity as the promoter and operator of the Gas Pipeline and Obajana Cement project on behalf of the Federal Government of Nigeria and Kogi State Government hereby declares her intention to abide by the existing international and national laws and regulations regarding environmental protection during the construction and operation of the Ajaokuta-Obajana Gas Pipeline Project. DIL is committed to the implementation of the Environmental Management Plan (EMP) proposed in this EIA report.

Need for the Project
The development of the proposed gas pipeline from Ajokuta to Obajana is undertaken to:

- Utilize abundant natural gas to power cement kilns and generate electricity of 75-100mw capacity at the proposed Obajana Cement Plant.
- Provide cheaper, cleaner and more efficient fuel for the cement factory production lines and operations;

Value / Benefit of the Project
The proposed Obajana cement factory shall enjoy quality and more reliable electric power supply. Consequently, the cost of production will be lowered due to the use of cheaper and cleaner source of energy, this will in-turn lower the cost of cement in the country.

Envisaged Sustainability
Complete reliance on NEPA with the present low/inadequate generation of electricity in the country by industries and individuals will lead to low activities culminating in facility under-utilisation. Gas, a by-product of oil production is presently being flared. Gas utilisation by industries to generate power, turning of kiln, etc. is a welcome development. Gas reserves in Nigeria runs into over 170 trillion cubic feet (tcf), and can be harnessed and put into commercial use. It is therefore hoped that the gas supply project to the cement factory can be sustained for a very long time - more than 25 years.

Project Alternatives

Gas Pipeline Development Options
No Action - This option would favour continued reliance on existing inadequate NEPA Power Supply to Obajana Cement Plant. This alternative was rejected because the present power load for Obajana cement factory of about 75-100mw cannot be met by NEPA alone.

Use Natural Gas to Produce Electric Power for Obajana Cement Factory
This option is **acceptable** due to the following reasons: Natural gas is readily available in Nigeria; utilisation of natural gas to produce power for electricity and turning of kiln is cleaner and more environmentally friendly, than liquid or solid fuels; the growth and increase in productivity of the Obajana Cement Factory will create more employment opportunities for the people.

Gas Pipeline Route Options
i. A new ROW route from NGC gas manifold at Ajaokuta Steel Complex along the Ajaokuta – Okene dual carriage road to Eganyin, passes through Itakpe Iron Ore Company, cut across Okene-Abuja road runs and terminates at Obajana.
This route was **not acceptable**.

2 The proposed new pipeline route from NGC gas manifold at Ajaokuta Steel Complex along the Ajaokuta – Okene dual carriage road to join the existing Pipeline Product

Marketing Company of NNPC (Oben –Kaduna) pipeline route at Eganyin in Ajaokuta Local Government Area and veer-off at Lokoja-Kabba junction to Obajana.

This **route is accepted** because of the following considerations:

- Avoidance of settlements
- Avoidance of archaeological sites particularly shrines and burial grounds
- Avoidance of natural routes for the movement or migration of animals
- Avoidance of forest reserve areas
- Acquired 53km of ROW as 37km of the route is already acquired by PPMC
- Avoidance of land areas with rock-outcrops or very shallow soils (< 2m deep).

Gas Pipeline Size Options

10" Pipeline

Although, this size is the least expensive of the four sizes considered, it was rejected in view of the fact that using pipe of this size will generate very high inlet pressures (up to 90 bar) that are higher than the maximum allowable operating pressure. Also, the throughput is far less than the gas demand by the cement factory.

16" Pipeline

This option was **rejected** in view of the fact that it has low liquid flow velocities that encourage scale deposition and internal corrosion problems. This size of pipeline is also the most expensive and has excess spare capacity.

18" Pipeline

This option was **accepted** because of the fact that, maximum inlet pressures in the peak years are about 40 bar (in the event of the Oben-Ajaokuta pipeline being derated to 40 bar due to age and disuse). The liquid flow velocity ranges from 0.35-2.5m/s. It has ullage for future expansion. The lower limit of the liquid flow velocity is above 0.3m/s, which is the minimum recommended by Pipeline Integrity International (PII) for pigging operations, while the upper limit is within the acceptable range.

Project Scope

Design, Procure, Install/Commission

- Develop the gas pipeline tie-in point to existing NGC Oben - Ajaokuta gas supply pipeline to Ajaokuta Steel Company;
- Engineering and construction of a 18" x 90-Km pipeline of API 5L X52, class 600;
- Install adequate Pigging manifolds and block valve stations;
- Establish a 70 Mmscfd capacity Gas Treatment/Metering Station about 1km to Obajana cement factory or within the cement yard;
- Acquire a (25 M) new pipeline right-of-way (ROW).

Location of Project

The Ajaokuta – Obajana Gas Pipeline Project falls within the following Co-ordinates 377641.9-450000N and 426764.5-475000E. The settlements along the route are mainly Ebira, Bassa, Gwari, Oworo and in some cases Hausa, Ibo, Tivs and Yoruba migrants. The main occupations are crop farming, animal husbandry, fishing and petty trading.

Pipeline Activities

Various sections of the pipeline length will be constructed in several stages, each by the main construction team. The activities of this team would result in sections of fully welded pipe, which would be laid in the trench and backfilled. Additional activities would involve field

bending of pipes, installation of manifold/valve stations and major water, road and railway crossings also operate as necessary.

In each stage, the pipeline laying and construction shall be through a cut and fill process.

Construction
Construction of the gas pipeline will be executed in accordance with a standard planning framework that will be reviewed as it becomes expedient by project team to ensure:

- Maximum efficiency in construction;
- Minimum adverse environmental and health impacts;
- Earliest completion time;
- Compliance with the laws of the land and all regulatory requirements.

Operations Control/Monitoring of Gas Pipeline
Pipeline pressure will be monitored at the pipeline manifold (valve) end at Ajaokuta and flow will be measured at the terminal points at Obajana. These measurements will act as additional indicators that the pipeline integrity is being maintained. Communication between the operations at the Ajaokuta terminal and the terminal at Obajana will be via both radio and telephone systems.

Maintenance and Inspection
Regular surveillance of the pipeline route will form an integral element of the integrity monitoring system.

Wastes and Disposal Activities
Effective and responsible handling and disposal of wastes are key elements in environmental management system. Wastes refer to any material (solid, liquid, gaseous or mixture) that is surplus to requirements. Wastes generated shall be segregated and disposed off in accordance with the Kogi State waste management guidelines.

Commissioning and Decommissioning/Abandonment
At the completion of installation of pipeline, pressure testing shall be carried out before commissioning. A period of two months shall be required before final testing of the pipeline. The project will be commissioned 21 months after kick-off of project execution. The pipeline is designed to last for a minimum of 25 years.

Schedule
EIA as a frontline activity for the proposed project is schedule to last for six months, material procurement will last for one month, logistic arrangement (movements of materials) will last for over three weeks, excavation and installation of the pipeline will last three months.

Existing Environmental Conditions
Relief/Topography/
The terrain heightening of most of the areas under study ranges from elevation of 45 - 205m. However, within these ranges, some isolated areas rise up to 400m particularly between Ajaokuta and Itakpe iron ore areas.

Climate/Meteorology
The project area is within the Savanna zone associated with high temperatures (31.2 – 36.9^{O}), low humidity and cloudless sky for most of the year. There is a marked wet and dry seasons. The dry season starts around November and ends in March/April. The effect of the dry dusty

northeast trade winds is strongly felt because of the latitudinal position of the area. The wet season on the other hand, occurs between the months of May and October.

Relative humidity, are low in early March (dry season) at around 40% and increases to over 94% during September in the wet season. The total annual rainfall varies between 1000mm to 1250mm. The wind speeds are lower in the nights than during the days. Ranges of 2 m/s and 20m/s are recorded for the Guinea Savanna area of Nigeria.

Air Quality and Noise

With the exception of SPM concentrations that exceeded the limits around Ajaokuta and Itakpe areas, the concentrations of all other air quality parameters measured were below FMENV limits.

The noise levels varied from 39.8 to 69.8dB(A). A high value of 69.8dB(A) was recorded near the NNPC pump station at Lokoja during the dry season.

Soil

The soil types observed ranged from sand to loam with the sand fraction varying from 68.3-95.3%. The percentage sand content generally decreased with depth at any particular sampling point. The percentage silt content varied from 2.3 – 20.7% while the clay content varied from 2.3 – 20.0%.

The soils are acidic to slightly alkaline (pH 3.8 – 7.6). The electrical conductivity values were low (15.3 – 270µs/cm) indicating that the study area is within the fresh water zone. The carbon concentrations (0.42 – 4.19%) were adequate to high compared to the critical level of 1%. The total nitrogen of the soils were low to adequate and ranged from 0.01 to 0.9% compared to 0.15 to 0.20% for moderate ranges in soil.

The phosphorus concentrations ranged from 0.2 - 62.7ppm and most of the values fall within the accepted range of 7.0-20.00ppm for agricultural purposes.

The soil macro-fauna encountered within the study area include various arthropods (insects, millipedes, mites termites), molluscs (snails), annelids (earthworms) and nematodes.

Vegetation

The vegetation of the entire study area is savanna woodland. It includes the vegetation of the southern and northern Guinea savanna types. Generally, this ecological zone is made up of mixtures of trees, shrubs, herbs and grasses. The vegetation along the pipeline route from Ajaokuta to Obajana is between 10-12m high.

Within the savanna woodland vegetation, mean tree and shrub density are higher between Eganyin and Obajana (1089/ha) than between Ajaokuta and Eganyin (895/ha), but there were more herbs with higher biomass between Ajaokuta and Eganyin (111/m^2 and 3804 kg/ha respectively) than between Eganyin and Obajana and beyond (76/m^2 and 3122 kg/ha respectively). Plant species diversity was high in the savanna woodland vegetation, but stem girth measurements at breast height were small. Due to this, timber-size trees decrease as one moved northwards. More than 50% of the total number of economic plants per hectare of land area are legumes of the subfamilies *Mimosaceae* and *Caesalpiniaceae*. The economic importance of these plants vary and they include their uses as fuel, timber, dyes, vegetable, edible fruits and seed trees, medicinal and religious plants and sponge. The economic trees include *Daniellia oliveri, Parkia clappertoniana* and *Vitex doniana*.

Animal Ecology
The study area is endowed with a large variety of animal species. They vary from small arthropods like mites and ticks to very large mammals like the hippopotamus. The Phylum Arthropoda dominated the invertebrate community; and they are represented by insects, spiders, millipedes, etc.

Various groups of vertebrates were encountered and they included amphibians, reptiles, birds and mammals. The large animals encountered were mainly browsers or grazers and they include antelopes and duikers. Others were the white bellied pangolin, monkeys and fruits bats.

Water Quality
Most water bodies are dry during the dry season depicting an ephemeral nature. The colour of the filtered surface water samples fluctuated between 5 and 550 PtCo during the wet season. However, during the dry season the values ranged from 47 to 520 PtCo.

Turbidity levels were high and fluctuated between 9 and 418NTU during the wet season and 9 -131NTU during the dry season indicating more turbid waters during the wet season. The values were generally above the FMENV/DPR limit of 10 NTU.

The water bodies were slightly acidic or slightly alkaline with pH values varying from 6.1-7.8. Electrical conductivity, which is a measure of the ionic richness of the river course, ranged between 45.2 and 218.0s/cm. These values are typical of fresh water bodies.

Fish/fisheries
Twenty-nine fish species distributed in 17 families were identified. In terms of species richness, the families Mochockidae, Bagridae, Characidae, and Cichidae were dominant. Generally, there were more fish during the wet season compared to the dry season. There was no observation of disease infestation, abnormalities or physical deformities. Analysis of the condition factors (KF), an index of the well being of the fish, showed that the fishes were healthy and well fed in relatively undisturbed environment. The factors on the average were well above the critical value of 1.0.

Sediment
The sediment samples were dark grey and sometimes bleached to whitish colouration. The sand fraction varied from 85.9% to 93.4% while the silt content varied from 0-17.8%. The clay content also varied from 0 to 12.0% making the sediment sandy in texture. The sediment samples were acidic (pH4.7-6.6). The electrical conductivity values varied from 29-172µs/cm^2 indicating that the environment under study is within the freshwater habitat. The organic carbon contents of the sediment samples were low and fluctuated between 0.29 and 1.60%. The nitrogen contents ranged from 0.019 to 0.123% and these values are considered low. The phoshorus concentrations were low to moderate and varied from 3.0 to 53.6ppm.

Geology
The geology of the area reveals that the rocks are of Pre-cambium crystalline basement complex and the cretaceous (Campbanian-Maastrichian) sedimentary of the Mid-Niger Basin. The surveyed area falls within the southern middle Niger Embayment (Bida Basin) covering places like Ajaokuta, Lokoja and Koton- Karfi. The zone comprises of the Agbaja Ironstone Formation, Lokoja Formation and Patti Formation.

Hydrology and Hydrogeology
The major water bodies encountered within the study area include River Niger, Ajaokuta, Atami and Osara. Only River Niger flows during the dry season.

The depth to water table ranges from 15 – 40m between Lokoja. The aquifer is unconfined and most of the wells are deep. The aquifer transmissivity of the area ranges between 0.4 and 1.3ms/day and the specific capacity of wells within the area range from 2.16 to .3.03m^3/day/m. The aquifer is between 0.39 and 1.21/sec discharge within the study area.

Wastes
Waste types encountered include tree trunks, pebbles, scraps from past constructions, motor vehicles involved in accidents, unused pipes, waste oil/grease, unused asbestos, fluorescent tubes and electrical fittings.

Socio-Economic Considerations
The entire project area falls within the middle belt of Nigeria. History and hinterland location shape much of the culture, religion, governance and overall development of the area. Two major political organizations govern the area – modern and traditional. The modern is represented by the State and Local Governments while the traditional is represented by the Emirate-in-council system and the chiefs-in-council system. The demographic structure of the project is one of a largely youthful population which constitutes 39.2% of the population.

With respect to religion, the two major religions (Christianity and Islam) and traditional religions are all represented in the project area. The economy of the area is characterized by poverty; as high as over 80% of people are below the poverty line which means, according to the World Bank and UNDP, they earn less than US$1.00 a day. There is general paucity of community structures such as schools, hospitals and health centers, village halls, shrines, markets, mosques, churches, etc, which are facilities owned and used by all. All of these, of course, underscore the overwhelming poverty of the project area.

Health Status
The public health facilities in the project area consist of health posts, primary healthcare centers and general hospitals. There are also patent medicine stores and traditional medicine practitioners in all the communities. Private healthcare centers exist and renders curative and preventive healthcare services. The tertiary healthcare institutions serve as referral centres

Based on hospital records, questionnaire responses and on-site observations, the health outcomes in the project area have been categorised as communicable diseases consisting of malaria, diarrhoea, upper respiratory tract infections (e.g., pneumonia), skin rashes, sexually transmitted diseases (STDs), and cerebrospinal meningitis; Non-communicable diseases include insufficient food intake and micronutrient deficiency among immigrants; injury from traffic crashes and collisions on the major highway traversing the project area, accidents from motor-cycle operation in towns and mental disorder caused by substance abuse (e.g., marijuana).

Consultation
Consultation initiatives and meetings were initiated and carried out with stakeholders that are likely to be affected by the proposed project activities. Consultation sessions shall be sustained with Kogi State, Ajaokuta, Adavi, Lokoja LGAs, communities and all the regulatory bodies.

Impacts

Land Acquisition

Land acquisition entails loss of farmland by the indigenous farmers who use the land to cultivate various crops such as maize, sorghum, rice and vegetables. However, if adequate compensation were paid, it would improve the personal income of landlords/indigenes. The impact is significant, irreversible and of long term effect

Site Preparation

Site preparation shall involve removal of limited amount of vegetation to provide path for survey. The removal of wildlife habitat (vegetation) will lead to temporal migration of wildlife.

Trenching

Trenching would involve the use of trenching machines and excavator. There may be changes in water quality at river crossing. Increase in SPM, (dust content) when the trenching is carried out during the dry season is anticipated. There shall be temporary road and railway obstruction/diversion during trenching activities.

Back Filling

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

Transportation of Personnel, Equipment, and Materials

Increase in traffic may increase the rate of exposure to accidents. Roads and railways may temporally be obstructed or diverted to allow for movement of heavy equipment and materials.

Operation and Maintenance

Changes in air quality may occur as a result of emissions from leaks during pipeline operation and maintenance.

Social Impact Assessment

Demographic

Influx of workers during the construction phase will significantly affect the demography of the communities, not just in terms of population numbers but also in terms of population structure.

Socio-economic

The project will bring about increase in employment resulting in increased income level.

Lifestyles

The project will lead to an influx of non-locals into predominantly rural, traditional and conservative communities which will have an influence on the lifestyles of the people. The most common impact on lifestyles may be inform of sexual and other forms of behaviour, as well as modes of dressing. Sexual laxity/prostitution and alcoholism are the most vexatious and are associated with migrant workers living alone, away from their families.

Cultural Properties

There are no cultural properties of note in the host communities. The possible exceptions are religious sites/shrines. However, traditional worship is no longer very significant in the areas

because of the influence of Islam and Christianity. Therefore, the impact of construction on cultural properties and practices will be very minimal, if any.

Social Infrastructure
The most common social infrastructures in the host communities are primary and secondary schools, healthcare facilities and water supply systems. The project will engender population growth due to the influx of workers. The capacity of local infrastructures in some of the communities is very limited and so cannot cope with the increased demand that will result from population growth during the construction of the pipeline.

Natural Resources
Ordinarily, a major impact on natural resources will be occasioned by land-uptake and destruction of vegetation along the pipeline and transmission line.

Health Impact Assessment
The beneficial health impacts from the activities of the pipeline project include availability of more job opportunities, which will improve income and make healthcare affordable, probable introduction of immigrants with new skills and perspectives, and the introduction of improved waste management/sanitation methods. The non-beneficial impacts include: increase in communicable diseases especially sexually transmitted diseases as a result of influx of casual labour force, injury from fire outbreaks that may result from pipeline damage and pressure on health facilities in clinics/hospitals as a result of increase in population.

Mitigation/Control Measures
Planning Phase
Dangote Industries Limited shall:
- Compensate communities for land take and farmlands in line with Federal Government Land use decree.

Site Preparation
Dangote Industries Limited shall:
- Use environmental route/path for site survey.
- Enforce “no hunting of game animals” during site preparatory activities.
- Avoid excess land take and minimize bush clearing during site survey.

Construction Phase
Dangote Industries Limited shall:
- Use equipment, which emit low levels of noise with acceptable exhaust gases, which conform to national standards and specifications.
- Enforce proper waste management practices and good in-house sanitary practices for base camp workforce.
- Use existing access/right of way if available.
- Carry out major construction/civil works during dry season or provide silt curtains to control the suspended particles in the run-offs. Wet grounds to reduce dust.
- Reduce water and road crossing for pipeline, plan for run-off during wet season.
- Reduce time frame between clearing trenching, pipe laying, and backfilling/re-vegetation.
- Prevent intruders/from inquisitive onlookers from work site to protect them against welding radiations.

Pre-commissioning Phase
Dangote Industries Limited shall:

- Enforce the installation of cathodic protection devices on the pipes to maintain their integrity/prevent corrosion
- Use fresh water for hydrotesting.
- Use proper PPE including ear defenders at high noise zones.
- Place/caution signs.

Operation Phase
Dangote Industries Limited shall:

- Ensure regular maintenance of right of way for pipeline.
- Provided security to prevent vandalisation.

Decommissioning and Abandonment Phase
Dangote Industries Limited shall:

- Re-vegetate all bare areas and restore site to original land use.
- Restore land to original form as much as possible and return to indigenes.
- Return ROW to indigenes for other land-use.
- Educate/guide road users on days of movement of dismantled parts.

Environmental Management Plan (EMP)

The EMP for the Ajaokuta-Obajana Gas Pipeline Project has been developed to meet long-term objectives of the project activities and operations. The EMP is designed to guarantee and achieve the implementations of the EIA findings highlighted in this report through the provision of project execution and maintenance guidelines, audit procedures, waste management plan, monitoring programme, resource requirements, responsibilities and training procedures. The project execution guidelines cover areas such as waste management, base camp operation, and contingency and monitoring plans.

Conclusion / Recommendation

The EIA has demonstrated that the overall impacts associated with the Ajaokuta-Obajana Gas Pipeline Project can be managed within reasonable and acceptable limits by applying all identified mitigation measures contained in the report.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

This is a final report for the Environmental Impact Assessment (EIA) of the proposed Ajaokuta-Obajana Gas Pipeline Project by Dangote Industries Limited.

Dangote Industries Limited in conjunction with Kogi State and the Federal Government of Nigeria proposed to build a modern cement factory at Obajana in Kogi State. The factory will be installed with a 75 MW – 100 MW Gas/Steam turbines to generate its own electric power for use by the cement kilns and other production processes. The natural Gas supply will originate from a suitable tie-in point on the NGC Oben - Ajaokuta gas supply line. The envisaged gas volume requirement is 62.40 Mmscfd.

The proposed project is an 18" x 90-km gas pipeline, which will be hooked to NGC gas line at Ajaokuta and will run along the edge of the (Okene-Ajaokuta) dual carriage road for over 32 km to Eganyin village. The pipeline will then join an existing ROW belonging to NNPC/PPMC from Eganyin to Lokoja/Kabba junction about 37km. The pipeline will continue from Lokoja/Kabba junction to Obajana for a distance of about 21km, where a metering station will be built for final gas treatment. 53km of new ROW will be acquired for the pipeline route. Over 37km of the remaining portion is already acquired and owned by NNPC. The project in a long run will enhance power supply to the cement factory and boost cement production in the country.

1.2 Terms of Reference

This report represents the Environmental Impact Assessment (EIA) for the Ajaokuta-Obajana Gas Pipeline Project proposed by Dangote Industries Limited, Marble House, Alfred Rewane Road, Falomo-Ikoyi, Lagos. In accordance with the FEPA (Now Federal Ministry of Environment (FMENV) EIA Procedural Guidelines of 1995, the Project Proposal and Terms of Reference (TOR) were submitted to the Federal Ministry of Environment through a letter referenced DG/EIA.OGPP/01 dated 3rd March 2003. FMENV evaluated the TOR and conveyed its approval of the TOR through a letter referenced FMENV / CONF / EIA / 123.467 / Vol.1 / 18 dated 29th April 2003.

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

- Provide a comprehensive environmental baseline data of the proposed Ajaokuta-Obajana Gas pipeline route;
- Identify and assess the environmental sensitivities of the pipeline route to project activities;
- Evaluate the associated and potential impacts of the pipeline activities on the environment,
- Confirm the environmental acceptability of the selected routes for the gas pipeline;
- Develop Environmental Management Plan that shall translate potential impact prevention and mitigative measures into control measures.

1.3 Nigeria

Nigeria is the largest and most populous country in sub-Saharan Africa. It lies between latitudes 4^o and 14^o North of the Equator and longitudes 3^o and 14^o East of the Greenwich Meridian (See **Attached Political Map of Nigeria Showing Kogi State (Map 1.1)**). It has a geographical area of 923,768km^2 and a population of approximately 88.5 million by the November 1991 Census. It is bordered by Chad and Niger Republics to the north, Cameroon to the East; Republics of Benin and Togo to the west and the Atlantic Ocean to the south. It is made up of several ethnic groups, the major ones being Hausa, Fulani, Igbo, Yoruba, Edo, Efik Ijaw and Kanuri. The oil industry, which is the mainstay of the economy, controls over 70% of Nigeria's total revenue and is concentrated within the Niger Delta ecosystem. The sub-sector of the economy employs a significant proportion of the population. Other socio-economic activities in the country include commerce, and agriculture (farming/fishing).

1.4 Applicant

Dangote Industries Limited is a member of the Dangote Group, which is a leading and corporate responsible organization in Nigeria with its operational headquarters in the bustling metropolis of Lagos. The group is a collection of companys' involved in various activities such as manufacturing, packaging and distribution of consumer and industrial food products. Some of the manufactured products include cement, building materials, and textiles. It is one of Nigeria's foremost-diversified business conglomerates, with a hard-earned reputation for excellent business practices. From a modest beginning, Dangote Group has grown into a multi-billion Naira company focusing on the essential needs of food, shelter and clothing.

Dangote Group remains committed to creating and sustaining excellence in the Nigerian economy. The group has four regional offices located in strategic locations throughout Nigeria. Each office has autonomy and responsibility for specific targets.

Dangote group has four business units (Dangote Sugar, Salt, Flour and Dangote Spaghetti & Macaroni) that are responsible for manufacturing of food product and they are organized as divisions under Dangote Industries Limited. Dangote Group also has two business units that are responsible for the manufacturing and distribution of building materials.

In the Cement business, Dangote Industries Limited has experienced spectacular growth in their share of the national cement market over the last 24 months. Its cements production capacity has been increased in excess of 8.0million metric-ton/annum. The company has made a strategic decision to establish cement-manufacturing plants in strategically located places around Nigeria. It is the desire of the Dangote Industries Limited to establish one of the cement manufacturing plant at Obajana in Kogi State in association with the Federal Government of Nigeria and Kogi State, that it has proposed the 18" x 90km Ajaokuta-Obajana Gas Pipeline Project to supply natural gas to the factory. The production capacity of the proposed Obajana Cement Plant is 10,000mt/day (minimum) and 14,000mt/day (maximum).

1.5 EIA Premises

The key premises that affect EIA process were established from the initial stages of the project and have provided the general guidance, framework, and commitment to standards acceptable nationally and internationally. The premises shall be retained and variations allowed only in certain circumstances with supporting evidence to do so. The premises include:

- the area is within the exclusive jurisdiction of the Federal Government of Nigeria. Therefore, federal laws, including the environmental laws apply,
- the project recognises the laws and regulations of the Federal Republic of Nigeria as represented by the Federal Ministry of Environment, the Department of Petroleum Resources (DPR), the State and the Local Government Environmental Agencies, and insist that best options will be adopted for the project execution;
- the project will be designed and operated to comply with local and national laws, together with all the international protocols, agreements and conventions entered into by Nigeria;
- the agreements and understanding reached with government officials during the course of the EIA process will be respected and honoured;
- extensive consultations have and will continue to be held with Federal, State, and Local Governments together with the host communities and concerned Non Governmental Organisations (NGOs); and
- an Environmental Management Plan (EMP) will be developed as part of the EIA process. The implementation of this plan will be the responsibility of Dangote Industries Limited.

This EIA has been prepared to evaluate the potential environmental impacts associated with the proposed Ajaokuta-Obajana Gas Pipeline Project. To this end, an intensive multidisciplinary one seasoned fieldwork was conducted between 17-28th March, 2003, this was complemented by the review of a two seasoned baseline data of the area conducted between 2001-2002. Data on ecological set up, socio-economic structures and health status of the area were obtained.

1.6 Administrative and Legal Framework

Dangote Industries Limited believes and adheres to the principle of sustainable development. Dangote Industries Limited (DIL) shall therefore conduct the project in line with local, national, regional and international statutes, guidelines, standards and specification for the protection of the environment with respect to the Ajaokuta-Obajana Gas Pipeline Project.

1.6.1 Regulatory Requirements

Several specific guidelines and standards regulate the activities of oil and gas companies in Nigeria, some of which are specifically targeted at the environment and are summarised below.

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

- The Petroleum Act, 1969, Section 8(1) b (iii) which empowers the Minister of Petroleum Resources to make regulations for the conservation of the ecosystem by the prevention of pollution of water courses and the atmosphere.

- Federal Environmental Protection Agency (FEPA) Decree No. 58, 1988 provides National Guidelines and Standards for industrial effluents, gaseous emissions, and hazardous wastes management for Nigeria. In this, the Federal Government of Nigeria established FEPA (now FMENV) to protect, restore and preserve the ecosystems of the Federal Republic of Nigeria.

- The Department of Petroleum Resources (DPR) Environmental Guidelines and Standards for the Petroleum industry in Nigeria (1991) Part viii (A) sections 1.4.3(ii) and 1.6 which makes preparation of EIA reports mandatory.

- The National Environmental Impact Assessment (EIA) Decree No.86 of 1992 which requires that an EIA report be prepared for all new major development activities.

- Federal Environmental Protection Agency (FEPA) EIA procedure for Nigeria (1994) category I projects which are subjected to full- scale EIA including construction of pipelines in excess of 50km.

- FEPA EIA Procedural Guidelines (FEPA 1995), which stipulates projects/ activities for EIA studies.

- FEPA 1995 sectorial guidelines for oil/gas industry projects, which specifies the procedures and methods for EIA.

- Federal laws of FEPA Guidelines Regulations S.1.8 National Environmental Protection (Effluent Limitation) Regulations 1991 and Regulation S.1.9 National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulation 1991, for example paragraphs 15(2) of regulation S.1.9 by FEPA.

- National Inland Waterways Authority (NIWA) of the Federal Ministry of Transport Decree 13 of 1997 covering the regulation of use of inland waterways and permitting requirements for dredging, etc. under NIWA with the responsibility of standards and regulation of non-routine activities within navigable waterways of Nigeria, example river crossings, etc.

- Kogi State Environmental Protection Agency Edict of 1995. This edict provides for the environmental protection of the State and other matters indicated thereto or connected therewith. Part II Sections 19 – 31 prohibits air, water, and land pollution, refuse disposal and noise in the State.

- Performance improvement in operations of Dangote Industries Limited

Endangered Species Decree No 11 of 1985
Endangered Species (Control of International Trade and Traffic) Decree No 11, 1985 lists those animal species under absolute prohibition from international trade and those allowed for trade.

World Bank Guidelines on Environmental Assessment (EA)
To be able to obtain financial assistance in the form of loans of some projects, the World Bank requires an EA report as a condition from the borrower before granting such loans. The EA report normally forms part of the feasibility study of the project. Projects are categorized based on their EA requirements and is very much similar to that of FEPA.

Checklists of potential issues for EA, which apply to upstream oil and gas projects, include: biological diversity, coastal and marine resources management, cultural properties, hazardous and toxic materials, and international waterways. Volume III (1991) of the World Bank EA source book states that "EA for oil and gas pipelines should include an analysis of reasonable alternatives to meet the ultimate project objective". This analysis may lead to improvement in designs from socio-economic point of view to insure that the project options under consideration are environmentally sound and sustainable.

International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines
The IUCN (The World Conservation Union) in conjunction with the oil Industry International Exploration and Production forum (E & P Forum) have guidelines, which contain internationally acceptable practices and standards for oil and gas exploration and production. These guidelines present practical measures to conserve wetlands and enhance protection of aquatic ecosystem during oil and gas E & P activities.

The general discussions are on Environmental Profile activity, preliminary Environment Impact Assessment, Environmental Impact Assessment (EIA), Environmental Management, Environmental Monitoring, and Environmental Audit. From the guidelines, it is recommended that a Preliminary EIA report be prepared before any activity commences at the project site; and it is to build on the findings of the environmental profile and examine sensitive issue in details.

Other international environmental conventions, which Nigeria is signatory to and national environmental laws and legislations, are presented in **Appendix 1.1.**

1.7 Policies of Dangote Industries Limited

HSE Policies
It is DIL Policy that all activities are planned and carried out to:

(i) Preserve the health, safety and security of all company and contractor personnel and members of the public;
(ii) Preserve the integrity and security of company assets;
(iii) Minimise the impact of operations on the environment, and
(iv) Is sensitive to the needs and concerns of the host communities.

Implications of implementing this policy are that:

(i) All activities shall be analysed to systematically identify related hazards, risks and sensitivities;

(ii) Arrangements shall be put in place to control the hazards, risks and sensitivities and to deal with consequences should they arise;

(iii) any activity which is unhealthy, unsafe, environmentally unsound or may adversely impact relations with the community, shall be suspended until an acceptable solution is found;

(iv) all personnel, including those of contractors, shall be trained and made fully aware of the hazards, risks, sensitivities and controls in place;

(v) plans and procedures shall be in place to respond to any emergency or loss of control.

(vi) Every Dangote Industries Limited employee and contractor's employee must plan and perform his work in accordance with this policy. Each employee is required to report, and where necessary, suspend any activity, which he considers is a contravention of this policy.

1.8 Environmental Impact Assessment

EIA is an acronym for Environmental Impact Assessment. It is a systematic study of impacts of proposed project activities on the physico-chemical, biological, ecological, socio-economic and health components of the environments. Dangote Industries Limited has undertaken this Environmental Impact Assessment (EIA) study, to predict the impacts of the proposed development on the environment and propose mitigation measures that will be incorporated into the project environmental management plan. The EIA covers the project description, baseline studies, consultation programmes, social and health impact assessment, environmental quality assessment and impact quantification and an Environmental Management Plan.

The EIA study will make an input into the conceptual design of the project, to ensure that any identified adverse impacts are addressed at the early stage of the project and mitigated during the activity stages, involving site preparation, construction/pipe laying, commissioning, operation, decommissioning and abandonment.

1.8.1 Purpose of the EIA

The purpose of this EIA is to establish the environmental sensitivities, impact and mitigation measures with respect to the Ajaokuta-Obajana Gas Pipeline Project. These will effectively and adequately enable the followings:

- Assessment of the state of the environment and establishment of environmental issues and factors associated with the Ajaokuta-Obajana Gas Pipeline Project.
- Assessment and prediction of all possible and potential impacts of the project on components of the environment in terms of magnitude and importance
- Evaluation of alternatives and identification of the best options that is both cost effective and with least potential environmental impact.
- Incorporation of EIA recommendations into the gas pipeline project detailed design as well as other stages of the project.

1.8.2 Benefits of the EIA

The benefits of the EIA will, among other things, include:

- Obtaining authorisation; this is required by regulatory authorities before the commencement of any major development;

- Providing a forward planning tool; when environmental implications are taken into account with other design considerations at the conceptual design stage. It allows for important decisions to be built into the project while avoiding undue damage to the environment;
- Providing a designing tool that would allow a systematic evaluation of potential environmental problems from the proposed development and identification of key issues which require special consideration for effective environmental management and controls;
- Involving all stakeholders through consultation so as to address common problems, impacts, and mitigating measures that might be proposed in order to obtain a social license for the project;
- Informing and assisting management with a view to establish and achieve long term management objectives in order to minimise associated financial and environmental risks; and
- Confidence building by Dangote Industries Limited.

1.9 Declaration

Dangote Industries Limited in its capacity as the promoter and operator of the Gas Pipeline and Obajana Cement project on behalf of the Federal Government of Nigeria and Kogi State Government hereby declares her intention to abide by the existing international and national laws and regulations regarding environmental protection during the construction and operation of the Ajaokuta-Obajana Gas Pipeline Project. DIL is committed to the implementation of the Environmental Management Plan (EMP) proposed in this EIA report. Dangote Industries Limited avows that it has prepared this EIA report using the best available expertise in personnel, equipment and internationally acceptable methods.

1.10 EIA Methodology

The methodologies adopted for conducting this EIA are as follows:

Desktop Research

Desktop research was used to establish an environmental information database for the EIA. Consulted materials include textbooks, articles, maps, internet, photographs and past EIA reports and baseline report of the area conducted between 2001 and 2002.

Consultation with Stakeholders

Experts in relevant fields, leaders of thought in environmental matters, Non Governmental Organisations and regulators, local communities have been consulted for their opinions on issues relating to the potential ecological and socio-economic impacts of the proposed project.

Field Research

One-seasoned fieldwork activities have been carried to verify and complement information gathered from desktop studies. The fieldwork covered all relevant components of ecological, socio-economic and health components of the environments.

Laboratory Analysis

Samples collected during the one-season field sampling were analysed in an established and accredited laboratory.

Impact Assessment and Evaluation
The assessment of all associated and potential impacts of the proposed project were carried out using checklist method. Impacts evaluation was carried out using ISO 14001 approach.

1.11 Structure of the Report

This report is presented in Nine Chapters. Chapter One is an introduction with the EIA Terms of Reference (TOR), relevant background information about Dangote Industries Limited (the Applicant), and Legal/Administrative Framework for EIA in Nigeria.

The second chapter discusses the project justification and presents the need/value of the project and project development options.

The third chapter describes the proposed project, location, project activities, excavation, pipelaying, waste management, commissioning, decommissioning / abandonment and the project schedule.

Chapter Four describes baseline condition of the study area. Information on socio-economic and health status of the area is contained in this chapter. The chapter also contains information consultation activities with stakeholders-Government Agencies, the public and the host communities within the project.

Chapter Five discusses the Associated and Potential Environmental Impacts of the proposed Gas Pipeline Project.

Chapter Six discusses the Mitigation Measures for the identified adverse impacts.

Chapter Seven recommends a cost-effective Environmental Management Plan to adopt throughout the project cycle. It also recommends an environmental monitoring and wastes management programme and outlines the plans for site restoration and remediation after closure/abandonment.

Chapter Eight gives the conclusion and offers advice on project implementation.

References and appendices are also included in this report.

CHAPTER TWO

2.0 PROJECT JUSTIFICATION

2.1 Need for the Project

The development of a gas pipeline to transport natural gas from NGC gas pipeline at Ajaokuta to Obajana is being undertaken in order to:

- Utilize natural gas to power the kilns and generate electricity of 75-100mw capacity at the proposed Obajana Cement Plant.
- Provide cheaper, cleaner and more efficient fuel for the cement factory production lines and operations;
- Promote the use of natural gas as a substitute for liquid fuel;
- Boost economic activities within Lokoja, Obajana, and Kogi State as a whole;
- Greatly enhance/encourage gas utilisation culture in Nigeria as fuel-of-first-choice
- Offer job opportunities in various categories to a number of Nigerian professionals, skilled and semi-skilled craftsmen;
- Enhance the environmental status of the area, as natural gas is environmentally friendly.

2.2 Value / Benefit of the Project

The proposed Obajana cement factory in Kogi State shall enjoy a better quality and a more reliable electric power supply. Consequently, the cost of production will be lowered due to the use of cheaper and cleaner source of energy, this will in-turn lower the cost of cement in the country.

The utilisation of gas for the factory will contribute to putting out unnecessary gas flares from oil wells as envisaged by the Federal Government of Nigeria. Besides, gas–for-money will be generated for all the parties to the project.

2.3 Envisaged Sustainability

Complete reliance on NEPA with the present low/ inadequate generation of electricity in the country by industries and individuals has been said to lead to low activities culminating in facility under-utilisation. Gas, a by-product of oil production is presently being flared. Gas utilisation by industries to generate power, turning of kiln, etc. which Dangote Industries Limited has initiated by undertaking the Ajaokuta-Obajana Gas Pipeline Project is a welcome development. Gas reserves in Nigeria are huge about 170 trillion cubic feet (tcf), and can be harnessed and put into commercial use. It is therefore hoped that the gas supply project to the cement factory can be sustained for a very long time - more than 25 years.

2.4 Project Setting

Gas is fed into the Escravos - Lagos pipeline system (ELPS) from Oben, Escravos, Utorogu, Jones Creek and Odidi fields as well as NGC compressor stations. Part of this gas volume is supplied to Ajaokuta Steel Company limited through a 24" x 196km Oban-Ajaokuta gasline. The take-off point for the cement company will be a suitable tie-in point on this pipeline. Dangote Industries Limited will "tie-in" at a suitable manifold with a 18" pipeline running along the Ajaokuta-Okene express road up to Eganyin. From Eganyin, the pipeline will be laid parallel to an existing PPMC products right of way (ROW). The pipeline will veer off at Lokoja-Kabba junction towards Obajana about 21 kilometers away. The proposed gas pipeline is extends over

90km, about 37km of the pipeline will be laid along an existing ROW, while 53km of the pipeline will be laid along a freshly acquired right of way 25m wide. The entire pipeline route falls within Ajaokuta, Lokoja and Adavi Local Government Areas of Kogi State (see **Attached Location Map 3.1 (Drwg Ref. 3.1)**).

2.5 Project Activities

The activities of the whole Ajaokuta-Obajana Gas Pipeline Project are as follows:

- Permit to survey and survey
- Environment Impact Assessment
- Land Acquisition
- Oil Pipeline License (OPL)
- Engineering Design
- Material Procurement and Transportation
- Bush clearing
- Excavation
- Construction (Tie-in Points and Terminal Gas Station TGS)
- Pipelaying (pipe stringing/welding, hydrostatic testing and cathodic protection).
- Commissioning and Handover
- System operation and maintenance (pumps, generators, corrosion control, emissions, leaks, grease, ROW clearing etc).
- Abandonment (removal of camp, scrap metals, industrial refuse and grease).
- Close out Report

2.5.1 EIA Activities

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

2.6 Project Alternatives

Gas Pipeline Development Options:

i) **No Action -** This option would favour the continued reliance on existing inadequate NEPA Power Supply to Obajana Cement Plant. This alternative was rejected because the present power load for Obajana cement factory of about 75-100mw cannot be met by NEPA alone. Also associated with this option are:

- Loss of resources already committed to the project;
- Deprive host communities of associated projects planned in their domain
- Deprive locals of employment opportunities that will avail to them

ii) **Other Sources of Energy for Generating Electric Power**

The use of petroleum products and coal, other than natural gas to generate power cannot be guaranteed since their supply is irregular and also there are no infrastructural facilities for their transportation and storage at site. Construction of the required infrastructure for these sources of energy would be expensive. The emissions/contrition products are not environmentally acceptable. This option was also rejected.

iii Use Natural Gas to Produce Electric Power for Obajana Cement Factory

Natural gas is readily available in Nigeria. The utilisation of natural gas to produce power for electricity and turning of kiln is cleaner and more environmentally friendly, than liquid or solid fuels, and will enhance constant power supply to boost cement production. The growth and increase in productivity of the Obajana Cement Factory will create more employment opportunities for the people. Gas burns effectively and produces very little or no smoke. The pipeline infrastructures are already in place and the extension of the pipeline to Obajana is viable economically. Considering the great advantages of gas utilisation as an energy source to provide constant supply of power for Obajana Cement Factory, this option was accepted.

Gas Pipeline Route Options:

Two alternative routes for the pipeline construction from Ajaokuta –Obajana were considered (**See Attached Map-Drwg Ref. 3.1**). These include:

i. A new ROW route from NGC gas manifold at Ajaokuta Steel Complex along the Ajaokuta – Okene dual carriage road to Eganyin, passes through Itakpe Iron Ore Company, cut across Okene-Abuja road runs and terminates at Obajana.

This route is not acceptable in view of the following considerations:

- It cut across settlements
- It has potential of passing through a burial grounds
- It may impede on natural routes for the movement or migration of animals
- It cut across a forest reserve area
- Over 71km of ROW acquisition is required
- Crosses Osara river in two places
- Passes through Itakpe Iron mining and requires clearance
- It may cut across land areas with rock-outcrops or very shallow soils (< 2m deep) thus, increase of construction and pose safety hazards.
- It is not therefore environmentally friendly.

ii. The proposed new pipeline route from NGC gas manifold at Ajaokuta Steel Complex along the Ajaokuta – Okene dual carriage road to join the existing Pipeline Product Marketing Company of NNPC (Oben –Kaduna) pipeline route at Eganyin in Ajaokuta Local Government Area and via-off close to Lokoja-Kabba junction to Obajana.

This route is preferred and is accepted because of the following considerations:

- Avoidance of settlements
- Avoidance of archaeological sites particularly shrines and burial grounds
- Avoidance of natural routes for the movement or migration of animals
- Avoidance of forest reserve areas
- Minimisation of water, road, and railway crossings
- Least acquisition as 37km of the route is already acquired by PPMC
- Avoidance of land areas with rock-outcrops or very shallow soils (< 2m deep).
- The route is environmentally friendly.

Gas Pipeline Size Options:

10" Pipeline

Although, this size is the least expensive of the four sizes considered, it was **rejected** in view of the fact that using pipe of this size will generate very high inlet pressures (up to 90 bar) that are higher than the maximum allowable operating pressure. Also, the throughput is far less than the gas demand by the cement factory.

12" Pipeline

It was **rejected** because the lower limit of the liquid flow velocity in the pipeline is below that recommended by PII for pigging operations.

16" Pipeline

This option was **rejected** in view of the fact that it has low liquid flow velocities that encourage scale deposition and internal corrosion problems. This size of pipeline is also the most expensive and has excess spare capacity.

18" Pipeline

This option was **accepted** because of the fact that, maximum inlet pressures in the peak years are about 40 bar (in the event of the Oben-Ajaokuta pipeline being derated to 40 bar due to age and disuse). The liquid flow velocity ranges from 0.35-2.5m/s. It has ullage for future expansion. The lower limit of the liquid flow velocity is above 0.3m/s, which is the minimum recommended by PII for pigging operations, while the upper limit is within the acceptable range.

CHAPTER THREE

3.0 PROJECT DESCRIPTION

3.1 Type of Project

The project consists of a 18"x 90km long Gas Pipeline that will run from Ajaokuta at a tie-in point from a manifold to Obajana. The gas pipeline will supply natural gas (62.4mmscfd) as the primary fuel for the generation of electricity and turning of kiln at the proposed Obajana Cement Factory in Kogi State.

Consequently, the gas pipeline system shall be designed to achieve a maximum delivery of 70 Mmscfd. A Gas Treatment/Metering Station shall be installed 1km to Obajana Cement Factory or within the cement yard, if space will permit.

3.2 Project Scope

Design, Procure, Install/Commission

- Develop the gas pipeline tie-in point to existing NGC Oben - Ajaokuta gas supply pipeline to Ajaokuta Steel Company;
- Engineering and construction of a 18" x 90-Km pipeline of API 5L X52, class 600;
- Install adequate Pigging manifolds and block valve stations;
- Establish a 70 Mmscfd capacity Gas Treatment/Metering Station about 1km to Obajana cement factory or within the cement yard;
- Acquire a (25 M) new pipeline right-of-way (ROW).

3.3 Location of Project

The Ajaokuta – Obajana Gas Pipeline Project falls within the following Co-ordinates 377641.9-450000N and 426764.5-475000E. The project area stretches from Ajaokuta in Ajaokuta LGA through Adavi and Lokoja Local Government Areas of Kogi State (see **Attached Location Map 3.1 (Drwg Ref. 3.1)**). The settlements inhabited mainly by Ebira, Bassa, Gwari, Oworo and in some cases Hausa, Ibo, Tivs and Yoruba migrants. The main occupations are crop farming, animal husbandry, fishing and petty trading. The area under study is about 90km of new ROW to be acquired between Ajaokuta, Eganyin and Obajana. The study stretch is mainly savanna woodland with fringing forest along some of the riverbanks. The terrain is undulating with occasional rock out crops. The major rivers include the River Niger and Osara River. Most of the existing smaller rivers dry up during the dry season.

3.4 Technical Layout and Process

Detailed Description of Facilities Selected for Design

The main facilities will include but not limited to the following:

- Engineering and construction of a 18" x 90km pipeline from Ajaokuta-Obajana
- Engineering and construction of all metering facilities
- Upgrade/modification works to enable pipeline hook-up.
- Pre-feasibility cost-benefit analysis of the pipeline project.

Terrain
Land terrain with a combination of lowland rocky and highland forest (savanna woodland).

System Characteristics
- Line size: 18".
- Length: 90km.
- Crossings: Roads at Eganyin, Irapana village, Kabba junction along Okene-Lokoja road (i.e. Kabba junction – Obajana road),
- End facilities: Gas Treatment/Metering Station about 1km to Obajana cement factory or within the cement factory yard as space may permit.

The pipeline will be laid mostly on new right of way (ROW). Block valve manifolds will be spaced along the pipeline and at either side of the river crossings to isolate pipeline sections in case of leakage. These will be carried out in order to prevent pollution, avoid hazardous situation, depressuring sections for maintenance, and repair. The block valve manifolds will be equipped with full-bore valves, pressure indicators and pipeline blow-down facilities on each side of the buried line break valve. The proposed pipeline diameter is 14", the pipeline terminating point is at Gas Metering Station (GMS) or Gas Treatment Station (GTS) at Obajana.

The pipeline will be designed according to API 5L X52 latest Edition and class 600-pressure rating. The maximum gas volume to be transported is expected to be 70MMscf with an average upstream pressure of 40 bar at an average temperature of 21-35^{o}C and delivered at the GTS at about 25 bar. The pipeline materials will be based on API 5L carbon steel not less than X60 and polyethylene externally coated for corrosion protection. Cathodic protection of the pipeline shall be provided by impressed current system.

For pigging purposes, the pipeline will be provided with launching and receiving scraper traps shall be located at the tie-in manifold and Metering station at Obajana.

The Obajana Gas Metering Station shall comprise the following facilities:
- Emergency shut down (ESD) valves
- Scrubbers
- Pressure reducing/regulating system
- Metering system
- Gas heaters (optional)
- Pressure relief/vent/flare and blowdown system
- Control room
- Radio/Telecom facilities
- Pigging facilities
- Slug catcher

Manifolds
Facilities to be provided at the primary manifold point shall include pressure reduction, gas scrubber, gas heaters, scrapper trap, custody transfer meter, valves. Allowance would be made for possible relocation of the Primary Manifold in future, and would also be designed to accommodate increases in the inlet pressure.

Line Break/Sectionalisation
The system would incorporate installation of line sectionalising valves as necessary to isolate specific sections during maintenance. The system would also incorporate emergency line break valves.

Venting
The system will incorporate installation of Blowdown assemblies to allow for the evacuation of gas from sections of the pipeline under emergency conditions or for scheduled maintenance operations. The assembly shall be sized to ensure minimum blowdown (venting) time and quantity of vented gas between two valves.

Pressure/Temperature regulation and ESD systems
Pressure would be regulated using automatic pressure control valves (PCVs). A double train of active and monitor PCVs would be required to achieve the desired reliability of supply. Quick acting/slam shut and relief valves will be incorporated to achieve satisfactory over-pressure protection of low-pressure pipeline and facilities. Temperature would also be regulated using temperature control valves (TCVs). Provision would be made for Emergency Shut Down (ESD) for protection against system malfunction and isolation of station from gas source in case of fire outbreak.

Power Supply
Power supply for the main facility at the Obajana metering station would be obtained from the Cement Factory at Obajana.

Supply Gas Composition and Conditions
The gas analysis is indicative of the gas fluid composition at the NGC station at Ajaokuta steel complex yard. The actual composition for engineering design shall be established at the detailed engineering stage.

Liquid drop out from the Gas scrubbers would be stored in a condensate tank from where they will be evacuated using BRVs (Bulk Road Vehicles or Bulk Lorry Trucks).

Special Considerations
It is therefore intended that the project implementation would have adequate consideration for all relevant environmental, technical and legal requirements for the works. The entire project schedule shall therefore take full account of the above factors and the following additional considerations:

- Applicable local and national legislation including PTS.
- Future expansion or capacity upgrade.
- System operating station must be on 24 hours basis.
- Adequate community management to prevent unnecessary work stoppage.
- Implementation of all agreed EIA recommendations.

3.4.1 General Pipeline Description

Pipeline route
In addition to the schematic Map, a final layout would be subjected to the detailed data, route survey and outcome of the EIA.

Temperature and Thermal Stresses
The pipeline is designed to withstand temperature variations as follows:

Inlet temperature at the NGC station at Ajaokuta Steel Complex yard for tie-in into the Main delivery line is assumed as $\pm$20 - 27^{o}C (ground temperature) and will be confirmed through physical measurements at the detailed design stage.

Design Life
The pipeline and associated facilities have been designed for a life of 25 years.

Gas Scrubbers
The specification and sizing of the gas scrubbers would be prepared during the final detailed design.

Road, Railway, Swamp and River Crossings
Final details of the road and river crossings would follow the provision of a Plan and Profile Survey map by nominated Survey contractor and the outcome of a detailed design. At major road and railway crossings, the pipeline would be laid inside a casing pipe. Along major highways (express or dual carriage) the method of crossing shall be by Thrust boring. Concrete coating would be applied over the anti-corrosion coating to maintain the lateral and vertical stability of the pipeline at swamp areas and all other locations where the pipe is located below Highest High Water Spring (HHWS) level. Calculation of concrete weight coating would be done at the detailed design stage after receiving the Plan and Profile Survey.

Thus the pipe within road and railway crossings shall be of special (heavy wall thickness) line pipe. The pipe shall be double coated and triple wrapped in accordance with Standard Construction Specifications. The coated pipe shall be placed on a sand bedded not less than 15cm thick and shall be surrounded with similar well compacted material to at least 15cm above the top of the pipe. A 20cm thick compacted layer of assorted sand and gravel shall then be placed in the trench, and on top of this layer a reinforced concrete slab shall be constructed over the entire length of the road or railway crossing. The slab shall be not less than 10cm thick and the width shall not be less than the overall diameter of the wrapped pipe plus 30cm.

Above the concrete slab, the road or railway bed and surfacing shall be backfilled and fully reinstated in accordance with Standard Construction Specifications. All reinstatement work shall be subjected to the approval of the road and highway Authorities concerned.

The contractor shall supply and install Permanent markers and caution signs of approved design shall be installed at all road and railway crossings, showing the position of the pipeline on each side of the crossing. For cased crossings, permanent approved indicator signs shall also be installed on the casing vent pipe at each side of the crossing.

Corrosion Protection
The pipeline shall be buried in accordance with Standard Construction Specification. External anti-corrosion coating would be supplemented with a Cathodic Protection system that would cover any damaged or deteriorated area of the coating. The Cathodic Protection system would comprise a transformer-rectifier combination for the provision of direct current and a deep well grounded approved anode material.

Pipeline data

The pipeline data involving the length of pipes, sizes, pressure regimes, width of ROW and depth of burial in different locations are presented in **Table 3.1**.

Table 3.1: Proposed Ajaokuta-Obajana Gas Pipeline Design Data

S/N	Design Parameters	Proposed Extension
1	Nominal pipe diameter (inches)	18"
2	Length of pipeline, km	90
3	Flange pressure rating	600#
4	Design pressure, upstream bar	100
5	Maximum Allowable Operating Pressure at TGS, bar.	25
6	Capacity at maximum operating pressure	70MMscf/d
7	Right of way width, m	25
8	Coating for external corrosion protection	PE coating
9	Depth of burial (swamp)	Minimum cover of 2.6m
10	Depth of burial (land)	1.0m
11	Depth of burial (across road and railways)	2.0m
12	Depth of burial (under water courses)	Minimum of 3.0m from riverbed.

3.4.2 Pipe Laying Processes

Materials

The pipes to be used for the gas transportation projects are coated seamless steel line pipes manufactured to API 5L carbon steel not less than X60 specifications. The coating is factory-applied external polyethylene for corrosion protection.

Pipe Laying

The pipeline will be buried with a minimum soil cover of I metre, with the pipe laying process depending on the particular environment.

1. ***Normal Ground***: In normal ground, the ditch would be excavated such that the sides are 200mm clear from the pipe and back filled with selected (usually granular) material.

2. ***Swamps***: The ditch would be excavated with side sloping at 2:1 to minimize side slippage. The pipe would be laid with a continuous concrete weight coating to prevent floatation from buoyancy effects. The width and depth of the ditch shall be sufficient to accommodate all floatation equipment and to provide the minimum distance from swamp level to top of pipeline. The bottom of the trench shall be uniformly graded and free from loose rocks, large gravel and other objects that may damage the pipe or its coating. The backfill material shall be silt or sand and free of rocks, which might damage the pipeline or its coating.

3. Special Crossings

i. Roads and Railways

Roads are classified as minor (earth) and major (tarred/express) roads. Minor roads are open cut and the pipe would be laid with a minimum cover of 1.5m to the top of the pipe. The extra cover would be extended 5m from the centre-line of the track, measured perpendicular to the track. For standard major road and railway crossing, pipes would be laid by thrust boring.

ii. Existing/Foreign service (NITEL cables and water pipes)

When existing/foreign service is at a depth of less than 300 mm below ground level, the distance between underside of Foreign Service and the new pipe shall be such that minimum specified cover would be maintained. Where the Foreign Service is deeper than 300 mm below ground level, there shall be deferred depth beneath the service to achieve 600 mm clearance. Precast reinforced concrete slabs shall be installed above existing service where required by the owing authority. 150 mm thick precast reinforced concrete slabs would be laid on all cross-country foreign services and would be extended on each side of the Foreign Service.

Design Codes, Standards and Regulatory Requirements

The pipeline system will be designed in accordance with the following code, standards and regulatory requirements:

American Petroleum Institute (API)

API 5L	Specification for Line Pipe
API 5LC	Specification for Corrosion Resistant Alloy Line Pipe
API 5LD	Specification for Clad Line Pipe
API 6D	Specification for Pipeline Valves

American National Standards Institute (ANSI)

ANSI B 16.5	Specification for Steel Pipe Flanges and Flanged Fittings
ANSI B 16.9	Steel Butt Weld Fittings
ANSI B 16.25	Butt Welding Ends
ANSI B31.3	Chemical Plant and Petroleum Refinery Piping
ANSI B 31.4	Oil Transmissions and Distribution Piping Systems
ANSI B 31.8	Gas Transmission and Distribution Systems

American Society for Testing Materials (ASTM)

ASTMA105	Carbon Steel Forgings for Piping Components
ASTM A 182	Stainless Steel Fittings
ASTM A 193	Alloy Steel and Stainless Steel

American Society of Mechanical Engineering (ASME)

ASME VIII	Boiler and Pressure Vessel Code

National Association of Corrosion Engineers (NACE)

MR-01-75	Sulphide Stress Cracking Resistant Metallic Material for Oil Field Equipment

Det Norske Veritas
DNV (1976) Rules for the Design, Construction and Inspection of Submarine Pipelines and Pipeline Risers
DNV (1981) Rules for Submarine Pipeline Systems
DNV RP-B401 Cathodic Protection Design

Manufacturing Standardisation Society
MSS SP-44 Steel Pipeline Flanges
MSS SP-75 Specification for High Test Wrought Butt Welding Fittings

Regulatory Requirements
The Mineral Oils (Safety) Regulations of the Federal Republic of Nigeria
The Oil Pipelines Act (1990)
Supplement to the Nigerian Oil and Gas Pipelines Regulations (1995)

e) Pipe Coatings

1) Coal Tar Coating

To protect the pipeline from external corrosion it would be covered with a high integrity anti-corrosion coating consisting of coal tar reinforced by a heavy-duty type resin impregnated with fibre tissue. These will be applied at the fabrication yard.

2) PVC Coating

Application of Serviwrap (PVC tape) as anti-corrosion coating at the pipeline weld joints would be carried out on the field during construction activities.

3) Concrete Coating

After application of the anti-corrosion coating, the pipeline shall be coated with concrete to:

- Ensure the stability of the line at both the river crossings and the swamp sections. The weight of the concrete will effectively offset the buoyancy of the pipeline.
- Supply the necessary weight to withstand the river currents during installation.
- Provide impact protection in case the pipeline is accidentally exposed.

f) Corrosion Protection

1) Internal Corrosion

To minimise threat of internal pipeline corrosion, an inhibitor may be injected into the pipeline. Further more, pigging of the line will prevent the accumulation of debris, which are known contributors to internal corrosion. The low concentration of sulphate in the pipeline will minimise the activity of sulphate reducing bacteria and consequently eliminate the risk of corrosion and hydrogen induced cracking from this source.

2) External Corrosion Cathodic Protection

Cathodic protection is based on galvanic corrosion. The efficiency will be improved through the use of an impressed electric current. The design of the cathodic protection scheme would be determined by the findings of the corrosion survey, the pipeline diameter, wall thickness and coating material, and application quality.

3.5 Site Preparation, Pre-Construction, Construction, and Operational Phases

3.5.1 Site Preparation

Prior to site preparation, land for the project would be acquired and owners of the delineated land compensated. Before bush clearing/site preparation, surveyors would mark both the boundaries of the working width (right of way) and the centre line of the pipeline with posts. The working width of the pipeline will be 25m.

Early activities of the construction phase will include site preparation by clearing vegetation. The activities will be carefully planned and co-ordinated by Dangote Industries Limited and construction contractors. Disposal activities associated with the above will be handled as described in the Waste Management and Environmental Management Plan (EMP) sections of the EIA report.

Within the working width, vegetation that would be removed would be piled on one side of the trench for the pipeline to prevent excavated materials from washing into the uncleared areas.

3.5.2 Construction

Construction of the gas pipeline will be executed in accordance with a standard planning framework that will be reviewed as it becomes expedient by project team to ensure:

- Maximum efficiency in construction
- Minimum adverse environmental and health impacts
- Earliest completion time
- Compliance with the laws of the land and all regulatory requirements

Construction Materials

All materials to be used in the construction of the gas pipeline shall be tested in accordance with the appropriate International Standard and requirements to verify their suitability for the purpose. The actual quantities of the various bulk materials required will vary depending on the outcome of the detailed design exercise, yet to be carried out. Sourcing of the materials is the responsibility of Dangote Industries Limited contractor, subject to any constraints imposed by this EIA report.

Logistics Arrangements

In consideration of the massive movement of construction equipment, materials and resources during the construction phase of the project, the construction work itself will need proper logistics arrangement. The operational focus of the project will be along the pipeline from Ajaokuta – Obajana and the logistics support will be provided through various outlets – sea, air and road transport. The bulk of the equipment will be supplied via Lagos port. Some smaller and highly sensitive equipment many be air freighted to Abuja. Additional facilities required will be storage areas for fuel, a work camp complete with water supply, electricity and communication facilities, logistics office and cranes for handling material.

Within Nigeria the logistic support for the project shall be provided mainly by road transport through which all materials and equipment including personnel shall be taken to site. The operational base for the project shall be Lokoja and Abuja. Considering the massive movement of construction equipment, materials, and resources during the

construction phase of the project, logistic arrangement shall be accorded adequate attention.

The construction of the pipeline will comply with the latest edition of international industry standards "Design and Construction of ANSI/ASME code B31.8-Gas Transmission and Distribution Systems.

The standard method for the construction and installation of buried welded steel pipelines is based on a continuous moving assembly line with each sequential activity maintaining a consistent rate of progress.

Main Construction Team Work (Main Spread Team)
The majority of the pipeline length will be constructed in several stages, each by the main construction team. The activities of this team result in sections of fully welded pipe being laid in the trench and roughly backfilled. In addition, special crews for such operations as field bending of pipes, installation of manifold/valve stations and major water crossings also operate as necessary. In each stage of main teamwork, construction is a cut and fills process generally involving the stages below:

- Top soil removal
- Ditching involving subsoil removal
- Coating
- Pipe laying
- Cleaning
- Welding
- Inspection
- Hydrotesting
- Backfilling
- Soil Management/Reinstatement:

i Topsoil Removal

The topsoil would be stripped from the working width and stored in an earth bound, which runs continuously parallel to the trench on one side of the working width.

ii Pipe Laying

Pre-coated pipes would be delivered from the pipe yard. After inspection, the welds and any other area of bare pipe would be coated with "serviwrap" PVC tape and concrete-coated so as to form a continuous protective coating. The pipes would then be laid on stands along the trench. Once a section has been completed, the trench profile is checked, the stands removed and the pipeline is settled on the bottom of the trench.

iii Backfilling

The working procedures for backfilling are determined by the nature of soils of the area and the mode of construction. In general, the first stage will be to return materials excavated from the trench in a reverse order.

iv Pressure Testing

The internal part of the pipeline will be cleaned using two wire brush pigs propelled through the line by compressed air. A gauging pig will then be installed and propelled through the pipeline with water. The gauging pig will identify any deformities in the pipeline shape. The water pressure will be increased and the line hydrostatiscally pressure tested. Once up to full test, the pressure will be monitored for 24 hours to ensure pressure maintenance. If pressure drops, it may indicate a leak and further inspection will be required.

v Regrading

Once hydrostatic tests have been completed, the working area will be regraded with topsoil and appropriate cultivation undertaken, where necessary. The returned soil is graded so as to allow settlement. The soil would be spread evenly over the working width to ensure maintenance of the working width bank.

Specialist Team

In addition to the main construction spreads, there will be specialist teams that precede the main spread. These are specialists on river crossing, reinstatement topography and erosion. Works in some cases will require the use of special vehicles (tractor and trailer).

i River Crossing

Streams and rivers are either tunneled by boring or directional drilling techniques or may be trenched across using either 'dry' or 'wet' techniques. The length of crossing, rate of flow of water and characteristics of the riverbed will determine the techniques to be chosen. Rivers and streams will be crossed using the same trenching technique employed on the other parts of the route. Rivers and streams likely to be crossed in the 'wet' will be excavated or dredged in the river bed by equipment operating in the water or along drag lines operating in the banks. 'Wet' crossings inevitably involve sediment disturbance and silt sedimentation. Each crossing will be subjected to an assessment of the ecology and water usage. Dry crossing technique involves trenching under the water such that the pipe will be below the riverbed. This has the advantage of reducing impacts on the water quality of the river/stream such as increased suspended particles, turbidity and flow rate. For this project, dry technique for river crossing will be adopted.

ii Restoration/Reinstatement

Correct construction techniques will be employed to guard against any long-term restoration problem, i.e. soil erosion. The success of any restoration process is measured by the similarity of the vegetation and firmness of the soil on the restored land to that of its surroundings.

Noise

The following activities during the construction phase of the project will generate noise: bush clearing, excavation, pipelaying, vehicular movement, operation of equipment and commissioning.

3.6 Operation

3.6.1 Operations Control/Monitoring of Gas Pipeline

The risks of pollution are small and as the pipeline system will be buried within a ROW, there will be negligible nuisance associated with its operation. Pipeline integrity is vital for operational reasons and management of the operational phase. To achieve effective operations, it is wise to look into the:

- Operational Management;
- Effects of Pipeline Temperature;
- Gas Leak.

Pipeline pressure will be monitored at the pipeline manifold (valve) end at Ajaokuta and flow will be measured at the terminal points at Obajana. These measurements will act as additional indicators that the pipeline integrity is being maintained. Communication between the operations at the Ajaokuta terminal and the terminal at Obajana will be via both radio and telephone systems.

3.7 Maintenance and Inspection

Regular surveillance of the pipeline route will form an integral element of the integrity monitoring system and will seek to:

- Detect and locate any activity which may interact with the pipeline including unauthorised third party activity;
- Locate any local changes or ground conditions which may threaten the pipeline including areas of ground erosion, movement or subsidence;
- Detect any leakage from the pipeline and its facilities.

To reduce the risk to the pipeline from third party activities, most often due to unauthorized building and construction work, valves and alarms shall be incorporated into the design and construction. As part of the operational integrity monitoring, the following inspection procedures will be introduced:

- Initial inspection of the pipeline coating to cover routine surveillance aided by the presence of marker posts at all major crossings and field boundaries. The pipeline route will be inspected at monthly intervals. Block valve stations will be regularly visited;
- Close liaison with all communities along the route will be maintained;
- Induced current density readings will be recorded and analysed to identify any areas where it is indicated that cathodic protection is not at the required level.

Pigging Operations

The pipeline system is provided with "pig" launching facilities. These enable various pigs to be sent down the pipeline for commissioning, maintenance and inspection purposes. Pigs fulfill a number of roles; they:

- Clean the line of unwanted debris;
- Check the pipeline for signs of damages or deformity;
- Detect areas of corrosion;

The frequency of pigging operations will be determined by operational circumstances.

3.8 Wastes and Disposal Activities

Effective and responsible handling and disposal of wastes are key elements in environmental management system. Wastes refer to any material (solid, liquid, gaseous or mixture) that is surplus to requirements. Waste management for the project shall be carried out in consultation and in line with the waste management guidelines of Kogi State Waste management board.

Dangote shall take all practical and cost effective measures to minimise the generation of wastes, by employing the four R's (Reduce, Reuse, Recycle, and Recovery) through process of optimisation or redesign, efficient procedures and good housekeeping.

Waste shall be managed in the following ways;

- Inventorisation
- Classification
- Segregation
- Wastes quantification
- Wastes tracking; and
- Wastes disposal

Wastes disposal shall be shall be carried out in consultation with the Kogi State Wastes management board.

Solid Wastes

These types of waste include cleared vegetation, domestic refuse, pigging trash, scrap metals, filters, welding torches and spent electrodes. Trees would be felled along ROW and cut into useable lengths. In line with waste management procedures, identified solid wastes will be sorted and disposed of in designated areas.

All chemicals used by Dangote Industries Limited would be handled and ultimately disposed of according to the requirements of Safe Handling of Chemicals (SHOC) system. There shall be maintained records of all chemicals stored on site, identifying their Health, Safety and Environmental implications.

Regular checks shall be made by Dangote Industries Limited to ensure that records are maintained and storage facilities are in good handling practices.
Solid wastes would be disposed of in the following manner:

- Plastic containers depending on their size will either be returned to the supplier, cleaned for reuse or crushed;
- The disposal of industrial wastes would be conducted in designated areas in accordance with regulation.

Aqueous /Non Aqueous Wastes

i) Black and Grey Water

Black water refers to sewage whereas grey water is domestic wastewater. These shall be disposed off in accordance with national standards and guidelines.

ii) Hydrotest Water

Prior to operation, the pipeline will be pressure-tested using fresh water from River Niger. The River Niger waters are confirmed fresh hence addition of inhibitors will not be required. Since inhibitor will not used along with the

pressure testing water, the waters used may not constitute any danger to the receiving environment. The water shall therefore be returned to River Niger.

iii) Diesel/Oil/Condensate

These wastes would emanate from working equipment such as welding machines, excavators, bulldozer etc. These wastes shall be scooped, contained and disposed off in designated sites. Liquid condensate from pigging operations will be reclaimed and sent to fuel depots/refinery for recycling.

Gaseous Emissions and Discharges

The atmospheric emissions principally associated with gaseous discharges during the construction activities are: Carbon Dioxide ($C0_2$), Carbon monoxide (CO), Methane (CH_4), Oxides of Nitrogen (NO_X) and Sulphur Dioxide (SO_2).

3.9 Commissioning and Decommissioning/Abandonment

At the completion of installation of pipeline, pressure testing will be conducted after which it will be commissioned. A period of approximately two months will be required for the final testing of the pipeline prior to its start-up. The pipeline is designed to last for a minimum of 25 years. When the use of the pipeline is no longer required, it will be abandoned. If the need arises in the future to decommission and abandon the pipeline, Dangote Industries Limited will set up a decommissioning team to plan and ultimately, implement standard procedures for decommissioning and abandonment of the project.

The decommissioning and abandonment exercise will involve:

- Removal of gas;
- Cleaning the pipeline;
- Removal of all surface facilities; and
- Capping and sealing all open ends

Adequate commitment shall be maintained with stakeholders to mutually ascertain alternative needs and possible use of the facilities, by other parties. Dangote Industries Limited will maintain a record of the abandoned facilities and a copy will be given to the regulators.

3.10 Project Schedule

EIA as a frontline activity for the proposed project is schedule to last for six months, material procurement will last for one month, logistic arrangement (movements of materials) will last for over three weeks, excavation and laying of pipeline will last for three months, testing will last for over a week. The gas pipeline project is scheduled for commissioning within 21 months.

CHAPTER FOUR

4.0 DESCRIPTION OF THE ENVIRONMENT

4.1 Introduction

Acquisition of environmental baseline of a project area is an important phase of any Environmental Assessment process. Baseline data provide vital information on the existing environmental quality in which a development is planned. It is also useful for delineating environmental sensitive areas and for preparing an Environmental Sensitivity Map for contingency planning. In this study, the environmental characteristics of the project area were established through extensive literature search, field sampling/measurements, laboratory analysis, stakeholder consultation and data interpretation.

Data from literature search were obtained from the existing two-season baseline study of Ajaokuta-Abuja Gas Pipeline, Thermal Plant and Transmission Project (Phase 1; from Ajaokuta-Abaji, Obajana area was also covered in this study). Fieldwork for the baseline was onducted between 11th and 25th May 2001, 2nd and 9th August 2001, 16th and 26th October 2001 and between 13th and 21st May 2002 by the Shell Petroleum Development Company (SPDC) of Nigeria (see **Appendix 4.1a** for approval issued by FMENv for the use of the existing baseline data). This environmental data covered the wet and dry seasons of the project area.

Gaps in environmental baseline information of the area were identified, and fieldwork activities designed to acquire additional data to fill these gaps was planned and conducted between 17 - 28th March, 2003.

4.2 Sampling Methods and Field Measurement

FMENV and DPR Guidelines and Standards Part VIII D (2) were strictly adhered to in the cause of field sampling and measurement. A multi-disciplinary approach was adopted for the ecological characterisation and data acquisition. The environmental components covered include topography, climate/Meteorology, air quality, and noise soil, vegetation, animal ecology, aquatic systems including ecology and fisheries, geology/geophysics/hydrogeology, socio-economics, health status assessment and waste management.

Sampling points were established and co-ordinates of the sampling points taken **(EIA Sample Location Map-Map 4.1)**. See **Appendix 4.1** for detailed field sampling methodologies. Fast changing parameters were determined *in-situ* using calibrated instruments.

A surveyor with the project team co-ordinated field sample positions using Global Positioning System (GPS).

4.3 Quality Assurance/Control Procedure

Standard methods and procedures have been strictly adhered to in the course of this study. QA/QC procedures were implemented during sample collection, labeling, analyses and data verification. Chain of custody procedures including sample handling, transportation, logging and cross-checking in the laboratory have also been implemented.

All analyses were carried out in DPR/FMENV accredited laboratories. The methods of analyses used in this study were those specified in EGASPIN 2002 and other internationally accepted analytical procedures, in order to ensure the reliability and integrity of the data obtained. Details of the analytical procedures for all the parameters are summarised in **Appendix 4.1.**

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

4.4 Environmental Field Data

Below is the description of the baseline status of environmental components of the proposed Ajaokuta-Obajana Gas Pipeline Project area.

4.4.1 Relief/Topography

The terrain heightening of most of the areas under study ranges from a lower elevation of 45 - 205m from Ajaokuta to obajana area. However, within these ranges, some isolated areas rise up to 400m particularly between Ajaokuta and Itakpe iron ore areas. The hills are steep sided and rugged. They are mainly associated with granite complexes and are characterized by sharp concave breaks of slope around their margins. In many areas (eg between Ajoakuta and Osara) they are strongly dissected with a high proportion of bare rocks (**Plate 4.1**). The valleys have irregular drains usually with fine to coarse textured sand and large amounts of rock outcrops. The sides of the drains are eroded and exposed during the dry season (**Plate 4.2**). Generally the proposed pipeline route from Ajaokuta through Eganyin to Obajana has undulating plains

4.4.2 Climate/Meteorology

The project area is within the Savanna zone associated with high temperatures, low humidity and cloudless sky for most of the year. The climate of the study area is tropical. It is under the influence of the Inter-Tropical Convergence Zone (ITCZ) or Inter-Tropical Discontinuity Zone (ITDZ). There are marked wet and dry seasons. The dry season starts around November and ends in March/April. The effect of the dry dusty northeast trade winds is strongly felt because of the latitudinal position of the area. The wet season on the other hand, occurs between the months of May and October. The meteorological conditions of the study area are greatly influenced by this seasonal alteration. Although weather/climatic data were collected during the field study, historical data were also collected covering the period 1960-1999 for the study area and are expected to be no different. The main characteristics of the climate and meteorology of the study area is described below.

Air Temperature

Temperatures are generally high with monthly maxima and minima of about 35^0 and 21^0C respectively (Hopkins, 1974). This is due to the latitudinal location of the region within the tropics, though some mild modifications are traceable to influences by sea breeze from the Atlantic Ocean and Northeast trade wind (harmattan). Analysis of long-term temperature records (1960-1999) indicates an annual mean of 32^0C. Air temperature values are generally slightly higher for the dry season months (33.3-36.6^0C) than the wet season months (30.0-33.1^0C) (**Table 4.1**). Nevertheless, temperature is uniformly high throughout the year with a small monthly range.

Plate 4.1: Undulating Relief/Topograpny within the Study Area

Plate 4.2: Eroded Banks of River Osara

Table 4.1: Maximum, Minimum, and Mean Temperatures (^oC) for Lokoja and Koton-Karfi (1960-1999)

Month	Average daily maximum		Average daily minimum		Mean daily	
	Lokoja	*Koton-Karfi*	*Lokoja*	*Koton-Karfi*	*Lokoja*	*Koton-Karfi*
January	36.0	36.3	23.3	22.8	28.9	28.1
February	36.3	36.6	25.6	26.0	30.0	30.6
March	34.4	36.0	25.3	20.1	29.7	30.0
April	32.8	33.1	23.3	24.2	28.3	27.8
May	31.1	31.4	23.1	23.3	27.2	27.5
June	30.3	30.6	22.8	21.7	26.4	27.5
July	30.0	30.3	22.8	23.1	26.1	26.4
August	30.6	30.6	22.5	22.8	26.4	26.4
September	31.7	31.7	22.8	23.1	27.2	26.9
October	33.1	33.1	22.2	22.5	27.8	27.2
November	33.3	33.3	20.0	20.6	25.6	26.1
December	32.5	33.1	22.9	23.1	27.6	27.7
Mean	**32.5**	**32.7**	**23.0**	**23.2**	**27.6**	**27.7**

Source Federal Department of Meteorological Services, Oshodi.

The highest mean temperature values occur in the month of February at the peak of the dry season while the lowest occur in the month of July at the peak of the wet season. During the field studies the temperatures recorded (**Table 4.2**) at various sampling locations between Ajaokuta and Obajana ranged from 31.2 – 36.9^{0}C and fall within the historical range of temperatures for the area. The dew point temperature ranged from 21.8 – 29.5^{0}C during the field studies. Field observation suggests that on a diurnal basis, maximum temperature occurs between 1300 and 1500h while minimum temperature occurs between 0100 and 0600h.

Relative Humidity

Mean monthly relative humidity is generally low with no month experiencing values greater than 85% (**Table 4.3**). As expected, mean monthly relative humidity values are slightly high for the wet season months (June to October) with the highest values occurring within the months of June and September (**Table 4.3**. This is when the influence of the moisture-laden southwesterlies is greatest.

Table 4.2: Summary of weather conditions recorded at various sampling stations between Ajaokuta and Obajana (Wet and dry sesons of between 2001, and 2002)

Meteorogical parameter		AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7
Mean windspeed (m/s)	Wet	1.1	1.1	1.2	0.8	1.7	1.8	0.8
	Dry	1.7	2.4	0.8	2.5	1.2	1.2	2.0
Wind direction	Wet	SW	SW	SSE	SW	S	S	SSE
	Dry	NW	NW	NE	N	NW	SE	E
RH(%)	Wet	80.0	82.0	82.0	56.0	59.0	50.0	79.0
	Dry	62.0	51.0	57.0	92.0	52.0	73.0	72.0
Dew point (^{0}C)	Wet	22.6	22.1	23.4	22.8	23.6	22.8	22.0
	Dry	24.0	23.8	23.6	23.9	24.7	23.4	26.1
Temperature (^{0}C)	Wet	32.9	33.5	28.0	33.4	32.4	36.2	29.8
	Dry	36.4	35.4	32.7	33.8	34.5	28.0	35.1

Locations:

AQ1 = Ajaokuta steel plant by manifold
AQ2 = Itakpe iron ore mining (quarry)
AQ3 = Irapana village
AQ4 = NNPC Pump Station, Lokoja
AQ5 = By River Niger at Jamata
AQ7 = Obajana village
AQ6 = Two bridge village

Table 4.3: Mean Monthly Relative Humidity (%) and Mean Monthly Total Rainfall (mm) for Lokoja and Koton-karfi (1961-1999)

Month	Mean Monthly Minimum Relative Humidity (%)		Mean Monthly Maximum Relative Humidity (%)		Mean Monthly Total rainfall (mm)	
	Lokoja	*Koton-Karfi*	*Lokoja*	*Koton-Karfi*	*Lokoja*	*Koton-Karfi*
January	64	60	51	48	0	12.7
February	57	59	42	44	0	22.86
March	65	67	56	51	50.8	76.0
April	72	75	58	56	101.6	88.9
May	78	79	56	56	152.4	152.4
June	78	76	68	67	152.4	177.8
July	77	78	57	52	177.8	215.9
August	74	75	60	66	177.8	177.8
September	82	84	68	69	203.7	215.9
October	77	78	56	61	127.0	152.4
November	75	78	53	51	25.4	38.1
December	69	68	40	44	0	0
Mean	72.3	73.1	56.3	55.1	97.4	110.9

Source: Federal Department of Meteorological Services, Oshodi

During the field monitoring, daily relative humidity of 55-90% was recorded for wet season and 50-72% for dry season (**Table 4.2**). Maximum relative humidity values generally occurred between 0700h and 0900h while minimum relative humidity values were recorded between 1000h and 1600h.

Rainfall and Sunshine

The mean annual rainfall of the Guinea Savanna lies between 1016 and 1270mm, the rainfall is seasonally distributed such that the length of the dry season varies from 4-5 months but not more than 5 or 6 months have less than 25mm of rain (Hopkins, 1974). Rainfall is mainly due to the influence of Southwesterly winds, which prevail during the wet season. However, conventionally and relief induced rains as well as thunderstorms are frequent during the early wet season (Oguntoyinbo 1976, Ojo 1977). The annual distribution of rainfall indicates a peak in September. The number of rain days varies **(Table 4.4**). At Lokoja and Koton-karfi rain rarely falls more than once in the months between December and March (**Table 4.4)**.

Table 4.4: Monthly Sunshine hours and Rain days at Lokoja and Koton-karfi (1961-1999)

Month	Rain day/Month		Mean Daily Sunshine Hours	
	Lokoja	*Koton-Karfi*	*Lokoja*	*Koton-Karfi*
January	1	1	7.4	7.6
February	1	1	7.9	7.9
March	2	2	7.6	7.8
April	5	4	6.5	6.6
May	7	6	6.4	6.5
June	12	11	6.4	6.4
July	13	14	4.8	4.8
August	12	11	4.3	4.3
September	18	17	4.4	4.4
October	13	13	6.6	6.6
November	3	2	8.3	8.3
December	2	2	8.5	8.5
Mean	**7.4**	**7.0**	**6.6**	**6.6**

Source: Federal Department of Meteorological Services, Oshodi

Wind Speed and Directions

The mean surface wind speed and direction depends on the seasonal variation. Two main air masses alternate with the season. During the dry season, the Northeast winds predominate while the Southwest winds are dominant during the wet season (Folorunsho and Awosika, 1995). The highest speed is recorded at the onset of the wet season when early rains are torrential and accompanied by squalls, lightning, and thunder. The wind speeds are lower in the nights than during the days. Ranges of 2 m/s and 20m/s are recorded for the Guinea Savanna area of Nigeria (PTF EIA, 1999).

During the field study the mean wind speed varied from 0.8 to 1.8m/s during the wet season and 0.6 – 3.1 m/s during the dry season (**Table 4.2**). The direction was mainly southwesterly (wet season) and northeasterly (dry season). An overall assessment of the sunshine hours revealed that the dullest month is during the peak of the wet season in August and September for Lokoja and Koton-karfi (**Table 4.4**).

A summary of the weather conditions at various sampling points during fieldwork activities to fill in data for the EIA study (March, 2003) are presented in **Table 4.5**.

Table 4.5: Summary of Weather Conditions for study area for the proposed Ajaokuta-Obajana Gas Pipeline, (March, 2003)

Location Code	Relative Humidity (%)	Wind Direction	Wind Speed (m/s)	Atmospheric stability	Cloud cover (oktas)	Heat Radiation (kw/m^2)	Temp. (^oC)
AQ1	80	SW	1.13	B	3	1.02	39.6
AQ2	82	SW	1.08	B	3	1.24	32.4
AQ3	2	SW	1.05	B	3	0.97	30.5
AQ4	78	SW	1.24	B	3	1.22	31.9

Key
AQ1 = Ajaokuta steel plant (by gas manifold).
AQ2 = Nigerian Iron ore quarry (Itakpe), by the main gate.
AQ3 = NNPC pumping station, Lokoja (by the main gate).
AQ4 = Obajana village (100m from the town along Lokoja-Kabba road).

4.4.3 Air Quality and Noise

A summary of the findings of the ambient air quality measurements taken for the project area is presented in **Tables 4.6 and 4.7** with due reference to FMENV standards. With the exception of SPM whose concentrations exceeded the limits around Ajaokuta and Itakpe areas, the concentrations of all other air quality parameters measured were below FMENV limits. The high SPM values around Ajaokuta and Itakpe are as a result of the various quarrying activities in these areas. Generally the SPM values ranged from 30.3 to 771.3µg/m^3 with a mean of 78.8µg/m^3 (wet season) and 237.1µg/m^3 (dry season) (**Table 4.6**). CO was not detected in all the sampling locations. The trend of results was observed during the EIA field study in March 2003.

The noise levels (**Table 4.6**) varied from 39.8 to 69.8dB(A). A high value of 69.8dB(A) was recorded near the NNPC pump station at Lokoja during the dry season. During the field study of May 2002, values recorded for Ajokuta Stell Company, Nigerian Iron ore quarry (Itakpe), by the main gate, and NNPC pumping station, Lokoja were 72.60dB(A), 71.48dB(A) and 70.00dB(A) respectively (**Table 4.6a**). These high noise values could be attributed to the on-going project activities at the time of field study.

Table 4.6a: Air Quality and Noise Characteristics of the Project Area (Wet and Dry Seasos of 2001-2002)

Location	Air Quality parameter									
	SO_x(µg/m^3)		NO_x(µg/m^3)		CO (µg/m^3)		SPM (µg/m^3)		NOISE dB(A)	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
AQ1	15.6	15.6	52.50	35.63	ND	ND	746.2	257.1	48.8	39.8
AQ2	15.6	ND	52.50	ND	ND	ND	751.3	302.5	48.5	46.1
AQ3	15.6	ND	52.50	ND	ND	ND	116.0	63.0	45.7	45.8
AQ4	15.6	ND	52.50	ND	ND	ND	216.8	37.8	69.8	43.0
AQ5	15.6	28.6	52.50	52.50	ND	ND	231.9	88.2	48.8	46.0
AQ6	15.6	15.6	52.50	26.25	ND	ND	123.5	27.7	40.5	40.5
AQ7	15.6	15.6	52.50	35.63	ND	ND	191.6	30.3	54.3	45.6
FMENV Limit	26-260		75-113		11.4-22.8		250-600		90	

Locations
AQ1 = Ajaokuta steel plant by mainfold
AQ2 = Itakpe iron ore mining (Quarry)
AQ3 = Irapaja village
AQ4 = NNPC pump station, Lokoja
AQ5 = By River Niger at Jamata
AQ6 = Two bridge village
AQ7 = Obajana village (100m from the town along Lokoja-Kabba road).

Table 4.6a: Summary of Ambient Air Quality and Noise Measurements for the Project Area (2002)

Air Quality code /parameter	AQ1	AQ2	AQ3	AQ4	MEAN	FMENV LIMIT
DATE	16/5/02	16/5/02	5/5/02	15/5/02		
TIME	12.00p.m	4.00p.m	12.00p.m	3.20p.m		
SOµg/m^3)	0.03	0.06	0.04	0.02	0.04	25.0
NOµg/m^3)	15.6	10.4	10.4	5.2	11.75	26.0-260
CO µg/m^3)	15.0	9.4	5.6	13.1	12.76	75-113
TSP µg/m^3)	ND	ND	ND	ND	-	11.4-22.8
VOC µg/m^3)	204.2	182.5	238.2	81.2	157.76	250-600
VOC µg/m^3)	0.003	0.007	0.001	0.006	0.0704	600
NOISE dB(A)	72.60	71.48	70.00	54.25	65.19	90.00

Key
AQ1 = Ajaokuta steel plant (by gas manifold).
AQ2 = Nigerian Iron ore quarry (Itakpe), by the main gate.
AQ3 = NNPC pumping station, Lokoja (by the main gate).
AQ4 = Obajana village (100m from the town along Lokoja-Kabba road).

4.4.4 Soil

4.4.4.1 Physical Properties

The major soils occurring in the study area are:

- Juvenile/lacustrine alluvium or hydromorphic soils
- Ferrisols/ferruginous
- Lithosols

a) The Juvenile soils on riverine and lacustrine alluvium have highly heterogeneous parent material with stratified profiles. They consists of soils of the flood plains, which are permanently or seasonally water logged located mainly on lower slopes and alluvial areas referred to as "fadama". Only mineral hydromorphic soils were

encountered within the study area particularly on the flood plains of the River Niger and other major rivers.

b) Ferrisols/ferruginous tropical soils of two main types (luvisols and cambisols) were encountered and these covered over half of the study area. These soils exhibited differentiated horizons and frequently had a leached A horizon and contained a textural or structural B-horizon. Free iron oxides were present within the profile in the form of mottles or concretions. The ferruginous soils were either developed on crystaline rocks, or were undifferentiated and developed from mixed rocks of basement complex. A summary of the characteristics of the ferrisols encountered within the study area is given in **Table 4.7**.

c) The lithosols are soils with weakly developed genetic horizons containing coarse elements and having solid rock within 30-60cm of the surface. They are of limited agricultural value as the profile is very shallow.

The ferrisols have deep profile with varying amounts of iron concretions. The clay fraction usually consists entirely of Kaolinite (1:1 clay), free iron oxides and amorphous gels with small quantities of 2:1 clay. The clay content of the hydromorphic soils was sometimes of the montmorillonite type with 2:1 lattice clay structure whose surfaces crack during the dry season.

The soil types observed ranged from sand to loam with the sand fraction varying from 68.3-95.3%. The percentage sand content generally decreased with depth at any particular sampling point. The percentage silt content varied from 2.3 – 20.7% while the clay content varied from 2.3 – 20.0%.

The soils varied in moisture content from dry through moist to wet types. The wet soils were encountered on the riverbanks. The colour of the soils varied from bleached whitish soils of the riverbanks through orange/reddish types to the dark brown/grey soils of the topsoils of the lowlands/flood plains. In some areas the brown to reddish brown laterite form the topmost soil; it is hard, stiff, and ferruginised in outlook and silty in texture. From available information, the underlying light brown/lateritic sand is loose and silty in texture. The next soil horizon has a finer sandy texture with inclusion of coarse-grained fragment/gravel of decomposed rock. Structurally, the soil aggregates are angular to sub-angular blocky and have crump consistency, loose and slightly sticky (**Appendices 4.2a-d**). The topsoil was therefore easy to till; but because of the presence of underlying stony concretions (at depths of 30-120cm), which make the soils shallow at some location, ridges/mounds were usually used to provide adequate topsoil for farming purposes by the indigenous farmers.

Table 4.7: Summary of Distribution of Soil types and Associated Basement Material between Ajaokuta and Obajana (March, 2003)

Basement Material	Soil Unit/type	Location
Undifferentiated basement complex	15G Ferrisols. Very deep well drained soils, sometimes with gravelly surfaces.	Ajaokuta, Eganyin, Obajana and Lokoja
Undifferentiated basement complex, hills and ridges	24B Lithosol. Shallow, sometimes gravelly over bedrock or gravelly sub-soils.	Lokoja
Recent Alluvium	2A Juvenile/hydromorphic soils. Deep well drained, or deep poorly drained soils and sometimes with gravelly sub-soils.	River Niger plain. Jamata Koton-karfi

4.4.4.2 Chemical Properties

The chemical properties of soils of the proposed pipeline route are presented for the wet and dry seasons in **Appendices 4.3a-d** and summerised in **Table 4.8**. The soils are acidic to slightly alkaline (pH 3.8 – 7.6). There was no distinct trend in pH values for the wet and dry seasons. The electrical conductivity values were low (15.3 – 270µs/cm) indicating that the study area is within the fresh water zone. The carbon concentration (0.42 – 4.19%) were adequate to high compared to the critical level of 1% (Okpidi, 1984). The soils at the project area contain high organic carbon due mainly to the denser vegetation. Similarly, the dry season recorded higher organic matter content compared to the wet season due to the fact that during the dry season, most of the organic carbon remained undecomposed as a result of low moisture content of the soils.

The total nitrogen of the soils along the proposed pipeline route right of way (ROW) were low to adequate and ranged from 0.01 to 0.9% compared to 0.15 to 0.20% for moderate ranges in soil (Adebusuyin, 1985). It must however be noted that a substantial amount of the nitrogen in the soils of the study area is contributed by nitrogen fixing bacteria of the genus *Rhizobium* associated with the leguminous plants of the area which constitute an appreciable proportion of the plant species. Thus the amount of nitrogen in the soil is small while the quantity fixed through nitrogen fixation by the leguminous plants and utilized is comparatively large.

The phosphorus concentrations ranged from 0.2 - 62.7ppm and most of the values fall within the accepted range of 7.0-20.00ppm for agricultural purposes (Sobulo and Adeputu, 1984). The concentrations of other anions were low to moderate and composed mainly of nitrates (0.001-0.46ppm); nitrites (0.006-0.498ppm); ammonium (0.078-40.0ppm) and sulphates (0.06-4.77ppm). The chloride concentrations were generally low (17.5 – 3551ppm). The application of fertilizers may account for the rather high levels of chloride encountered at some isolated sampling point within the study area.

The total content of the basic cations like Ca, Mg and K, also give the extent of leaching of the soil. The effective cation exchange capacity (ECEC) of the soils ranged from 0.50 to 9.61meq/100g soil. FAO (1979) puts the value for normal soil at 8.0 – 16.0 meq/100g soil. Thus the values recorded for the study area are low. Ca (0.24 – 11.68meq/100g soil) and Mg (0.08-8.96meq/100g) dominated the observed ECEC values. The exchangeable acidity ($H^+ + Al^{3+}$) values were relatively low to high compared to that of ECEC and this accounted for the observed low to high base saturation values (15.1 – 99.9%). Most of the values (>80%) were above the critical level of 50% base saturation.

The soils contain adequate concentrations of microelements or heavy metals for the healthy growth of plants. There was no indication of accumulation of microelements as a result of past/present farming practices, industrial activities or the construction of the existing pipeline route. The total hydrocarbon concentrations of the soils of the study area were low (0.29 – 9.6ppm) and these could be from biogenic sources (decaying plant and animal parts - suberins, waxes, chitin etc). There is therefore no addition of hydrocarbon from anthropogenic or petrogenic sources within the study area.

Table 4.8: Summary of Physico-chemical Parameters of the Soils of the Study Area (Wet and Dry Seasos of 2001-2002)

Parameters	Dry	Wet	Critical Level	Reference
pH	5.5 - 7.6	3.8-6.9	5.0 – 6.0	Brady 1990
EC µS/cm	15.3-251	21.0-270		
C %	0.64-4.19	0.64-4.10	1.0	Okpidi 1985, Aweto 1981
N%	0.04-0.90	0.058-0.400	0.15	Adebusuyi 1985
Av. P ppm	0.60-43.3	0.1-62.7	7 – 20	Sobulo & Adepetu 1986
NO_3 ppm	0.024-0.180	0.01-0.46		
NO_2 ppm	0.006-0.245	0.01-0.26	2 – 15	Sobulo & Adepetu 1986
NH_4 ppm	0.078-17.183	5.7-40.0	6 – 10	Sobulo & Adepetu 1986
SO_4 ppm	0.280-5.290	0.06-4.77		
Cl^- ppm	17.6-71.0	247-3551		
Na meq/100g soil	0.11-0.51	0.06-0.22		
K meq/100g soil	0.007-0.45	0.02-0.22		
Ca meq/100g soil	1.28-11.68	0.24-2.24	2 – 5	Sobulo & Adepetu 1986
Mg meq/100g soil	0.24-8.96	0.08-1.04	0.10 – 1.0	Sobulo & Adepetu 1986
H^+ meq/100g soil	0.60	0.10-2.90		
Al^{3+} meq/100g soil	0	0.0-0.90		
ECEC meq/100g soil	1.03-20.72	0.60-4.43	8.0 – 16	FAO - 1994
B Sat %	91.40-99.90	15.1-98.5	50	
Fe ppm	0-423	70-345	4.5 mg/kg	Viets & Lindsay 1984
Mn ppm	0-89.16	13.5-181.0	1.0	Viets & Lindsay 1984
Zn ppm	0.23-31.51	2.68-49.75	1.0	Viets & Lindsay 1984
Cu ppm	0.19-2.74	0.01-2.75	0.2	Viets & Lindsay 1984
Cr ppm	0-1.26	0.01-2.34		
Cd ppm	0-0.08	0.01-0.31		
Ni ppm	0-1.08	0.01-0.89		
V ppm	0-0.36	0.01-0.56		
Pb ppm	0-11.68	0.01-467		
Hg ppm	0-0.001	0.0-0.001		
THC ppm	1.4-25.9	0.29-5.03	30	DPR, 1991
Sand %	68.3-92.3	70.2-95.2		
Silt %	4.2-24.7	2.3-19.8		
Clay %	2.5-18.0	2.5-20		

4.4.4.3 Soil Ecology

Soil fauna

Life in the soil is diverse ranging from microscopic single celled organisms to large burrowing animals. Hence there are well-defined food chain/energy flows within the soil ecosystem. The soil macro-fauna encountered within the study area include various arthropods (insects, millipedes, mites), molluscs (snails), annelids (earthworms) and nematodes (**Table 4.9**). These organisms are primary consumers; decomposers, mixers and utilizers of energy stored in plants and plant residues, and contribute to the re-cycling of nutrients. Others were secondary consumers such as centipedes, scorpions and spiders. These animals consume smaller sized animals and they may also serve as food for organisms occupying higher levels of the food chain. There were increases (8-25%) in the total population of soil fauna during the wet season compared to the dry season.

The soil fauna of special interest within the savanna ecosystem under study were termites and earthworms. The importance of earthworms to soil includes aeration, improvement of texture, mixing (materials from the surface taken to lower depths and *vice versa*) and nutrient re-cycling. Currently, 16 genera of earthworms have been described in Nigeria, and of these, seven occur in the Savanna ecosystem (Segun, 1980). However, three genera (*Hyperiodrilus, Ephyriodrilus* and *Eudrilus)* were encountered in the present study. The earthworms were mainly encountered in the moist-wet soils of the river plains and "fadama" areas. Their populations were relatively high during the wet season compared to the dry season.

Dotted over the land surface are termite mounds of various types inhabited by different genera (*Macrotermes, Odontotermes Amitermes, Anastrotermes* and C*ubitermes)* (**Table 4.9**). These are mainly dead wood and grass feeding types. Dry cow dung, (regarded as partly decomposed plant material) was common in the study area and was particularly consumed by *Macrotermes subhyalinus* and *Odontotermes* spp. (*O. soeathmani*, *O. pauperans*). Among the *Macrotermes,* there appears to be a fungus-termite symbiotic system, which ensures complete utilization of ingested food (Wood, 1978). The dung beette (*Oryetes* sp) was also associated with fresh cow dung; they re-distributed the dung to different locations. These animal groups are the major contributors to the re-cycling of material within the ecosystem of the study area.

Soil Microorganisms

The microorganisms and macro-fauna work together as a team in organic matter decomposition. The microorganisms of concern in this study were fungi and bacteria and these play important roles in the transformation of soil nutrients.

The pre-dominant heterotrophic bacterial isolates were *Serratia* sp, *Bacillus* sp, *Escherichia* sp*, Pseudomonas* sp*, Vibro* sp*, Flavobacterium* sp and *Alkalegenes* sp (**Table 4.10a**). Their populations varied from 8.1 - 10^6 – 20.1 - 10^7cfu/g soil with 0.029 – 0.45% of petroleum biodegraders. The low percentage of petroleum biodegraders is indicative of low levels of utilization of petroleum products in the study area. The fungi population ranged from 0.24 – 16.7 x 10^6 propagules/g soil. The major fungal isolates are *Pseudomonas* sp*, Candida sp, Aspergillus sp* and *Mucor sp*. The growth of petroleum degraders was scanty and constituted 0 – 0.83% of the total fungal population (**Table 4.10b**).

Table 4.9: Soil Fauna Encountered in Soils of the Study Area (March, 2003)

Group	Genera	Common Name	Trophic Level
Arthropods	*Trinervitermes*	Termite	Primary
	Ancistrotermes	Termites	Consumers
	Amitermes	Termites	Decomposes
	Macrotermes	Termites	"
	Odontotermes	Termites	"
	Cubitermes	Termites	"
	Collembola	Beetle	Decomposers
	Oryetes	Dung beetle	"
Myriapoda	*Lithobius*	Centipedes	Secondary Consumers
	Spirotreplus	Millipedes	Primary Consumers
Arachnida	*Gastrocantha*	Spiders	Secondary Consumers
	Pandinus	Scorpion	Secondary Consumers
Annelids	*Ephyridrilus*	Earthworm	Decomposers
	Eudrilus	Earthworm	"
	Hyperidrilus	Earthworm	"
Molluscs	*Limicolaria*	Garden snail	Primary Consumer

Table 4.10a: Microbial Analysis from Soils of the Study Area (Bacteria) (Wet and Dry Seasos of 2001-2002)

Location	Depth of sampling (cm)	Heterotrophic Conut (cfu/g soil		Petroleum Degraders Count cfu/g soil		Percentage Degraders		Predominant bacterial Isolates
		Dry ($x10^6$)	Wet ($x 10^7$)	Dry ($x10^4$)	Wet ($x10^5$)	Dry	Wet	
SS 1	0-30	10.0	11.1	0.42	0.39	0.04	0.035	*Bacillus sp; Serretia sp; Pseudomonas sp*
SS 4	0-30	11.1	15.0	0.39	0.44	0.04	0.029	*Bacillus sp; Alkalegenes sp;*
SS 9	0-30	12.8	17.4	0.41	0.65	0.03	0.37	*Enterobacter sp, Salmorella sp, Vibro sp*
SS 21	0-30	8.3	18.3	0.28	0.62	0.03	0.34	*Flavobacterium sp; Pseudomonas sp*
SS 26	0-30	8.1	18.1	0.41	0.65	0.05	0.36	*Bacillus sp, Escherichia sp; Proteus sp*
SS 33	0-30	10.1	17.0	0.43	0.71	0.04	0.42	*Pseudomonas sp; Bacillus sp*
NRS 1	0-30	11.5	18.4	0.45	0.72	0.04	0.39	*Micrococcus sp. Pseudomonas sp*
NRS 8	0-30	11.8	18.5	0.39	0.73	0.03	0.39	*Clostridium sp, Pseudomonas sp*
NRS 12	0-30	12.7	20.1	0.37	0.91	0.03	0.45	*Serretia sp, Pseudomonas sp, Vibro sp*
P2 SS 1	0-30	10.2	9.5	0.38	0.35	0.037	0.037	*Bacillus sp, Pseudomonas sp*
P2 SS 8	0-30	11.1	10.2	0.40	0.37	0.036	0.036	*Pseudomonas sp, Bacillus sp*
P2 SS 12	0-30	11.6	10.5	0.46	0.42	0.040	0.04	*Alkalegenes sp, Bacillus sp*

Table 4.10b: Soil Microbial Analysis of soils of the study area (Fungi) (Wet and Dry Seasos of 2001-2002)

Location	Depth of sampling (cm)	Heterotrophic count (propagales /g soil)		Petroleum Degraders (propagales/g soil)		Percentage Degraders		Predominant fungal Isolates
		Dry ($x10^5$)	Wet ($x 10^6$)	Dry ($x10^3$)	Wet ($x10^4$)	Dry	Wet	
SS 1	0-30	2.6	16.0	1.8	0.82	-	0.05	*Penicillium sp; Aspergillus sp*
SS 4	0-30	2.6	18.0	1.6	0.64	0.64	0.04	*Candida sp; Saccharomyces sp*
SS 9	0-30	2.6	15.6	1.4	0.42	0.60	0.04	*Penicillium sp; Cladosporum sp*
SS 21	0-30	2.7	16.5	1.7	0.65	0.53	0.04	*Penicillium sp; Mucor sp*
SS 26	0-30	2.5	15.3	1.5	0.53	0.63	0.04	*Candida sp; Aspergillus*
SS 33	0-30	2.5	14.5	1.5	0.51	0.60	0.04	*Aspergillus sp; Mucor sp*
NRS 1	0-30	2.4	12.8	2.0	1.1	0.83	0.04	*Aspergillus sp; Mucor sp*
NRS 8	0-30	2.6	13.1	1.6	-	0.62	-	*Candida sp*
NRS 12	0-30	2.7	13.7	1.6	1.0	0.60	0.07	*Candida sp; Clodosporum sp*
P2 SS 1	0-30	8.2	15.0	4.2	0.73	0.051	0.049	*Aspergillus sp; Mucor sp*
P2 SS 8	0-30	8.1	16.7	4.3	0.75	0.053	0.048	*Sccharomyces sp; Cladosporium sp*
P2 SS 12	0-30	7.8	14.9	4.1	0.74	0.053	0.050	*Candida sp; Clodosporum sp*

4.4.5 Land use Pattern

The various land uses encountered in the study area include, Crop farming to produce cowpea, groundnuts, maize, sorghum, benniseed and leafy vegetables. Shifting cultivation or land rotation practices are however, generally fairly rudimentary, based almost entirely on traditional slash and burn techniques being enhanced by the annual bush fires. This takes place on the upslopes and middle slopes. Under suitable conditions, flood plains are used for intensive cultivation of rice in the wet season, and in the dry season irrigated leafy vegetables are cultivated. The shrubs of the savanna woodland and the herbaceous grass undergrowth are used generally by the nomadic herdsmen to feed their cattle. Water pools, streams and ponds are used for domestic purposes or as drinking water for livestock.

Changing economic consideration inherent in the concept of the highest and best use of the land has put pressure on the indigenes to sell their farmlands to industrialist/enterpreneurs for the building of houses, quarries and industries. The major industries encountered were stone quarries, the iron ore mining at Itakpe and the Ajaokuta Steel Company Limited. The building of new residential areas, roads/railways and acquisition of pipeline right of way (ROW) are some of the changes in land use pattern observed within the study area (**Plates 4.3 & 4.4**).

4.4.5.1 Erosion and Soil Re-instatement Practices

In the tropics, areas with annual rainfall higher than 1000mm are susceptible to erosion when their vegetation is removed for agricultural or industrial purposes. When the cropping system adopted is monoculture, the risk of soil erosion is much greater than with traditional practices (David, 1973). In the savanna zone of Nigeria, water erosion presents a hazard due in part to the high-energy load of the rain, which is positively correlated with the soil erosion. The losses incurred by water erosion are not restricted to soil particles only. Nutrient losses from leaching are significant (Aina *et al.,* 1976). Thus shifting cultivation sequence was the safest, followed by manual clearing (no tillage). Lai (1979) has previously recorded that mechanical clearing with no tillage was better than mechanical clearing with conventional tillage of a harrow. Because the soils are shallow and have hardpan of rocky material or stony concretions at some locations, crops are cultivated on ridges and mounds. This method was observed to be effective in reducing sheet erosion.

Erosion was a problem on the existing pipeline right of way between the Eganyin-Lokoja/Kabba junction stretch (37km), where soil had been excavated for pipelaying and poorly back filled (**Plates 4.5 & 4.6**). Effects of overgrazing in the area were not extensive.

Plate 4.3: Existing Railway Road within the Study Area

Plate 4.4: Existing Road Network in the Study Area

Plate 4.5: Exposed Existing Pipeline along the ROW

Plate 4.6: An Exposed Existing Pipeline at a River Crossing

4.4.6 Vegetation

4.4.6.1 General

The vegetation of the entire study area from Ajaokuta to Obajana is savanna woodland. It includes vegetation of the southern and northern Guinea savanna types (see **Attached Vegetation Cover Map (Map 4.2))**. Generally, this ecological zone is made up of mixtures of trees, shrubs, herbs and grasses.

4.4.6.2 Floristic Composition, Distribution, Density and Diversity of Vegetation

Terrestrial

The vegetation along the pipeline route from Ajaokuta to Obajana is Savanna woodland of between 10-12m high. The floristic composition is highly diverse in species even over a relatively homogenous area. Where there are changes in the environment, this variation is further increased. It consists of typical southern Guinea Savanna genera with its herbaceous species and grasses.

A total of 62 plant species belonging to 27 families/sub-families and comprising trees/shrubs, herbs and grasses were recorded within the proposed pipeline route from Ajaokuta Steel Company to Obajana. The families/sub-families that had the highest frequency of occurrence of plant species include Caesalpiniaceae, Ochnaceae, Cochlospermaceae, Mimosaece, Annonaceae, Verbanceae, Ulmaceae, Cleomaceae, Lamiaceae, Loganiaceae, Euphorbiaceae, Araceae and Poaceae. Plant species with frequencies of occurrence of 50% and above within this vegetational zone along the proposed pipeline route include:
Trees/shrubs*: Daniellia oliveri, Lophira lanceolata, Piliostigma, thonningii, Cochlospernum planchoni, Vitex doniana, Parkia clappertoniana, Annona senegalensis, Celtis integrifolia, Anacardium occidentalis*.

Herbs: *Aspilia africana, Cleome viscosa, Calopogonium sp, Centrosema pubescens, Phyllanthus amarus, Tridax procumbens, Euphorbia heterophylla, E. hirta, Hyptis suavolens, Spigellia anthelmia, Anchomanes welwitschii.*

Grasses: *Andropogon gayanus, Brachiaria lata, Imperata cylindrica, Hyparrhenia involucrata, H.rufa, Sporobolus pyramidalis, Pennisetum polystachion*.

Trees of the family Caesalpiniaceae (eg *Daniellia oliveri, Piliostigma thonningii*) are particularly common in the study area. The legumes thus accounted for a greater proportion of the trees. This is similar to the observations of Hopkins (1974). Chachu (1980) also observed that legumes accounted for 55 – 70% of trees in the wooded savanna vegetation of the Kainji Lake Basin. According to Sanford (1980), the Nigerian savanna has a great number of Leguminosae (Fabaceae). Within the study area the dominant trees were thus *Daniellia oliveri, Piliostigma thonningii* (Caesalpiniaceae), *Parkia clappertoniana* (Mimosaceae), *Lophira lanceolata* (Ochnaceae), and *Vitex doniana* (Verbanaceae) and these form an association. Palm trees (Oil, Borrassus and Raffia) and other riparian forest trees were encountered along river/stream courses mainly between Eganyin and Obajana village (**Appendices 4.4a-b**).

Of the smaller trees and shrubs, species of *Piliostigma thonningii, Annona senegalensis*, and *Cochlospermum planchoni* are common. Along the pipeline route

where there were rock outcrops or rocky hills particularly between Ajaokuta and Adogo, and also between Eganyin and Elueteba-Osara, *Bombax costatum* and *Uapaca togoensis* were recorded on hillsides whereas the valley bottoms with poor drainage had species like *Terminalia glucescens*, T. *avicennioides, Syzygium guineense, Borassus aethiopium*, and *Raphia sudanica*. The herbaceous genera encountered belonged mainly to the families Fabaceae, Euphorbiaceae, Cleomaceae and Asteraceae. The commonest monocotyledonous plants belonged to the families Poaceae, Araceae and Cyperaceae.

The results of the mean plant density and diversity, as well as biomass of the herbaceous layer are presented in **Table 4.11.** Within the same savanna woodland vegetation, mean tree and shrub density between Ajaokuta and Obajana is (895/ha), the herbs between Ajaokuta and Obajana have biomass of between (111/m^2 and 3804 kg/ha). Plant species diversity is high in the savanna woodland vegetation, but stem girth measurements at breast height are small. Due to this, timber sized trees are fewer as one moves northwards (**Plates 5.7-5.9**).

Aquatic Macrophytes

Between Ajaokuta and Obajana a total of 12 families represented the plants in streams/rivers (aquatic macrophytes) and vegetation supported by wetlands within the study area (**Appendices 4.4c & d)**. The most conspicuous or abundant true aquatic plant species were *Lemna pausicostata Nymphaea spp, Pistia stratiotes, Ceratophyllum demersum*, and *Eichhornia crassipes* associated with the River Niger at Jamata and Lokoja. The edges of rivers/streams or swamps or pools of stagnant/ still water/dry swamp had macrophytes such as grasses and sedges mainly *Cyperus iria, Fuirena umbellate, Vossia cuspidata, Echinocloa pyramidalis* and *Paspalum polystachyum*. The herbs include *Alternanthera sesilis, Aeschynomene indica, Ipomoea aquatica* and *I.asaerifolia*.

Table 4.11: Plant density, diversity and biomass of vegetation within the study area (March 2003)

S/N	Vegetation Type	Mean Plant Density		Biomass of herbaceous layer (kg/ha)	Species Diversity Index
		Trees and Shrubs (No/ha)	Herbaceous layer (No/m^2)		
1	Savanna Woodland	895 - 23.2	111 - 23.5	3804.0	0.491
2	Fringing forest	150 - 10.1	17 - 1.4	1435.5	0.450
3	Aquatic macrophytes	-	88 - 6.2	-	0.171

4.4.6.3 Structures and Physiognomy

The description of the vegetation structure and physiognomy of the area studied follows that of Hopkins (1974), Odum (1971) and Sanford (1980). The vegetation is typically savanna woodland. Trees and shrubs are present and the physiognomic classification of this savanna depends on the woody plants. In this savanna woodland, the trees and shrubs form a canopy, which is generally light; and this is the most complex type of savanna. The grasses are at a height of about 1.00 – 3.0m between Ajaokuta and Obajana during wet season. The grasses together with the non-grass or forb species dominate the herb stratum.

In terms of its vertical structure, the savanna woodland of the study area is a much less complex type of vegetation than forest. The profile shows a tree stratum 8-12m high with a generally high canopy, but varies from almost closed in some places to open in some others. Below this tree stratum and indistinctly differentiated from it, is a shrub stratum also with an irregular canopy 2-5m high. Finally is the herb stratum, consisting mainly of grasses growing up to about 1.0 – 3.0m high.

About 65% of the plant species are Phanerophytes, whereas about 15% are Hemicryptophytes (mainly grasses), 12% Crytophytes (including geophytes) and 8% therophytes (annual plants). No epihytes and chamaephytes were encountered. Within the woody plants, very tall ones (megaphanerophytes) were absent. Most of the phanerophytes here were deciduous and shed their leaves during the dry season.

4.4.6.4 Morphology of the Plants

Most of the trees and shrubs have barks/trunks that are twisted and gnarled as a result of the frequent fires in the zone which have regulated their growth. The bark of most species is very thick and corky usually more than 1cm thick and resistant to fire. Over 90% of the margins of leaves of the woody species had prominent mid-ribs and veins.

Most of the grasses are perennial and grow in tufts with bare grounds between them during the dry season but close-up during the wet season. The outer portions of these turfts appear to protect the inner parts from fire; thus enabling these grasses, most of which have their surviving buds at the ground level (Hemicryptophytes), to survive the burning during the dry season. Growing on the bare ground between the perennial grass turfts during the dry season were occasional Geophytes mainly *Anchomanes welwitschii* (Araceae) and Therophytes. Most of the herbs, both grasses and forbs, possess fibrous root system.

4.4.6.5 Economic Plants

A checklist of the common economic plants within the study area is presented in **Table 4.12**. The density of the economic plants in the study area is about 240/ha. More than 50% of the total number of economic plants per hectare of land area is legumes of the subfamilies Mimosaceae and Caesalpiniaceae. The economic importance of these plants vary and they include their uses as fuel (**Plate 4.10**), timber, dyes, vegetable, edible fruits and seed trees, medicinal and religious plants and sponge. The economic trees include *Daniellia oliveri, Parkia clappertoniana* and *Vitex doniana*. The study area thus has a diverse of plants that are economically important.

4.4.6.6 Agriculture

About 25 crop plants belonging to 12 families are cultivated in farms (**Table 4.13**). The system of farming practiced in the area is mainly land rotation with mixed cropping. The crops include melon, okro, corn, cassava, plantain, groundnut, cowpea, yam, cocoyam, sweet potato, pepper, tomato, sugar cane, benniseed and green leafy vegetables. In most cases, crop plants density was high but farm sizes were small between Ajaokuta to Obajana ranging from 0.01-2.0ha. Most of these crops were planted on ridges due to the presence of the basement rock in the study area. The farms were weeded regularly using the hoe to reduce competition from weeds. The farm sizes increase northwards as the soils become deeper with fewer rocks.

Plate 4.7: Typical Savanna Vegetation within the Study Area

Plate 4.8: Sparse Savanna Vegetation Stand

Plate 4.9: Vegetation Stand Mix with Grasses within the Study Area

Plate 4.10: Cut down Wood Displayed along Kabba Road for Sale as Fuelwood

4.4.6.7 Plant Tissue Analysis

The concentrations of the macro and micronutrients as well as some heavy metals in the tissues (mature levels) of the commonest plants at some sampling locations along the proposed pipeline route are presented in **Appendices 4.4e & f**. The low shrub legumes (*Mimosa pigra, Piliostigma thonuingii)* and cassava (*Manihot esculenta*) that accumulated adequate concentrations of nitrogen, while all other plants along the pipeline route accumulated low levels of nitrogen. The concentration of nitrogen in the grass species analysed in this study is similar to the finding of Isichei (1980) in some savanna grasses in Nigeria. However, the concentrations of P, K, Ca, and Mg in the samples were generally higher than standards. Iron (Fe), Zn and Cu concentrations in the tissues were higher than standards, but Mn accumulated mainly in the legumes. This observation is a reflection on the nature of the soils in the study area, which are mainly ferrugenous with high concentrations of Fe and moderate concentration of Mn, Zn and Cu.

4.4.6.8 Plant Pathological

The plants were generally healthy except some few scattered pathological problems like chlorotic and necrotic leaf spot, which were, in some cases, associated with the tropical red ants (*Oecophylla sp*). The occurrence and severity of the few diseases encountered varied from site to site within the study area. Although the symptoms in some cases were identical, laboratory investigations revealed the presence of different pathogenic organisms (**Table 4.14**). The disease severity indices revealed that the few diseases encountered were of very light to moderate infection. It is only the partial parasitic plant attack on some *Lophira* trees by mistletoes which were of severe infection in some cases. There were occasionally different plant species with a similar type of disease problem caused by the same pathogenic organism. For instance most of the leaf spot diseases were caused by *Cercospora spp*. While there were no devastation insect or animal pests observed in the study area, termite mounds were often observed as common landmarks in the area.

Thus the appearance and the state of health of the plant communities and of the commonest species were quite normal. There was no evidence of endemic vegetation problems. In discussing the type of plant diseases observed, it is pertinent to remark that none of the diseases was unusual either in its nature or severity. The few diseases observed are common and comparable in nature and intensity to those on plant species all over the savanna zone of the country.

4.4.6.9 Human Activities and Vegetation

i) Cultivation

Vegetation of the study area is cleared annually for cultivation. In the course of the cultivation, the shrubs and some of the trees are cut down and the stumps (about 1m high) are used as yam poles. The dried stems and branches of the cut down trees and shrubs are gathered for fuel wood (**Plate 4.10**). The remaining trees on the farms include *Daniellia oliveri* (African copaiba balsam), *Parkia clappertoniana* (African locust bean) and *Vitex doniana* (black plum), which are of economic value. During cultivation of crops such as groundnuts, melon, corn, cowpea etc, weeds and sucker regrowth from the rootstocks of the felled tress and shoot are kept in check by hoeing. Abandoned farms as bush fallows had sucker re-growth which was prominent with *Daniellia oliveri* and *Lophira lanceolata*, together with perennial grasses such as *Andropogon* and forbs which survived the farming period. This human interference

within the savanna woodland of the study area has reduced its complexity. The secondary succession on the abandoned farmlands is much more a process of the regrowth of surviving plants than of new plants, as seeds, invading and colonizing, as is the case in the forest secondary succession.

ii) Grazing

In addition to the host of wild species of grazing and browsing animals recorded under wildlife for the study area, cattle and sheep were observed in many places within the study area grazing mainly on the grasses and forbs. Flush of new leaves after the bush burning period provides fodder for the livestock. Herbs are pruned to grazing by the livestock. The factor that enhances soil erosion during the wet season is trampling effect of cattle on the soil in the course of grazing particularly towards areas with pools of water along the pipeline right of way during the dry season.

iii)Fire

Annual bush burning is a common phenomenon in the savanna woodland of the study area. There were signs that burning of the vegetation takes place during the dry season. Bush burning in the study area is carried out for a variety of reasons including the following:

- Clearing the land for cultivation and travel;
- Providing a flush of new leaves for grazing at a time of the year when these are scarce;
- Driving game from cover thus facilitating their capture;
- Decreasing tick and other parasite populations; and
- Enjoyment of the sight of a good blaze especially at night by the indegenes.

According to Hopkins (1961), savanna bush fires stimulate the renewed growth of many savanna species which was also the observation on most of the plant species encountered in the study area, but the fires had severely damaged many of the woody plants even though most of them are fire tolerant.

Table 4.12: Checklist of Common Economic Trees/Plants in the Study Area (March, 2003)

S/	Scientific Name	Family/Sub family	Common Name	Uses/Economic Importance	Density (No./ha)
1	*Parkia clappertoniana*	Mimosaceae	Tiv: nune; African locust bean	Fermented seeds used as condiment for soup making.	15
2	*Daniellia oliveri*	Caesalpinaceae	African copaiba balsam	Timber, fuel wood	38
3	*Vitex doniana*	Verbanaceae	Black plum Yoruba: orinla	Fuel wood, Edible fruits	17
4	*Lophia lanceolata*	Ochnaceae	Ibo: okopia	Fuel wood, Edible fruits	33
5	*Piliostigma thonningii*	Caesalpiniaceae	Thonning's piliostigm	Dye yielding, Religions purposes	41
6	*Annona senegalensis*	Annonaceae	Custard apple		19
7	*Borassus aethiopum*	Palmae	Borrassus palm	Sap tapped for beverage/wine; Used as food, dye yielding, medicinal	3
8	*Ficus polita*	Moraceae	Tiv: kondam	Shade tree	4
9	*Azadirachta indica*	Meliaceae	Neem	Medicinal	2
10	*Tectonia grandis*	Verbanaceae	Teak	Used as poles for high/low tension electric lines	28
11	*Anacardium occidentalis*	Anacardiaceae	Cashew	Edible fruit, Medicinal	10
12	*Mangifera indica*	Anacardiaceae	Mango	Edible fruit, Medicinal	5
13	*Adansonia digitata*	Bombaceae	Baobab	Medicinal, Religious	1
14	*Newbouldia laevis*	Bignoniaceae	Newbouldia	Medicinal, Religious	11
15	*Dialium guineense*	Caesalpiniaceae	Blackvelvet tamarind	Edible fruits	3
16	*Calotropis procera*	Asclepiadaceae	Calotropis	Medicinal	4
17	*Elaeis guineensis*	Palmae	Oil palm	Palm oil, brooms, etc.	3
18	*Citrus aurantium*	Rutaceae	Orange	Edible fruit	1
19	*Cocos nucifera*	Palmae	Coconut	Edible fruit	1
20	*Luffa aegyptica*	Cucurbitaceae	Loofah, Loofah gourd	Sponge	29
21	*Antidesma venosum*	Euphorbiaceae	Hausa: kirni	Edible fruits	8
22	*Celtis integcifolia*	Ulmaceae	Hausa: zuwo	Fuel wood, Edible fruits	13
23	*Khaya senegalensis*	Meliaceae	Dry zone mahogany	Timber, fuel wood	1

Table 4.13: Checklist of Crops Plants in Farms Encountered along the Pipeline Routes (March, 2003)

S/N	Crop Plants					
	Scientific Name	**Family/Sub family**	**Common Name**	**Importance**	**Density (No./ha)**	**Range of farm size (ha)**
1	*Citrulus lanatus*	Cucurbitaceae	Melon	Seeds for soup	2,500	0.5 - 0.7
2	*Carica papaya*	Caricaceae	Pawpaw	Edible fruit	4	0.25 – 0.30
3	*Hibiscus esculentus*	Malvaceae	Okro	Edible fruit	5,000	0.25 – 0.5
4	*Corchorus olitorus*	Malvaceae	Yoruba: Ewedu	Leafy vegetable edible fruits	10,000	0.25 – 0.5
5	*Zea mays*	Poaceae	Corn	Grains	10,000	0.25 – 1.5
6	*Mainhot esculenta*	Euphoriace	Cassava	Root tuber	2,500	0.25 – 2.0
7	*Musa sapientum*	Musaceae	Plantain	Edible fruits	120	0.2 – 0.25
8	*Musa sapientum*	Musaceae	Banana	Edible fruits	90	0.2 – 0.25
9	*Elaeis guineensis*	Palmae	Oil palm	Palm oil, etc	110	0.9 – 1.2
10	*Cocos nucifera*	Palmae	Coconut	Edible fruits	3	0.1 – 0.2
11	*Arachis hypogea*	Fabaceae (papilionaceae)	Groundnut	Peanuts	30,000	0.25 – 1.5
12	*Dioscorea rotundata*	Dioscoreaceae	White yam	Stem tuber	5,000	0.25 – 1.5
13	*Dioscorea alata*	Discoreaceae	Water yam	Stem tuber	5,000	0.25 – 1.5
14	*Vigna unguiculata*	Fabaceae	Cowpea	Grain legume	20,000	0.25 – 1.5
15	*Cajanus cajan*	Fabaceae	Pigeon pea	Grain legume	5,000	0.5 – 0.7
16	*Sorghum bicolor*	Poaceae	Sorghum	Grains	2,500	0.1 – 0.2
17	*Oryza sativa*	Poaceae	Rice	Grains	80,000	0.3 – 0.7
18	*Panicum miliaceum*	Poaceae	Common millet	Grains	2,500	0.1 – 0.2
19	*Dioscorea trifoliate*	Dioscoreaceae	Yellow yam	Stem tuber	2,500	0.2 – 1.0
20	*Ricinus communis*	Euphorbiaceae	Castor oil	Vegetable	10,000	0.25 – 0.5
21	*Colocasia esculenta*	Araceae	Cocoyam	Edible tubers	2,500	0.01 – 0.02
22	*Capsicum annum*	Solanaceae	Pepper	Spice	5,000	0.01 – 0.02
23	*Lycopersicon esculentum*	Solanaceae	Tomato	Fruit vegetable	5,000	0.10 – 0.50
24	*Ipomoea batata*	Solanaceae	Sweet potato	Stem tuber	2,500	0.10 – 0.50
25	*Saccharum officinarum*	Poaceae	Sugar cane	Edible stem/sugar	2,500	0.01 – 0.02

Table 4.14: List of Plant Species their Disease Symptoms, Severity Indices and Causative Organisms within the Study Area (Wet and Dry Seasos of 2001-2002)

S/N	Plant Species	Disease symptom	Disease severity index		Causative organisms
			Dry	Wet	
1	*Musa paradisiaca*	Moko	2	1	*Pseudomonas solanacearum*
2	*Musa paradisiaca*	Sigatoka	2	1	*Pseudomonas solanacearum*
3	*Lophira lanceolata*	Leaf spot	2	2-3	*Cercospora sp*
4	*Zea mays*	Bacterial stripe	-	1	*Pseudomonas andropogoni*
5	*Vigna unguiculata*	Leaf spot	1	-	*Cercospora sp*
6	*Zea mays*	Stem borers	-	2	*Weevils*
7	*Daniellia oliveri*	Leaf spots	2	2	*Cercospora sp*
8	*Elaeis guineensis*	Rusts	2	2	*Curvularia sp*
9	*Manihot esculeuta*	Cassava mosaic	1	2	*Virus*
10	*Lophira lanceolata*	Parasitic plant attack	2-3	2-3	*Mistletoe*
11	*Lophira lanceolata*	Leaf spot	-	1	*Cercospora sp*
12	*Dioscorea rotundata*	Anthracnose leaf spot	-	1	*Colletotrichum gloeosporioides*
13	*Andropoger gayanus*	Rust	1	2	*Currularia*
14	*Arachis hypogea*	Leaf spot	-	2	*Cercospora sp*

4.4.7 Animal Ecology

Animals constitute an important component of the natural ecosystem of the savanna. The animal communities are important because of their uses as sources of biodiversity conservation and research studies, recreation, and more importantly the provision of protein in the diet of rural communities. The savanna is an important habitat for location of game reserves because of low population of tsetse fly, which are prevalent in the southern forest, less human population and availability of land. For the present and foreseeable future, the savanna is the most important vegetation zone as regards wildlife conservation and utilization in Nigeria.

Ecologically, the animal population plays an important role in the transfer of food energy and cycling of essential elements in the savanna ecosystem. The study area is endowed with a large variety of animal species (**Table 4.15**). They vary from small arthropods like mites and ticks to very large mammals like the hippopotamus. The Phylum Arthropoda dominated the invertebrate community and is represented by insects, spiders, millipedes, etc.

In terms of numbers, the insects were the most important and were represented by the order diptera (the flies), which included the tse-tse fly (*Glossina* spp) and fruit flies (C*eratitis* spp). Other insects are termites (*Macrotermes* sp), butterflies (*Acrae terpicore*), sand flies (*Leishmania tropica*), mosquito (*Anopheles* and *Aedes* spp), black fly (*Simulium* sp), and bees (*Apis mellifera*). The molluscs were represented by garden snails and slugs and were common on the fringes of the forest/savanna interface and the riparian vegetation; however, population decreased progressively northwards.

Various groups of vertebrates were encountered and they included amphibians, reptiles, birds and mammals. The amphibians are organisms that spend part of the developmental stage in their life cycle in water and the adult stage on land. Toads were represented by the genus *Bufo* while the frogs were mainly *Rana* spp. Published systematic studies of Nigerian reptiles include those of Dunger (1967a & b, 1973), Grandison (1968), and Child (1974). The reptiles were represented by snakes (*Dendnaspis viridis*, tree viper; *Bitis arietans,* Puff adder; and *Python sebae,* African python); lizards (*Hemidactylus brooki*, Brook's gecko; *Chameleo senegalensis*, African chameleon; and *Agama agama*, the rainbow lizard).

The species composition and systematics of the Nigerian avifauna have been studied by several amateur naturalists and professional zoologists (Mason, 1940; Bannerman, 1953; Heigham, 1976; Gearling, 1978). On the whole, Nigerian birds have received more attention than other groups of vertebrates in the country. This, no doubt, is due partly to the efforts of the Nigerian Ornithologists Society and partly to the fact that most birds are conspicuous and easy to observe. The avian population was preponderant in terms of numbers and types. They include the village weavers, queleas, red eye doves, cattle egrets, hooded vultures, bush fowls and splendid sunbird.

The mammalian community was made up of diverse organisms. Rosevear published several taxonomic studies of the Nigerian small mammals between 1953 and 1974. There are also field guides by Booth (1960), and Dorst and Dandelot (1972). The large animals encountered were mainly browsers or grazers and they include antelopes and duikers. Others were the white-bellied pangolin, monkeys and fruits bats. Most of the mammals are crepuscular in habit, feeding in the early hours of the day (0500-0700h) or just before dusk (1700-1930h).

Table 4.15: Checklist of Animals in the Study Area (March, 2003)

BIOLOGICAL NAME	COMMON NAME	FEEDING	REPRODUCTION METHOD	POP.	HABITAT
Invertebrate hyllum Arthropoda					
Pandinus imperator	Scorpion	Insectivorous	Viviparity	++	Savanna wooded grass land
Gatrocantha sp	Spider	Insectivorous	Oviparity	+++	Savanna wooded grass land
Orthetrom branchiale	Dragonfly	Insectivorous	Oviparity	++	Savanna wooded grass land
Mantis religiosa	Preying mantis	Insectivorous	Oviparity	+	Savanna wooded grass land
Zonocerus variagatus	Varigated grasshopper	Phytophagous	Oviparity	+++	Savanna wooded grass land
Macrotermis bellicosus	Termites	Herbivores	Oviparity	+++	Savanna wooded grass land
Acrae terpicore	Butterfly	Phytophagous	Oviparity	++	Savanna wooded grass land
Leishmania tropica	Sandfly	Haematophagous	Oviparity	+	Savanna wooded grass land
Apis mellifera	Honey bee	Phytophagous	Oviparity	+++	Savanna wooded grass land
Anopheles sp	Mosquito	Haematophagou	Oviparity	++	Savanna wooded grass land
Simulium sp	Black-fly	Haematophagous	Oviparity	+	Savanna wooded grass land
Glossina sp	Tse-tse-fly	Haematophagous	Oviparity	+	Savanna wooded grass land
Phyllum chordata			Oviparity		
CLASS AMPHIBIA					
Bufo regularis	West African toad	Insectivorous	Oviparity	+	Savanna wooded grass land
Rana galamensis	Frog	Insectivorous	Oviparity		Savanna wooded grass land

CLASS REPTILIA					
Chameleo senegalensis	African chameleon	Insectivorous	Oviparity	+	Savanna wooded grass land
Hemidactylus brooki	Brook's gecko	Insectivorous	Oviparity	++	Savanna wooded grass land
Crocodylus niloticus	Nile crocodile	Carnivorous	Oviparity	+	Aquatic
Varanus niloticus	Nile monitor lizard	Carnivorous	Oviparity	+	Aquatic
Agama agama	West African rainbow lizard	Insectivorous	Oviparity	++	Savanna wooded grass land
Bitis orietons	Puff adder	Carnivorous	Oviparity		
Python sebae	African python	Carnivorous	Oviparity	+	Savanna wooded forest
CLASS AVES					
Ardeola ibis	Cattle egret	Insectivorous	Oviparity	+++	Savanna wooded grass land
Neophron moncus	Hooded vulture	scavenger	Oviparity	++	Savanna wooded grass land
Masopicos goertae	Grey woodpecker	Insectivorous	Oviparity	+	Savanna wooded grass land
Streptopeli semitorgquata	Red eyed dove	Herbivores	Oviparity	+++	Savanna wooded grass land
S. senegalensis	Laughing dove	Herbivores	Oviparity	+	Savanna wooded grass land
S. roseogrisea	Rose grey dove	Herbivores	Oviparity	+	Savanna wooded grass land
Fruncolinus bilacoratus	Bush fowl	Herbivores	Oviparity	++	Savanna wooded grass land
Petronia dentata	Bush sparrow	Herbivores	Oviparity	+	Savanna wooded grass land
Ploceus cucillatus	Village weaker bird	Herbivores	Oviparity	++	Savanna wooded grass land
Quelea quelea	Quelea	Herbivores	Oviparity	+++	Savanna wooded grass land
Milvus migrans	Black kite	Carnivorous	Oviparity	++	Savanna wooded grass land
Bubo Africanus	Spotted eagle owl	Carnivorous	Oviparity	+	Savanna wooded grass land
Nectarinia	Copper	Herbivores	Oviparity	++	Savanna

cuprea	sunbird				wooded grass land
Hirundo nigrita	White throated swallow	Herbivores	Oviparity	+	Savanna wooded grass land
CLASS MAMMALIA					
Lepus capenzi	Togo hare	Herbivores	Viviparity	++	Savanna wooded grass land
Helioseiurus gambianus	Gambianson squirrel	Herbivores	Viviparity	+	Savanna wooded grass land
Xerus erythropus	West African ground squirrel	Herbivores	Viviparity	+++	Savanna wooded grass land
Lemniscomys straitus	Spotted grass mouse	Herbivores	Viviparity	+	Savanna wooded grass land
Rattus natalensis	Giant rat	Herbivores	Viviparity	++	Savanna wooded grass land
Cricetomys gambianus	Crested poroapine	Herbivores	Viviparity	+	Savanna wooded grass land
Hystrix cristata	Cane rat	Herbivores	Viviparity	++	Savanna wooded grass land
Thyronomys swinderianus	Hunting dog	Carnivorous	Viviparity	+	
Lycacon pictus	Fruit bat	Herbivores	Viviparity	+	Savanna wooded forest
Epomophorus anurus	White bellied pargolin	Insectivorous	Viviparity	+	Savanna wooded forest
Manis tricuspis	Multir mammate	Omnivorous	Viviparity	++	
Colobus polykomos	Black colobus	Herbivores	Viviparity	+	Savanna wooded forest
Cecopithecus aethrops	Green monkey	Herbivores	Viviparity	+	Savanna wooded forest
Pan troglodytes	Chimpanzee	Herbivores	Viviparity	+	Savanna wooded forest

Key

+	=	Present
++	=	Common
+++	=	Abundant

4.4.8 Aquatic Study

4.4.8.1 Water Quality

Baseline information on the existing water quality of the study area is presented in **Appendices 4.5a & b**. Generally most water bodies were dry during the dry season depicting an ephemeral nature.

Colour

The apparent colour of river water results from light scattered upwards after it has passed through the water to various depths and undergone selective attenuation en-route. In this study, the colour of the filtered surface water samples fluctuated between 5(RK, (DS)) and 550 PtCo during the wet season. However, during the dry season the values ranged from 47 to 520 PtCo. The study showed that high colour values were depended on dissolved organic matter and biological activities, especially human and livestock perturbation. The values are generally lower in the dry season compared to the wet season.

Turbidity

Turbidity in water is caused by suspensoids (organic and inorganic) and is a major concern in aquatic systems where most aquatic organisms especially filter feeders cannot tolerate appreciable concentrations of inorganic particulate matter. Turbidity levels were high and fluctuated between 9 and 418NTU during the wet season and 9 - 131NTU during the dry season indicating more turbid waters during the wet season. The values were generally above the FMENV/DPR limit of 10 NTU. The turbidity level followed the same trend with colour determinations. This is mainly due to high level of supended solids arising from vigorous perturbations at the various sampling stations. In all the rivers studied, human activity played vital roles in the elevated levels observed for turbidity.

Total Dissolved Solids (TDS)

The total dissolved solids varied from 14 – 250mg/l during the wet season. The dry season values range from 21.0 – 134.0mg/l. The river crossings had high TDS compared with the up and downstream locations. Evidence of erosion and perturbation around the pipeline crossings may be responsible for the high TDS values. These values are however lower than the FMENV/ DPR limit of 200mg/l for surface water and 500-1500mg/l WHO limits for drinking water.

pH

The water bodies were slightly acidic or slightly alkaline and had pH values varying from 6.1-7.8. The pH had no significant trend except that they were lower at the river crossings. All values fell within the tolerable limits of pH 6 –9 stipulated by FMENV/DPR for surface waters in both seasons.

Conductivity

Electrical conductivity, which is a measure of the ionic richness of the river course, ranged between 45.2 and 218.0µs/cm. These values are typical of fresh water bodies. High levels observed at the river crossings are collaborated by the observations recorded for TDS. Studies from Nigerian Inland water bodies show that conductivity values much less than 500µs/cm at the peak of the dry season are reported (Egborge 2001). This is attributed to evapo-transpiraton and mineralisation of organic matter.

Wet season values are lower because of dilution from run-off which also bring in nutrients.

Alkalinity (HCO_3)

Alkalinity refers to the capacity of water to neutralise acid. Alkalinity (expressed as HCO_3) ranged from 36.6 to 152.5mg/l during the wet season. The dry season values ranged from 24.4 to 134.2mg/l. Alkalinity in water is due to any dissolved substance, usually weak anions that can accept and neutralise protons. Most freshwaters contain bicarbonate alkalinity. This observation is similar to that reported in this study.

Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) is an expression of the reducing capacity that measures the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. The COD values ranged from 2.4mg/l – 26.0mg/l. These values were all below the 50mg/l limit recommended for surface waters by DPR/FMENV.

Anions

Monovalent, divalent and tetravalent anions were determined and occurred in varying amounts at all sampling stations. These are NO_3-N, NO_2-N and NH_4^+-N (which are different forms of nitrogen in the aquatic ecosystem), phosphates, sulphates and chlorides. Ammonia is toxic to aquatic organisms in its unionised form. In water, some ammonia usually combines with water molecules to produce the non-toxic ionised form known as Ammonium (NH_4). Ammonium ions were generally higher than the DPR/FMENV limit of 0.2mg/l. The values ranged from 0.020 – 10.42mg/l. In reduced pH and neutral waters (pH 1 – 7), the non-toxic ionised ammonium ion predominates (Egborge, 2001). In general, there is a moderately high level of NH_4^+-N, which is expected, given the high human and livestock presence in the stations.

Compounds of nitrogen and especially those of phosphorus are major cellular components of organisms. They are highly dynamic in the aquatic ecosystem. Of all forms of nitrogen, the most stable and easily utilised is the nitrate derived from the oxidation of nitrite. Aquatic organisms need nitrates as essential nutrient for primary productivity. The values recorded were low and fluctuated between 0.001 – 3.45mg/l. In this study low nitrate values also characterised the waters. The nitrite levels were significantly low (0.001 – 1.86mg/l) and only few sampling stations recorded values above the 1.0mg/l FMENV limit.

Phosphorus is a basic element in living matter and occurs in natural waters and wastewaters almost solely as phosphates. This major component of agricultural fertilisers is a limiting nutrient in many river systems. The phosphate values recorded from the study area varied from 0.033 – 6.92mg/l. Elevated levels observed in some rivers may be attributable to soil leaching from surrounding fertile soil, livestock activities and human faeces.

Sulphate values recorded were quite low and ranged from 0.003 – 18.42mg/l. Beauchamp (1953) had reported that African inland waters are generally deficient in this anion, which is due to its low concentration in the non-sedimentary rock of drainage areas. Chloride anions were the most abundant anion reported; they ranged from 14-2-71.2mg/l-. The chloride values observed were basically of the freshwater

bracket. All values reported were lower than the recommended limits of <2000mg/l set by DPR/FMENV.

Exchangeable Cations

The major cations dissolved in natural freshwaters are calcium, magnesium, sodium and potassium, and of these, calcium and sodium are normally dominant. This observation was made by Willoughby (1976) and Chukwunogo (1990) and was also confirmed in this study.

Monovalent Cations Sodium (Na) and Potassium (K)

In this study, sodium concentrations ranged from 1.54- 15.20mg/l. Potassium ranged from 1.88 at 8.75mg/l.

Divalent Cations Calcium (Ca^{++}) and Magnesium (Mg^{++})

Calcium was the most abundant of all the cations with a range of 6.41 to 22.44mg/l. Magnesium concentrations ranged from 0.96mg/l to 13.53mg/l. The high values of Ca and Mg reported are attributable to the geomorphology of the area. The total concentration of calcium and magnesium expressed as their $CaCO_3$ equivalent denotes the total hardness of waters. The presence of a generous amount of dissolved calcium bicarbonates makes the water "hard".

Heavy metals

The results of the heavy metals analysed show that all the metals occurred in trace levels or very minute quantities far below recommended limits set by DPR/FMENV. The values were lower than that reported for Nigerian inland and coastal waters (Kakalu *et a1* 1987, Egborge1991, Ezemonye and Egborge, 1992).

Total Hydrocarbon (THC)

The total hydrocarbon values reported were quite low in most sampling stations. It fluctuated between 0.15mg/l and 172.8mg/l. These levels are generally lower than recommended limits for inland waters in Nigeria, except at some isolated sampling stations where increased human activities have introduced various sources of organic materials. Nontheless they are not from petrogenic sources.

4.4.8.2 Phytoplankton

Twenty-nine taxa of phytoplankton were identified during the studies. These belong to four divisions namely bacillariophyta or diatoms, cyanophyta or blue-green algae, chlorophyta or green algae, and euglenophyta or euglenoids (**Tables 4.16 & 4.17**). The green algae comprised the bulk of the flora with 57% followed by Cyanophyta with 29%. Bacilleriophyta constituted 11% and Euglenophyta forming 3%.

The diatoms, blue-greens and euglenoids occurred in a very few sampling stations. The chlorophyta were widely distributed in all stations. The blue-greens and euglenoids are known to be tolerant of pollution because of their ability to utilise high nutrient levels, and have been known to tolerate high levels of stress in aquatic environment (Palmer 1969, Morns 1967, Gannon and Stemberger, 1978).

Instability in the ecological balance of the ecosystem are known to retard biological productivity (Ezemonye and Kadiri 1998). Thus the low diversity levels reported for the phytoplankton flora may be attributable to alterations of the physio-chemical

conditions of the water (Copper and Wihun 1975). Generally, the wet season recorded higher numbers of phytoplankton than the dry season.

Reduced density is attributable to grazing and unfavourable environmental conditions such as poor nutrient status and low light intensity. Copper and Wihum (1975) and Gaur and Kumar (1985) have reported that decline in phytoplankton diversity results from alteration of physico-chemical properties of water bodies.

Table 4.16: Check list of Phytoplankton Groups (March, 2003)

Phytoplankton Groups		
Division Bacillariophyta *Aulocoseira granulata* *Frustulia rhomboides* *Pinnularia viridis* *Surirella elegans*	**Division Chlorophyta** *Closterium moniliferum* *C. turgidum* *Cosmarium sp.* *Desmidium quadrum* *Eudorina elegans* *Hyalotheca dissiliens* *Microspora sp.* *Mongeilia spherocarpa* *Mongeitia sp.* *Oedogonium crassum* *O. grande* *Pediastrum duplex* *Spirogyra dubia* *S. communis* *S. majuscula* *Ulothrix zonanta* *U. tenuissima* *Zygnema pectinatum*	**Division Cyanophyta** *Anabaena solitaria* *Chroococcus limieticum* *Microcystis aeruginosa* *Oscillatoria borneltia* *O. limosa*

Table 4.17: Phytoplankton Composition, Distribution and Abundance of Water Bodies (Wet and Dry Seasos of 2001-2002)

Phtyoplankto Group	Season	STATIONS																			
		1	4	5	6	7	8	10	12	13	14	E2	E3	E6	E8	E10	E12	E13	E14	E15	E18
Chlorophyta	Dry	178	90	150	232	20	352	60	4	20	20	11	21	0	20	0	0	170	0	201	30
	Wet	220	331	222	296	30	407	74	14	36	0	0	0	0	14	36	0	37	0		
Bacillariophyta	Dry	0	61	95	28	0	0	0	0	0	0	0	0	0	0	0	0	370	0	0	37
	Wet	0	74	148	37	0	0	0	0	0	0	0	0	0	0	0	0	370	0	0	0
Cyanophyta	Dry	257	180	380	0	72	0	72	0	0	0	0	0	45	21	55	74	75	50	0	0
	Wet	296	185	518	0	15	75	0	0	0	0	0	0	74	37	74	74	101	74	0	0
Euglenophyta	Dry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0
	Wet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	0	0
Abundance	Dry	459	331	625	260	92	352	132	4	20	30	11	21	45	41	55	74	615	50	229	30
	Wet	516	370	948	333	45	407	148	14	36	0	14	36	74	74	74	74	777	74	294	37
Total taxa	Dry	10	7	7	9	3	6	3	2	3	3	2	4	2	2	2	2	6	2	8	1
	Wet	10	7	7	9	3	6	3	2	3	6	2	3	2	2	2	2	6	2	6	1

4.4.8.3 Zooplankton

The taxa composition and distribution of zooplankton in the study stations are shown in **Table 4.18**. A total of 20 taxa were encountered. The cladocerans made up 22% while copepods constituted 31% of the total population. Cladocerans and copepods dominated the water bodies.

Generally, the zooplanktons are sparse in terms of numbers of individuals and taxa richness. In terms of abundance, Nauplius larvae are relatively the most abundant, followed by insect larvae. Specie diversity, which expresses specie richness, was determined using the Simpson's Diversity Index.

Species diversity at the various sampling stations was determined using the Simpson Diversity Index. The analysis showed low species diversity as reflected in **Table 4.18a**. The overall specie diversity varied amongst stations and within the various seasons with the wet season recording higher populations than the dry season.

4.4.8.4 Water Microbiology

The water samples were analysed for heterotrophic bacteria (including coliforms), and fungi. The results are presented in **Table 4.19a & b** and revealed that most of the waterbodies contain coliforms confirmed as faecal in origin in exess of 50 MPN/100ml. In addition, other bacteria and fungi species were isolated from the water bodies. *Saccharomyces* (yeast), *Mucor, Aspergillus, Candida,* and *Penicillium* were the predominant fungi species whereas *Bacillus, Staphylococcus, Serretia, Proteus* and *Pseudomonas* were the major bacteria species.

Table 4.18: Check list of Zooplanktons Taxa (March, 2003)

Zooplanktons Taxa				
Protozoa: *Difflugia sp.* *Rhinochrysis sp.*	**Rotifera:** *Keretella tropica* *Lecane lunaris* *Platyias quadricornis*	**Cladocera:** *Alona sp.* *Bosmina longirostris* *Diaphanosoma sp.* *Ceriodaphinna sp.* *Moina sp.*	**Copepoda:** *Microcyclops varicans* *Mesocyclops ogunnus* *Thermocyclops neglectus* *Macrocyclops distinctus* *Tropodiaptomus sp.* *Atthyella africana* *Eucyclops sp.* *Microcyclops*	**Larval forms**: Nauplius larvae Insect larvae

Table 4.18a: The species composition, distribution and abundance of zooplankton communities in the study Area (Wet and Dry Seasos of 2001-2002)

Taxa	Seasons	Stations																					
		1	**4**	**5**	**6**	**7**	**8**	**10**	**12**	**13**	**14**	**E2**	**E3**	**E6**	**E8**	**E10**	**E12**	**E13**	**E14**	**E15**	**E16**	**E18**	**E20**
Protozoa	Dry	10	0	10	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Wet	15	0	15	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rotifera	Dry	16	0	0	10	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Wet	16	0	0	13	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera	Dry	11	16	0	45	5	20	0	0	0	0	0	0	6	10	5	0	10	0	0	10	6	0
	Wet	10	17	0	33	8	27	0	0	0	0	0	0	6	14	9	0	12	0	0	13	10	0
Copepodo	Dry	20	45	10	16	15	8	0	4	4	4	6	4	4	2	6	8	11	1	4	15	12	7
	Wet	27	41	10	34	24	16	14	04	0	0	15	4	4	13	14	13	19	3	8	17	13	8
Larval forms	Dry	18	54	35	40	40	40	32	24	30	51	22	17	14	15	25	25	28	18	27	44	34	24
	Wet	26	54	39	41	45	48	32	24	0	0	32	24	15	24	32	35	39	19	34	49	36	39
Ecological indices																							
Total Number of Species	Dry	5	4	5	6	4	3	2	1	1	1	2	1	2	2	3	2	3	1	1	2	2	1
	Wet	5	4	2	6	4	4	3	2	1	6	2	1	2	3	2	3	1	0	1	2	2	1
Total number of individuals	Dry	47	61	20	61	40	38	15	04	04	04	6	4	10	12	11	8	21	1	4	25	18	7
	Wet	26	42	28	22	27	38	14	10	1	0	15	4	10	27	23	14	31	3	8	30	23	8
Diversity index	Dry	0.9893	0.7297	0.3338	1.2163	0.8133	0.5498	0.3692	1.3862	1.3862	1.3862	0.5581	1.3862	0.4342	0.4024	0.8341	0.4808	0.6569	1.0986	1.3862	0.3107	0.3459	1.9459
	Wet	0.7960	0.7342	0.4800	0.8145	0.7026	0.6274	0.4800	0.000	0.000	0.00	0.4800	0.00	0.4800	0.7386	0.6578	0.3542	0.6578	0.00	0.00	0.4902	0.4902	0.00

Table 4.19a: Water Microbiology of some Water Bodies within the Study Area (Wet and Dry Seasos of 2001-2002)

S/N	Sample Location	MPN Coliform 100 ml		Confirmed coliform per 100ml		Bacteria Count cfu/ml 10^6		Bacteria species isolated	Fungi count (No of Propagles ml) 10^5		Fungi species Isolated
		Wet	Dry	Wet	Dry	Wet	Dry		Wet	Dry	
1	STN 7	650	600	+	+	15.8	12.5	*Serretia sp, Bacillus sp*	3.5	3.2	*Mucor sp*
2	STN 10	400	400	+	+	-	-	*Bacillus sp, Proteus sp*	2.8	-	*Mucor sp*
3	STN 11	-	-	-	-	11.5	10.4	*Bacillus sp*	4.8	4.5	*Saccharomyces sp*
4	STN 14	250	200	-	-	7.1	6.5	*Staphylococcus sp*	1.5	-	*Mucor sp*
5	STN 15	-	-			8.1	7.7	*Eschericlia sp,*	3.5	3.8	*Aspergillus sp*
6	STN 16	2000	2400	+	+	13.5	14	*Pseudomonas sp, Proteus sp*	2.5	-	*Saccharomyes Candida sp*
7	STN 19	800	1000	+	+	9.2	8.2	*Escherichia sp, Bacillus sp*	1.5	-	*Pencillium sp*
8	STN 20	2500	2400	+	+	14.5	15	*Escherichia sp,*	3.4	3.4	*Mucor sp Candida sp*
9	STN 21	210	300	-	-	5.2	4.3	*Escherichia sp, Serretia sp,*	4.0	4.1	*Penicillium sp candida sp*
10	STN 22	950	1200	+	+	7.5	8.1	*Escherichia sp, Pseudomonas sp,*	2.8	3.6	*Saccharomyces, Esherichia sp*

Table 4.19b: Water Microbiology of some Water Bodies within the Study Area (Wet and Dry Seasos of 2001-2002)

S/N	Sample Location	MPN Coliform 100 ml		Confirmed coliform 100ml		Bacteria Count cfu/ml 10^6		Bacteria species isolated	Fungi count (No of Propagles ml) 10^5		Fungi species Isolated
		Wet	Dry	Wet	Dry	Wet	Dry		Wet	Dry	
1	STN 1	150	200	+	+	8.4	8.8	*Serretia sp, Bacillus sp*	3.6	3.8	*Mucor sp, Candida sp*
2	STN 2	200	200	+	+	10.5	10.5	*Bacillus sp, Proteus sp*	-	-	*Mucor sp*
3	STN 3	100	100	+	+	11.3	12.2	*Bacillus sp*	3.8	4.4	*Saccharomyces sp, Mucor sp*
4	STN 4	400	400	+	+	12.8	13.4	*Staphylococcus sp*	3.8	4.2	*Mucor sp, Aspergillus sp*
5	STN 8	300	400	+	+	10.8	12.7	*Eschericlia sp,*	3.7	3.9	*Aspergillus sp*
6	STN 9	500	500	+	+	10.4	10.1	*Pseudomonas sp Proteus sp*	4.1	3.8	*Saccharomyes Candida sp, Aspergillus sp*
7	STN 12	600	600	+	+	11.0	12	*Escherichia sp, Bacillus sp*	3.9	4.1	*Pencillium sp, Mucor sp*
8	STN 13	1000	1000	+	+	10.8	10.1	*Escherichia sp,*	3.9	3.8	*Mucor sp Candida sp*
9	STN 16	500	500	-	-	10.7	11.7	*Escherichia sp, Serretia sp,*	3.9	4.1	*Penicillium sp, Candida sp*
10	STN 19	200	200	+	+	9.1	9.1	*Escherichia sp, Pseudomonas sp,*	3.8	3.7	*Saccharomyces*

4.4.8.5 Fish/fisheries

Fish study was conducted on fishes obtained from River Niger and through interviews and literature search. Fishing activities are carried out mostly in the nights, early mornings and evenings, and generally done from dug out canoes operating from the camps along River Niger. The fishing gears commonly used includes castnets, set nets, drift nets, gill nets and hook on line as well as fish fence (**Plates 4.11 & 4.12**). Fishing is carried out by migrant fishermen, few indigenes also participate in fishing activities.

Twenty-nine fish species distributed in 17 families were identified (**Table 4.20**). In terms of species richness, the families Mochockidae, Bagridae, Characidae, and Cichidae were dominant. Shellfish of economic importance in the area belongs to the Decapoda (Crayfish). Generally, there was more fish during the wet season compared to the dry season.

Fish processing within the study area is basically traditional using indigenous technology. Traditional smoking kiln or earthen ovens were prevalent throughout the study area. The smoked fish is consumed within the family unit and/or sold at the local markets at Lokoja, Jamata and Koton-karfi.

Gymnarchus niloticus (Mormyrid), *Channa obscura* (Snake head fish), *Heterotis niloticus* (African bony tongue fish), and *Chrysichthys auratus* (Silver cat fish) were the most palatable among the fish species. All the fishes examined did not show any physical evidence of parasitic infestation. There was no observation of disease infestation, abnormalities or physical deformities.

Analysis of the condition factors (KF), an index of the well being of the fish, showed that the fishes were healthy and well fed in relatively undisturbed environment. The factors on the average were well above the critical value of 1.0.

Plate 4.11: Fishing Nets used in the Study area

Plate 4.12: Fishing Traps and Nets Set for Catching Fish

Table 4.20: Fishes caught and Identified together with some of their Characteristics in the Rivers/Streams (March, 2003)

S/No	Families	Species	Common Name	Local Name	No of Invididualy Observed		% Composition		Mean Standard Length (cm)		Mean Standard Weight (g)		Mean Condition Factor (KF)	
					W	D	W	D	W	D	W	D	W	D
1	Mochockidae	*Synodonits filamentosus*	Cat fish	Abuka	8	7	4.5	5.2	11	10	18	20	1.8	1.9
		S. membranacius	Cat fish		10	6	5.6	4.5	15	12	38	41	2.2	2.2
		S. clarias	Cat fish		15	12	8.4	9.0	12	9.9	18.4	22	1.9	1.9
		S. nigerica	Cat fish		5	4	2.8	3.0	10	12.5	50.7	49	2.6	2.7
2	Bagridae	*Bagrus bayad*	Silver cat fish	Ebute/Abukoko	5	4	2.8	3.0	17	15	50.6	52	1.5	1.5
		Chrysichthys nigrodigitatus	"		2	2	1.1	1.5	20	17	83.5	84	1.7	1.8
		Chrysichths auratus	"		3	3	1.7	2.2	20	15	50.7	52.3	1.5	1.5
3	Claridae	*Clarias gariepinnus*	Mud Cat fish	Irike	5	4	2.8	3.0	20	18	69.9	70.2	1.2	1.3
4	Characidae	*Alestes baremose*	Silverside	Ebbe	10	8	5.6	6.0	11	10	19	22	1.9	2.0
		A. dentex			10	10	5.6	7.5	11	11	26.6	28.4	2.0	2.0
		B. A. imberi			5	4	2.8	3.0	12.2	10.5	26.6	30.3	2.3	2.3
5	Mormyridae	*Mormyrus macrophthalmus*	Elephant snout fish	Abura	2	2	1.1	1.5	10	8	8.2	10.5	1.8	1.9
		Gnathonemus tamadua			6	1	3.3	0.8	11.4	9.9	18.4	20.8	1.9	2.0
6	Cyprinidae	*Labeo coubie*	African carp	Liza obu	6	6	3.2	4.5	10	9	13.9	14.5	1.9	1.9
		Labeo snegalensis			8	4	4.5	3.0	16	15	50.7	52.0	1.5	1.8
7	Hepseptidae	*Hepsetus odoe*	African pike	Ohochi/Yinkozagh a	2	1	1.1	0.8	15	13	50.5	49.5	2.3	2.3
8	Cichlidae	*Tilapia Zilli*	Cichlids	Ahi/Tokunji	10	8	5.6	6.0	7	8	13.3	12.5	2.6	2.6
		Orecochromis Niloticus			8	7	4.5	5.2	9	10	54.0	52.0	5.4	5.4
		Tilapia melanopleura			10	6	5.6	4.5	10	9	35.0	36.1	4.8	5.2
9	Malapteruridae	*Malapterurus electicus*	Electric Cat fish	Osa/dindoro	3	2	1.7	1.5	14	15	94.5	94.5	2.8	2.8
10	Gymnachidae	*Gymnarchus Niloticus*	Mormyrid	Ozurukpa	4	1	2.2	0.8	33	35	115.0	112	2.6	2.6
11	Citharinidae	*Citharinus citherus*	Mood fish	Ibobo/Owhere	12	10	6.7	7.5	12	11	29.3	29.5	2.2	2.2
		Distichodus rostratus			4	3	2.2	2.2	9	10.5	26.6	25.8	2.3	2.3
12	Osteoglosidae	*Channa obscura*	African bony tongue	Akpade/Ewhoji	12	12	8.4	9.0	26	28	483.0	400	2.2	2.2
13	Channidae	*Papyrochranus afer*	Snake head	Oguobi	4	2	2.2	1.5	16	18	93.3	90	1.6	1.7
14	Notoperidae	*Protopterus annectons*	Feather back	Ogbuka	2	1	1.1	0.8	10	9	13.9	14.5	1.9	2.0

15	Lepidosirendiae	*Calamichthys calabaricus*	African lung fish		1	1	0.6	0.8	15	10	19	21.5	1.9	1.9
16	Polyteridae	*Eutropius Niloticus*			1	1	0.6	0.8	6	8	9.2	8.5	1.8	1.8
17	Schilbeidae		Butter fly		2	1	1.1	1.5	12	9.8	18.4	20.8	1.9	2.0
	Total No. of Individuals				178	134								

Key:
D = Dry;
W = Wet

4.4.9 Sediment

4.4.9.1 Physico-chemical Characteristics

The sediment samples were dark grey and sometimes bleached to whitish colouration. The sand fraction varied from 85.9% to 93.4% while the silt content varied from 0-17.8%. The clay content also varied from 0 to 12.0% making the sediment sandy in texture. The sediment samples were acidic (pH4.7-6.6). The electrical conductivity values varied from 29-172μs/cm^2 indicating that the environment under study is within the freshwater habitat. The organic content of the sediment samples were low and fluctuated between 0.29 and 1.60%. The nitrogen contents ranged from 0.019 to 0.123% and these values are considered low. The phoshorus concentrations were low to moderate and varied from 3.0 to 53.6ppm (**Apendices 4.6a to d**).

The concentrations of nitrate (0.004-0.033ppm), nitrite (0.010-0.215ppm), ammonium (13.9 – 40.8ppm), sulphate (0.06-4.56ppm), and chloride (35.50-213.00ppm) are considered low. The nutrients are adequate to support the healthy growth of benthic population. The exchangeable cation exchange capacity (ECEC) ranged from 0.79 to 4.96meq/100g sediment and is considered low. The major contributors to the ECEC were Ca (0.52-2.24meq/100g sediment), Mg (0.12 to 1.40meq/100g sediment), and Na (0.07 to 0.39 meq/100g sediment). As a result of the relatively low values of the exchangeable acidity, the base saturation values were high and ranged from 83.6 to 93.4%.

The heavy metal concentrations are low in the sediment samples and there is no indication of their accumulation in the samples. No mercury (Hg) was detected in the sediment samples. The total hydrocabon content (THC) varied from 0.18 to 2.98ppm and these can be accounted for from biogenic sources mainly of vegetal debris. Thus there was no oil pollution of the sediment.

4.4.9.2 Benthic Fauna

A total of 40 taxa of macro-benthic invertebrate were identified in the samples collected from the various rivers investigated. The macrofauna is composed of 2.6% of Nematoda, 15.4% of Oligochaeta, 2.6% of Ostracoda, 7.7% of Ephemeroptera and 10.3% of Odonata. Others are Hemiptera 10.2%, Coleoptera 7.7%, Trichoptera 5.1%, Diptera 23.0%, and Amphibia 2.6%, **Tables 4.21a & b** summarises the taxa recorded from the rivers with their distribution and relative abundance.

The dominant macro-invertebrates in the study area are *Nais sp*., *Ceratopogonids*, and *Anopheles sp*. Subdorminant groups include *Chironomus sp*. *Tanytarsus sp*. and *Bufo calamita*. Species of *Crustacea*, *Odonata*, *Coleoptera*, *Trichoptera* and *Lepidoptera* were poorly represented in the various rivers investigated. The relative low abundance of macro-invertebrates in these rivers indicates some prevailing factors affecting the indwelling organisms. Such factors include the bottom substrate, which is rocky in nature. It is important to remark that other prevailing factors capable of influencing the diversity and relative abundance of aquatic macrobenthic organisms include food availability, presence or absence of aquatic macrophytes, nature of substrate and basic hydrologic features of the Rivers. These factors seem to vary in the different stations.

Table 4.21a: Check list of macro-benthic invertebrates (March, 2003)

Nematoda					
Oligochaeta *Aulophorus furcatus* *Aulophorus vagus.* *Nais sp.* *Stylaria sp.*	**Hirudinea** *Haemopsis sp.*	**Crustacea** **Decapoda** *Caridina africana* *Caridina gabonensis* *Desmocaris bislineata*	**Ostracoda** *Cypris sp.*	**Ephemeroptera** *Bactis sp.* *Centroptilum sp.* *Cloeon sp.* *Unidentified Ephemeroptera*	**Odonata** *Coenagrion sp.* *Libellula sp.* *Enallagma sp.* *Lestes*

Hemiptera *Corixa sp.* *Ilyocoris sp.* *Lethocerus sp.* Unidentified Hemiptera	**Coleoptera** *Dytiscus sp.* *Dytiscus marginalis* Other coleoptera larvae	**Trichoptera** *Hydroptila sp.* *Limnophilus sp.*	**Diptera** *Ceratopogonid* *Chironomidae* *Chironomus sp.* *Pseudochironomus sp.* *Tanypus sp.* *Tanytarsus sp.* *Clinotanypus sp.* *Pentaneusa sp.* *Anopheles sp.*	**Amphibia** *Bufo calamita*

Table 4.21b: Distribution and Abundance of Macrobenthic Invertebrate Fauna in Rivers (Dry & Wet Seasons of 2001 & 2002)

Taxa	Season	Stations														
		4	5	6	7	8	10	11	12	13	14	16	19	20	21	22
Nematoda oct	Dry	5	0	0	4	0	0	0	0	0	0	0	0	0	0	6
	Wet	0	0	0	0	0	9	11	0	4	0	0	0	0	0	0
Oligochaeta	Dry	26	0	1	10	0	0	0	0	0	0	0	0	0	0	0
	Wet	0	0	0	0	0	33	0	0	13	0	0	0	0	0	0
Hirudinea	Dry	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Wet	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0
Crustacea	Dry	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
	Wet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ostracoda	Dry	10	0	0	8	0	0	0	0	0	0	0	0	0	0	0
	Wet	0	0	0	0	0	16	0	0	11	0	0	0	0	0	0
Ephemeroptera	Dry	16	8	5	1	0	25	0	0	0	3	0	0	0	0	0
	Wet	0	0	0	0	0	20	9	7	2	0	0	32	0	24	6
Odonata	Dry	0	0	0	2	0	2	0	0	2	3	0	0	0	0	0
	Wet	0	0	0	0	0	0	2	0	2	0	0	2	0	3	4
Hemiptera	Dry	0	5	0	0	0	0	0	0	6	0	0	0	0	0	0
	Wet	0	0	0	0	0	0	5	0	0	0	1	1	1	7	1
Cloleoptera	Dry	14	0	0	0	0	0	0	2	0	0	0	0	0	0	0
	Wet	0	0	0	0	0	26	0	0	0	0	0	1	4	0	0
Trichoptera	Dry	3	0	0	0	0	0	0	0	0	6	0	0	0	0	0
	Wet	0	0	0	0	0	3	0	0	0	0	0	0	0	1	6
Diptera	Dry	8	0	2	53	2	6	0	5	4	6	0	0	0	0	6
	Wet	0	0	0	0	0	4	0	2	77	0	2	8	5	5	6
Amphibians	Dry	2	0	2	0	0	2	0	2	0	2	0	0	0	0	0
	Wet	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Total	Dry	86	10	5	73	3	35	0	6	34	21	0	0	0	0	0
	Wet	0	0	0	0	0	120	13	11	107		3	44	10	44	27
No of Species	Dry	15	2	4	11	2	11	0	3	6	12	0	0	0	0	0
	Wet	0	0	0	0	0	16	4	5	12		2	12	5	10	12
Species Diversity (H)	Dry	0.81	0.55	0.58	0.96	0.27	0.99	0	0.18	0.91	0.99	0	0	0	0	0
	Wet	0	0	0	0	0	1.07	0.53	0.69	0.93	0	0.27	0.85	0.63	0.91	1.02
Eveness	Dry	0.69	1.83	0.96	0.96	0.38	0	0.95	0	0.38	0.16	0.91	0	0	0	0
	Wet	0	0	0	0	0	0	0.37	0.38	0.42	0.37	0	0	0.38	0	0

4.4.10 Geology

The geology of the area reveals that the rocks are of Pre-cambium crystalline basement complex and the cretaceous (Campanian-Maastrichian) sedimentary of the Mid-Niger Basin (Alconer, 1911; Adeleye, 1973). The northern segment of the area falls within the southern middle Niger Embayment (Bida Basin) covering places like Lokoja, Obajana and Koton- Karfi. The zone comprises of the Agbaja Ironstone Formation (Jones, 1958), Lokoja Formation and Patti Formation, which are essentially made up of conglomerates, coarse to fine grained feldsparthic, sandstones, siltstones (Gegubeki) clay and oolitic, pisolitic and concretionary ironstone.

Lithology

The lithologs are best described through the VES studies (**Appendices 4.7a to e**). Typical curves are of QHA, KHA, KH, KQA or HKHK type showing 4 – 6 layers. The first two layers are interpreted as possibly lateritic topsoil underlain by dry regolith of layers 3 and 4, which lie over wet weathered basement. The geoelectric substratum could possibly be of undifferentiated basement units. Sometimes, the top layer reflects a micaceous fine earthy material that is then underlain by regolith that makes up the geoelectric layers. These layers contain water with downward decreasing saturations and a characteristic clayey nature.

4.4.11 Hydrology and Hydrogeology

The major rivers encountered within the study area include River Ajaokuta, Atami, Osara, Akpomoba, Agbogu, Omeme and River Niger. These water bodies are seasonal except for river Niger.

Table 4.22 shows the hydrological characteristics of some of the water bodies. Hydrology studies all waters in and upon the Earth. It includes underground water, surface water and rainfall, and embraces the concept of the hydrological cycle. Hydrogeology studies the geological factors relating to the earth's water. The surface water is obtained from runoff, stream, rivers, and rainfall while groundwater is the water associated with the subsurface rocks.

Table 4.22: Hydrological Properties of some Rivers within the Study Area (March, 2003)

Water Body	Width (m)	Depth (m)	Variation in level (m)	Flow rate (m/s)	Discharge rate (m^3/s)
River Ajaokuta	15	1.0	0.28	0.021	0.32
River Omeme	60	0.15	0.52	0.051	0.46
River Niger	950 1150	2.8 7.3	4.5	0.516 0.49	1372.56 4113.6

Aquifer Depth- Fluctuation and Flow Direction

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

As for the deep-seated weathered basement aquifer, the depth to the water table ranges from 30- 70m with water level of 5m in the wet season. In the shallow overburden

aquifer the water level during the wet season is between the surface in lowland areas and about 2- 5m in highland areas.

Aquifer Properties

The porosity of the study area varies from the highly porous and permeable overburden to the less porous and permeable weathered basement rock. The weathered migmatites are rich in clay minerals hence less permeable. Permeability of different types of soils by Todd (1959) gives the soil in the weathered basement aquifer a coefficient of permeability value of 100- 10-2 gal/day (poor) while that of the overburden ranges from 102- 104 gal/day (Good) the deeper fractured rock aquifer (if so confirmed) is characterized by high permeability and high flow rate. The two main types of aquifer in the study area are the weathered basement and the joint fractured basement aquifer with the latter sometimes occurring below the former. Areas such as this hold more potential for ground water than areas with only weathered basement.

Aquifer Recharge

The main source of recharge for the aquifer in the area is rainwater. The amount of rainfall within the region is high and lies between 900 and 1,200mm per annum. The rate of infiltration is also quite high due to the porous nature of the overburden. Aquifer lateral recharge also results from the difference in gradient of groundwater.

Groundwater Quality and Contamination

Groundwater is never chemically pure; it is a solution of substances taking place during the course of percolation through the rocks. However, the water observed in the hand dug wells and surface water in the area of investigation was found to be colourless, odourless and taste free. Other properties are as indicated in **Table 4.24**.

Table 4.23: Groundwater Quality of the Study Area (Dry & Wet Seasons of 2001 & 2002)

Parameters	BH1		BH2		BH3		BH4	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
pH	6.6	6.6	6.7	7.1	6.8	7.4	6.4	6.6
EC µS	97.8	22.9	98.2	220.0	71.5	85.0	144.7	129.0
TDS mg/l	48.9	11.5	49.1	110.0	35.7	42.4	72.3	64.5
Color PtCo	73	14	75	71.0	194	168	-	18
Turbidity NTU	27	8	32	19	144	142	-	29
COD mg/l	15.2	9.0	17.2	2.0	12.8	5.4	15.2	14.4
CO_3 mg/l	0	0	0	0	0	0	0	0
HCO_3 mg/l	18.3	61.0	146.4	183.0	61.0	91.5	145.3	91.5
Cl mg/l	28.4	21.3	28.4	28.4	35.5	21.3	21.3	21.3
P mg/l	2.65	1.18	1.89	2.67	39.31	3.06	15.65	1.20
SO_4 mg/l	0.003	0.293	0.063	0.003	0.115	0.351	0.807	0.132
NO_3 mg/l	0.003	0.002	0.054	0.002	0.003	0.003	0.040	0.002
NO_2 mg/l	0.002	0.008	0.003	0.004	0.002	0.004	0.010	0.052
NH_4 mg/l	0.045	1.10	1.19	2.47	2.74	6.31	2.17	0.64
Na mg/l	5.20	4.08	5.36	9.36	8.32	7.92	11.92	8.00
K mg/l	5.09	1.27	5.14	8.69	3.18	2.86	4.13	5.99
Ca mg/l	22.44	57.72	44.89	38.41	35.28	48.10	22.44	48.10
Mg mg/l	1.93	13.52	3.87	5.80	7.73	11.60	5.80	5.80
Fe mg/l	0.009	0.009	0.001	0.001	0.068	0.088	0.865	0.012
Mn mg/l	0.062	0.016	0.005	0.001	0.060	0.081	0.089	0.003
Zn mg/l	0.047	0.075	0.058	0.051	0.047	0.067	0.047	0.032

Cu mg/l	0.215	0.215	0.215	0.007	0.562	0.693	0.586	0.215
Cr mg/l	0	0.001	0	0.001	0.007	0.011	0.015	0.006
Cd mg/l	0.001	0	0.001	0.001	0.001	0.001	0.002	0
Ni mg/l	0.027	0.034	0.040	0.009	0.173	0.156	1.806	0.059
V mg/l	0.018	0.020	0.003	0.013	0.087	0.080	0.033	0.005
Pb mg/l	0.005	0.003	0.007	0.006	0.014	0.020	0.016	0.004
Hg mg/l	0	0	0	0	0	0	0	0
THC mg/l	1.03	0.10	1.0	0.09	1.08	0.09	1.31	0.08

4.4.12 Wastes Management

Waste types encountered include tree trunks, pebbles, and scraps from past constructions, accidented motor vehicles, unused pipes, waste oil/grease, unused asbestos, fluorescent tubes and electrical fitting. **Table 4.24a** shows the checklist of waste types and the areas in which they were encountered.

Table 4.24a: The checklist of waste types in the study area (March, 2003)

S/N	Waste Type	Area
1	Caravan scraps	By Ajaokuta plant manifold
2	Pebbles and rocky substratum	Pebbles almost at 80% of the ROW
3	Relics from railway line	By railway crossing at Atami and Inera areas
4	Electrical fittings	By Lokoja Pump Station
5	Asbestos	By Lokoja Pump Station
6	Fluorescent tubes	By Lokoja Pump Station
7	Spill from oil and grease	By Lokoja Pump Station
8	Concrete and slabs	By Atami
9	Scraps of vehicle involved in accidents	Along Ajaokuta- Okene Highway, and Okene-Kabba Junction

4.4.13 Socio-Economics

4.4.13.1 The Project Environment

The proposed Ajaokuta-Obajana Gas Pipeline Project falls within three Local government Areas (LGAs) namely Ajaokuta, Adavi and Lokoja in Kogi State. The study area consists of three main axes:

- Ajaokuta – Eganyin stretch without previous pipeline Right of Way (32km).
- Eganyin – Lokoja/Kabba Junction stretch with an existing pipeline Right of Way (37km).
- Lokoja/Kabba junction-Obajana stretch without previous pipeline Right of Way (21km).

In all, over 20 settlements are considered host communities **(Plates 4.13-4.15**). The names of these settlements, their LGAs and relative distances from the pipeline ROW are contained in **Table 4.25.**

Plate 4.13: Obajana Village

Plate 4.14: A typical Village Setting within the Study Area

Plate 4.15: A Village Located on the Edge of Kabba Road

Table 4.25: Names of Settlements, LGAs and Relative Distances from the Proposed Pipeline (March, 2003)

LGA	Name of Settlement	Relative Distance from Pipeline (m)
Ajaokuta	Ajaokuta	
	Unosi	Unconfirmed
	Odomu	
	Adogo	
	Ogigiri	
	Eganyin	0
	Inare	750
Adavi	Atami	500
	Osara	1000
	Aku	750
	Irepeana	500
	Irepeni	500
	Irukura / Idodenge	0
	Irepeni III	250
	Zariagi	1000
Lokoja	Obajana	100
	Igbonla	500
	Adogbe	1000
	Ohiji	500
	Lokoja	Unconfirmed
	Apata-Oworo	Unconfirmed

Source: ***Field Survey (March 2003)***

4.4.13.2 Ethnic Composition

A number of ethnic groups exist within the project area. These ethnic groups and where they can be found are presented in **Table 4.26.**

Table 4.26: Ethnic Groups and their Locations within the Study Area

Ethnicity	Local Governments			Average (%)
	Adavi (%)	Ajaokuta (%)	Lokoja (%)	
Ebira	41.3	77.5	6.2	35.3
Gwari	0.0	5.0	0.0	7.0
Bassa	1.3	0.0	13.4	5.6
Oworo	3.8	0.0	74.3	21.6
Hausa	0.0	0.0	2.1	0.9
Ganagana	0.0	0.0	1.0	2.8
Igala	0.0	12.3	0.0	2.4
Ibo	0.0	0.7	1.0	2.4
Yoruba	1.3	0.0	1.0	0.7
Nupe	0.0	1.7	0.0	0.6
Fulani	0.0	0.8	0.0	0.2
Others	1.3	0.0	1.0	7.2
No Response	51	2	0.0	13.3
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: ***Fieldwork 2002***

From the Table above, Ebira is the single largest ethnic group and is followed by Oworo, Bassa, and Gwari. Hausa, Yoruba, Ganagana, Igalla and Ibo are least represented. It is worthy to note that some ethnic groups exist in these settlements though not reported above. This is due to the fact that they are not significant in terms of population.

4.4.13.3 Occupation

The occupational distribution of the people in the project area as revealed from the field survey conducted is shown in **Table 4.27** below:

Table 4.27: Occupational Distribution of Respondents in the Study Area

Occupation	No	%
Farming	590	40.4
Civil Service	180	12.4
Business	144	9.9
Crafts/Arts	58	3.9
Company Workers	122	8.4
Fishing	65	4.5
Hunting	43	2.9
Others	80	5.5
Unemployed	176	12.1
Total	**1460**	**100.00**

Source: Field Survey (March, 2003).

It is clear from the above that majority of the inhabitants in the project area are farmers (40.4%). Civil Servants, including teachers, accounted for 12.4% of the sample. Businessmen, Craftsmen and Company workers constituted 9.9%, 3.9% and 8.4% respectively. Fishermen were only 4.5% of those interviewed while 5.5% were hunters. However, lot of unemployment, especially among the youths also existed in the area. From the sample, 12.1% claimed that they were job -seekers.

Crops produced by these farmers include yam, maize, cassava, millet, guinea corn, melon, okro, and rice. Those engaged in hunting, kill animals (game) of various types especially grass cutters, fox, hares, antelopes and rabbits.

4.4.13.4 Religion

A survey of the project area revealed three major religions professed by inhabitants of the area. These are Islam, Christianity and African Traditional Religion. Muslims accounted for about 55% while Christians are over 38%. Only a small proportion (7%) professed African traditional Religion. This distribution is shown in **Figure 3.13** below.

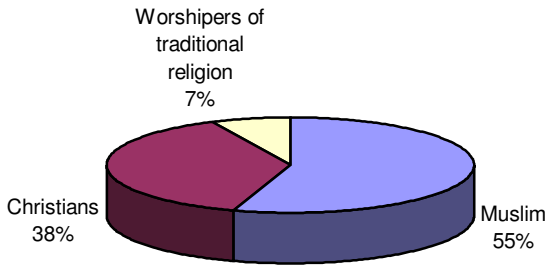


Figure 4.1: Relative Sizes of Various Religious Groups in the Project Area

4.4.13.5 Demographic Characteristics

The demographic characteristics of the population of the study area are presented in **Table 4.28**.

Table 4.28: Demographic Characteristics of the Study Area

Age Distribution	Percentage Distribution
0-4	11.6
5-9	10.6
10-14	7.8
15-19	6.9
20-24	8.8
25-29	7.9
30-34	6.8
35-39	6.4
40-44	6.3
45-49	6.0
50-54	5.6
55-59	5.2
60-64	4.5
65-69	3.1
70+	2.5
TOTAL	**100**

Source: ***Field Survey March, 2003***

As usual, children (aged 0 – 4yrs) have the largest proportion of 11.6%. When taken together, as large as 30.0% of the sample are below the age of 15. The productive segment of the population (20 – 55yrs) is about 39.2% while old people (> 55 years) accounted for 15.1%. The situation is presented in **Figure 3.14** below:

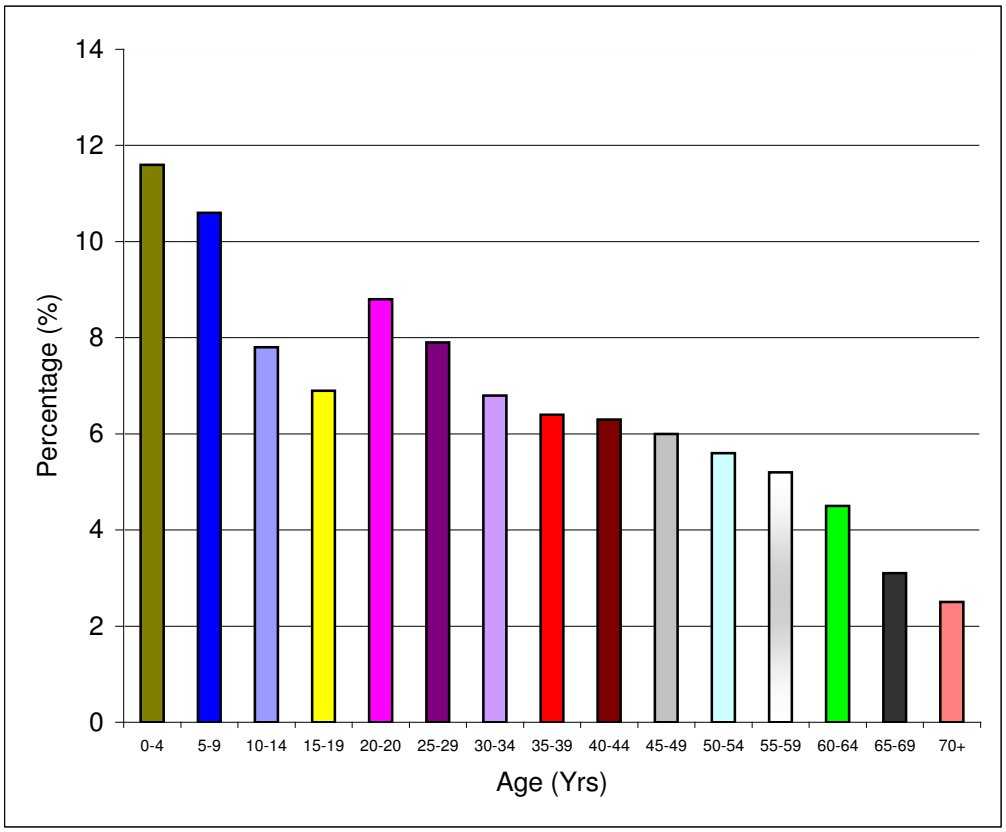


Figure 4.2: Demographic Structure According to the Ages of the Population in the Study Area (Field Survey, May 2001).

4.4.13.6 Income Profile

The annual income of selected respondents in the study area is shown in the **Table 4.29a & b** below:

Table 4.29a: Estimated Annual income of the respondents in the Study Area (March, 2003)

Income (₦)	No	%
Below 20,000	320	19.0
20,001 – 35,000	345	20.5
35,001 – 55,000	361	21.5
55,001 – 80,000	209	12.4
Above 110,000	445	26.6
Total	**1680**	**100.0**

The table shows that 19.0% of the respondents earn less than ₦20,000 per annum. In addition 20.5% which is one-fifth of the entire respondents earn between ₦20,001 and ₦35,000. Some 21.5% of the surveyed population earn between ₦35,001 and ₦55,000. However, only 12.4% admitted that they earn between ₦55,001 and ₦80,000 annually. Finally, 26.6% which is the largest proportion of the respondents earn above ₦100,000 annually.

The income profile is not surprising because perhaps majority of those interviewed are teachers, local government staff and Ajaokuta Steel Complex workers who earn enhanced income.

Table 4.29b: Income Distribution

Income/Month	LOCAL GOVERNMENTS			Average (%)
	Adavi (%)	Ajaokuta (%)	Lokoja (%)	
No Response	10	13.3	13.4	13.0
<₦5000	35	37.5	47.4	39
₦5,000 – ₦10,000	43.8	25	16.5	29.3
₦10,000 – ₦20,000	8.8	16.7	11.3	13.0
₦20,000 – ₦25000	2.5	5.8	7.2	4.4
>₦25,000	-	1.7	4.4	1.9
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: *Fieldwork 2002*

At theLGA level, Income levels (**Table 4.29b**) are very low. About 39% of the sample earn less than ₦5,000. The percentages earning more than ₦20,000 are really small indeed. Clearly, the households in the project area are poor. If we use the World Bank definition of a poor person as someone earning less than US$1.00 a day, then almost all the people in the project area are below the poverty line.

4.4.13.7 Population

The population figure for the settlements as per 1991 census and projections therefrom are presented **Table 4.30**.

Table 4.30: Population Figures of some Settlements within the Project Area

Settlements	1991			1996	2001
	Male	Female	Total		
Ajaokuta	19,664	15,543	35,207	39,634	46,720
Unosi Odomu Adogo	6,174	7,456	13,630	15,344	18,087
Eganyin	4,650	6,093	13,630	15,344	18,087
Inare	420	441	861	969	1,143
Atami	360	405	765	861	1,015
Osara					
Aku	775	688	1,463	1,647	1,941
Irepeana Irepeni I	197	200	397	447	527
Irukura/Idodenge Irepeni III	481	583	1,064	1,198	1,412
Zariagi	726	748	1,469	1,654	1,949
Igbonla Adogbe Ohiji	185	183	368	414	489
Okpaka Ozi Akpogu	183	237	420	473	558
Gaba	266	379	645	726	856

Uhana Orehi/Akuyabo	389	426	815	917	1,082
Manyanre	191	191	382	430	507
Adabo	285	288	573	645	761
Ahoko	157	172	329	370	437
Aseni	188	199	387	436	514
Omoko	256	243	501	501	665
Shekara	494	539	1,033	1,163	1,371

Source: ***Data extrapolated from 1991 census figures.***

From the table above, it is obvious that women are more in the project area than men. This might be due to the fact that some of the men migrate to other places for employment so as to sustain their families. In terms of the growth of the population, it maintains a steady growth rate of between 2.5% - 3.0% per annum. From the projections carried out on the basis of the 1991 Population Census figures, it is estimated that the project area had a population of about 99,631 by 2001.

4.4.13.8 State of Social Infrastructure

a) Water Supply

Pipe-borne water is available in Ajaokuta and Ahoko. Investigation revealed that Odomu, Inare, Aku and Irepeni I had borehole facilities, but are broken down. The other communities rely on rivers, streams and wells for water supply. Some of the wells were dug during the First Republic by Sir Ahmadu Bello.

b) Educational Institutions

Primary schools are fairly well spread over the project area. Over 69% of the settlements have such facilities while 31% do not have at all. Secondary schools exist in 31% of the settlements only Ajaokuta has more than one secondary school. It also houses the Nigerian Metallurgical Institute. None of the settlement in the Project has any form of tertiary institution.

c) Roads

Majority of the Communities are located along the Right of Way (ROW). As a result, they enjoy good road facilities. For others less fortunate, they are connected to each other by earth road, constructed and maintained by the various local government councils. Three settlements are linked by poor road network and thus largely inaccessible. The communities are Igbonla, Adogbe and Ohiji all in Lokoja Local Government Area.

d) Health Facilities

About 17.3% of the communities have hospitals, and are owned and administered by the State Government; Local Government Areas own health facilities (clinic) which service these groups of people. Over 31.0% of the communities have one form of clinic or the other providing health services for people in the localities **(Plate 4.16**). A total of 51.7% do not have any form of health facility.

e) Electricity

Only 13.7% of localities have electricity such communities include Ajaokuta, Adogo and Zariagi. The other settlements in the project area representing 86.3% do not have any form of electricity supply. People in these areas depend on lanterns, coal, kerosene and other forms of energy for domestic use.

f) Transportation

Vehicles (cars, buses, pick-ups and lorries) are used as means of transportation between settlements. Motorcycles are also widely used in the area especially for conveying farm produce to various localities. Bicycles are hardly used. Boats and canoes are rarely used too.

g) Housing

With the exception of Ajaokuta where there are numerous estates and staff quarters, other areas do not have these quality houses. Some settlements such as Adogo, Zariagi and a few others have good housing while majority have substandard structures. Although a number of mud structures exist in the project area, inhabitants of the area reported that they do not experience any form of accommodation problem or overcrowding.

h) Telephone Service

This facility exists only in Ajaokuta primarily due to the presence of the Steel Complex. The other settlements in the project area are yet to have this vital service.

Plate 4.16: A Privately Owned Clinic/Medicine Store in Obajana

4.4.13.9 Economic Environment

a) Markets

Eleven communities have at least one market each in the area. In these markets, all household goods and services in addition to food items can be found. However, in almost all the settlements, the markets are constructed with wooden structures. In some cases, businesses are conducted in the open environment and under the trees. There are no lock-up stalls in the area.

b) Land Ownership and Use

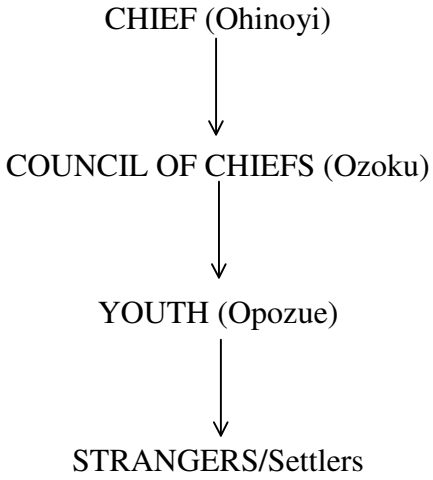
The system of land ownership in some settlements is communal in nature. In some communities especially where a number of ethnic groups exist such as Irukura/Idodenge, Irepeni III and Zariagi the land is owned by the host community (original settlers) while other settlers maintain tenancy status. The implication of this system for the success of the gas pipeline is that there is need to identify the host community (land owners) anytime some form of consultation is to be done so that discussions are carried out only with the right group of people.

4.4.13.10 Social Organisation

There is no uniform pattern of social organisation in the study area. The patterns of organisation that are clearly discernible from the point of view of the major tribes in the study area are those associated with Ebira, Gwari and Bassa, who constitute majority of the inhabitants.

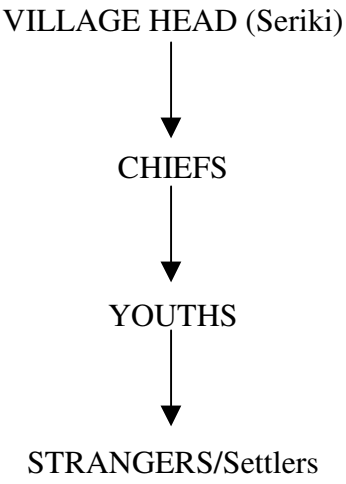
EBIRA

Like most ethnic groups in Nigeria, the system of social organization among the Ebira is hierarchical. At the head is the Chief (Ohinoyi). He is supported in the day-to-day administration of his kingdom by a council of Chiefs drawn among the elders (Ozoku). The youths (Opozue) are also very active in the administration. Strangers are incorporated into the administration in cases where they distinguish themselves, but they enjoy lower status than indigenes.



GWARI

Among the Gwaris, social organization is also hierarchical. At the head of the administration is the Chief (Seriki). He is the symbol of unity and the chief custodian of the people's culture. Next to him is the Council of Chiefs, followed by the Youths and finally by Strangers.



BASSA

Bassa system of social organization is similar to the two systems described above. However the main difference is that the status accorded women is much lower than what obtains in the case of Ebira and Gwari.

4.4.13.11 Recreational Facilities

There is severe limitation in terms of recreation facilities in the project area. Facilities like lawn tennis court, hotels, clubhouses playgrounds are very few. Infact they can only be found in Ajaokuta because of the nature of the town. A number of expatriates working for Julius Berger, Feugerolle, Dumez and the Ajaokuta Steel Complex (ASCON) reside in this town hence these facilities are provided for them.

In other settlements, such as Adogo, Gegu-Beki and a few others, the best one can find is a football field where people go to exercise themselves. A few town halls can be spotted in some localities in the area but they are of low quality.

4.4.13.12 Sacred Groves/Festivals

Survey data revealed that less than 25% of the settlements have sacred groves and celebrate festivals. To be specific, the settlements and the name of the sacred grove/god that exists are presented in **Table 4.31** below.

Table 4.31: Names of Settlements and type of Sacred Grove/God Worshipped in the Areas

Settlement	Name of Sacred grove/god worshipped
Unosi	Echeri
Odomu	Echeri
Adogo	Echeri
Ogigiri	Echeri
Eganyin	Echeri
Idodenge/Idodenge	Egere
Irepeni III	Tuwa (Bassa) Eku (Ebira)

Source: ***Field Survey (March, 2003)***

From the table above, it is clear that some inhabitants in the study area worship four (4) major gods. These are **Echeri**, **Egere**, **Tuwa** and **Eku**. According to the respondents, festivals connected with the worship of these deities are celebrated annually.

4.4.13.13 Social Problems

A few social problems exist in the project area. Respondents narrated some of these problems while others were directly encountered during the fieldwork.

i. **Communal Clash/Political Unrest:** Generally, this appears to be a common phenomenon within the country in rescent times. In Ebira land especially Idoji and Idozumi districts in Adavi LGA, a long-standing intra-clannish unrest has existed between the two districts and could possibly pose serious security problem to all and sundry. The problem between Idoji and Idozumi clan has existed for a very long time as a result of rivary between the Eku's of the two areas. At Eganyin area of Ajaokuta Local Government Area, the clash is between the pastoral Fulani and Ebira over existing abundant pastoral land for cattle rearing. This may also pose security problem.

ii. **Youth Unrest:** this appears to be common in the area too, especially at Ajaokuta Local Government Area.

iii. **Pipe-Vandalization:** Although there is no Petroleum Pipeline presently between Ajaokuta and Eganyin, however the then chairman of Ajaokuta Local Government Area (Hon. Salihu Onekata) explained to the consultation team that the council spent a lot of money when there was oil spillage occasioned by vandals around Bogiri and Inare a few years ago.

iv. **Unemployment:** As has been discussed earlier in this report, serious unemployment problem exists in the project area. This may be due to the general high rate of unemployment that is plaguing the entire nation at the moment.

v. **Prostitution:** This problem was reported mainly in Ajaokuta and a few other towns in the area, and it was of a low magnitude.

4.4.13.14 Environmental Problems

A few of these problems were reported. These include:

- Flooding
- Rainstorm
- Bush Burning

Flooding or heavy erosion appeared to be the most serious of the three, occurring in a number of settlements such as Unosi, Adogo, Ogigiri, Zariagi and Ahoko among others. Rainstorm and bush burning have also caused severe hardship to some communities in the project area.

4.4.14 Health Status Assessment

The health status of the communities in the project area was determined by means of health data collected from the following sources:

i. Local health statistics from hospitals and clinics.
ii. Personal interviews conducted by the investigator.
iii. Field data relating to:
   - Water supply
   - Waste disposal
   - Refuse disposal

- Health institutions
- Immunization status

4.4.14.1 Water Supply

Pipe borne water is available only in about three localities throughout the project area. These are Ajaokuta and Ahoko. Other settlements namely Odomu, Inare, Aku and Irepeni I have boreholes but as at the time of the study, they were not functioning. Majority of the people in the project area source their drinking water from wells, ponds and rivers. About 72.4% of the villages depend on these sources for their drinking water. From the above, we conclude that the state of water supply both for drinking and domestic use is far from being satisfactory.

4.4.14.2 Waste Disposal

Data available showed that 68% of the people in the area use pit latrines, 22% dispose of their waste in the openings in and around the premise, while only 10% claimed they use water system in their houses. This puts a greater proportion of the people at risk in terms of epidemic that may result from improper disposal of human facecs.

4.4.14.3 Refuse Disposal

With the exception of Ajaokuta, Adogo, other communities lack organized waste disposal system. Most inhabitants in the project area dump domestic waste product (refuse) in bushes in and around their homes. These sites have become breeding grounds for mosquitoes and domestic mice/rats thus increasing health risks in the study area.

4.4.14.4 Health Institutions

Ajaokuta, Adogo, Zariagi have hospitals, other settlements have clinics and patent medicine stores, which provide one form of assistance or the other. A total of 51.7% of settlements have no health facility at all. The implication of the above health situation is that majority of the people in the project area do not have the opportunity of seeking medical care even though they may be willing to attend one when sick.

4.4.14.5 Immunization Status

National Immunization Programme aimed at stemming some killer diseases plaguing children has covered most of the settlements.

4.4.14.6 Disease Prevalence

Data relating to disease prevalence are contained in **Tables 4.32 – 4.34** below. Specifically **Table 4.32** refers to the situation in Adogo area, which by implication depicted the health situation in Ajaokuta Local Government Area. The situation in Adavi Local Government Area is reported in **Table 4.33** while the situation in Lokoja LGA is dipected in **Table 4.34.**

Table 4.32: Local Health Statistics in Adogo Town (January- December, 2000)

Effective Diseases	No of Reported Cases	% of Total Illness Reported
Malaria	472	28.6
Gastroenteritis (Diarrhoea)	226	13.7
Urinary Tract Infection	38	2.3
Upper Respiratory Tract Infection	47	2.9
Amoebiasis	62	3.8
Anaemia	82	5.0
Measles	146	8.9
Pneumonia	80	4.9
Tetanus	27	1.6
Meningitis	14	0.8
Hypertension	61	3.7
Diabetes Mellitus	68	4.1
Peptic Ulcer	37	2.2
Malnutrition	26	1.6
Asthmatic Attack	61	3.7
Sexually Tramsmitted Diseses	201	12.2
Total	1,648	100

Source: ***Medical Records Unit Cottage Hospital, Adogo.***

Table 4.33: Medical Health Statistics of the Disease Trends in Adavi Local Government Area (December, 2000)

Diseases	Number of Reported Cases	Proportion (%)
Cough	74	15.5
Malaria	154	32.2
Diarrhoea	57	11.9
Common Cold	71	14.9
Measles	10	2.1
Ear/Eye Infections	6	1.3
Malnutrition	4	0.8
Skin Infection	23	4.8
Cuts and Bruises	16	3.3
Others	63	13.2
Total	478	100

Source: ***Health Dept. Adavi LGA Headquarters.***

Table 4.34: Percentage Distribution of Prevalent Diseases within Lokoja (January – December 2000)

Diseases	Number of Reported Cases	Proportion (%)
Malaria	405	38.6
Diarrhoea	189	18.0
Pneumonia	54	5.1
Worm Infestation	66	6.3
Urinary Tract Infection	35	3.3
Tuberculosis	16	1.5
Upper Respiratory Infection	60	5.7
Ear/Nose/ Throat Infections	72	6.9
Measles	93	8.9
Cholera	28	2.7
Skin Infection	32	3.0
Total	1,050	100.0

Source: ***Health Dept. Lokoja, LGA Headquarters.***

From the above, one can conclude that malaria is the commonest disease suffered in the project area. Scores of other diseases also plague the people. The situation poses a great challenge to stakeholders along the proposed gas pipeline routet. There is an urgent need to upgrade health facilities and also establish new ones where necessary.

4.5 CONSULTATION PROGRAMME

4.5.1 Introduction

Consultation, as defined by the World Bank, is the 'soliciting of peoples' views on proposed actions and engaging them in a dialogue'. It is an interactive 2-way flow of information and engagement, ideas and opinions between stakeholders and project proponents. Lee and Wood (1995) defined consultation as a process of seeking information about the environmental implication of a development project. Consultation is an act of meeting with a person or a group of persons with an objective of seeking people's views on a proposed project. Stakeholders may include project affected peoples such as individuals and families living near the project site or indigenous groups and communities, regulators, Non Governmental Organisation's (NGOs), Community Based Organisation's (CBOs) business associations etc.

Consultation with principal stakeholders and regulators for Ajaokuta-Obajana Gas Pipeline Project shall be a continuous process from concept through development to operational phases and abandonment. The objective has been to acquire and disseminate information, identify and address legislative, community and environmental concerns and to proffer appropriate mitigation options for all identified negative impacts.

4.5.2 Objectives

The objectives of embarking on the consultations process for the project are:

- Inform and educate to avoid misunderstandings about the proposed project/development;
- Establish areas of co-operation and development;
- Identify problems, concerns and needs;
- Obtain feedback;
- Learn through local knowledge and understanding, particularly for environmental and social baseline feedback;
- Dissemination of information on the project;
- Promote ownership and enhance social acceptability;
- Build trust amongst the various stakeholders;
- Evaluate alternatives and seek solutions;
- Resolve and avoid conflicts.

4.5.3 Identification and involvement of key stakeholders

Previous experience shows that certain potentially contentious issues never get to the public domain if the correct consultation process is not maintained from the conceptual stage of any development. Dangote Industries Limited has maintained a steady consultation process with all relevant parties, to ensure that all issues of concern are rationalised and sorted out prior to implementation of the proposed Ajaokuta – Obajana Gas Pipeline Project.

With over 20 communities cutting across the project area, consultation is identified as a key issue, on which the entire EIA process could depend. This issue was approached in the following ways:-

- Issuance of notice of intent to carry out an EIA for the proposed development alongside;
- With terms of reference to regulatory Agencies and potential stakeholders;
- Adopting a transparent method of surface right compensation payment to all affected parties;
- Sustaining consultation with stakeholders with explanations on key issues as they arise and affect the people;
- Maintaining effective communication with communities;
- Assured full commitment to implement mutually accepted Community Assistance Project.

Primary Stakeholders

The primary stakeholders are:

- The Immediate communities along the proposed gas pipeline ROW
- The Local Government Areas along the project area.
- The Traditional councils in the project area.
- Nigeria Gas Company (NGC).
- The Pipeline Products and Marketing Company Limited (PPMC)
- Nigeria Inland Waterways Authority (NIWA), Lokoja and
- Kogi State Government.

The stakeholders were consulted indirectly through letters on intent and directly by group discussions.

Identified Local Government Areas

The identified local government areas (see **the attached Administrative Map of Kogi State showing the LGAs**) include:

- Ajaokuta L.G.A
- Adavi L.G.A
- Lokoja L.G.A.

The above Local Government Areas and Traditional Council were consulted through written letters of intent and direct discussions (**Appendix 4.8**).

The Regulators

The identified regulators are:

- The Federal Ministry of Environment Abuja (FMENV);
- The Kogi State Environmental Protection Agency (KOSEPB);
- Kogi State Ministry of Environment and Physical Development;
- The Department of Petroleum Resources (DPR);
- Kogi State Department of Surveys.

The above regulators were informed of the proposed project through letters (**Appendix 4.8**) as well as visit to their officeses and direct discussion. Discussions were also held with the local authorities, community leaders and traditional leaders/Emirs (**Plates 4.17 & 4.18**), and this shall be maintained to ensure that all issues of local concerns are adequately addressed.

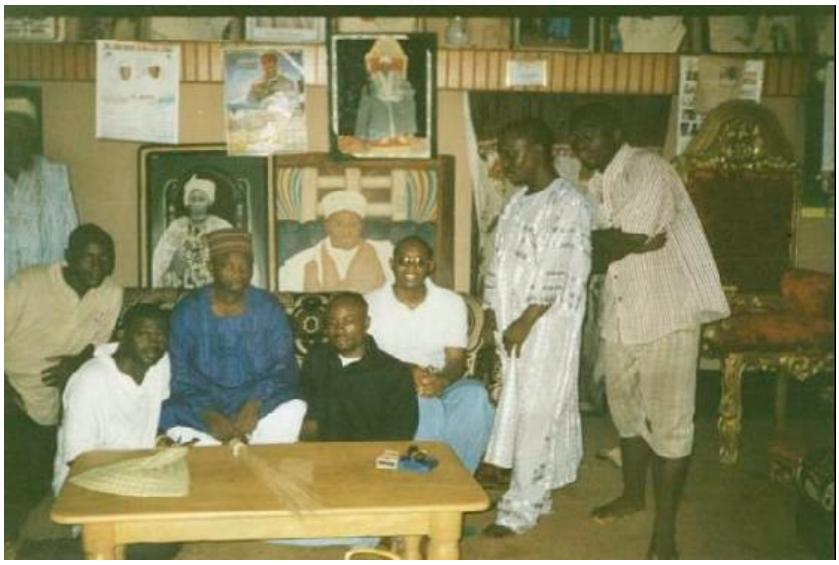


Plate 4.17: Group Photograph with Emir of Adogo during Cosultation visit

Plate 4.18: A member of Consultation team explaining a Point

The NGO's and CBO's

Throughout the period of consultation, the visible and relevant CBO identified were the DPC, National Union of Road Transport Workers (NURTW) and the National Council of Women Societies (NCWS).

4.5.4 Field Interaction

Field activities that took place between 17-28th March, 2003 offered the opportunity to interact with host communities. The socio-economic aspect of the studies involved field interviews and consultation with the host communities, the leaders, and other community representatives. Issues of concern raised by the communities during the meetings and interviews are as summarised below. The community leaders interviewed included the chiefs of the different villages. His Royal Highness (HRH) the Emir of Adavi and the Adavi Local Government Area could not be reached; this was due to crises in the area during the period of our consultation visit.

4.5.5 Community Responses

General

In general, interactions with the communities were positive and there was widespread appreciation of the consultation process undertaken. In terms of the project, the communities were of the view that it afforded considerable potential for providing significant socio-economic benefits and community assistance projects. However, their priority was to ensure that compensations are paid.

Community Perception of the Proposed Project

Opinions gathered through interaction with stakeholders within the project area indicate that the people are well disposed to the project. This position derives from the advantages they foresee the project will usher into their localities. However, a few settlements expressed misgivings in connection with the project. Reasons adduced include:

i. That construction works associated with such projects often deny them their means of livelihood.
ii. Pipeline-laying activities across major streams and rivers, which serve as sources of drinking water for the people, often make these water bodies impure, thus denying them good water supply.
iii. There is fear among some communities as to whether they will be adequately compensated by the relevant authorities should their crops, houses and valuables get destroyed during the process of construction.
iv. Considering the volatile nature of gas, it is feared that their existence as social entities might be seriously threatened should there be vandalization or other destructive incidents associated with the pipes.

Although the proportion of persons who expressed these views is less than 5% of those interviewed, there is need to evolve appropriate safety policies to alleviate their fears.

Issues and Concerns

The main concern of all the communities was the neglect by previous governments in terms of provision of infrastructure and social amenities.

- Payment of compensation for damages to their farmlands and other developments that might be destroyed during laying of the gas pipeline;
- Employment of their people during and after construction;

- Proposed pipeline route should not cut across town/villages
- The traditional rulers to be informed when the project is about to commence. This is to enable them inform their people to forestall any uncooperative attitude
- Social amenities to be provided for them as they have been neglected during previous pipeline activities.

4.5.6 Future Consultations

Dangote Industries Limited shall maintain continuous consultation with all relevant parties (host communities, NGOS, affected LGAs, Kogi State Government through KOSEPB and the regulators) concerned with or likely to be affected by the proposed project at all stages of the development.

CHAPTER FIVE

5.0 ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1 Assessment Methodology

5.1.1 Introduction

There are many methods for environmental impact assessments. The different methods however employ the following steps:

- Identification of impacts;
- Prediction of impacts;
- Evaluation of impacts;
- Communication of impacts.

The methods employed in this report are discussed below:

5.1.2 Scoping

Scoping seeks to identify those aspects of the proposed activities, which based on past experience; literature searches or intuitive perception could have significant impacts on the environment. The scoping process attempts to obtain answers to such questions as:

- What impacts will occur as a result of the execution and operation of the Ajaokuta-Obajana Gas Pipeline Project?
- What will be the extent, magnitude, and duration of the impacts?
- Which of these impacts will be important within local and national contexts?
- What can be done to mitigate, reduce or avoid altogether the adverse impact or to enhance/ maximise positive impacts?

Scoping was thus an important part of the impact assessment process and involved identification and "narrowing down" of potential environmental impacts to ensure that the assessment focuses on the key issues for decision-making. Thus scoping is an activity aimed at identifying those components (biological, physical, chemical, health, and social) of the environment, which may be impacted by the project and for which there are common concerns by stakeholders/National regulators. The boundaries (spatial and temporal) of this EIA study were determined through the scoping process involving consultation with stakeholders, social, economic and health studies. The project activities that would impact on the environment were identified as:

- Site investigations (Route Survey);
- Bush clearing;
- Excavation;
- Pipeline laying/construction;
- Gas conditioning facilities installation;
- System testing, operations and maintenance;
- Abandonment.

The following Priority Issues/Impacts have been identified:

- Land take/Land acquisition;
- Potential effects of the project on the economic quality of life of the members of the community;
- Potential effects of pollution incidents (Water & Air) as a result of construction;

- Potential effect of noise and vibration generated during pipeline construction on the nearby communities and animals;
- Potential effect of influx of migrant and contract workers on capacity of community facilities/infrastructure, communicable disease and cultural values;
- Increased competition from migrant workers for employment, leading to fewer opportunities for the local population;
- Potential conflict between community members and other stakeholders;
- Erosion at the construction stage affecting the community land, herdsmen and animals;
- Potential effect of waste generation and management on community, water & soil quality and animals;
- Possibility of fire and/or explosions and other accidents/incidents affecting community, workers and shareholders.

5.1.3 Associated and Potential Impacts

Table 5.1 shows checklist of the Associated and potential environmental impacts of the proposed project activities. The impacts have been categorized based on the stage of the project at which they are anticipated to occur and the related project activity or activities.

Table 5.1: Checklist of Associated and Potential Impacts of Proposal Project

Project Phase	Project Activity	Environmental Component	Potential / Associated Impacts
Design	Land acquisition	Soil, Vegetation	Loss of land, loss of economic crops, Increase in income
Site Preparation	Site Survey Soil Testing Bush Clearing	Vegetation, Soil, Wildlife	Vegetation removal exposes soil to weather conditions. Migration of wildlife
Construction Phase	Trenching	Soil	Damage to NITEL fibre leading to disruption of communication. Damage to roads and other foreign bodies
		Water System	Change in water quality due to inflow of run-offs, suspended particles etc.
		Air Quality	Changes in noise and exhaust gases from excavators. Increase in dust during the dry season. Temporal road obstruction/diversion
	Pipe laying	Light, heat and radiation (Air Quality)	Exposure of welders to heat and light radiation. Integrity testers exposed to X-rays.
	Back filling	Soil, water systems	Increase in turbidity due to expose of soil surface run-offs carry sediment drainage pattern due to changes in topography and improper re-instatement. Existing PPMC product pipeline.
	Transportation of cables, electrical generators, equipment and personnel	-	Road users would be exposed to higher road accidents due to increase in heavy traffic. Temporary road obstructions/diversions
	Hooking up equipment and other cables	Noise	Noise associated with hook-up procedure
	Operations of machines and vehicles	Air Quality, Noise, vibrations	Emission of exhaust gases from the fuel combustion engines can alter the local ambient air quality. Soil contamination and loss of aesthetics from liquid leaks, vibrations affecting communities and existing PPMC pipelines
	Base camp	Vegetation, soil, water	Domestic waste from base camp shall alter the water quality if dumped in water system. Poor aesthetic if it is dumped on soil and vegetation
Pre-Commissioning	Pressure testing, cathodic protection, lightening condition Test running of thermal plants and power lines	Water, Soil, Air quality Noise and electro-magnetic radiation, Electricity	Maintain the integrity of pipelines and prevention of corrosion. Pressure test water can contaminate soil and water. Increase in temperature due to discharged hydrotest water. Effect on humans, birds and wildlife; execution
Operation	Pigging	Soil, water	Contamination of soil and water system with condensate
	Disposal of industrial and domestic wastes	Soil, water, vegetation.	Odour and aesthetic devaluation may result from improper handling. Increase in disease if dumped in water
	Maintenance Gas leaks	Soil, water, air quality Air Quality	Release of gases through isolation valves. Accidental damage to equipment or fire
Decommissioning	Decommissioning	Landuse, Soil, Vegetation	Return of land to indigenes for farming; Increase in income, re-vegetation of areas previously occupied by structures. Contamination of soil/vegetation by liquids, cleaning agents etc.

5.2 Environmental Screening

5.2.1 Basis of Screening

The areas of concern in assessing the potential impact of the activities of the Ajaokuta-Obajana Gas Pipeline Project are water and air quality, soil, ecology, land-use pattern, wildlife, vegetation, geology and hydrogeology as well as socio-economic and health status of the host communities. The screening was based on the following considerations:

- Knowledge of the project activities (bush clearing, destumping, spoil disposal, trenching, pipe stringing, coating, welding;
- Knowledge of the equipment types, operational procedures relating to pipe laying;
- Information from literature survey, historical data and rapid "on the spot" assessment of water and air quality and meteorology
- Comparison of available results with FEPA (FMENV) and DPR guidelines and standards.
- Past experience on other EIA projects relating to pipeline laying, such as the Utorogu-UQCC (UPS) Pipeline Project, Odidi I- Forcados Export Gas Link line, Beneside-Brass Gas Pipeline Project, Agbara/Ota Gas distribution project, Ogun State, gas supply pipeline to Oluwa Glass Factory at Igbokoda and the Odidi AGG project.

5.2.2 Screening Approach

The checklist of project activities and their potential impacts identified were subjected to comprehensive environmental impact assessment, which is consistent with its scale and complexity. The technique used for rapid assessment of the activities involved in the Ajaokuta-Obajana Gas Pipeline Project include:

- Identification of key impacts and their indicator parameters.
- Determination of the magnitude and significance of the impacts.
- Evaluation of the importance of the impacts for decision-makers.
- Incorporation of concerns of host communities during consultation initiatives, and socio-economic/ health studies.

5.3 Impact Quantification and Determination of Significant Impacts

The identified associated and potential impacts of the proposed Ajaokuta-Obajana Gas Pipeline Project were quantified using the Risk Assessment Matrix and the ISO 14001 Procedure for evaluation and registration of Environmental Aspects and identifying significant environmental aspects/impacts.

Criteria and Ratings for Identifying Significant Environmental Impacts of the project are as follows:

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

0 = There is no legal/regulatory requirement
3 = There is a legal/regulatory requirement
5 = There is a permit required

Risk (R) – What is risk/hazard rating based on Risk Assessment Matrix (RAM) (**Tables 5.2a & 5.2b**)?

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

Environmental Impact Frequency (F) – What is frequency rating of impact Based on RAM?
1 = Low frequency
3 = Medium / intermediate frequency
5 = High frequency

Importance of Affected Environmental Component and Impact (I) – What is the rating of importance based on consensus of opinions?
1 = Low importance
3 = Medium/intermediate importance
5 = High importance

Public Perception (P) – What is the rating of public perception and interest in proposed project and impacts based on consultation with stakeholders?
1 = Low perception and interest
3 = Medium/intermediate perception and interest
5 = High perception and interest

The significant potential impacts of the proposed project (**Table 5.3**) were identified as those impacts in the checklist of **Table 5.1** that satisfy the following criteria.

(L+R+F+I+P) ≥15**:** Sum of weight of legal requirements. Risk factor, frequency of occurrence, importance and public perception greater than or equal to the benchmark (15).

(F+I) is >6**:** Sum of weight of frequency of occurrence and importance of affected environmental component exceeds the benchmark (6).

P=5: The weight of the public perception/interest in the potential impact exceeds the benchmark (5).

Table 5.2a: Risk Assessment Matrix for Environmental Consequences

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

Table 5.2b: Example of Further Definition of Consequence – Severity Rating for Risk Matrix

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

Table 5.3: Significant Impacts of the Proposed Project

Potential/Associated Impacts			Assessment criteria					Total score L+R+F+I+P	Category
Project Phase	**Project activity**	**Potential/Associated Impacts**	**L**	**R**	**F**	**I**	**P**		
Planning	Land acquisition	Loss of land/economic crop	5	1	3	5	5	19	Significant
Site Preparation Pipe line Row	Site survey	Removal of vegetation	3	3	3	3	3	15	Significant
		Wildlife immigration	0	1	1	1	1	4	Not significant
	Soil investigation	Lose of farms	0	1	1	1	1	4	Not significant
		Soil strata inversion during back filling	0	1	3	1	3	8	Not significant
	Bush clearing	Vegetation loss, increased in soil. Erosion, Migration of wildlife Dust during clearing	0	1	3	3	3	10	Significant
Construction Pipe line	Trenching	Changes in water quality at River crossing. Increase in TSP during dry season. Temporary vehicular traffic obstruction/diversion at road and rail way crossing	3	1	3	3	3	13	Significant
	Pipe laying	Increased exposure to radiation	3	5	3	3	5	19	Significant
	Back filling/ re-instatement	Soil structure inversion, changes in drainage pattern if soil is not properly re-instated, erosion at existing PPMC product pipeline	0	1	3	3	1	8	Significant
	Transportation of equipment and materials	Soil compaction, increase in rate of exposure to accidents temporary obstruction of road or road diversion	0	1	3	3	5	12	Significant
	Operation of machines and vehicles	Changes in air quality due to exhaust gases; soil contamination and loss of esthetics associated with fuelling and lubricate leaks, increase in ambient noise and due to operation of machines.	3	3	3	3	3	15	Significant
	Waste disposal	- Soil and water contamination from improper disposal of waste, - Loss of aesthetics, - Risk of accidents/injury from improper handling of industrial waste.	3	3	3	3	5	17	Significant
Pre-Commission	Pressure testing, Hydrotesting with fresh water from river Niger, cathodic protection	Contamination of river Niger from disposal of pressure test water. Increase in temperature of receiving environment, corrosion and pipeline rupture.	3	1	1	3	3	11	Not Significant
Operational Phase	Waste disposal	Odour and aesthetic devaluation due to waste dumping	5	5	3	3	3	18	Significant
	Pigging	Temporal Changes in air quality may occur from release of gaseous/misty bye products. Condensate may contaminate soil/water bodies. Due to spillage or valve and seal failure	3	3	1	3	1	11	Not significant
	Gas leak	Accidental damage to equipment	3	5	1	3	5	17	Significant
Abandonment	Decommissioning and abandonment	Excavation to remove pipeline would lead to contamination of soil	3	3	3	5	5	20	Significant
		Transportation of removed structures from site may lead to accident	0	3	1	1	1	6	Not Significant

It is apparent that the activities of the Ajaokuta-Obajana Gas Pipeline Project, which would exert significant impacts, based on Risk Assessment matrix and ISO 14001 criteria are: Land acquisition, site survey and trenching pipe laying. Facilities operations/maintenance, waste disposal, and decommissioning/abandonment. These activities would have effect on the air quality, vegetation, soil and surface water. **Table 5.4** below summarizes the indicator parameters of each identified environmental component.

Table 5.4: Indicator Parameters of each Identified Environmental Component

Project Phase	Project activity	Potential/Associated Impacts	Indicator Parameters
Planning	Land acquisition	Loss of land/economic crop	Changes in economic activities
Site Preparation Pipe line Row	Site survey	Removal of vegetation	Plant density, wild life density
		Wildlife immigration	Plant density, wild life density
	Soil investigation	Lose of farms	Soil fertility
		Soil strata inversion during back filling	Soil fertility
	Bush clearing	Vegetation loss, increased in soil. Erosion, Migration of wildlife Dust during clearing	Soil fertility; plant density TSP
Construction Pipeline	Trenching	Changes in water quality at River crossing. Increase in TSP during dry season. Temporary vehicular traffic obstruction/diversion at road and rail way crossing	TSP, (Air Quality), DO, TDS, TSS, water nutrients, soil aggregates/density
	Pipe laying	Increased exposure to radiation	Light, heat and x-ray dosages
	Back filling/ re-instatement	Soil structure inversion, changes in drainage pattern if soil is not properly re-instated, erosion at existing PPMC product pipeline	Soil profile studies, soil structure, Drainage pattern and flooding intensity.
	Transportation of equipment and materials	Soil compaction, increase in rate of exposure to accidents temporary obstruction of road or road diversion	Soil compaction; (CBR), frequency of road accidents during the construction phase;
	Operation of machines and vehicles	Changes in air quality due to exhaust gases; soil contamination and loss of aesthetics associated with fuelling and lubricate leaks increase in ambient noise and due to operation of machines.	Noise level, VOC, TSP, soil THC and noxious gases (CO_2, NO_2, SO_2, NH_3), vibrations
	Waste disposal	- Soil and water contamination from improper disposal of waste, - Loss of aesthetics, - Risk of accidents/injury from improper handling of industrial waste.	Waste management procedures at site THC in soil and water
Pre-Commission	Pressure testing, Hydrotesting, cathodic protection	Contamination of river Niger from disposal of pressure test water. Increase in temperature of receiving environment, corrosion and pipeline rupture.	THC in soil and water, water and soil temperature
Operational Phase	Waste disposal	Odour and aesthetic devaluation due to waste dumping	H_2S

	Pigging Gas leak	Temporal Changes in air quality may occur from release of gaseous/misty bye products. Condensate may contaminate soil/water bodies. Due to spillage or valve and seal failure Accidental damage to equipment	VOC, THC in soil and water
Abandonment	Decommissioning and abandonment	Excavation to remove pipeline would lead to contamination of soil	Plant density, aesthetics clean environment, soil mechanical properties.

A. Environmental Assessment

Land Acquisition

During the design/planning stage, land acquisition would be planned for. About 53km of the pipeline route shall be freshly acquired. Land acquisition entails loss of farmland by the indigenous farmers who use the land to cultivate various crops such as maize, sorghum, rice and vegetables. However, if adequate compensation is paid, it would improve the personal income of landlords/indigenes. The impact is significant, irreversible and of long-term effect.

Site Preparation

Site preparation shall involve removal of limited amount of vegetation to provide path for survey. The removal of wildlife habitat (vegetation) will lead to temporal migration of wildlife. The effect is not significant in the short term since the survey routes would be re-vegetated naturally.

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

Bush clearing activities during site preparation shall involve the removal of the vegetation, which would lead to exposure of the soil to adverse weather conditions. The width of the pipeline ROW shall be 25m. The removal of the vegetation shall lead to migration of wildlife from the area. The effect is significant; irreversible (since the ROW shall be maintained at a low height), and permanent until the life span of the project (> 25 years).

Trenching

Trenching would involve the use of trenching machines and excavator. This shall be supplemented with manual means where local hands are to benefit from the project. Minimum depth of the pipeline shall be 1.0m. There may be changes in water quality at river crossing. Increase in SPM, (dust content) when the trenching is carried out during the dry season is anticipated. There shall be temporary road and railway obstruction/diversion during trenching activities. The effects are not significant, temporary but irreversible.

Pipe Laying

Pre-coated pipes would be delivered from the pipe yard Dangote/contractor base camp. The pipes would be laid on stands along the trench, once a section has been completed and the trench profile is checked, the stand would be

removed and the pipeline seated on the bottom of the trench. The effect of pipe laying is significant long term, but reversible.

Back Filling

Back filling involves the dumping of soil back on the pipeline. The working procedure for back filling shall be based on the nature of the soil/terrain. In general, the first stage will be to return the soil in the reverse order. The back filling may affect the drainage pattern of the area if not properly done. The back-filling may induce erosion if soil is not properly re-instated. The effect is non-significant, reversible and has short-term duration. Poor reinstatement practices may lead to serious erosion problems along the ROW.

Transportation of Personnel, Equipment, and Materials

The soils of the project area would be compacted if vehicles drive on earth roads and materials were stored on the ground. The increase in traffic may increase the rate of exposure to accidents. Roads and railways may temporarily be obstructed or diverted to allow for movement of heavy equipment and materials. The effect is not significant, short term and reversible.

Civil Works

Minor civil works may be needed at Gas Metering station and at base camp. The effect is non-significant and permanent, irreversible until the economic life span of the project.

5.4 Social Impact Assessment

Demographic Impacts

The settlements in the project area are predominantly rural and therefore their population sizes are generally small. The only exceptions are Ajaokuta which had a total population of 35,207 in1991, and Adogo 13,630. Apart from Eganyi (10,743) in Ajaokuta LGA other smaller settlements have population sizes of less than 2,100.

Given the very small size of most of the communities, the influx of workers during the construction phase will significantly affect the demography of the communities, not just in terms of population numbers but also in terms of population structure. The latter will be a function of the selective nature of migration which is often dominated by adult male population. Construction activity will no doubt affect the sex ratio of communities for the period the activity is taking place in particular communities.

Socio-economic Impacts

Farming is by far the dominant occupation in the host communities, and as a result, personal incomes are generally on the low side. The project will potentially impact occupation and income, among others. Because employment in the pipeline project will attract higher income, there would be some redirection of labour from agriculture and other sectors of the local economy to the project. In addition, the higher personal incomes associated with employment in the project could cause some inflation in the local economy. Therefore, price increases and redirection of labour are likely to be among the major consequences of the project in the local economy.

Impacts on Lifestyles

Projects of the type under review (pipeline construction) which lead to the influx of non-locals into predominantly rural, traditional and conservative communities, have some visible impacts on lifestyles, some of which may be offensive to local norms, customs and practices. A common impact on lifestyles concerns sexual and other forms of behaviour, as well as modes of dressing. Sexual laxity/prostitution and alcoholism are the most vexatious and are associated with migrant workers living alone, away from their families. In some cases, youth militancy develops as youths organize in order to extract largesse from companies either for themselves or for their communities.

Impacts on Cultural Properties

There are no cultural properties of note in the host communities. The possible exceptions are religious sites/shrines. However, traditional worship is no longer very significant in the areas because of the influence of Islam and Christianity. Therefore, the impact of the pipeline construction on cultural properties and practices will be very minimal, if any.

Impacts on Social Infrastructure

The most common social infrastructures in the host communities are primary and secondary schools, healthcare facilities and water supply systems. The project will engender population growth due to the influx of workers. The capacity of local infrastructures in some of the communities is very limited and so cannot cope with the increased demand that will result from population growth during the construction of the pipeline.

Impact on Natural Resources

Ordinarily, a major impact on natural resources will be occasioned by land-uptake and destruction of vegetation along the pipeline route. Of necessity, these farms will have to be destroyed while laying the gas pipeline. In addition, the expected increase in population will lead to increased demand for fuel wood and to some deforestation.

5.5 Perception of Impacts

During the survey, the views of the respondents were sought concerning the possible impacts (both positive and negative) of the pipeline project. These views were used to construct a social impact matrix for the project. **Tables 5.5 to 5.8** set out the perceived benefits and adverse effects of the different phases of the project. The figures in the tables refer to percentages of respondents in the communities surveyed who indicated specific (severity of) impacts. **Tables 5.5 and 5.6** pertain to the possible benefits during the construction and operation phases while **Tables 5.7 and 5.8** pertain to the possible adverse effects during the construction and operation phases respectively.

It is clear from **Table 5.5** that the respondents expect a lot of impact in respect of the in-migration of male and youths, increase in income, new job opportunities and mode of dressing. These are, more or less, the priority expectations of the respondents during the construction phase of the project. During the operation phase (**Table 5.6**), the priority expectations are increased male in-migration, new job opportunities, change in mode of dress, and increased income. It would appear, therefore, that the major expectations of the people are in the areas of improved employment opportunities and improved income.

Concerning the adverse effects, **Table 5.7** indicates that the perceived problems during the construction phase include over-population, inflation, reduced agricultural production, encroachment on land, pressure on social infrastructure, loss of farmland, loss of drinking water sources, alcoholism and crime. Increased sexual laxity does not appear to be a major concern, contrary to experience elsewhere. During the operation phase, the major concerns are somewhat different from the concerns during the construction phase. The concerns include occupational change, out-migration, and encroachment on land **(Table 5.8).** The problems that would be insignificant during this phase are inflation, pressure on social infrastructure, loss of farmland, loss of drinking water sources, loss of wildlife, surface water contamination, sexual laxity, alcoholism, crime and discrimination against new migrants.

In summary, **Tables 5.5 to 5.8** show that the expected impacts of the project are demographic (migration/population growth) and socio-economic (employment, income in nature. There are also expected impacts on social infrastructures, natural resources (water supply sources) and lifestyles.

Table 5.5: Possible Benefits of the Project at Construction Phase

Variable	No Response (%)	Very Little (%)	Little (%)	A lot (%)	Total (%)
Increase in female migration	3	36	34	27	**100**
In male-migration	2.1	17.9	40	40	**100**
Youth in-migration	1	24	32	43	**100**
Adult in-migration	0.9	38	30.1	31	**100**
Increase Income	1	19	34	46	**100**
New job opportunities	2.9	20.1	31	46	**100**
New/Improved Schools	2.6	31	36.4	30	**100**
New/Improved Health	2	34	31.9	32.1	**100**
New/Improved Roads	2	31	35	32	**100**
New/Improved water supply	2.6	32	34	31.4	**100**
Increased participation in local festival	2	43	34	21	**100**
Change in Food Habits	2	38	30	30	**100**
Change mode of carrying load	3	41	30	26	**100**
Change mode of dressing	2	30	30	38	**100**

Table 5.6: Possible Benefits of the Proposed Project at Operational Phase

Variable	No Response (%)	Very Little (%)	Little (%)	A lot (%)	Total (%)
Increase in female migration	2.9	40	30	27.1	**100**
In male-migration	1.2	23.8	32	43	**100**
Youth in-migration	2.1	29.9	36	32	**100**
Adult in-migration	1	34	35	30	**100**
Increase Income	1	28	35	36	**100**
New job opportunities	1	21	38	40	**100**
New/Improve Schools	2	38	40	20	**100**
New/Improved Health facilities	1	35	34	30	**100**
New/Improved Roads	1	34	45	20	**100**
New/Improved water supply	1	30	38	31	**100**

Increased participation in local festival	2	48	30	20	**100**
Change in Food Habits	1	40	30	29	**100**
Change in mode of carrying load	1	45	31	23	**100**
Change in mode of dressing	0.3	30	32	37.7	**100**

Table 5.7: Possible Adverse Effects of the Proposed Project at Construction Phase

Variable	No Response (%)	Very Little (%)	Little (%)	A lot (%)	Total (%)
Overpopulation	4.8	8.9	37.2	49.1	**100**
Occupation change	6.9	32.5	30.2	30.4	**100**
Sex imbalance	6.5	34	38	21.5	**100**
Out migration	4	51	25	20	**100**
Inflation	3.9	30.1	30	36	**100**
Reduced Agricultural production	1	32	30	37	**100**
Destruction/encroachment on land	2.8	27.2	30	40	**100**
Pressure on Social Infrastructure	6.1	37.4	16.3	40.2	**100**
Loss of farmland	4	29	27	40	**100**
Loss of Drinking water	3	39	35	23	**100**
Loss of wild life	4.9	35.1	35	25	**100**
Groundwater contamination	16	65	18	1	**100**
Surface water contamination	12.5	23.5	35	29	**100**
Deforestation	4.1	20	40.4	35.5	**100**
Sexual Laxity	5.6	35.9	39.4	19.1	**100**
Alcoholism	0.6	26.2	32	41.2	**100**
Crime	4	32	34	30	**100**
Discrimination of new migrant	1	37	30	32	**100**

Table 5.8: Possible Adverse Effects of the Proposed Project at Operational Phase

Variable	No Response (%)	Very Little (%)	Little (%)	A lot (%)	Total (%)
Overpopulation	1	31	39	29	**100**
Occupation change	1	32	31	36	**100**
Sex imbalance	0.9	33.1	36	30	**100**
Out migration	2	32	30	36	**100**
Inflation	1	37	36	26	**100**
Reduced Agricultural production	2	37	34	27	**100**
Destruction/encroachment on land	1	22	41	36	**100**
Pressure on Social Infrastructure	1	39	30	30	**100**
Loss of farmland	1	38	33	28	**100**
Loss of Drinking water	2	43	40	15	**100**
Loss of wild life	10	40	30	20	**100**
Groundwater contamination	3	45	40	12	**100**
Surface water contamination	2	44	42	12	**100**
Deforestation	5	44	38	13	**100**

Sexual Laxity	6	42	20	32	**100**
Alcoholism	1	39	30	30	**100**
Crime	1.2	40	31	27.8	**100**
Discrimination of new migrant	5.8	37	34	23.2	**100**

5.6 Health Impact Assessment

The main impacts of the pipeline activities are waste generation and disposal, noise, pressure on health infrastructure, water and air quality impairment, which are adverse, short term, and of low magnitude and significance. The others – injuries, population changes, influx of commercial sex workers - are adverse, long term and of medium to high magnitude and significance. Economic/income, and population changes are beneficial/adverse, long term and of medium/high magnitude and significance (**Table 5.9**).

Table 5.9: Potential Health Impacts of the Pipeline Activities

Project Phase	Activity	Impact	Impact indicator	Type of Impact		Duration (Short/long term)	Magnitude *	Significance **
				Beneficial	Adverse			
Site preparation	ROW Clearance	Noise	Noise level		X	Short term	Low	Low
		Waste disposal	Garbage heaps, foul odour (H_2S),		X	Short term	Low	Low
		Pressure on health infrastructure	Prevalence of diseases		X	Short term	Low	Low
Construction	Trenching, Dredging, pipe laying , sand Filling compacting	Water quality impairment	Water-borne diseases turbidity, trace elements e.g., iron, oil & grease		X	Short term	Low	Low
		Waste disposal	As for site Preparation		X	Short term	Low	Low
		Pressure on health infrastructure	Increased prevalence of diseases & complications		X	Medium/ Long term	Medium	Medium
		Air quality impairment	Air quality		X	Long term	Low	Low
Operations	Collection and disposal of asters;	Waste disposal	As for site preparation		X	Long term	Medium	Medium
		Injuries	Injury		X	Long term	High	High
		Noise	Noise level		X	Long term	Low	Low
		Economic/ Income	Affordable access to healthcare and food	X	X	Long term	High	High
Decommiss-ioning and abandonment	Collection and disposal of wastes	Waste disposal	As for site preparation		X	Short term	High	High
All phases	Migration	Population changes	Population density and structure	X	X	Long term	Medium	Medium

		Commercial sex workers	Sexually transmitted diseases (STDs)		X	Long term	High	High
		Housing (availability and quality)	Overcrowding, contagious diseases.		X	Long term	Medium	Medium
	All activities	Injury	Wound/Sore / Fracture		X	Long term	High	High

** Magnitude represents the degree and extent of interaction between activity and health of the community.*

*** Significance is severity of impact and the importance of the health component impacted*

Low	=	*Incident has occurred rarely in the community*
Medium	=	*Incident has occurred several times per year in the community.*
High	=	*Incident has occurred several times in every section of the community per year.*

5.7 Description of identified health risks and potential impacts

Housing

The Ajaokuta-Obajana Gas pipeline Project will encourage immigration of different categories of people including skilled and unskilled labour force and service providers. This will result in added pressure on the already inadequate housing (both in quality and quantity) and the attendant problems of overcrowding and spread of communicable diseases.

The communicable diseases associated with inadequate housing in the project area include malaria, skin infections, respiratory tract infections, sexually transmitted diseases, cerebrospinal meningitis, and diarrhoea.

Income Status

The job opportunities offered by the project will result in improved income for the working class and hence improved ability to afford adequate food and healthcare. The old people and children who are not able to generate any income will be adversely affected because prices of food and healthcare will probably increase.

Water Quality

Water samples from some of the sources of water used for drinking in the project area did not meet the WHO requirements for potable water. The water sources contained high coliform and *E. coli* counts, which confirmed that the water is polluted with faeces. The chemical parameters of the water showed that the levels of turbidity and iron exceeded the WHO standards. Contamination of surface water sources by spilled chemical agents such as lubricating oil and diesel may occur during the site preparation and construction phases.

The communicable and non-communicable diseases associated with water quality impairment include diarrhea, typhoid and paratyphoid fever, and food/chemical poisoning.

Air Quality

The potential for air quality impairment as a result of the construction activities of the Ajaokuta-Obajana Gas Pipeline Project is confined to exhaust emissions from vehicles and equipment and it is low. During operation, pipeline leakage of compressed gases may occur and cause explosion and consequent fire outbreak. These emissions and fire incidents will increase the health risk associated with the project.

The communicable diseases associated with air quality impairment are respiratory tract infections and skin rashes while the non-communicable diseases are injuries, noise-related hearing loss.

Environmental Sanitation and Waste Management
Increase in population will lead to more waste production, which will require greater attention to refuse collection and disposal, sewage disposal and disease vector control. In addition, waste will be generated during some of the project activities such as site clearing, trenching, and in the operational and decommissioning/abandonment phases. Sewage disposal techniques are inadequate but the introduction of cheap sanitary latrines will eliminate the potential project-related increase in health risk associated with improper waste disposal and sanitation practices.

Noise
Even though the existing noise-level measurements in the communities of the project area range from 40 to 50 dBA, noise has the potential of causing disturbance and inconvenience to communities. The activities during the site clearing and construction phases of the project will produce noise.

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

Accidents
Increased job opportunities will enhance the chances for occupational accidents leading to injuries, especially with unskilled labour force.

5.8 Disease Risks Associated with the Project

5.8.1 Communicable diseases

Malaria
All the communities are vulnerable to the risk of malaria, but those members of the communities with immunity are less vulnerable and may not be affected by the disease. Some migrant workers including expatriates from temperate regions who have no previous exposure to malaria will contract it.

Construction workers and camp followers will be exposed to the malaria parasite. Inadequate accommodation will increase their exposure to mosquitoes.

Malaria vectors are widespread along the Ajaokuta-Obajana area especially during the rainy season. In the dry season, they are confined to the vicinity of permanent ponds, and river pools. The health risk is therefore high and may increase.

Control measures
Control measures include: provision of screened accommodation for workforce; use of netting treated with mosquito repellents; use of insect repellent paint on interior of walls of houses.

Diarrhoea
Diarrhoea has a high prevalence rate in the project area. The project is not likely to alter the existing disease pattern in the communities.

The environmental condition such as faecally contaminated water and food, which encourages disease development, are not likely to increase in magnitude during the construction and operational phases of the project. The transient increase in water turbidity, which may occur during trenching in the construction phase, can cause irritation of bowel in some individuals.

The health services available in the communities in the project area have the capability to deal with diarrhoea cases. The health sector in the project area has been acquainted with the proposed project and may require increased budget to accommodate the additional pressure on their infrastructure and drug supply.

The project will produce no change in diarrhoea prevalence.

Respiratory tract infections
The prevalence rate of these diseases is moderately high in the project area especially in the dry season with its dusty air. All members of the communities are vulnerable to the infections.

Activities such as trenching and rock blasting during the construction phase of the project will produce dust particles which, if inhaled, will predispose the workforce and nearby communities to respiratory tract infections. The North-East trade winds from the Sahara desert bring dusty, cool air during the harmattan period (December-January) and may increase the prevalence of the diseases. Suspected cases of respiratory tract infections are referred to hospitals for full diagnosis and treatment.

The risk of respiratory tract infections is moderately high. However, an increase is expected during trenching and rock blasting which will produce additional dust particles. These particles will further predispose the vulnerable groups in the communities to infection.

Skin rashes
These diseases, which result from poor sanitation and its spread aided by overcrowding, are of low prevalence. The prevalence may increase due to the presence of poor, job-seeking immigrants in the communities of the project area. The available health facilities have the capability to cope with the expected increase.

Injury
The prevalence rate of injuries is high along the Okene-Abuja highway despite the under- reporting because many of the victims go to private clinics and hospitals. The proposed project will involve transportation of heavy equipment, pipes and personnel, thus increasing the density of vehicles on the road. The potential for road accidents will likely increase considering the present level of reckless driving on the highway.

During the construction phase, occupational accidents may occur particularly among unskilled labour force. In the operational phase, fire outbreak may result from gas leakage. Snake bite and scorpion sting may occur in all the phases of the project. The available health facilities in the project area will require reinforcement in terms of

equipment, medication and personnel to cope with the expected increase in the rate of accidents and injuries.

5.9 Waste Disposal

A number of waste types shall be produced during the construction and operational phases of the projects. These include metal scraps, gaskets, lubricant filters, domestic waste associated with base camp etc. Improper waste disposal would lead to loss of aesthetics, risk of accidents by sharp objects/scrap piles, and contamination of soil and water bodies (through run-offs). The effects of improper waste disposal are significant, can be reversed and are of short term.

Pigging

The pipeline system is provided with pig launching facilities. These enable various pigs to be sent down the pipeline for maintenance and inspection purposes. Pigs fulfill the following roles:

- Cleaning the line of unwanted debris.
- Check the pipeline for signs of damage or deformity.

The internal part of the pipeline will be cleaned using two wired brush pigs propelled through the line by compressor air. A gauging pig will then be installed and propelled through the pipeline with water. The gauging pig will identify any deformities in the pipeline shape. The water pressure will be increased and the line hydrostatically pressure-tested.

The soil/water may be contaminated by the test water, which may be hot and induce temperature increase. The product of pigging is condensate, which is collected in the enclosed area of the pig trap. The effect is not significant, short term and reversible if the condensate/debris contamination is not massive and properly contained.

Hydrotesting

Hydrotesting involves using water (often containing an inhibitor) to check for leaks. The effects of the hydrotest water on surrounding environment if used with an inhibitor has adverse effect on the receiving environment. In the case of the Ajaokuta-Obajana gas pipeline project, hydrotest water shall be obtained from River which is confirmed to be fresh water. Fresh water used for hydrotesting when disposed back into the environment does not damage the receiving environment. Hydrotesting water for this project shall be release back into river Niger.

Abandonment

When the use of the pipeline is no longer required, it would be decommissioned and abandoned. The abandonment process involves a number of stages including:

- Removal of all surface facilities;
- Capping and sealing all open ends.

Dangote Industries Limited shall maintain a record of the abandoned facility and a copy will be given to the department of Petroleum Resources (DPR), FMENV, communities, and other stakeholders. The impact from abandonment programme is significant, long term and restores the environment to its original form as much as possible. The effects are significant positive and long term.

5.10 Project Specific Risk and Hazard Assessment

The purpose of undertaking a risk and hazard assessment is to present non-routine environmental hazards, which may arise during the construction and operational phases of the gas pipeline project. Risks addressed include potential effects on the terrestrial, air environment as well as health effects on the local population of the affected areas. **Table 5.10** provides a quick overview of the main contributions to overall risk for each area of the project.

Table 5.10: Applicable Risks by project component.

Hazardous Events leading to release of hazardous material or effect on the environment (construction/operational phase)	Construction/ Installation	Operation
Construction activities (spills, welding, radiography etc.)	✓	
Brittle failure, corrosion, defect, operator Failure		✓
Hazard or toxic chemicals	✓	
Condensate storage and transport refueling.		✓
Dropped objects	✓	✓
Rains	✓	✓

5.11 Hazards and Effects Management Process (HEMP)

The approach adopted to describe the management of the acute hazards that have been identified in this project is consistent with Hazards and Effects Management Process (HEMP). HEMP is a structured methodology for assessing hazards and associated risks where the focus is on Health, safety and Environment. The process describes the hazards in four phases; identify, assess, control and recovery (**Table 6.11**).

Table 6.11: Hazards and Effects Management Process

Identify	What are the Hazards?
	What could go wrong?
Assess	How likely?
	What consequence? i.e. what is the risk?
Control	Is there a better way?
	Controls adequate?
Recovery	Consequence limited?
	Recovery adequate?

The HEMP structured methodology aims to secure awareness of the relevant hazards and manages the associated risks. By recognizing and preventing that "potential to harm" being realized, harm will be avoided. There are many hazards, and associated with each hazard are risks. A risk is likelihood of consequences. Thus risk is a function of the likelihood, or chance of something going wrong and the severity of the potential consequences or outcome. Mismanagement of one particular hazard can have consequences that simultaneously impact to a varying degree on several of the broad risk types. For instance a gas leak and subsequent fire outbreak or loss of contaminant being primarily an environmental risk can also escalate to asset damage and loss of life.

5.12 Methodologies

The methodologies used to perform the risk assessment study for this project included the following:

- HAZID (Hazard identification) analysis
- HAZOP (Hazard and operability) analysis
- Faulty Trees or the similar Cause and Effect Diagrams
- Event Trees

The quantitative analysis of this study was carried out using the HAZID technique.

5.12.1 Evaluation of Hazards

The identified hazards are shown in **Tables 5.10** for external / environmental and facility hazards respectively**. Table 5.11** shows the various hazards that may occur, their causes and effects including the description of their controls for various phases of the project development. **Table 5.12** gives a summary of the health hazards associated with the project.

The probability of such hazards occurring is also included. A number of the identified hazards are occasional while relatively fewer ones are either probable or remote. The terms probable, occasional, and remote in this context refer to high, medium and low chances of occurrence respectively.

5.13 Summary of Environmental Risks by each Project Activity

(a) Fuel and lubricant Spills

There is a potential for minor oil spillage to occur during refueling operations of the construction equipment. Single incidents of small volume spills are likely to pose a threat to terrestrial habitat. Depending on the spill volume, the impact is expected to be localized. Other construction related threats include vehicle collisions and welding. The impact from this event will be local and should be managed by using standard procedures and contingency plans.

(b) Radiography of pipe Welds

During the pipe-laying activities normal weld testing will be undertaken using X-ray. The threat to the local environment and population is small. The project site will be isolated from on lookers and unauthorized people to reduce exposure risk.

5.13.1 Risks Associated with Construction Activities

Major Pipeline Rupture

Total loss of gas containment is regarded as unlikely but could occur in the event of pipeline rupture. The probability of such event is considered very small because it would likely occur only as a result of a major seismic event or sabotage.

Damage from vibratory ground motion is closely dependent upon soil conditions. Loose fill surrounding the pipeline in any area of faults and/or clay soil types will greatly reduce the risk. Generic pipeline failure could arise in several ways, including possible leaks caused by brittle failure, corrosion, and mechanical failure or operator error. The design intent is that the pipeline will be inherently safe as regards operator error and it is very unlikely that there could be a process over pressure cause of pipeline rupture as the pipeline rating exceeds the maximum rating of the pipeline compressors. Past experience indicates that, although such failure would create a potentially serious

hazard through uncontrolled releases of gas into the surrounding environment, the probability of such failure is extremely low. The risk of generic failures of the pipeline will be minimized by the appropriate selection of design standards, high quality construction materials, welding techniques and procedure. These will be supported by the use of anti-corrosion coatings, the inclusion of sacrificial anodes and regular maintenance and checking of the pipeline during its operational life. The impact of a line failure will be mitigated by monitoring the pressure in the pipeline stopping the compressors, and closing isolation valves at selected locations/manifolds along the pipeline.

5.13.2 Risk Associated with Sabotage and Terrorist Activities

Risks from such activities are unquantifiable and beyond the Proponent's control. They are acknowledged to be significant enough to warrant attention in the facility HSE and security management plan, which will advise manager on proper proactive response to all sources of risk in the normal operation of the facility.

Table 5.12: External and Environmental Hazards

Guide Word	Potential Hazards and Effects	Threats	Controls	Development Phase	P*	No.
Climate Extremes	Flooding along gas pipeline ROW arising from heavy rain and over flowing of river. Ultimately, excavation staff are placed at risk	Heavy rains Proximity to river	Project phasing into Dry Season. Concrete coating in seasonally swampy areas. Excavation in accordance with Standard Construction Specification.	Construction	L	1
Lightening	Lightening Discharge	Lightening	Static and active protection	Construction and operation	M	2
Erosion	Hydrocarbon gas under pressure	Sabotage Corrosion Mechanical Impact	Avoid erosion prone areas of the gas line ROW. Surveillance clause in the Operating and Maintenance (O & M) Manual. Corrosion protection of pipeline compliance with Standard Construction Specification.	Construction and Operation Phase	H	3
Subsidence	Subsidence	Damage to pipe supports	Periodic inspection of the supports in O & M Manual	Operation Phase	M	4
Community Crises	Crises: Civil and communal Disturbances	Poor Community relations	1. Include community issues in the construction contract 2. Consultation with the host communities	Construction Phase	M	5
Sabotage	Hydrocarbon gas under pressure	Sabotage Mechanical Impact of the gas pipeline	Markers on ROW. Warning signs and Public Forum/awareness.	Operation	M	6
Normal Communications	Dynamic hazards (road transport vehicles in motion)	Tight Access Road	Road Transportation Management Procedure	Construction and Operations	M	7
Communications for Contingency Planning and Supply Support	Security hazards resulting into damage to equipment and loss of goods	Hostility from neighbouring communities	Radio link on site Emergency evacuation procedures Emergency response management	Construction and Operations	M	8
Continuous Discharge to Air	Loss of gas containment through Vents, Fugitive Emissions, Depressurising etc. Nitrogen Emission	Process Upsets Poor maintenance Nitrogen Purging	Odourizing the gas stream. Apply applicable design and construction standards. Facility integrity inspection and maintenance. Pilot Flaring instead of Cold Vent Dry pipeline with Nitrogen before the use of air.	Commissioning and Operation “	L L	9
Continuous Discharges to Water	Water Contamination	Water for pressure testing	Discharge into drainage system. Possible reduction in volume of inventory (water). Bio-treatment of the water.	Commissioning and Operation	L	10

P* = HSE Priority ***H = High Severity*** ***M = Medium Severity*** ***L = Low Severity***

Table 5.13: Facility Hazards

Guide Word	Potential Hazards and Effects	Threats	Controls	Development Phase	P*	No.
Manning Operations	Operational psychological hazards	Frequency of Personnel Exposure	Evolve Operations philosophy. Access and lighting facilities for pigging facilities	Design / Operation	L	1
Emergency Response	Loss of Hydrocarbon gas containment resulting from isolation, ESD philosophy, Blowdown and Flaring.	Overpressure Gas line erosion.	Design control (wall thickness compensation, pipe rated to full pressure) Operation control (inspection and surveillance) Evaluation procedure for the inhabitant at built up area. Gas odourisation. Government Agencies (FMENV) involvement in campaign on sabotage effects on gasline.	Operation	M	2
Stored Flammables	Loss of hydrocarbon gas from pipeline under pressure	Sabotage Corrosion	Burying of Gasline External coating & wrapping Internal corrosion inhibition	Operation	H	3
Tie-ins	Construction and Maintenance Hazards	Existing facilities in service next to construction areas. Strict shutdown requirements	Pro-active provision of tie-in during facilities upgrade or operation windows	Construction phase	M	4
		Presence of gas under pressure at the tie-in point	Specify isolation procedure in Operation & Maintenance Manual. Design double block and bleed valve arrangement in the process.	Construction	M	5

P* = HSE Priority ***H = High Severity*** ***M = Medium Severity*** ***L = Low Severity***

Table 5.14: Health Hazards

Guide Word	Potential Hazards and Effects	Threats	Controls	Development Phase	P*	No.
Diseases	Malaria transmitting mosquitoes HIV	Stagnant water Lack of mosquitoes screen Ill health (weak anti-bodies) Ill health (week anti-bodies)	Design project site drainage to avoid stagnant water Administrative control (induction for the expatriates) Mosquitoes screen for site offices. Use prophylactic drugs. Pre-mobilisation medical certification	Design and Construction Operation	M	15
Food/Drinks	Catering hazards: Food borne bacteria Catering hazards: Water borne bacteria Alcohol, smoking, recreational drugs	Indiscriminate eating and drinking Unauthorized food/drink vendors Psychological stresses	Messing facility Messing facility Compliance with smoking in work location policy Compliance with drugs and alcohol policy	Construction	M	16
	Human Immune deficiency Virus Other communicable diseases	Body fluids contact. Blood transfusions.	Administrative controls: PPEs, induction and briefings Medical retainership for all workers	Design, construction & Operation	M	17
	Endemic situations	Personal hygiene Inadequate sanitary facilities	Awareness campaign Provide sanitary facilities to standard specifications	Design and Construction	L	18
Asphyxiation	Insufficient oxygen Smoke	Confined spaces Unplanned vessel entry Wrong PPE	Vessel entry Procedures PPEs Procedural controls (Work permits system)	Construction & Operations	M	19
Carcinogenic / Toxic	Chemicals hazards: Corrosive substances	Poor chemical handling Asphyxiating atmosphere	Guideline on safe handling of chemicals (SHOC) PPE	Commissioning & Operations	M	20
Physical	Loud Steady Noise	Wrong Equipment selection	PPEs for specific work areas	Commissioning & Operations	M	21
	Ionising Radiation	Radiographic activities	Compliance with PTW procedures PPE administration	Construction	M	22
	Non-ionising Radiation Electro-magnetic	Existing flare/Exhaust heat in work area High tension cable	Radiation calculation in design FRED consideration in plant layout Maintain safe distance	Construction & operations	L	23
Working hazards	Working at heights	Low Awareness Wrong use of PPE Inadequate PPE	Training Sufficient PPE	Construction & Operation	M	24
Working hazards	Hazardous equipment/Surface	Inadequate guard on equipment Low awareness	Equipment specification Training Warning signs	Design a& Construction	M	25
	Electricity	Exposed cables Wrong use of PPE Poor earthing	Design specification Structured HSE review (SAFOP, etc)	Design & Construction	M	26
Transportation	Excessive journey	Long distances Time constraint	Journey management	Construction	M	27

P* = HSE Priority ***H = High Severity*** ***M = Medium Severity*** ***L = Low Severity***

CHAPTER SIX

6.0 MITIGATION MEASURES

6.1 Introduction

The rationale for impact quantification and significance has earlier been discussed in the previous chapter. The results indicate that various components would be impacted positively or negatively. In order to preserve the present integrity of the environment certain steps have been recommended to mitigate or control the major negative impacts identified in this study. The control/mitigation measures have been based on the baseline conditions with regards to the biophysical environment, socio-economic and health status of the host communities. Also considered were the project activities and their envisaged impacts and concerns of stakeholders during consultation meetings and socio-economic/health status of the host communities.

Mitigation measures are defined for the identified significant associated and potential impacts based on the following criteria:

Prevention - design and management measures for ensuring that significant potential impacts and risks do not occur,

Reduction - Operational and management measures for ensuring that the effects or consequences of those significant associated and potential impacts that cannot be prevented are reduced to a level as low as reasonably practical,

Control - Operational and management measures for ensuring that residual associated impacts are reduced to a level as low as reasonably practical,

Table 6.0, presents a summary of the mitigative measures recommended to ameliorate all the significant associated and potential impacts identified for the proposed Gas Pipeline Project.

6.1.1 Planning Phase

Dangote Industries Limited shall:

- Compensate communities for land take and farmlands in line with Federal Government Land use decree.

6.1.2 Site Preparation

Dangote Industries Limited shall:

- Use environmental route/path for site survey.
- Enforce “no hunting of game animals” during site preparatory activities.
- Avoid excess land take and minimize bush clearing during site survey.

6.1.3 Construction Phase

Dangote Industries Limited shall:

- Use equipment, which emit low levels of noise with acceptable exhaust gases, which conform to national standards and specifications.
- Enforce proper waste management practices and good in-house sanitary practices for base camp workforce.
- Use existing access/right of way if available.

- Carry out major construction/civil works during dry season or provide silt curtains to control the suspended particles in the run-offs. Wet grounds to reduce dust.
- Reduce water and road crossing for pipeline, plan for run-off during wet season.
- Reduce time frame between clearing trenching, pipe laying, and backfilling/re-vegetation.
- Prevent intruders/from inquisitive onlookers from work site to protect them against welding radiations.
- Avoid interference/destruction of infrastructures such as NITEL lines, existing NEPA transmission lines, and settlement.
- Use noise defenders at high noise zones.
- Educate road users on road regulations especially those involved in the project.
- Use qualified and experienced staff to undertake project.
- Ensure no contamination of soil, water and vegetation, liquid fuel/lubricants from machines and vehicles during refueling.
- Guide road users on days for moving equipment etc.

6.1.4 Pre-commissioning Phase

Dangote Industries Limited shall:

- Enforce the installation of cathodic protection devices on the pipes to maintain their integrity/prevent corrosion
- Use fresh water for hydrotesting.
- Use proper PPE including ear defenders at high noise zones.
- Place/caution signs.

6.1.5 Operation Phase

Dangote Industries Limited shall:

- Ensure regular maintenance of right of way for pipeline.
- Provided security to prevent vandalisation.

6.1.6 Decommissioning and Abandonment Phase

Dangote Industries Limited shall:

- Re-vegetate all bare areas and restore site to original land use.
- Restore land to original form as much as possible and return to indigenes.
- Return ROW to indigenes for other land-use.
- Educate/guide road users on days of movement of dismantled parts.

Table 6.1: Summary of Identified Impacts and Proposed Mitigation Measures For the Gas Pipeline Project

Project Phase	Project Activity	Environmental Component	Potential / Associated Impacts	Mitigation/Control Measures	Timing/Action Party
Design	Land acquisition	Soil, Vegetation	Loss of land, loss of economic crops, Increase in income	• Compensate communities for landtake and farmlands.	During land take/Dangote
Site Preparation	Site Survey Soil Testing Bush Clearing	Vegetation, Soil, Wildlife	Vegetation removal exposes soil to weather conditions. Migration of wildlife	• Use existing route/path for site survey. • Avoid excess landtake and minimize bush clearing. • Enforce no hunting ban during bush cleaning	Bush clearing/Dangote
Construction Phase	Trenching	Soil	Damage to NITEL fibre leading to disruption of communication. Damage to roads and other foreign bodies	• Plan to prevent damage to foreign bodies (NITEL cable, etc) roads. • Undertake trenching with care.	Trenching/Dangote
		Water System	Change in water quality due to inflow of run-offs, suspended particles etc.	• Plan for run-off into water bodies by using silt trap to remove sediments/particles.	Trenching/ Dangote
		Air Quality	Changes in noise and exhaust gases from excavators. Increase in dust during the season. Temporal road obstruction/diversion	• Use equipment, which emits low exhaust gases, and noise, which conform to national standards and specification.	Trenching/ Dangote
	Pipe laying	Light, heat and radiation (Air Quality)	Exposure of welders to heat and light radiation. Integrity testers exposed to X-rays.	• Prevent intruders/inquisitive on-lookers from work site to protect them against welding radiation. • Protect integrity testers from exposure to X-ray.	Pipelaying/ Dangote
	Back filling	Soil, water systems	Increase in turbidity due to exposure of soil surface run-offs carrying sediment Alteration drainage pattern due to changes in topography and improper re-instatement	• Carry out excavation during the dry season or provide silt traps to control impact on water system. • Reduce water crossing for pipeline ROW plan for run-offs during wet season. • Undertake proper re-instatement procedures after backfilling exercise to maintain existing drainage pattern. Restrict the landtake to selected areas for the various facilities. • Use noise defenders at high noise zones	Pipelaying/ Dangote
	Operations of	Air Quality, Noise	Emission of exhaust gases from the fuel	• Use equipment, which emits low levels	Construction/ Dangote

	machines and vehicles		combustion engines can alter the local ambient air quality. Soil contamination and loss of aesthetics from liquid leaks	of noise, and exhaust gases. • Ensure no contamination from machines and vehicles.	
	Base camp	Vegetation, soil, water	Domestic waste from base camp shall alter the water quality if dumped in water system. Poor aesthetic if is dumped on soil and vegetation	• Enforce proper waste management plan and good in-house sanitary practices.	Base camp/ Dangote
Pre-Commissioning	Pressure testing, cathodic protection Lightening conditions	Water, Soil, Air quality Air quality	Maintain the integrity of pipelines and prevention of corrosion. Pressure test water can contaminate soil and water. Increase in temperature due to thermal loading or discharged hydrotest water. Lightening	• Treat hydrotest water and dispose responsibly. • Enforce the installation of cathodic protection devices to maintain the integrity of pipeline. Install lightening conductors.	Pre-commissioning/ Dangote
Operation	Pigging	Soil, water	Contamination of soil and water system with condensate	• Contain condensate, treat it	Pigging/ Dangote
	Disposal of industrial and domestic wastes Gas leaks	Soil, water, vegetation. Air quality	Odour and aesthetic devaluation may result from improper handling. Increase in disease if dumped in water. Odour Increased incidence of fire	• Enforce good in-house practices to control domestic and industrial waste; enforce the implementation of a waste management plan at site. • Make contingency for fire out break.	Waste generation/ Dangote
	Maintenance	Soil, water, air quality	Occurrence of work place accidents during operations due to lack of maintenance, or during maintenance as a result of human error. Extensive, liquid spills (lubricants, fuel, chemicals). Release of gases through isolation valves or equipment failure.	• Ensure regular maintenance of machines and ROW. • Use skilled workers for maintenance and operation exercise.	Maintenance/ Dangote
Decommissioning	Decommissioning	Land-use, Soil, Vegetation	Return of land to indigenes for farming; Increase in income, re-vegetation of areas previously occupied by structures. Contamination of soil/vegetation by liquids, cleaning agents etc.	• Re-vegetate all bare areas and restore site to original land-use . • Keep a clean environment after the decommissioning and abandonment	Decommissioning/ Dangote

B. Socio- Economic

Mitigation measures are measures designed to address the impacts of projects. The measures are largely a function of the adverse social impacts of projects since it is such impacts that require mitigation. The expected impacts of the Ajaokuta-Obajana Gas Pipeline Project include the following:

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

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

Mitigation Measures

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

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

Table 6.2: Key Mitigation Measures

Impacts	Mitigation Measures
1. Population growth due to in-migration	a. Use local labour as much as possible
2. Inflation in the local economy	a. Use local labour as much as possible
3. Pressure on local infrastructure	a. 1(a) above in order to minimize additional demand for infrastructure. b. Help increase the capacity of local infrastructure
4. Destruction/Loss of farms	a. Compensation
5. Deforestation	a. 1(a) above in order to minimize additional demand for fuel wood. b. Facilitate reforestation
	a. 1(a) above in order to minimize social

6. Sexual laxity	disruption b. Public enlightenment about potential health risks (STDs).
7. Youth militancy/unemployment	a. 1(a) above to have the youths gainfully employed. b. Facilitate skills acquisition programmes.

Table 6.2 shows the major mitigation measures required to address each impact. Population growth, consequent on in-migration, which will be particularly a feature of the construction phase.

The mitigation measure of engaging local labour, as shown in **Table 6.2**, applies to several of the impacts. Farmer/farm relocation and compensation are very sensitive issues that need to be addressed after effective consultation with, and participation of the local people.

C. Health

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

Environmental Sanitation/Waste Management

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

Refuse Management

The current unsatisfactory refuse management needs to be overhauled. The proffered mitigation measure includes:

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

Sewage

The use of VIP latrines shall be encouraged.

Disease

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

Water Quality Impairment

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

Noise

The present low noise level (40 – 50) dBA should be sustained. In the project area, excessive noise from heavy machinery used in construction and operational activities require mitigation as follows:

- Ear protection devices (muffs) should be provided and worn by construction staff within the working zone.
- Deploy low noise type equipment

Housing

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

- Use of base camps.

Health Education

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

CHAPTER SEVEN

7.0 ENVIRONMENTAL MANAGEMENT PLAN

7.1 Introduction

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

In keeping with Dangote Industry Limited policy on the environment, consideration of the environmental implications of this project began from preliminary study, conceptual design, up to the present stage of EIA. This EIA report is intended to provide an environmental input into the planning and execution of the project.

Environmental management activities of the proposed Ajaokuta-Obajana Gas Pipeline Project will be governed by a series of regulations that impose standards and mitigation of environmental hazards. Thus, it is a planned and integrated programme aimed at ensuring that both identified and unidentified impacts that may arise during the various phases of the project are brought to an acceptable level.

This Environmental Management Plan has the following specific long-term objectives:

- Ensure compliance with legislation and Company policy;
- Achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- Integrate environment fully into the business;
- Rationalise and streamline existing environmental activities to add value in efficiency and effectiveness;
- Encourage and achieve the highest performance and response from individual employees and contractors;
- Provide standards for overall planning, operation, audit and review;
- Enable management to establish environmental priorities;
- Be applicable throughout the organisation.
- Hold early consultations with communities and regulating authorities to ensure hitch free operations.

7.2 Waste Management

Any field development project involving bush clearing and excavation is bound to encounter waste management problems that must be handled in compliance with required local, national and International regulations

It is, thus, important that an effective waste management scheme be in place to avoid contravening guiding regulations and Dangote Group Policy on environment.

7.2.1 Waste Management Strategies

For effective management, wastes generated by Dangote activities shall be classified by type, source, quality and quantity.

All activities shall be planned and executed in such a manner as to:

- Take all practical and cost effective measures to minimise the generation of wastes, by employing the four R's (Reduce, Reuse, Recycle, Recover) through process optimisation or redesign, efficient procedures and good housekeeping.
- Minimise the hazards presented by all wastes and to ensure that all wastes are managed and disposed of in an environmentally acceptable manner.
- Waste management shall be carried out in full compliance with applicable local, State, and national legislation and guidelines of relevant regulatory agencies (e.g. MENV and DPR);
- Wastes generated by Dangote activities shall be managed from "cradle to grave" to eliminate the potential liabilities that could result from improper disposal;
- The management of wastes shall be the responsibility of the company key/front-line staff.

Fell trees and stumps shall be cut into small pieces and given to the local communities for use as firewood.

7.2.2 Sources and Inventory of Wastes

Wastes are expected from all phases of the project implementation, viz.: site preparation, excavation/construction, operation and abandonment.

The Environmental Management Plan for the proposed Ajaokuta – Obajana Gas Pipeline Project is as summarized in **Tables 7.1, 7.2 & 7.3**.

7.3 Environmental Audit

An Environmental Audit process provides an assessment of the environmental performance during the operational phase of the facilities. It is an internal control process to ensure those environmental issues and management procedures are strictly followed. This audit should be carried out every three years to ensure that environmental standards are maintained and EMP is followed.

Each environmental audit:

- Examines line management systems, plant operations, monitoring practices, procedures and plans;
- Identifies current and potential environmental problems, and
- Examines compliance with regulatory requirements.

Table 7.1: Environmental Management Plan for Gas Pipeline Project

S/N	Potential Impacts	Description of Impact	Severity Rating	Mitigation Measures	Action Party	Timing
1.	Vegetation Clearing	○ Destruction of plant communities ○ Fragmentation of vegetation ○ Introduction of alien species	High Low Medium	○ Restrict vegetation clearing to acquired ROW and narrow strips needed for development and safety of operations. ○ Eliminate alien or exotic plant species from ROW by frequent inspection	Construction supervisor Environmental supervisor	○ Prior to onset of site preparation ○ During operation
2.	Surface water pollution and sedimentation	○ Resuspension of bottom sediments ○ Deposition of soil particles in water column ○ Generation of silt at banks of creeks. ○ Discharge of hydrotesting wastewater. ○ Leaks, spills and discharges of oil, grease and effluents	High High High Low Low	○ Employ best available technology for laying pipes on riverbeds. ○ Establish water quality standards for all wastewater discharges. ○ Ensure that sewage treatment plants are built. ○ Control contaminated run- off or drainage water by containment. ○ Minimise oil spills and leaks by adherence to good housekeeping and good work practices	Construction supervisor Environmental supervisor Facilities supervisor	○ Duration of construction ○ Prior to commencement of installation ○ Duration of site preparation, construction and preparation.
3	Ground water pollution	○ Pipeline rupture	High	○ Prevent rupture by enhancing pipeline integrity ○ Coat pipeline with anti-corrosion coating and supplement by cathodic protection.	Construction supervisor Environment supervisor	○ During installation and pressure testing ○ During construction

4	Soil degradation	○ Exposure to direct sunshine ○ Elevated soil temperature ○ High mortality of soil fauna. ○ Erosion. ○ Topographic changes	High High Medium High Low	○ Reduce vegetation clearing and soil disturbance to barest minimum ○ Minimise exposed land area and duration of exposure. ○ Install temporary (during construction) and permanent erosion control measures. ○ Ensure proper backfilling and revegetation of all excavated areas and trenches ○ Maintain a ground cover of native plant species at all times	Construction supervisor Civil engineering supervisor	○ Prior to and after Commencement of construction.
5	Socio-economic impact/cultural conflicts	○ Increased demand on services of local communities because of large concentration of workers. ○ Economic depression due to withdrawal of labour force at the end of project. ○ Conflict between locals and non-native workers on culture, traditions and lifestyles ○ Increased road traffic may disrupt cattle rearing activities. ○ Risk of car accidents on the roads as a result of increased traffic.		○ Employ majority of unskilled labour force from the communities. ○ Ensure gradual and phased withdrawal of personnel at the end of construction. ○ Educate all employees to ensure awareness of, and sensitivity to, the local cultures, traditions and life style. ○ Regulate and coordinate traffic flow. ○ Create awareness on all safety and security issues ○ Impose load and speed limits.	Project Manager Environemental Manager	○ During construction, Installation.

7.4 Social Management Plan

This is essentially concerned with the social action plan for the host communities. Social action plan consists of measures designed to mitigate the adverse social impacts of projects. Among other things, SAP lists mitigation measures, the means by which the measures will be implemented, the time schedule for the implementation, as well as the implementing agency. Social action plan is therefore based on clearly identified mitigation measures. These measures are usually designed in collaboration with host communities in order to engender a sense of ownership. This can be achieved by holding wide-ranging discussions with cross sections of the communities. This is necessary for the success of the measures.

7.4.1 Mitigation

It is clear from the literature and from experience that development projects do generate some adverse social impacts, in addition to the positive effects they have. Mitigation measures are usually designed to address the adverse impacts. The mitigation measures for the respective adverse social impacts were spelt out in previous chapter. On the basis of the proposed mitigation measures, a proposed social action plan is provided in **Table 7.2**:

Table 7.2: Proposed Social Action Plan

Goals	Actions	Implementing Agency	Time Frame
1. Stem population growth due to in-migration	b. Recruit and train locals for project jobs.	Dangote	Immediate.
2. Minimize the depletion of the farming population and agricultural production	a. Meet with farmers or farmers' groups. b. Assist with agricultural extension service.	Dangote	Immediate
4. Ease pressure on local infrastructure	a. 1 a and b above b. Expand or improve existing infrastructure (e.g water supply) c. Provide infrastructure for project staff	Dangote	Immediate
5. Minimize disruption of means of livelihood	a. Relocate farms and farmers where necessary. b. Pay compensation where necessary	Dangote	Immediate
6. Curb deforestation due to demand for fuelwood	a. 1 a and b above in order to minimize additional demand for fuel wood	Dangote	Immediate
7. Curb possible sexual laxity	a. 1 a and b above in order to minimize social disruption due to the influx of non-locals. b. Promote health	Dangote	Immediate

	education and public enlightenment concerning STDs.		
8. Reduce the potentials for youth militancy and disruptive activities	a. 1 a and b above b. Facilitate the establishment of strengthening of public safety institutions. c. Cultivate good community relations	Community Development Department Public Affairs Department	Immediate

7.5 Health Management Plan

The health concerns enumerated must be properly managed. The tool for achieving this is the incorporation of a health management plan into the project plan. The health management plan provides the measure of assessing the accuracy of the predicted project impacts and monitoring of the effectiveness of the proposed mitigation/enhancement measures contained in the HIA report. The recommended health management plan indicates how the health concerns highlighted in the HIA would be managed (**Table 7.3**).

The health risk associated with the proposed pipeline project will be alleviated if the mitigation measures suggested are implemented.

Table 7.3: Recommended health intervention activities and performance indicators

Health intervention activity	Phase	Performance indicators	Time frame	Action party
Health education (operations phase)	All	Number of Community-Based Health Education Activities carried out	Quarterly	Dangote
Provision of safe water (operations phase)	All	Number of communities with functional potable water supply system	Quarterly	Dangote
Provision of sanitary facilities (operations phase)	All	Number of Sanitary facilities per community	Quarterly	Dangote
Strengthen Health Management Information System (HMIS) (operations phase)	Operational	Number of communities with efficient HMIS in place	Quarterly	Dangote
Train and equip Village Health Workers and Traditional Birth Attendants (VHWs/TBA) (operations phase)	Operational	Number of communities with functional VHWs/TBAs	Quarterly	Dangote
Sustain and strengthen immunization services (operations phase)	All	Polio vaccine coverage	Quarterly	Dangote

Dangote Industries Limited has institutionalized audit schemes aimed at verifying the effectiveness of environmental control and highlighting areas of weakness in environmental management. The field development audit should take the form of

periodic inspections and surveillance, which should focus mainly on environmental performance, through appropriately designed checklists. Part of the audit activities includes evaluation of environmental integrity of field facilities and identification of the residual environmental risks retained after implementation of mitigation measures.

7.6 Resourcing

Dangote Industries Limited considers environmental management an important aspect of project procedures. Consequently, in any project for which a project management team is set up, an environmental specialist is always an integral part of the team. In this project, an environmental focal point has been appointed to liaise between the engineering project managers and the environmental specialist consultants as well as advise on all environmental issues in conformity with the Group policy.

Dangote Industries Limited recognizes the need to use external environmental consultants to supplement in-house environmental specialists. To this end, environmental consultants will continue to provide expert advice to environmental managers throughout the development of this project.

In Dangote Industries Limited, environmental protection, like safety, is the responsibility of all staff at all levels. The environmental specialist assists with advice on environmental matters from an expert point of view. However, responsibility and accountability must be clearly defined, from those who monitor environmental performance to individual contractors who have responsibility for environmentally sound practices in their workplace and surrounding area. All staff will be made aware of their responsibilities through induction and training courses. The following mitigation steps shall be clearly borne in mind:

- Adherence to the environmental and social issues raised in this study (Chapter 7) ensure compliance with statutory standards;
- For every mature tree greater than 60cm girth cut down as a result of construction, at least one tree will be planted in replacement;
- Land uptake for ROW will be kept to the barest minimum
- At crossings of rivers, construction time will be reduced to a minimum and restoration of riverbanks to avoid erosion will be undertaken.

7.7 Contingency/Emergency Plans

Dangote Industries Limited has contingency plans that respond rapidly to gas leakages. These may occur as a result of equipment failure, malfunctioning, obsolescence or sabotage. Consequently, gas contingency plan to respond to emergencies is available to back up this project (**Figures 7.1 & 7.2**)

7.8 Consultation

Dangote Industries Limited has a principle of direct line of communication with all third parties, including all local communities. The primary objective has always been to ensure that its operations are devoid of interruption and disturbances arising from community - related issues. The proposed pipeline project will involve this form of consultation during the site preparation and development phases.

Dangote Industries Limited shall also maintain regular communication with all the regulatory bodies–Federal Ministry of Environment, State Environmental Protection

Agencies and Local Governments Areas on issues that may arise as a result of this project.

7.9 Monitoring: Measurements and Procedures

Systematic observation and measurement of selected variables shall be undertaken in order to identify the nature and magnitude of longer-term impacts of the project. The procedures shall include:

- Identifying the sources and characteristics of all observed environmental effects;
- Quantifying claims on resources and discharges to the environment;
- Quantifying and qualifying indirect effects on the environment.

Details of the monitoring program are given below: (Table 8.4)

7.10 Decommissioning, Abandonment and Restoration Plans

The pipeline project is designed last over minimum period of 25 years, at the end of the project life span; Dangote Industries Limited shall invoke the standard decommissioning and abandonment programme. The tasks shall include the following:

- Ensuring that the decommissioning and abandonment are done with the same care and respect for the environment with which the pipeline project was designed, constructed and operated.
- Assessing residual impacts that the project has had on the environment during its life span.
- Monitoring the abandoned environment.
- Restoring the environment as much as possible to its original state.

The abandonment process shall involve the following:

- Removal of all gas from system
- Capping and sealing of all open ends of buried pipeline
- Remediation of impacted sites in order to restore them to their original condition as far as possible.

Dangote Industries Limited shall maintain a record of the abandoned facilities and a copy will be given to the relevant Government - FMENV, host communities and other stakeholders.

Table 7.4 Monitoring Programme for Gas Pipeline

S/N	Impact Parameter	Impact Indicator	Sampling Location	Sampling Method	Sampling Frequency	Monitoring Duration	End Use of Data
1	Air Quality	Ambient air quality	Along pipeline route	In-situ measurement	Weekly during excavation/construction /yearly thereafter	Long-term	
1	Vegetation status	Diversity Morphology Pathology	Pipeline Route	Field Assessment Taxonomic studies Culturing and identification	Bi-annual	Long- term	Compliance Data bank
2	Surface water quality	PH TDS TSS BOD, COD Turbidity THC Oil & Grease	Pipeline River Crossing Points	In-situ measurement Photospectometry AAS PH meter	Monthly during construction and Bi-annually after construction along river crosses used as drinking water by host communities	During construction	Compliance Data bank
5	Soil quality	PH Organic Carbon THC Oil & Grease	Pipeline Route	AAS PH Meter	Quarterly after construction	Long- term	Compliance Data bank
6	Consultation		All stakeholders	Interviews, Dialogue	Yearly	Long-term	Openness/constant discussion

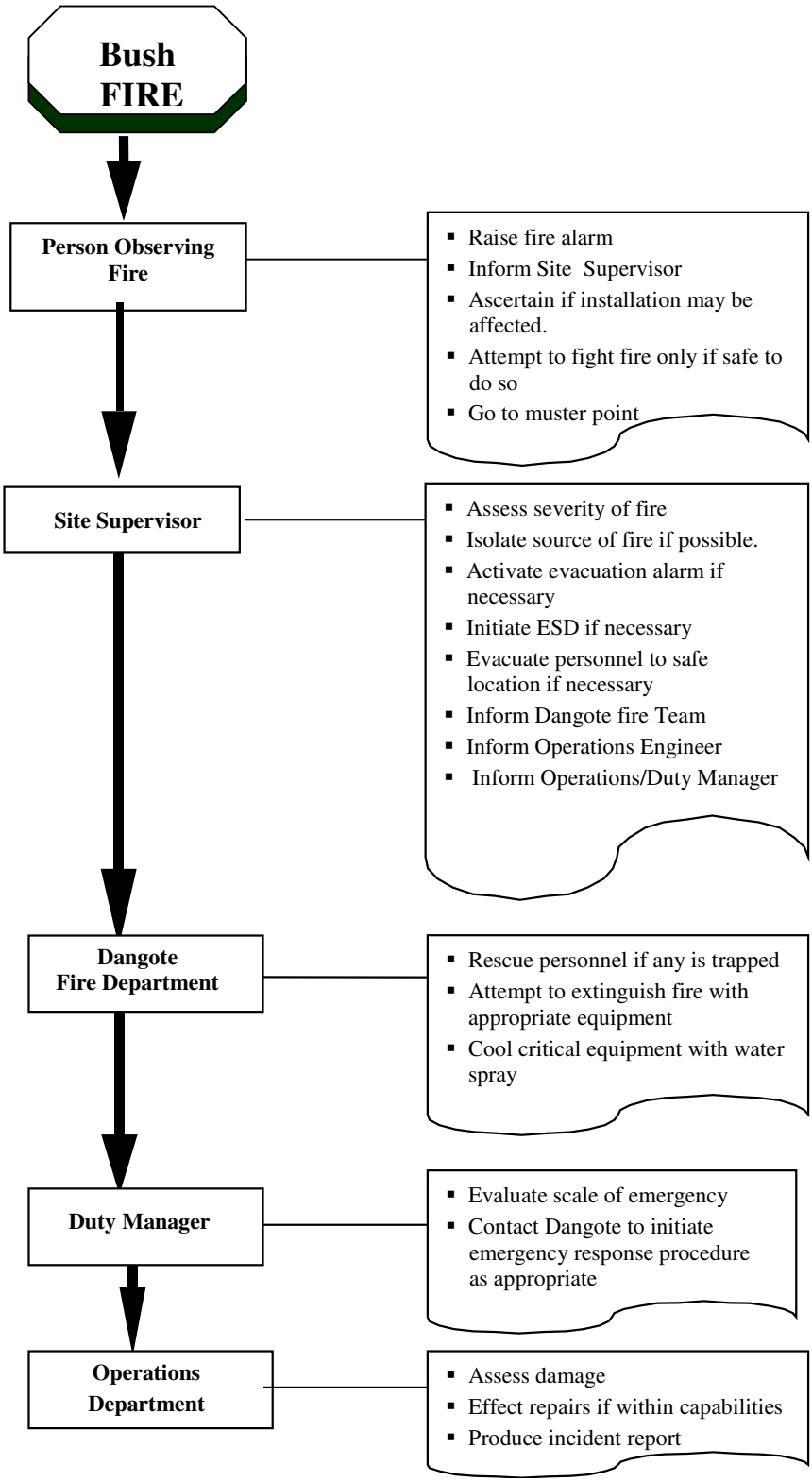


Figure 7.1: Flowchart Response to Bush Fire

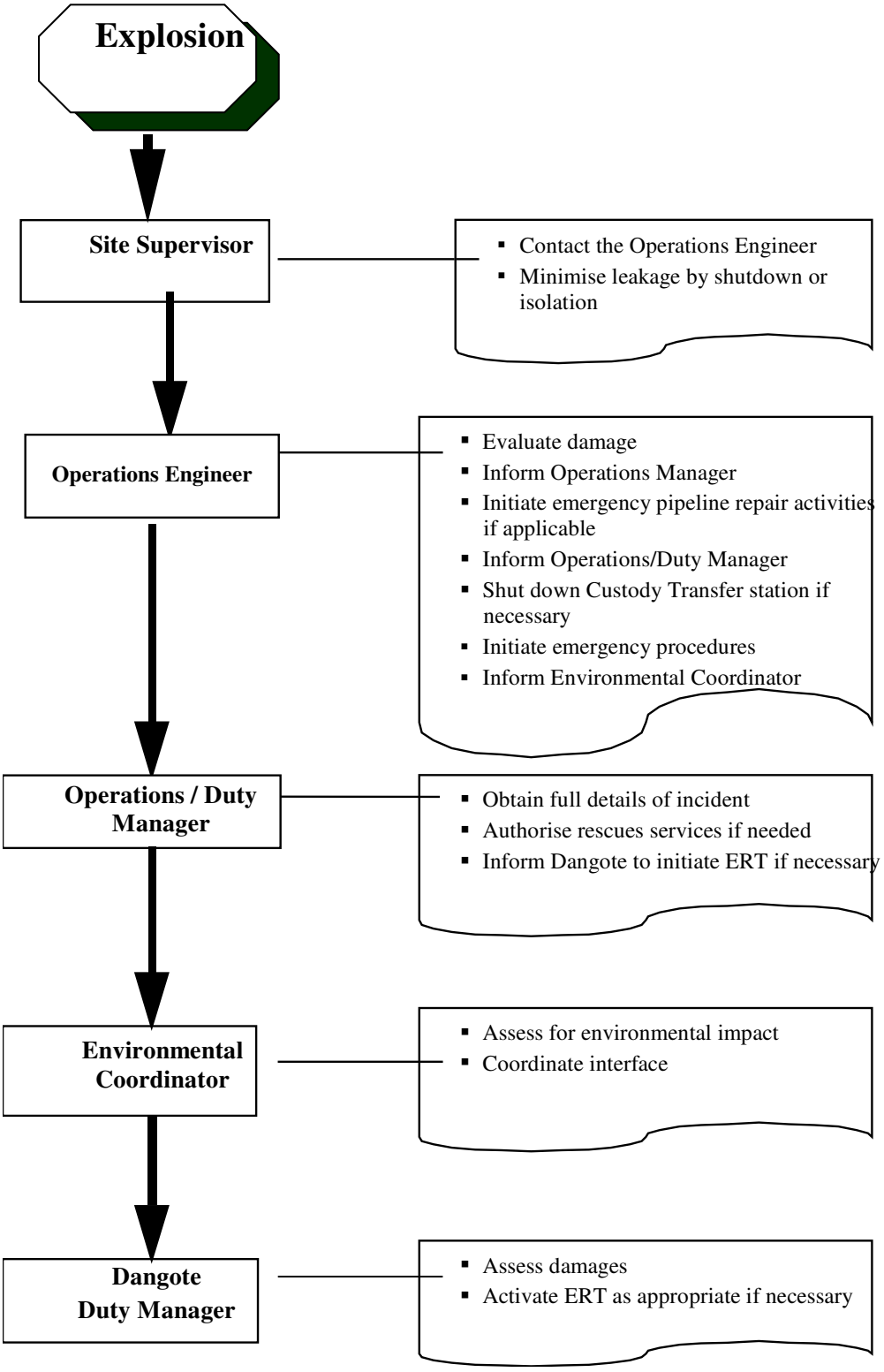


Figure 7.2: Flowchart Response to Explosion

CHAPTER EIGHT

8.0 CONCLUSIONS

The EIA for the proposed Ajaokuta-Obajana Gas Pipeline Project was conducted in accordance with the required local, national and international standards, using a team of Nigerian environmental consultants.

In undertaking the EIA study, a holistic approach was used whereby Dangote Industries Limited NGC, the host communities, and the Governments of Kogi State (the primary stakeholders) as well as the regulatory bodies (the secondary stakeholders) were widely consulted. General consensus on key environmental sensitivities of the gas pipeline on the project area in terms of natural environment, socio-economic/cultural and health characteristics were identified and quantified.

The significance of the impacts were duly assessed through standard field and laboratory methodologies, predictive modeling as well as desk reviews.

The EIA has demonstrated that the overall impacts associated with the Ajaokuta-Obajana Gas Pipeline Project can be managed within reasonable and acceptable limits by applying all identified mitigation measures contained in this report.

In consideration of the above therefore, there is no major environmental issue to impede the development of the proposed Ajaokuta-Obajana Gas Pipeline Project, which is designed to supply constant electricity to Dangote Industries Limited for the running of the ultra-modern Obajana Cement Factory in Kogi State.

All the identified potential adverse impacts of the proposed project shall be eliminated or reduced through the implementation of the recommended mitigation measures. The benefits that will be derived from the proposed gas pipeline project are therefore much greater than the short-term environmental effect.

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APPENDIX 1.1

International Environmental Conventions Signed by Nigeria

YEAR	CONVENTION
1948	Convention of the Intergovernmental Maritime Consultative Organisation (IMCO)
1954	Convention for the Prevention of Pollution of the Sea by Oil (not the 1978 Protocol)
1958	Convention on fishing and conservation of living Resources of the High Sea (note: into force 20 March 1966)
1958	Convention on the High Seas
1958	Convention on the Continental Shelf
1958	Convention on the Territorial Sea and Contiguous Zone
1968	African Convention on the Conservation of Nature and nature Resources
1969	Convention on Civil Liability for Oil Pollution Damage (not the 1976 and 1992 Protocols)
1972	Convention concerning the Protection of the World Cultural and Natural Heritage
1972	Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter
1973	Convention to Regulate international trade in Endangered species of Fauna and Flora (CITES)
1974	International Convention for the Safety of Life at Sea
1979	Convention on Conservation of Migratory species of Wild Animals
1981	Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Regions
1982	Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Regions
1985	Vienna Convention for the Protection of the Ozone Layer
1987	Montreal protocol on Substances that Deplete the Ozone Layer
1989	Basle Convention on the Control of Trans boundary movements of Hazardous Wastes and their Disposal
1990	Convention on Oil Pollution Preparedness, response, and Co-operation
1992	United Nations Framework Convention on Biological Diversity
1992	United Nations Framework Convention on Climate Change (+ 1997 Kyoto Protocol)
1994	United Nations Convention to Comfort Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in African.

Nigerian Environmental Laws and Regulations

1956	Act No. 31	Oil pipelines Act
1965	Act No. 24	Oil pipelines Act (Amendment)
1967	Act No. 28	Petroleum Control Act
1968	Act No. 34	Oil in Navigable Waters Act i) Oil in Navigable Waters Regulations
1969	Decree No. 51	Petroleum Drilling and Production Decree
1969		Petroleum (Drilling and Production) Regulations
1971	Act No. 30	Sea Fisheries Act
1973	Act No. 25	Petroleum Technology Department Fund Act
1978	Act No. 6	Land Use Act
1979	Act No. 99	Associated Gas Re-injection Act
1985		Associated Gas Re-injection (continued Flaring of Gas regulations
1988	Decree No. 58	Federal Environmental Protection Agency Decree
1988	Decree No. 42	Harmful Wastes (Special Criminal Provisions, etc)
1991		National Environmental protection (Effluent Limitations) Regulations
1991		National Environmental Protection (Pollution Abatement in Industries and Facilities Producing Waste) Regulations
1991		National Environmental Protection (Management of Solid Hazardous Wastes) Regulations
1991		National Guidelines and Standards for Environmental Pollution Control in Nigeria
1991	Decree No. 36	Federal National Parks Decree
1991		Environmental Guidelines and Standards for the Petroleum Industry in Nigeria – Department of Petroleum Resources
1992	Decree No. 59	Federal Environmental Protection Agency (Amendment) Decree
1992	Decree No. 71	Sea Fisheries Decree
1992	Decree No. 86	Environmental Impact Assessment Decree
1992		Proposed National Guideline and Standards for Waste Management in the Oil and Gas Industry in Nigeria – FEPA
1993	Decree No. 94	Nigerian National Petroleum Corporation) Projects Decree
1993	Decree No. 101	Water Resources Decree
1993		Guidelines for the establishment of a Petroleum Refinery, Petrochemicals and Gas Processing Plants in Nigeria
1994		Environmental Impact Assessment Procedure for Nigeria – FEPA

1995		Petroleum (Drilling and production) (Amendment) Regulations
1995		Sectoral Guidelines for Oil and Gas Industry Projects (Oil and Gas exploration and production – onshore) – FEPA
1995		Sectoral Guidelines for Oil and Gas Industry Projects (Oil and gas exploration and production – offshore) – FEPA
1995		Sectional Guidelines for Oil and Gas Industry Projects (oil and gas pipelines – onshore and offshore) – FEPA
1996		Petroleum Refining (Amendment) Regulations
1996	Decree No. 8	Oil and Gas Free Export Zone Decree

INTERNATIONAL CODES, STANDARDS AND GUIDELINES

ISO 7731: Danger signals for work places – "Auditory danger signals"
ISO 8201: Acoustics – " Audible emergency evacuation signal"
ISO 8995: " Principles of visual ergonomics – the lighting of indoor work system".
World Health Organization (WHO) Guidelines for drinking water quality."
Part 1: Recommendations. 2nd ed.
Part 2: Health criteria and other supportive information. 2nd ed
Part 3: Surveillance and control of community supplies. 2nd ed
ISO 6385: " Ergonomic principles in the design of the work systems"
ISO 9241-1 "Ergonomics requirements for office work with visual display terminals (VDTs)"
Part 1: Guidance on Regulations L23"
UK Health and Safety Executive Code of Practice
"The Control of Legionellosis including Legionnaires' disease, second edition"
ISO/CD 11014 " safety data sheet for chemical products. Part 1: Content and order of sections.
ISO 7730, Moderate thermal environment – " Determination of the PWV and PPD indices and specification of the conditions for thermal comfort."
ISO 13852: "Safety of machinery – Safety distances to prevent danger zones being reached by the upper limbs"
ISO 11429: Ergonomics – "System of auditory and visual danger and information signals"
ISO/DIS 13853: Safety of machinery – "Safety distances to prevent danger zones being reached by the lower limbs"
ISO 13854: Safety of machinery – "Minimum gaps to avoid crushing of parts of the human body"
ISO 11428: Ergonomic – "Visual danger signals – general requirements, design and testing"
ISO 11429: "Ergonomics – System of auditory and visual danger and information signals"

APPENDIX 4.1

Detailed field Sampling & Laboratory Strategies

Field Work

Field sampling was conducted between 26-30th March, 2003 for all environmental components.

The inter-disciplinary field study involved data acquisition on topology, climate and meteorology, air quality and noise, soil, aquatic, vegetation, groundwater, geology/geophysics and socio-economics. Each of these components of the environment was sampled in accordance with DPR guidelines and standards (Part VIII) D (2) on sampling and handling of samples.

Apart from random sampling for soil, vegetation and water samples, wildlife search and geophysical investigations were carried out at designated spots along transects. Field investigations also included supplementary interviews (in cases of wildlife and fisheries survey) and structured questionnaire for socio-economic survey.

Topology

A systematic sampling technique was adopted as a scheme to extrapolate data evenly about the target area for the study. Vehicle and foot traversed the entire area. The distribution and pattern of the physical features defining the terrain in the project area were used as common approach to landscape description and assessment. Physiographic or land systems approach were used to identify the units forming the terrain.

Climate and Meteorology

Meteorological data were also collected from the fieldwork. The impacts for most quarrying activities and the iron ore mining at Itakpe and that of the Ajaokuta steel complex on the local meteorology were determined.

Field monitoring of the micro scale climate of the project sites was carried out by a weather station set up during the period of the field study.

Wind speed and direction were monitored using a cup anemometer and wind vane respectively. A rain gauge was used to measure the daily precipitation in the field while relative humidity was determined using an automatic self-recording Hydrograph. Temperature data were recorded with the aid of a mercury-in-glass thermometer.

During the report preparation the laboratory, historical data collected on the climatic variables were analyzed to provide the general characteristics of the mesoscale climate of the project area.

Using historical and field data for the region, wind roses (frequency and speed) were constructed for the different seasons. The main features of humidity examined were the mean, maximum and minimum relative humidity, all calculated from the historical data of the project region. On the whole, data on climatic factors were used to prepare and compute, respectively:

· Wind roses (a picture of historical wind direction and speed).
· Aridity Index using rainfall and temperature data according to the formula of Ewer and Hall (1978).

$$Aridity\ Index = \frac{12\,p}{T + 10}$$

where,
p is mean monthly rainfall (mm) and
T is mean monthly air temperature (°C).

· Flood flow maps in relation to seasonal spatial distribution of rainfall.

Air Quality

(a) Field Procedures

Air sampling field equipment was set up in the field at the positions of the weather stations. This comprised an electrically driven vacuum pump and a box containing air sampling trains for SO2, total nitrogen oxides (NOx), O_3, NH_3 and particulate. Sampling was carried out using an air sampling train mounted on a platform at a height of 1.5-2.5 metres from the ground. Air was drawn at a flow rate determined by a fitted calibrated critical orifice, into a series of glass scrubbers fitted with about 10ml absorbent solutions to absorb specific gases. Sampling was done for about one hour at each sampling site. With this set up sulphur dioxide, nitrogen oxides etc were determined in the field. After one hour the solutions in the scrubbers in the sampling train were poured into glass vials. These were then taken back to the laboratory and each analysed by specific standard methods. Typical air sampling trains, with their components, for SO_2 and NOx are shown in Figures 2.5 & 2.6.

(b) Laboratory Procedures

The details of the analytical methods including the principles and laboratory procedures for the different components are shown below:

(i) Sulphur Dioxide (SO_2)

Principle

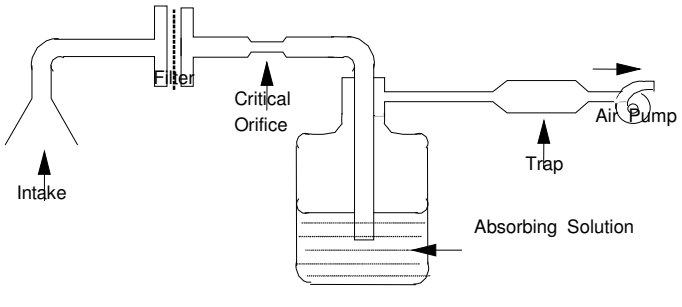
The para-rosaniline method West and Gaeke (1956) was used. This method is essentially specific for sulphur dioxide. It involves the use of a scrubbing solution containing tetrachloromercurate ion to collect sulphur dioxide from air. The SO2 is trapped as dichlorosulphitomercurate ion. This complex is stable and is later reacted with formaldehyde and pararosaniline to produce pararosaniline methyl sulphonic acid, which has an intense red-violet colour with maximum absorbance at 548 nm. The sensitivity of the procedure is normally 5 mg/m3. In this exercise a detection limit of 20 mg/m3 was achieved by scrubbing 30 litres of air through 10 ml of absorbing solution.

Reagents

(a) Absorbing solution: This was prepared from analytical reagent grade chemicals and double-distilled water. It was prepared by dissolving 10.86 g mercuric chloride, 0.066g disodium salts of ethylenediamine-tetra-acetic acid and 6.0g potassium chloride in 1000 ml distilled water.

(b) Sulphamic acid solution: The solution was prepared as required by dissolving 0.6 g sulphamic acid in 100 ml solution.

(c) Formaldehyde: This was also prepared as required by diluting 5 ml 36% formaldehyde to 1000 ml.



(d) Stock iodine solution: 12.7g iodine and 40.0g potassium iodide were dissolved in 25 ml water and made up to one litre in a standard flask to give 0.10 N stock iodine solution. From this solution, 0.010 N iodine was prepared as required, by diluting 50.00 ml to 500.0 ml.

(e) Starch indicator: A paste of 0.4 g starch and 0.002 g mercuric iodine was added to 200 ml boiling water and kept boiling to dissolve.

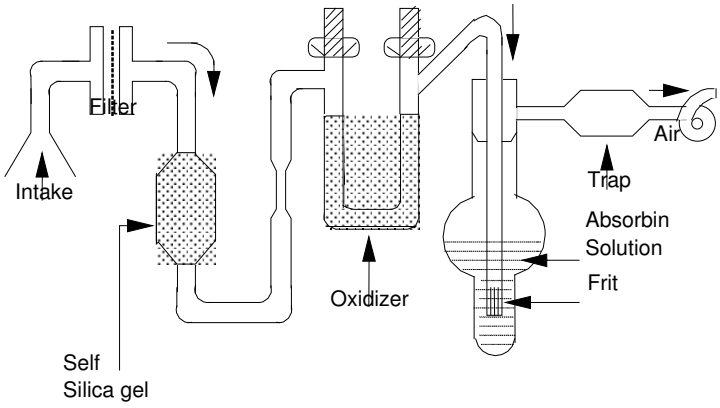
(f) Stock sodium thiosulphate solution: The solution was prepared by using freshly boiled and cooled distilled water to dissolved 25g sodium thiosulphate. 0.50 g Na2CO3 was added to the mixture before making up to 1000 ml. It was standardised against dried (180°C) potassium iodate. From this, 0.01 N solutions was prepared as required by diluting 100 ml of the stock solution to 1000 ml using standard flask.

(g) Standard sulphite-TCM solution: Standard sulphite solution was first prepared from sodium sulphite (0.5 g sodium sulphite per 500 ml solution using fresh double distilled water) and standardised by back-titration using excess iodine and standard thiosulphate solution. The standard sulphite-TCM solution was then prepared by making up 2.00 ml of the sulphite standard to 100.0 ml in a standard flask using the absorbing solution.

(h) Pararosaniline reagent: 20.0 ml of 0.20% purified pararosaniline and 25 ml of 3 M orthophosphoric acid were diluted to 250 ml with water in a standard flask.

Laboratory Procedure

(a) Sample Analysis: A minimum of 30 minutes was allowed to elapse after sampling before analysis commenced. This is recommended to allow for the complete decomposition of any ozone in the sample. The absorbing solution was quantitatively transferred into 25 ml standard flask, using minimum amount of water for rinsing. 1.0 ml of 0.6% sulphamic acid was added and allowed to react for 10 minutes to destroy any absorbed oxides of nitrogen. 2.0 ml of 0.2% formaldehyde solution and 5 ml pararosaniline solution were then added to the flask. The mixture was allowed to stand for exactly 30 minutes before making up to mark with freshly boiled and cooled distilled water. The absorbance (A2) of the solution was taken at 548 nm in 10 mm cell, using distilled water as reference. A blank was prepared by similar treatment of 10 ml of unexposed absorbing solution. A control was also prepared by taking a mixture of 2 ml standard sulphite-TCM solution and 8 ml absorbing solution through the same process as the sample solutions. The absorbance of the blank (Ao) and the control were then measured at 548 nm in 10 mm cell.



(b) Calibration of Laboratory Procedure: 0.50, 1.0, 2.0, 3.0, 4.0 ml of the sulphite-TCM standard solution were measured into separate 25 ml standard flasks. 9.5, 9.0, 8.0, 7.0, 6.0 ml absorbing solutions were added in that order to the flasks containing the standards. The colour reaction was carried out as described for the sample and absorbances were measured at 548 nm in 10 mm cell. A calibration graph (absorbance vs. concentration of SO2) was plotted and the calibration factor, reciprocal of the slope of the calibration line, as calculated and used as the calibration factor.

(c) Calculation: The ambient SO2 concentration was calculated from the experimental data as follows:

$$\text{Con } (\mu g\ SO_2 \ / \ m^3) = \frac{(A_s - A_o) \times (10^3) \times (F)}{V}$$

As = Absorbance of sample
Ao = Absorbance of reagent blank
F = Calibration factor
V = volume of sample (ml).

(ii) Nitrogen oxides (NOx)

Principle

Total nitrogen oxides (nitric oxide and nitrogen dioxide) were determined by the Griess-Saltzman reaction as described in ASTM standard method D3608.77T (1977). Essentially, the method involves sampling air at the rate of 0.4 litre/min for one hour using a sampling train with an oxidant to convert oxides of nitrogen-to-nitrogen dioxide, and with an absorbing reagent, which immediately converts the total nitrogen dioxide to a red-violet azo dye, which absorbs at 550 nm. The procedure operated at a detection limit of 4 mg/m3.

Reagents

(a) Absorbing solution: The absorbing solution was prepared by first dissolving 5.0 g of anhydrous sulphanilic acid in a mixture of 140 ml glacial acetic and 700 ml water. The mixture was heated to dissolve the sulphanilic acid. The cooled mixture was transferred into a 2 litre standard flask. 20 ml of 0.1 % N- (1-naphthyl)-ethylenediamine dihydrochloric acid and 10 ml acetone were added to the flask. The mixture was made up to one litre with distilled water and mixed thoroughly. The solution was stored in a brown reagent bottle and kept in a refrigerator when not in use.

(b) Chromic acid oxidant: This was prepared by dissolving 17 g of chromium (VI) oxide in 100 ml distilled water.

(c) 0.1% N- (1-Naphthy1)-ethylenediamine dihydrochloric acid: 0.10 g of the compound was dissolved in 100 ml of water and stored in a brown bottle. The solution was normally kept in a refrigerator when not in use.

(d) Standard sodium nitrite solution: A stock solution containing 2.5 g sodium nitrite was prepared and standardised. The strength of the solution was adjusted to 2.16 g/litre. From this stock solution a working nitrite standard solution containing 2.16 mg sodium nitrite per litre (equivalent to 20.0 mg N02/L) was prepared by dilution as and when required.

Laboratory Procedure

(a) Sample Analysis: The absorbances of the red-violet colour of the samples were read at 550 nm.

(b) Calibration of Laboratory Procedure: 0.10, 0.20, 0.40, 0.60, 0.80 and 1.00 ml of the standard nitrite solution were measured into separate 25 ml standard flasks. Each one was diluted to mark with the absorbing reagent. After fifteen minutes, the absorbances of the standards were read at 550 nm. A calibration graph (Absorbance vs. concentration of NOx) was plotted and the calibration factor (reciprocal of the slope of the calibration line) was calculated.

(c) Calculation: The ambient NOx concentration was calculated from the experimental data as follows:

$$\text{Conc } (\mu g\ NOx \ / \ m^3) = \frac{(A \times F \times 10^3 \times v)}{V}$$

A = Absorbance of sample
F = Calibration factor
V = Volume of sample (ml)
V = volume of absorbing solution (ml)

(iii) Ammonia (NH_3)

Principle

Ammonia was absorbed in dilute acid solution and the resulting solution was treated with Nessler's Reagent. The reagent is alkaline solutions of mercury (II) ion in the stoichiometric quantity of potassium iodide required to produce tetraiodo mercurate (II) ion. The product of the reaction between ammonia and this reagent is yellow to orange-brown, depending on the concentration of ammonia. Its absorbance is measured at 410 nm for the low-end concentration end of the wavelength range.

The reaction is:

HgI4- + NH3 + 30H- = I-Hg-0-Hg-NH2 + 71- + 2H20

Reagents

(a) The absorbing solution: The absorbing solution was 0.01 M HCl solution.

(b) Nessler's Reagent: 100 g reagent grade mercury (II) chloride and 70 g reagent grade potassium iodide were dissolved in about 200 ml ammonia-free distilled water. The mixture was added gradually and with continuous stirring to a solution of 160 g NaOH in 500 ml water. The solution obtained was made up to one litre and stored in a dark borosilicate reagent bottle.

(c) Standard ammonia solution: Stock ammonia standard (1000 ppm) was prepared by dissolving 3.819 g analar grade ammonium chloride (dried at 100°C) in one litre water in a standard flask.

From this solution, 10.0 ppm ammonia standard was prepared as required by diluting 10.0 ml to one litre in a standard flask.

Laboratory Procedure

(a) Sample Analysis: 2.0 ml of the Nessler's reagent was added to the sample solution. 10 min was allowed for colour development. Absorbance measurement was made at 410 nm.

(b) Calibration of Laboratory Procedure: 0.0 (blank), 2.0, 4.0, 8.0, 10.0, 12.5, 15.0 and 20.0 ml of the ammonia working standard were measured into separate 100 ml standard flasks and made up to mark with ammonia-free water. 10.0 ml of each standard was measured into a tube. 2.0 ml Nessler's reagent was added to each and absorbances were read at 410 nm. The reciprocal of the calibration graph was used as the calibration factor. Distilled water used for preparing the reagent was used as reference.

(c) Calculation: The ambient NH3 concentration was calculated from the experimental data as follows:

$$\text{Conc}\ (\mu g\, O_3 / m^3) = \frac{17\, F\, (A_s - A_b) \times 10^3}{V}$$

As = Absorbance of sample
Ab = Absorbance of air blank
F = Calibration factor
V = Volume of sample (ml)

(iv) Particulate

Laboratory Procedure

The filter paper was dried at 105°C for one hour. After cooling in a desiccator to room temperature, it was weighed to the nearest milligram. Particulate level was calculated as follow:

$$\text{Conc } (\mu g / m^3) = \frac{(M_s - M_o) \times 10^3}{V}$$

Ms = Mass of filter paper after sampling
Mo = Mass of filter paper before sampling
V = Volume of sample (ml).

Noise

Introduction

Background noise levels are those noise levels, which prevail 90% of the time. In the rural areas, it is typically 30-40 dBA.

Noise Survey

Noise level measurements were made with CEL Precision Integrating Sound Level Meter Type 493, fitted with ½" condenser microphone and windshield. Measurements were made at each of the weather stations established in the field. The noise meter was held at full arm's length away from observer's body to minimize reflection. Sound power measurements to determine the sound power of the noise source were made with the microphone held 25 mm from the radiating surface. Before commencement of measurement, and in-between measurements, the meter was re-calibrated with CEL Pistonphone.

Chemical Programme

Field and Laboratory Procedures

Water Study

All the surface water bodies were dried up during the study; however, surface water samples were obtained at a controlled point on River Niger. Water quality assessment is thus a vital component of the baseline studies of an environmental assessment.

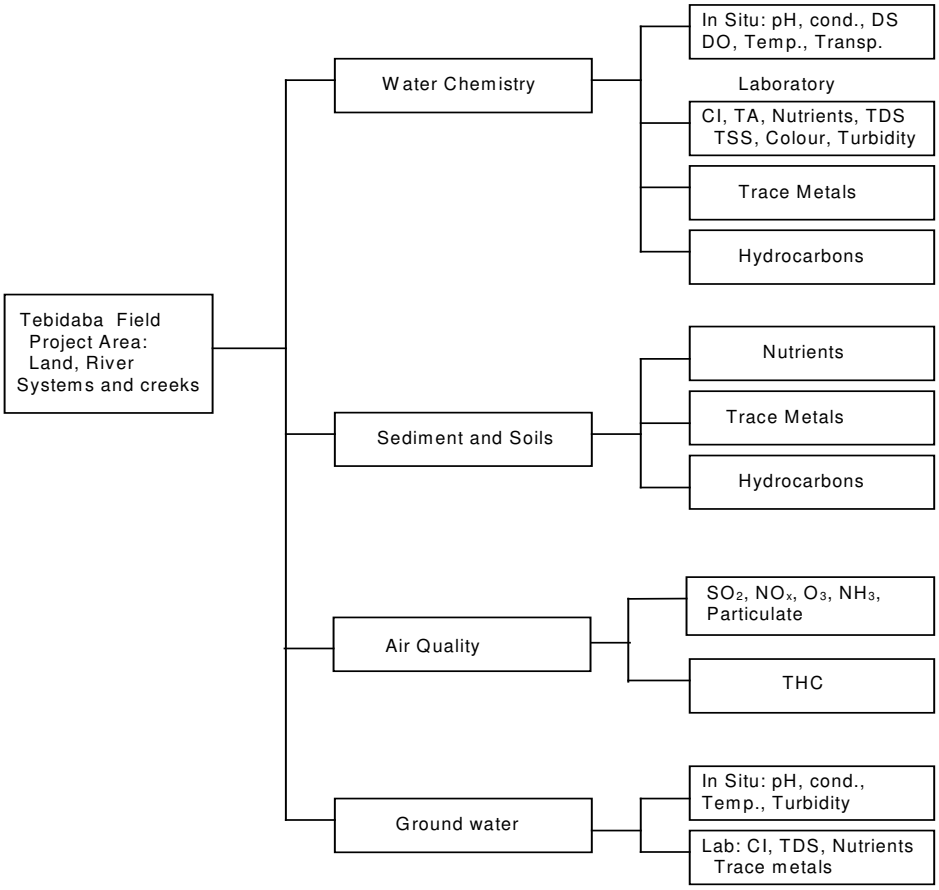


Fig 2.1: Diagram Showing the Different Components of the Chemical Study Programme.

Water Quality

At each water sampling station, composite water samples were taken from the surface and near the bottom using a Hydrobios 2 litre water sampler. The precaution taken during the sampling of surface water included avoiding contact with the sides and bottom of the sampling points since this could detach slime or sludge accumulated there. Analyses were carried out in the order dictated by the stability of the parameters. All laboratory procedures were adequately standardised and all instruments appropriately calibrated. While groundwater samples were collected from the dug boreholes in accordance with DPR (1991) quality assurance guidelines and standards after flushing the boreholes to stability. Samples were collected directly into clean plastic or glass containers after rinsing with portions of the water being sampled.

Transfer, storage and preservation: Samples could be subjected to microbial degradation and transformation, they were therefore analysed at minimum time after collection. Since, however, storage is necessary, preservatives were used as necessary. Samples for physico-chemical analysis were stored in ice-chest packed in well-sealed coolers and then transported conveniently to the laboratory where they were refrigerated at 4^oC until required for physico-chemical analyses. Samples for heavy metals were appropriately preserved with 1:1 nitric acid and those for oil & grease with 1:1 sulphuric acid to pH $\leq$ 2 (see Table 2.2 for details).

Sample identification/coding: To ensure preservation of the integrity of the sample collected, sample identification/coding were designed on a permanent label to contain specific details so as to ensure sample authenticity. Samples were properly sealed, carrying labels with information such as:

- Identification code or sample number
- Date and time of sampling.
- Type of preservation
- Description of sample

The following physical and chemical parameters were then measured some ***in situ*** and others in the laboratory.

(a) Temperature

Air and surface water temperatures were determined *in situ* using a mercury-in-glass thermometer while sub-surface water temperatures at depths of between 0.5 and 1 m from the bottom were taken *in situ* with a temperature probe.

(b) Transparency

Water transparency was determined *in situ* using a white metallic Secchi disk lowered into the water and the average of the points of disappearance and appearance recorded as the water transparency.

(c) Colour (True)

Colour may be expressed as "apparent" or "true" colour. The apparent colour includes that from dissolved materials plus that from suspended matter. By filtering or centrifuging out the suspended materials, the true colour can be determined. The true colour was determined by a modified method of APHA (1989) using a HACH model 2000 Environmental laboratory spectrophotometer.

(d) Total, Dissolved and Suspended Solids

Total solids (TS) are the solid matter in water, also referred to as residue. It has two components, suspended solids (SS) and dissolved solids (DS). The dissolved solid component was determined *in situ* in the field using the HACH dissolved solid meter.

The field results were crosschecked gravimetrically in the laboratory. Total solids (TS) in water were determined gravimetrically by evaporating to dryness 100 ml of unfiltered water in a pre-weighed and pre-dried evaporating basin. Dissolved solids were determined as above using filtered water and the difference in weight between total and dissolved solids gave the suspended solids.

(e) Hydrogen ion concentration (pH)

pH was determined *in situ* using a Hach-One pH Meter.

(f) Alkalinity (mg l-1)

Phenolphthalein and total alkalinity were determined using the Hach Digital Titration Method with phenolphthalein and Bromocresol Green Methyl-Red as indicators and titrating with 1.600N sulphuric acid. This is a modification of the titrimetric method of the Standard Methods for the Examination of Water and Wastewater (APHA, 1989).

(g) Dissolved Oxygen (DO)

Dissolved oxygen (DO) was determined by the Azide modification of Winkler Method adapted for the HACH equipment from Standard Methods. Clean 60 ml glass-stoppered BOD bottles were filled to overflowing with water samples directly from source. Fixation in the field was carried out by adding the contents of Dissolved Oxygen 1 and Dissolved Oxygen 2 powder pillows, and the bottle stoppered and thoroughly mixed by rotation and inversion until a flocculent brownish precipitate was produced. The bottles were stored away in darkened containers under water until required for titration in the laboratory. The content of Dissolved Oxygen 3 powdered pillow (sulphamic acid) was added, thoroughly mixed to dissolved the brown precipitate, out of which 20 ml aliquots was accurately measured and titrated with 0.200 N sodium thiosulphate using the HACH Digital Titrator, until the sample changed from yellow to colourless. With the aid starch indicator, which, was added as the yellow colour was discharged to faint yellow towards the end of the titration, this remarkably improved the end point from deep blue to colourless. The number of digits from the digital counter window multiplied by 0.1 gave the concentration of dissolved oxygen in mg l.-1.

(h) Conductivity (µScm-1)

This is the capacity of water for conveying electrical current and is directly related to the concentrations of ionized substances in the water. Conductivity was measured *in situ* using a HACH Portable Conductivity Meter.

(i) Salinity (‰)

Water salinity was determined *in situ* in the field using an Oceanographic Salinity Measuring Bridge, Model MC5 equipped with a platinized electrode and supplied by Kents Industrial Measurements Ltd., Huttington, UK. The field readings were confirmed in the laboratory by the Harvey's (1955) titrimetric method with an accuracy of ± 0.1%.

(j) Sulphate

The procedure employed to determine sulphate is a modification of the Barium Sulphate Turbidimetric Method using the HACH equipment.

(k) Available Reactive Phosphorus

Phosphorus as reactive orthophosphate was determined using the stannous chloride method specially suited for determining low amounts of phosphate concentrations. In this method molybdophosphoric acid is formed and reduced by stannous chloride to intensely coloured molybdenum blue. The colour produced was determined photometrically after correction with a blank at 700nm wavelength. This is a very sensitive method, which makes feasible measurements down to 7 mg P per litre.

(l) Nitrate and Nitrite

The low range nitrate test employed in the analysis of water is the HACH modification of the cadmium reduction method using a very sensitive chromotropic acid indicator. The test registers both nitrates and nitrites present in the water sample.

(m) Sodium and Potassium

Sodium and potassium were analyzed by flame photometry.

(n) Calcium

Calcium was determined by the EDTA titration method using CalVer 2 Calcium Reagent in a HACH modification of the Standard Methods according to APHA (1989). A 100 ml water sample was taken in a clean titration flask and 2 ml of 8N KOH was added and swirled to mix. The content of one CalVer 2 Calcium Reagent indicator was added and the content of the flask titrated with 0.800N EDTA solution using the HACH digital titrator until the colour changed from pink to blue. The concentration of calcium hardness is read from the digital counter as mg/L CaCO3.

(o) Magnesium

Magnesium hardness (as CaCO3) was determined by subtracting the amount of calcium hardness from the results of the total hardness test. Total hardness of water was determined using the ManVer 2 Total Hardness reagent (Eriochrome black T) as indicator after adding 2 ml of buffer solution. This was titrated with a standard EDTA titrant until the last reddish tinge disappeared. Magnesium hardness was converted to mg/L magnesium by multiplying with 0.243.

(p) Heavy Metals

The Flame Atomic Absorption Spectrophotometry was used to determine zinc, Copper, Nickel, Lead, Chromium, Cadmium and Manganese. The water sample is aspirated through a nebulizer into an air-acetylene flame. Free atoms of the elements were generated in the flame Resonance line of the element, which was generated in a hollow cathode lamp, and this was simultaneously passed through the flame. The absorbance of radiant energy by the element of interest was related to its concentration in the water sample by the Beer-Lambert law.

Sample Pre-treatment

A preliminary test showed that the levels of metals in the samples were generally either at background level or below the detection limit of the Atomic Absorption Spectrophotometer used (Table 2.1). To raise the signal measured to an order above this detection limit without resort to unnecessarily high electronic scale expansion with its attendant noise, a pre-concentration step was included in the analytical procedure. The detection limits achieved are adequate for environmental decision-making purposes. 200 ml of the sample (filtered when necessary) was placed in an evaporating dish on a hot plate. It was gently evaporated to about 15 ml and then made up to 20 ml in a standard flask.

Instrument Calibration and Sample Analysis
The instrument was set up and optimized for each metal as recommended by the manufacturer. Working standards prepared from dilution of 1000ppm stock standards, and in concentration range of the same order of magnitude as in the concentrated samples, were used to standardise the instrument. In cases where the sample absorbances were very close to the lower end of the linear response range for the element, the instrument was operated in the absorbance mode. Otherwise the instrument was operated in the direct concentration mode.

The concentrated samples were aspirated into the flame and absorbances or concentrations were read as appropriate. Absorbances were converted to concentration using the calibration graph for each element. The reference was double-deionised water concentrated ten-fold as the samples. Allowance was made for the concentration factor in tabulating final results.

(i) **Vanadium**
Vanadium was also analysed by flame atomic absorption spectrophotometry, using nitrous oxide-acetylene flame and a concentration factor of 20.

(ii) **Mercury**
Because of the very poor sensitivity of AAS in flame mode for mercury, the cold-vapour mode was used. Here the mercury is reduced to elemental state in aqueous phase. Taking advantage of the high volatility of elemental mercury, air was used to sweep the reduced mercury into a cell with quartz window in the path of mercury resonance line in an atomic absorption spectrophotometer. The peak absorbance signal is proportional to the concentration of mercury in the sample.

Detection limit of the Atomic Absorption Spectrophotometer

Metal	* Sensitivity Check	! Operational Detection Limits
Lead	25	0.05
Copper	4	0.01
Cadmium	1.2	0.02
Zinc	0.8	0.01
Nickel	7	0.05
Vanadium	75	0.10
Mercury	350	0.002+
Chromium	4	0.05
Manganese	2.5	0.005

* Concentrations, which give an absorbance of 02 at peak instrumental performance. The current performance level of the instrument used was 80 % of peak performance level.
! Determined for the instrument used at current optimum performance level.
+ By cold vapour technique without pre-concentration.

Reagents
All reagents used were analytical grade and water was double-deionised water.
(a) Stannous chloride: 75 g of stannous chloride was dissolved by heating in 100 ml 1:1 HCl.
(b) Hydroxylamine hydrochloride: 50g hydroxylamine hydrochloride was dissolved in 250 ml water.
(c) Mercury Standard: 1.354 mercury (II) chloride was dissolved in one litre aqueous solution made 5% with respect to nitric acid and 0.01 % in potassium dichromate.

Procedure
The samples were analysed without pre-concentration. 10.0 ml sample was placed in the reaction vessel (Fig. 2.3). Two (2) ml stannous chloride and 4 ml hydroxlamine hydrochloride were added and the reaction vessel was immediately coupled into the flow system. The ground state mercury atoms generated were swept by air flowing at a rate of 1200 ml/min into the atom-cell. The absorbance peak was recorded. The system was calibrated with standards in the range 2.0 ppb to 40 ppb, each one treated as the samples. The reciprocal of the calibration graph was used to convert the sample absorbance to concentration.

Iron
Iron was determined colorimetrically by the very sensitive ferrozine method of the HACH spectrophotometer, which allows measurement down to 4 mg/l of the element in water.

(q) Hydrocarbon Content

Principle
Total hydrocarbon in the water sample was extracted with CCI4 at pH 5. The height of the C--H stretching band peak at 2950 to 2800 cm-1 was compared with height of the peaks of standards for quantitative purposes.

Reagents
All reagents used were analytical grade.
(a) Dilute sodium hydroxide acid: 4.0 g sodium hydroxide was dissolved in water.
(b) Dilute hydrochloric acid: Concentrated acid was diluted 10 times with water.
(c) Solid sodium chloride:
(d) Solid anhydrous sodium sulphate.
(e) Silica gel.
(f) Total hydrocarbon standard: Forcados Natural Crude was used as standard mixed hydrocarbon.

1.0 of the standard was diluted to 100.0 ml solution in CCl4. This stock standard was used as 10,000 ppm THC.

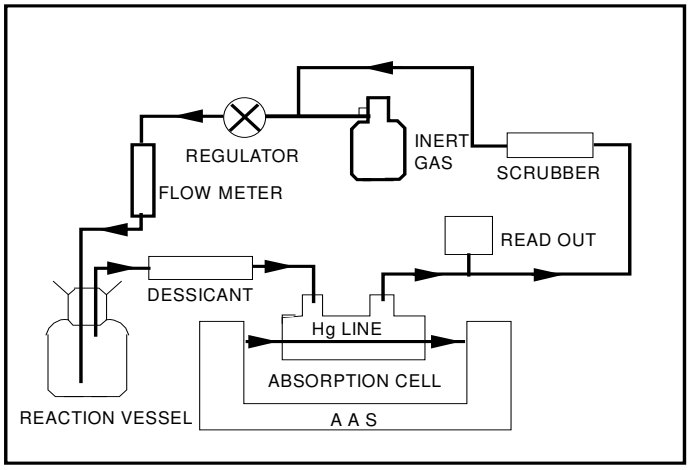


Figure 2.3: Cold Vapour sector for mercury determination

Sample Analysis
750 ml of sample was placed in a one litre-separating funnel. The pH of the sample was adjusted to 5 using diluted hydrochloric acid or diluted sodium hydroxide as necessary. A pH meter was used to monitor the pH. About 1g sodium chloride was added to the sample and taken to dissolve. 10ml tetrachloromethane was added to the separating funnel. The funnel was stoppered and the separating funnel was shaken gently for 15 min to extract total hydrocarbon from the sample.

The phases were allowed to separate. The tetrachloromethane layer was run through a filter paper containing anhydrous sodium sulphate into 25ml standard flask.

The sample was re-extracted with a second 10ml portion of tetrachloromethane. The extract was also filtered through anhydrous sodium sulphate into 25ml standard flask. The combined extract was made up to 25 ml.

The diluted extract was run through silica gel column for clean up. The IR spectrum of the samples was scanned from 3100 to 2800cm-1. The height of the C--H stretch band at 2850cm-1 was calculated and converted to concentration using the calibration graph.

Calibration
From the stock standard, 0, 10, 20, 40, 60, 60 80, and 100ppm standards were prepared as required. The standards were scanned as for the samples and height of the peak at 2850 cm-1 was plotted against concentration and used as calibration graph.

Soil and Sediment

Introduction
Sediment-Once water body is impacted, it is usually readily reflected in the quality of the bottom sediment. Many contamination in water such as heavy metals and hydrocarbon oils, are accumulated and magnified in the sediment, which is relatively more stationary than the free-flowing surface water. Sediment study is thus well accepted as a valuable measure of the long-term quality of aquatic systems and a useful EIA tool.

This baseline soil study seeks to determine the present physical, chemical and biological status of the area field. Soil parameters analysed were assessed with reference to standard limits and ascertain its sensitivity to future development impact.

Soil-Soil is of ecological and economic importance, serving as a support and growth medium for plants, habitat for soil fauna, and medium of growth for economic crops, among other functions. A change in the normal characteristics of a given soil may significantly alter its ability to serve a given function. Construction activities and the operation of industrial facilities may impact soil properties; hence soil studies are useful in EIA studies.

In a study to identify the changes in biotic and mineral composition of leaking natural gas in soil, reported that the soil atmosphere becomes anerobic with large number of hydrocarbon utilizing and sulphur reducing bacteria present. He also noted an increase in manganese, which is detrimental to plants, and organic matter, which makes the soil boggy. Sulphides of hydrogen and iron and associated "sour gas" smell were also observed to be present with an increase in the number of nematodes, actinomycetes and fungi when compared with the control.

The soils and sediments of study area were investigated to determine their physico-chemical, erosional and nutrient characteristics so as to evaluate the probable impacts of the activities of the proposed project on them.

Sediment samples were collected from the water stations within the study locations. At each location were water was picked, the sediment samples were collected by means of an Eckman sediment Grab, the same sampling stations was maintain for both season. After sieving to remove dirt and debris, and draining the water, the sediment samples were placed in sampling bags, labelled and stored in an ice-block cooler to prevent microbial degradation of the hydrocarbon.

Soil Colour
Each soil sample colour was determined in the field using munsell soil colour charts with reference to the combination in the munsell system of time, value and chrome. The most matching colour is chosen and its three components time, value and chrome recorded against each soil sample.

Soil Texture and Soil Moisture Content
Soil texture and soil moisture in the field was examined by feel and visual observation. Confirmatory tests and exact estimate will be carried out in the laboratory.

Laboratory Analysis

Samples collected from the field were air-dried, crushed (except for those meant for analyses of NH4+, NO3- and NO2-), passed through 2mm sieve and analysed for the following physico-chemical parameters. All analysis was carried out using standard methods (Van Reeuwijk, 1987 and IITA, 1984) with the appropriate quality assurance protocols.

(i) Hydrogen ion concentration (pH)

The pH values of the soil and sediment samples were determined by dipping the glass electrode of a pH meter into a 1:2 soil/water suspension that had been stirred and allowed to equilibrate for some time.

(ii) Electrical Conductivity

The conductivity of the saturation extract of the soils was determined using a Hilgar portable conductivity meter. Results were expressed in Siemens (S) per cm.

(iii) Mechanical Analysis

Particle size distributions were determined by the hydrometer method of Bouyoucus as described by Day (1965); textural classes were obtained from soil textural triangle shown in **Fig 2.4**

(iv) Organic Carbon

This was determined by the Wet combustion method of Walkey and Black (1934). The organic carbon determined was expressed as percentage of the sample taken.

(v) Available Phosphorus

The available phosphorus of the soil was extracted with Bray No. 1 solution (0.03N NH4F + 0.02N HCl) and the phosphate in solution assayed by the ascorbic acid-molybdenum blue colour method of Murphy and Riley (1972).

(vi) Total Nitrogen

The total nitrogen was determined by the micro-Kjeldahl digestion method (Bremner, 1965). No3-N and NH4-N were analysed using an auto analyzer.

(vii) Exchangeable Bases

The exchangeable cations were determined by extracting with 1N neutral ammonium acetate. The calcium and magnesium in the extract were measured by atomic absorption spectrophotometry while sodium and potassium were measured by flame photometry.

(viii) Exchangeable Acidity (EA)

The EA was determined by the KCl method as described by Jackson (1962). The exchangeable acidity of the soils was extracted with 1M KCl solutions and titrated for acidity with 0.1M NaOH solutions. Results were expressed in milli-equivalents per 100 g soil.

(ix) Effective Cation Exchange Capacity (ECEC)

The effective cation exchange capacity of the soils and sediments were determined by summation of exchangeable cations and exchangeable acidity.

(x) Base Saturation

The Base saturation was calculated using the following equation:

$$\%\ B.\ Sat. = \frac{(\ ECEC\ -\ Exch.\ Acidity\ )\ x\,100}{ECEC}$$

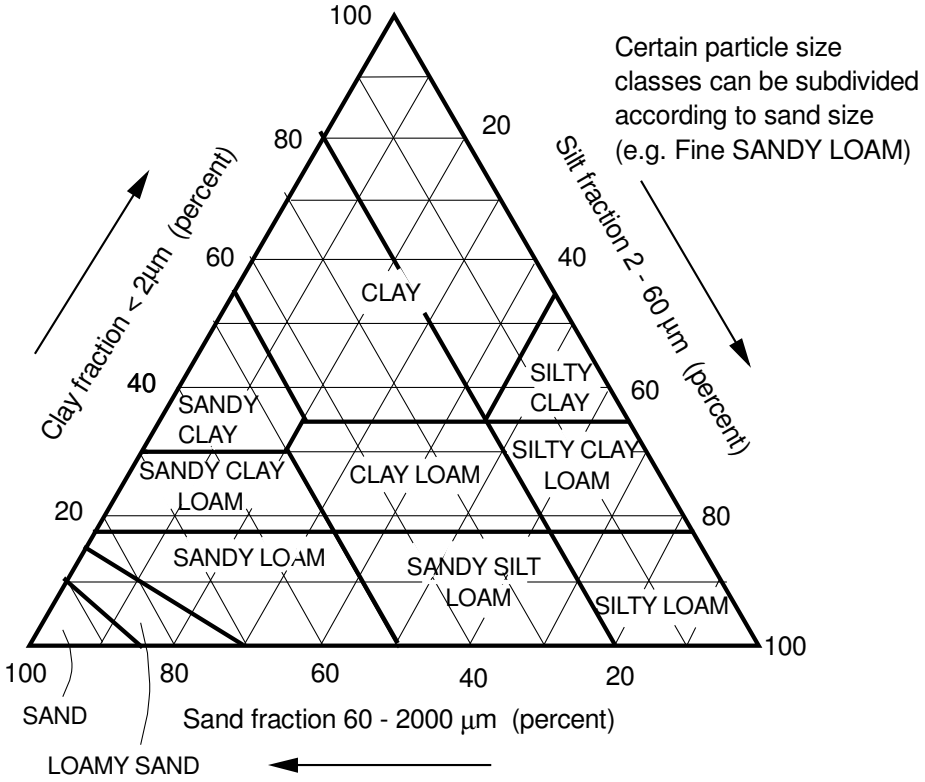


Figure 2.4: Textural triangle showing the percentages of Clay (below 0.002 MM) Silt (0.002 - 0.05 MM), and Sand (0.05 - 2.0 MM) in the basic soil textural classes

(xi) Extractable Ammonium (NH4+)

For the determination of ammonium in the soils, field fresh samples were extracted with acidified 1.7 M NaCl and the ammonium in the extract assayed by the alkaline phenate method.

(xii) Nitrate and Nitrite (NO_3^-, NO_2^-)

The nitrate and nitrite nitrogen in the soils was extracted from fresh samples with 1 M sodium acetate solution. Nitrate in the extract was determined by the Brucine method of Greweling and Peech (1964), while nitrite nitrogen was determined by the alpha-naphthol method.

(xiii) Sulphate (SO_4^{2-})

The sulphate sulphur in the soil was extracted with a solution of potassium orthophosphate and the sulphate determined by the turbidometric method.

(xiv) Heavy metals

The heavy metals in soils and sediments were analysed by first carrying out a leaching extraction of a weighed portion with 2M nitric acid. Final analysis was by use of air acetylene Flame atomic spectrophotometry. Blanks were incorporated into the sample, treatment procedures while other appropriate quality assurance steps were observed. The final analysis of the soil and sediment solutions and standard solutions were aspirated, respectively, into the air-acetylene flame of a Perkin Elmer Atomic Absorption spectrophotometer, Model 403.

(xv) Hydrocarbon Content

The hydrocarbon content of soil samples was determined by shaking 5 g of air-dried soil with 30 ml of carbon tetrachloride and the concentration in mg l-1 of oil in the extract was determined by means of a spectrophotometer at 420 nm. A calibration curve was prepared from the readings obtained from known concentrations of oil standards in the extract.

Vegetation Study

Field Procedure

The rapid assessment method was used to provide information on plant species composition. All plants within the field of study were identified and listed while the unidentified ones were collected, pressed and taken to the herbarium for correct identification using the flora of West Tropical Africa and reference to the herbarium of specimens in the University of Benin.

The state of health of crops and vegetation were also noted, while infected crops and vegetation were collected and kept in moisture polythene bags for onward transfer to the laboratory for further tests. This will include isolation and characterisation of pathogenic fungi bacteria from infected plant materials. Also, the vegetation types within and around the study area were determined for their density and health status. Four transects each of 500m long Oriented North, South, East and West of the pipeline routes was used to carry out qualitative and quantitative assessment of the vegetation. Random quadrants were used to determine population density of the plant species by counting the number of plants in each quadrant.

Structure

For the determination of the vegetation structure, the crown diameter of all woody trees over 3 m in height and 10 cm in girth at breast height were estimated. In order to quantify the above ground biomass of the herb layer, eight 1 m x 1 m quadrants were selected along sub-transects in the study sites. All the plant materials within each quadrant were cut, sub-sampled and taken to the laboratory for analysis of dry matter according to Chapman (1976). Structural information was obtained from 80m long transects established within homogenous vegetation community as described by Muiller-Dombois and Ellenberg, (1974) and Smith (1990). Information on the economic uses of plants was obtained through oral interview and literature.

Crop and Plant pathology

The state of health of crops and vegetation were noted while infected crops and vegetation were collected and kept in moistened polythene bags and transported to the laboratory for further study. Laboratory study included isolation and characterization of pathogenic fungi and bacteria from infected plant materials.

Herbarium and Laboratory Procedure

Unidentified pressed specimens were taken to the laboratory and identified using the Flora of West Tropical Africa (Hutchinson and Dalziel, 1958 - 1968) and reference to herbarium specimens in the University of Benin. The plant biomass was obtained by drying the plant material in the oven at 105°C till they attained a constant weight. The dry matter to fresh weight ratio of each sample was used to convert field fresh weight to dry weight.

Ecological Programme

Phytoplankton Composition and Diversity

In each of the surface water sampling stations, phytoplankton were collected just below the water surface with a quantitative 55 micron mesh tow net attached to a cowl with an aperture diameter of 17 cm. Fixed into the inside of the cowl was a flow meterwhich, measured the flow rate of the water which passed through the net. Each tow was made for 2 minutes at an approximate speed of 8 km per hour. The catches were immediately removed from the net, bottled and preserved in a solution of 4% formaldehyde. The phytoplankton was examined in the laboratory using a Leitz Orthoplan Universal Wide-field Research Microscope equipped with tracing and measuring devices. One ml of the concentrated sample was introduced into a counting chamber and an average of 10 rows counted. The average frequency distribution of the different species was recorded. Diversity index D, and Dominance C° were calculated from the following expressions:

$$D = \frac{N_o}{\sqrt{N_x}},$$

$$C^{o}=\sum_{i=1}^{N0}\left(\frac{ni}{N}\right)^{2}$$

Where:

Nx = No. of individuals in cells/station,
ni = Importance value for each species,
N = Total of importance values,
No = Number of species in sample.

Zooplankton Composition and Diversity

For qualitative study, zooplankton hauls were made with a 55 micron mesh tow net fitted with a flow meter. Zooplankton collected was preserved in buffered 4% formalin in 200 ml plastic containers. For quantitative study forty (40) litres of water were filtered through a 55 micron mesh plankton net and reduced to 50 ml concentration. In the laboratory, counting was done in a l ml Koltwitz counting chamber with grids. Row after row of the counting chamber was examined by means of an Olympus Vanox Research Microscope and the numbers of individual species recorded. Zooplankton numbers were computed from the equation:

$$\frac{N \times S \times 1000}{V}$$

Where,

N = number of zooplankton in 1 ml of sample
S = volume of sample (50 ml)
V = initial volume of sample (40L).

Fauna

Macrobenthic fauna are those organisms, which are over 1.0 mm in size, living on or in the substrate. They may be infauna (living wholly or partially buried in soft or hard substrates e.g. bottom dwelling annelids, chironomids and bivalve molluscs) or epifauna (living on the surface, either, crawling as mobile benthic inhabitants or attached to different types of substrates e.g. crabs; littorinids, barnacles and oysters attached to the roots of Rhizophora).

The fauna were investigated by the methods outlined below. Two types of sampling were carried out at each station for the estimation of abundance and diversity of fauna. Organisms were identified and counted *in situ*, and specimens, which could not be identified in the field, were collected and preserved in some quantities of 40% formaldehyde. For the infauna, an Eckman grab was used to collect the sediment from 0.0225 square metre areas.

Sorting of organisms from the residue and counting were done under the binocular dissecting microscope and the compound microscope. Identification was carried out from whole specimens and prepared slides using relevant identification manuals and keys. All indices of diversity used in statistical analyses were adapted from Odum (1971) and Zar (1983).

Fauna of bottom sediments of river

The bottom samples were sieved in the field using a set of Tyler sieves of different mesh apertures (150 mm, 300 mm, 500 mm, 650 mm, 1 mm and 2 mm). The sediment sampling stations, which coincided with water sampling stations.

Preservation

All organisms collected were preserved in 10% formaldehyde.

Laboratory analyses
All samples collected during the fieldwork were examined using the binocular dissecting microscope. Identifications were made using relevant identification manuals and literature.

Statistical analyses
Indices of species diversity and evenness were used to characterize the faunal community structure. Collections are believed to be representative of the community at the site of collection and the numbers of taxa and their relative abundance are the essential properties. The Margalef's index (d) of taxa richness, Shannon-Wienner index of general diversity (H) and Evenness (E) were used to express the descriptive properties.

Margalef's Index (d):

$$d = s-1/\ln N$$

where,
s = number of taxa
N = total number of individuals
Shannon-Wienner Index (H):

$$H = \frac{N\log N - S\, ni \log ni}{N}$$

Where,
N = total number of individuals
K = total number of species
ni = number of individuals in the ith species

The Evenness component of diversity expresses the degree of uniformity in the distribution of individuals of each taxon in the collections.

$$E = H/Hmax.$$

where,

$Hmax. = \log K$ (Zar, 1983).

The Slack system was used in the determination of dominant, sub-dominant, common and rare groups of genera. Taxonomic groups or genera comprising:
15% or more of the total number of individuals collected = Dominant
5 - 14% = Sub-dominant
1 - 4% = common
<1% = Rare.

2.3.5 Fisheries
Delineation of the important species and harvest methodology were arrived at, through:
1. Inspection of catches by local fishermen both in the field and in fishing camps,
2. Interviews of fishermen in camps regarding catch composition and methodology,
3. Survey of the fishes on sale within the project environment, and interview with the fisheries middlemen about the source of their fishes.

Fish Analysis
(a) Laboratory Analysis
The species collected from the project area were used for laboratory analyses. Specimens were thawed at room temperature, coded and identified. The following parameters were determined prior to anatomical examination : Total and standard length (cm), body weight (g), sex which was confirmed when the fishes were dissected by noting the presence of testes or ovaries. Each specimen was closely examined for disease signs and the presence and details of internal parasites.

(b) Calculation

· Fultons condition factor = w/L3 x 100 is an index of the well being for whole fish where,

w = weight of fish

L = length.

· Gonado-somatic index: This is the percentage of the whole weight of the ovary (gm) over the whole weight of the fish (gm). The gonado-somatic index changes in accordance with the breeding cycle and serve as an independent quantitative means of determining the season or period of highest gonadal development and maturity. It is also an indicator of the well being of the gonads.

Length - weight relationship.

The length - weight relationship was calculated using the formula described by Le Cren (1951):

$w = a\,Lb$ - - - - - - - (1)

The data were transformed into logarithms before the calculations made. Thus equation (1) was transformed into: -

$\log w = \log a + b \log L$ - - - - - - (2)

Where,

w = weight of the fish in g

L = Total length of the fish in cm

a = constant and b = an exponential value.

(c) Gustatory analysis

Questionnaires were given out to families so as to evaluate the taste, flavour, and quality of the flesh of the fishes of different species collected from the various stations during the course of this study.

Microbiology

Surface and bottom water, bottom sediments and random soil samples (RSS), collected into sterile plastic bottles and polythene bags respectively, were kept in a cooler containing ice-chest and analysed for microbial contents within 12 hours of collection.

Heterotrophic bacterial counts

The total heterotrophic bacteria in both water and soil were enumerated using modified yeast extract agar (Cruickshank *et al*, 1975). Bacteria isolates were identified according to the scheme of Buchanan and Gibbons (1974).

Determination of Fungal Content

The total fungal counts in the water and soil samples were determined using Emmons, Binford and Utz's modified Sabouraud Dextrose Agar (Cruickshank, *et al*, 1975). Isolated fungi were identified based on the associated spores and mycelia and their growth characteristic on the isolation medium.

Determination of Percentage Petroleum Degrading Bacteria and Fungi

The petroleum degrading bacteria were enumerated on petroleum agar medium while chloramphenicol was added to this medium for the selective isolation and enumeration of petroleum degrading fungi. Any bacteria or fungi growing on these media were regarded as petroleum utilizers or degraders.

The percentage of these counts to the total heterotrophic bacteria or fungal counts was then calculated to obtain the percentage petroleum degrading bacteria and fungi respectively in each sample.

Socio-Cultural Programme

The socio-economic/cultural studies in the study area were based on extensive literature materials and interviews using structured questionnaires.

Socio-economics

The principal objective of this socio-economic study is to identify and examine the specific effects of the project on the socio-economic life of the inhabitants of the area. This objective was pursued by carrying out a series of investigations to collect and collate data on the prevailing situation.

In selecting the communities to sample, the cluster sampling method was used. Contiguous communities were grouped together over 20 communities were picked.

Methodology

The socio-economic environment can be identified as including:

(a) Population structure and dynamics;
(b) Land use and settlement patterns;
(c) Labour supply and employment structure;
(d) Production, income distribution and consumption;
(e) Social organisation and institutions.

Two broad categories of methodologies were utilised in this study, namely, ethnographic and socio-demographic survey method.

Ethnographic Method

This method entails visiting and interacting with the settlers in the project vicinity and observing, asking questions and recording gathered information. In some settlements, where no settlers spoke nor understood English language, services of interpreters were enlisted. The ethnographic method is ideal for studying social organisation and institutions such as marriage and family, religion, economy and polity of the localities and their land/water use and settlement pattern.

Socio-Demographic Survey

In studying the socio-demographic structure and dynamics of the localities, we concentrated on inquiring into the population structure (age, sex and other compositional characteristics) and dynamics (birth, death, migration and marriage rates) of the inhabitants. We emphasised the educational, occupational and work statuses of the population of the settlements.

Data Collection

Four main methods of data collection were used - namely:

- Questionnaire
- Focus Group Discussion (FGD)
- In-depth Interview (IDI)
- Observation

In the questionnaire method, over 1000 questionnaires were administered in each community to the heads of households in communities. In selecting the heads of households however, systematic random sampling was adopted.

For the FGD, one session each was conducted in the three communities. Furthermore, three in-depth interview sessions were held in all the communities. The observable physical features in the communities such as markets, house types, shrines, and roads were recorded. Where necessary, photographs of these places were taken.

Hydrogeology

Methodology
Geophysical investigation

Field Techniques

a. Hydrogeology

Surface hydro-geological mapping was conducted to evaluate surface water distribution and flow direction in the area.

b. Geophysical Investigation

The field equipment used in this investigation is the ABEM TERRAMETER SAS 300C in Combination with the ABEM TERRAMETER 300C BOOSTER and the GEOMAC III FIELD COMPUTER. Based on the pre-knowledge of the Geology of the Niger delta Basin, the standard Schlumberger electrode configuration was employed for VES (Vertical Electrical Sounding) profiling. Measurements were taken at expanding current electrode distance such that, as in theory, greater penetration depth of the injected electrical current is achieved for successive readings. The potential electrode position was kept constant for successive measurements, but changed only when the voltage reading became too small to be accommodated by the Terrameter's sensitivity for a VES station measurements. The ratio of potential electrode separation to the current electrode spacing was kept at 1: 5.

The Geomac III field computer in addition to its use for data acquisition provided a direct means of ensuring that spurious data were not accepted in error. This is because it gives an immediate field plot of the apparent resistivity values (which is a product of the internal resistance as measured by the Terrameter) and the geometric factors (a parameter dependents on the relative disposition of the potential and current electrodes i.e. AB/2). This plot is qualitatively interpreted on the field and if considered satisfactory is accepted and stored in the memory to be recalled and used for further computation and interpretation. Five (5) VES stations: - VES- 1, 2, 3, 4 and 5 (see Figures 3.12a-e) were run to cover the area under investigation. VES station spread was between 215m (approximately 705ft) to 464m (approximately 1521.5ft). This spread was limited to the presence of water bodies and other surface structural obstructions surrounding the site. Only in the station VES-4, was the maximum current electrode separation of 464m (approximately 1521.5ft) attained.

Interpretation

VES investigation penetrated horizons in which the depth recognition of the instrument was at infinity. These geoelectrical layers are: 11.10Ωm beyond 10.6m depth at VES station 1, 14.15Ωm beyond 11.8m depth at VES station 2, 9.55Ωm beyond 15m depth at VES station 3, 44.56Ωm beyond 35.5m depth at VES station 4 and 39.64Ωm beyond 22.5m depth at VES station 5. Initial interpretation was done using the curve matching technique. Layer parameter were subsequently derived and defined for the initial model and used in the computer-assisted interpretation of the VES station data. Final interpretation was achieved using linear filters for the computation of apparent resistivity standard curves for a horizontally stratified earth (Ghosh, 1971).

Boring / Drilling Operations and Measurement of Water Levels

The equipment used were a Rotary Drilling Rig (hand-operated), Water Level Indicator with metric graduations, Clinometer (directional compass) and Magnify lens. Other materials used are a measuring steel tape, borehole water sampler and sterilised sample bottles.

The boring of the holes were carried out by hand-operated percussion rig to obtain core samples that are in their natural state and unpolluted by drilling fluids.

During the boring process, the interim casings (conductor pipes) were gradually pilled down to prevent possible caving in of the borehole wall. After drilling to the required depth, the interim

casings were withdrawn to give way for installation of permanent PVC casings and screen. The annular space between the PVC casing and the drilled hole were later backfilled with granular materials (i.e. gravel packed), followed by cement slurry. Then, the top of the boring out-side the PVC casing was cemented for propose seating of the installed casing (cement base). Thereafter, a surficial elevated pad was constructed to facilitate drainage around the well installation and to prevent ponding of water in the immediate vicinity and thus protecting the borehole from being contaminated.

Water Sampling and Analysis

Sampling of core samples and borehole (groundwater) for laboratory analysis was done during borehole boring operation. Core samples were collected and logged at regular interval of 1m down to the (first) aquifer depth of each borehole. Measuring, observing and recording of water levels in boreholes with their corresponding depth was also carried out using water level meter/indicator. Seven groundwater samples were also collected from the bored holes.

Subsequently, the surface and groundwater samples were analysed for their respective cations and anions alongside with other quality parameters at the analytical laboratory.

Quality Assurance

Introduction

Standard Quality Assurance and Quality Control Procedures was applied in carrying out this study, to eliminate ambiguous data, improve interpretation and to ensure conferment of data validity and reliability during sample collection, preservation, storage, transportation, laboratory analysis and data generation and presentation.

The quality assurance procedures used in this study are highlighted below to provide information concerning AMBAH procedures and methods of compliance with quality concerns and requirements. These standards are set by the regulators (DPR and Federal Ministry of Environment) and meet the requirements of ISO 9002 Standard. They include all activities used to ensure and document the accuracy, precision, completeness and representativeness of the analytical results and field observations.

Sample Procedures

Field Sampling

To ensure the accuracy and reliability of *in situ* field measurements, field instruments were calibrated prior to use and crosschecked from time to time. The field portable pH meter was calibrated using pH 4, pH 7 and pH 9 buffer solutions. The conductivity and dissolved solid meter was checked against TDS/conductivity solutions whose concentrations are known. Water sample containers were washed with detergent and thoroughly rinsed first with clean water and finally with distilled water. DPR (1991) quality assurance guidelines were followed. Samples were collected directly into clean plastic containers, after rinsing with portions of the water being sampled. Preservatives were used as necessary. Analyses were carried out in the order dictated by the stability of the parameter. Water samples for plankton analyses were preserved in accordance with DPR guidelines of 1991. Water and soil samples for special analyses were kept and transported in ice chests before the time for analyses.

Soils /Sediments

Sampling equipment was normally rinsed with water and was further 'washed' with soil from the area to be sampled to prevent cross contamination. Samples were stored in fresh polythene bags; aluminium or glass jars as soon as collected. Drying was carried out in a plastic tray in a clean well-ventilated room. Samples were adequately spaced while drying to avoid all sort of cross-contamination.

The quality assurance protocol employed for vegetation sampling included:

(i) Slashing the woody bark to choose the colour of the wood in case of doubt in species identification and also to determine the latex from the species.

(ii) In collecting unidentified species, efforts were made to collect samplings with the flowers, fruits and seeds because these attributes aid identification in the herbarium.

(iii) Plant tissues or materials to be pressed were placed inside folded absorbent sheets in such a way as to avoid unnecessary folds of the parts. These were then placed in between two boards with corrugated lining, with the press being fastened with straps or twine while in the field.

(iv) The adsorbent folder was changed daily to hasten drying and to prevent the growth of moulds and insect attack on the specimen.

(v) The specimen collected were preserved by spraying saturated solution of paradichlorobenzene or 2% alcohol solution of mercuric chloride to prevent attack by insects or moulds.

(vi) In the herbarium, plant materials were compared with previously preserved authenticated collection.

Socio-economics study employed the following quality assurance strategy:

(i) Community relations were carried out prior to the commencement of the study.
(ii) Field assistant was selected on the basis of his adequate educational background and ability to speak English and the local languages of the Ijaws fluently. This guaranteed easy communication with the inhabitants of the settlements.
(iii) Interview was conducted only when it became clear that the interviewee was convinced that the information being collected was not for tax assessment or any other adverse purpose.
(iv) The interview schedule/questionnaires were pre-tested in and around Warri and standardized prior to the commencement of the actual fieldwork.

Quality Assurance of Geophysical Studies

VES measurements were taken such that there were six (6) readings for every logarithmic decade. This gave a very good sampling density, which should enhance the signal to noise ratio of the field data. The potential electrodes were only expanded when the potential difference became too low.

Additional precautions taken to assure quality included:

(i) Reduction of contact resistance, especially at large electrode spacing.

(ii) Double electrodes were used for low resistance measurements.

(iii) Possible sources of noise such as metal objects were avoided.

(iv) An average of four readings at each position was usually taken.

(v) As a control, it was ensured that increase in the magnitude of current injected into the ground did not lead to a change in the measured resistance.

(vi) In the absence of previous geophysical data, the sounding results were compared with geophysical information collected on existing boreholes, where available.

Laboratory Procedures

All laboratory procedures were adequately standardised and all instruments appropriately calibrated. Standard laboratory quality control procedures were adhered to for wet chemical analyses of water samples. These included determination of reagent blanks, use of fresh standards and replicate analysis for confidence limit, and cleaning of glassware and other containers. Water samples for hydrocarbon determinations, and microbiological analyses for the above determinations were similarly treated.

Laboratory Sample Custody

Sample custody is defined as all records and documentation that is required to trace a sample from point of origin through disposal after analysis. The sample custody documentation used in this study includes:

Field Notebooks/samples tags
Field sample custody records (Chain of Custody and Analytical Requests)
Laboratory sample receipts logs
Analytical (instrument) logs and worksheets
Final Reports
Sample Disposition logs

Sample Containers and Preservatives

Table 2.3: Shows the various containers and preservatives used as recommended by DPR Standard.

Parameters	Container	Sample Volume	Preservation	Max. Holding Time
Table 1A: Bacterial Test:				
Total and Faecal Coliform	P,G	100ml	Cool 4°C, 0.008% NaS_20_3	6 hours
Table 1B-Inorganic Tests:				
Acidity	P,G	100ml	Cool 4°C	14 days
Alkalinity	P,G	100ml	Cool 4°C	14 days
Ammonia	P,G	100ml	Cool 4°C, H_2SO_4 to pH<2	28 days
BOD	P,G	1 liter	Cool 4°C	48 days
COD	P,G	50 ml	Cool 4°C, H_2SO_4 to pH<2	28 hours
Chloride	P,G	50ml	None Required	28 days
PH	P,G	50ml	None required	Analyse immediately
Nitrogen, Kjeldahl and Organic	P,G	1 Liter	Cool 4°C, H_2SO_4 to pH,2	28 days
Nitrate	P,G	50ml	Cool 4°C	48 hrs.
Nitrate/Nitrite	P,G	50ml	Cool 4°C, H_2SO_4 to pH<2	28 days
Nitrite	P,G	50ml	Cool 4°C	48 hrs.
Oil and Grease	P,G	1 liter	Cool 4°C, H_2SO_4 to pH<2	28 days
Organic Carbon	P,G	25ml	Cool 4°C, H_2SO_4 to pH<2	28 days
Orthophosphate	P,G	50ml	Filter immediately	28 hrs
Dissolved Oxygen (Probe Method)	G. top and bottle	1 liter	None required	Analyse immediately
Dissolved Oxygen	G, top and bottle	1 liter	Fix on site, store in	8 hours

(Winkler's Method)			dark	
Phosphorous, Elemental	G	50ml	4°C	48 hours
Phosphorous, Total	P,G	50ml	Cool 4°C, H_2SO_4 to pH<2	28 days
TS	P,G	100ml	Cool 4°C	7 days
TDS	P,G	100ml	Cool 4°C	7 days
TSS	P,G	100ml	Cool 4°C	7 days
Specific Conductance	P,G	100ml	Cool 4°C	28 days
Sulphate	P,G	100ml	Cool 4°C	28 days
Temperature	P,G	100ml	None Required	Analyse immediately
Turbidity	P,G	100ml	Cool 4°C	48 hours
METALS : C				
Hexavalent Cr	P,G	200ml or 50g	Cool 4°C	24 hours
Mercury	P,G	200ml or 50g	Cool 4°C	24 hours
All other metals	P,G	100ml	HNO3 pH<2	6 months
TPH	Wide mouth glass jars with teflon liner or stainless steel/brass cylinder	1000ml	Cool 4°C	14 days

LEGEND:
P=PLASTIC ,G=GLASS

Sample Receipt
Upon receipts of samples, the following procedure as enumerated in Table 2.4 is adhered to:

Table 2.4: Sample receipt chain of custody procedure

Action Required	Responsible Person	Evidence
Inspection of Sample for breakage	Sample Management Officer	Note to Project Co-ordinator
Verification of chain of custody	Sample management Officer	Note to Project Co-ordinator
Testing for preservative (pH)	Sample Management Officer	Open non-conformance record. Record result and notify Laboratory manager, Project Co-ordinator and Client.
In case of any anomaly	Sample Management Officer	Open non-conformance chart, Record result and notify Laboratory Manager, Project Co-ordinator and Client
Acceptance of Sample	Sample management Officer	Sign the COC, keep a copy and return copy to client.
Logging	Sample Management Officer	Logbook and Databse on Computer.
Sample preservation	Sample Management Officer	Stored in refrigerators

Duties and Responsibilities of the Laboratory
The Management of the laboratory is channelled towards ensuring good assurance attitude, by providing the following:-

- Regular Calibration of Equipment.
- All calibration procedures are written down, including description of calibration standards and schedule for calibration.
- Analytical procedures are written and are adopted from the ASTM and APHA methods as recommended by DPR (DPR Appendix D2, Page 135-136).
- Documentation of prevention procedures including a schedule for maintenance intervals is provided.
- Contamination of samples is avoided by keeping the laboratory out of bound to unauthourised persons and environmental interference.

Control of Data Storage and Recording
Record of submitted samples and completed analysis are kept in separate logbooks in a manner that ensures for data retrivation and tractability of sample source.

Also, the laboratory data sheets logbooks have provision for the procedures and Names of persons responsible for the sampling and analysis. All such data sheets are dated and signed by the analyst and approved by the laboratory Manager.

Data handling through the use of dedicated Pentium 100MHZ computers ensures minimal data loss.

For every project we handle, data account is opened in our computer data bank to ensure easy retrieval.

To prevent electronic loss of data on the computer, we also keep hard copies in our results master files as well as diskette copies.

Data Validation
The Laboratory Manager has the responsibility of carrying out validation activities. As a general guideline, QA procedures shall be carried out on at least 20% of our workload. Steps are taken to ensure reliability of results.

Data Verification
Field data sheets were carefully kept and inspected at the end of the day's fieldwork to make sure that no samples were missed out. Laboratory data for wet chemistry were subjected to analyses such as plotting of chloride values vs. conductivity or conductivity vs. TDS to draw attention to those stations whose values fell outside of the observed range. Such station samples were given closer scrutiny in subsequent data analysis to see whether the particular values could be explained. If no reasons could be found for the anomalous values, the conclusion was drawn that the values were in error.

Deficiency Correction
The QA/QC Manager has the responsibility to carry out investigation into out of control procedures and report it to the laboratory Manager.

When such a deficiency is noted a current log is kept for future reference.

The following investigative shooting procedure is to be carried out each time analytical laboratory result is found to be unreliable or questionable.

SAMPLING: Review the records of the sampling
SAMPE HANDLING: Check the record for the sample preservation technique, the time of transit and the condition of the sample upon arrival in the laboratory.
ANALYTICAL PROCEDURE: Check methodology, calibration and maintenance log on the measurement system used and the raw data that are recorded. Check the reagents used for quality and date of expiration. Crosscheck the mathematics of all calculations.
Carry a reagent blank through sampling and analytical procedures.

Deficiencies that have been discovered and corrected are recorded in our log filling system, stating the parameters involved, the problem, the action taken, and the date of the action and the results of investigation.

Appendix 4.2a: Analysis of Soil Samples at Profile Pit 1 (Between Imera and Atami) (Dry season)

Parameters	0-30cm	30-60cm	60-100cm
pH	5.80	5.70	5.70
EC$\mu S/cm^2$	62.0	80.0	141.0
C %	1.92	2.18	2.06
N%	0.109	0.185	0.167
NO_3 ppm	0.08	0.08	0.06
Av.P ppm	6.20	9.53	9.10
Na meq/100g soil	0.08	0.08	0.08
K meq/100g soil	0.04	0.04	0.04
Ca meq/100g soil	0.40	0.70	0.72
Mg meq/100g soil	0.08	0.20	0.16
Ex Acidity meq/100g soil	0.30	0.40	0.70
ECEC meq/100g soil	0.90	0.98	1.70
B Sat %	66.70	67.50	58.80
Clay%	14.00	12.50	5.00
Silt%	15.80	14.30	4.80
Sand%	70.20	73.20	90.20

Appendix 4.2b: Analysis of Soil Samples at Profile pit 2 Kaba Junction at Lokoja NNPC Station (Dry season)

Parameters	0-30cm	30-60cm	60-90cm	90-120cm
pH	4.2	5.9	5.3	5.3
EC$\mu S/cm^2$	110	46	141	73.0
C %	2.75	2.18	205	1.98
N%	0.233	0.183	0.167	0.158
NO_3 ppm	0.10	0.20	0.20	0.17
Av.P ppm	5.5	9.7	9.1	6.2
Na meq/100g soil	0.13	0.13	0.08	0.11
K meq/100g soil	0.08	0.05	0.04	0.09
Ca meq/100g soil	0.32	0.64	0.72	0.96
Mg meq/100g soil	0.24	0.16	0.16	0.16
Ex A meq/100g soil	1.50	0.20	0.70	0.20
ECEC meq/100g soil	2.27	1.18	1.70	1.52
B Sat %	33.9	83.1	58.8	89.6
Clay%	9.5	3.0	5.0	3.0
Silt%	15.3	4.3	4.8	6.3
Sand%	75.2	92.7	90.2	89.2

Appendix 4.2c: Analysis of soil samples at profile pit 1 (Between Imera and Atami) (Wet Season)

Parameters	0-30cm	30-60cm	60-100cm
PH	6.0	5.80	5.60
ECμS/cm^2	162.0	80.0	141.0
C %	2.15	2.18	20.6
N%	0.20	0.180	0.170
NO_3 ppm	0.10	0.08	0.06
Av.P ppm	12.0	0.58	9.10
Na meq/100g soil	0.10	0.08	0.08
K meq/100g soil	0.06	0.05	0.04
Ca meq/100g soil	0.40	0.80	0.72
Mg meq/100g soil	0.20	0.20	0.18
Ex Acidity meq/100g soil	0.30	0.50	0.70
ECEC meq/100g soil	1.06	1.28	1.72
B Sat %	71.70	60.9	59.3
Clay%	14.00	12.50	15.00
Silt%	15.80	14.30	14.80
Sand%	70.20	73.20	70.20

Appendix 4.2d: Analysis of soil samples at Profile pit 2 Kaba Junction at Lokoja NNPC Station (Wet season)

Parameters	0-30cm	30-60cm	60-90cm	90-120cm
PH	5.8	5.8	5.4	5.3
ECμS/cm^2	120	10	141	73.0
C %	2.75	2.18	205	1.98
N%	0.233	0.183	0.167	0.158
NO_3 ppm	0.15	0.20	0.20	0.17
Av.P ppm	10.5	19.7	19.1	10.2
Na meq/100g soil	0.14	0.13	0.08	0.11
K meq/100g soil	0.10	0.05	0.04	0.09
Ca meq/100g soil	0.35	0.64	0.72	0.96
Mg meq/100g soil	0.25	0.18	0.16	0.16
Ex A meq/100g soil	1.50	0.20	0.70	0.20
ECEC meq/100g soil	2.35	1.20	1.70	1.52
B Sat %	35.9	83.3	58.8	89.6
Clay%	9.5	13.0	8.0	13.8
Silt%	15.3	4.3	4.8	6.3
Sand%	75.2	82.7	87.2	79.9

Appendix 4.3a: Chemical Characteristics of Soils Along the Proposed Pipeline Route (May 2001 Dry Season)

Codes	pH	EC	C	N	Av.P	NO_3	NO_2	NH_4	SO_4	Cl	Na	K	Ca	Mg	H^+	Al^{3+}	ECEC	B.Sat
	H_2O	µs	%	%	Ppm					Meq/100g soil								%
SS 1 (0-15)	7.6	464	1.28	0.07	14.5	0.024	0.021	81.646	2.366	17.7	0.28	0.16	4.00	1.68	0.40	0	6.52	93.9
SS2 (15-30)	6.6	66.9	0.96	0.07	4.9	0.041	0.010	3.583	0.460	35.5	0.19	0.14	3.20	1.60	0.10	0	5.23	98.1
SS 2 (0-30)	6.3	15.3	1.38	0.07	1.3	0.033	0.001	0.877	2.128	53.3	0.13	0.07	1.28	0.72	0.10	0	2.30	95.7
SS 4 (0-30)	6.2	45.3	2.30	0.12	5.1	0.051	0.006	0.073	0.460	53.3	0.23	0.12	4.00	2.24	0.10	0	6.69	98.5
SS 6 (0-30)	6.3	48.4	2.24	0.12	1.6	0.060	0.009	9.140	2.013	35.4	0.45	0.26	7.36	4.88	0.10	0	13.05	99.2
SS 7 (0-30)	6.1	52.6	1.06	0.08	10.6	0.027	0.022	0.658	1.438	35.6	0.27	0.20	6.64	2.40	0.10	0	9.61	99.0
SS 7 (0-30)	6.2	51.8	1.22	0.07	6.7	0.031	0.006	9.140	2.645	35.5	0.16	0.11	3.60	1.20	0.10	0	5.17	98.1
SS 8 (0-30)	6.2	44.7	1.92	0.09	3.6	0.042	0.003	0.219	0.633	35.5	0.17	0.14	3.20	1.44	0.10	0	5.05	98.0
SS 9 (0-30)	6.1	90.2	2.14	0.16	2.3	0.024	0.005	0.951	2.875	17.6	0.21	0.14	6.40	1.92	0.10	0	8.77	98.9
SS 10 (30-60)	6.0	59.2	1.27	0.08	48.3	0.034	0.018	4.607	1.265	53.4	0.23	0.16	3.92	1.92	0.10	0	6.33	98.4
SS 11 (0-30)	6.0	21.0	1.70	0.08	4.5	0.071	0.023	4.022	2.128	35.4	0.15	0.06	1.60	0.32	0.20	0	2.33	91.4
SS 12 (0-30)	6.0	96.8	1.54	0.12	6.2	0.043	0.026	0.877	1.323	35.4	0.28	0.25	4.48	1.60	0.10	0	6.71	98.5
SS 13 (0-20)	5.9	36.8	1.12	0.10	8.2	0.025	0.022	3.802	3.680	17.8	0.30	0.22	2.40	0.96	0.30	0	4.18	92.8
SS 15 (20-30)	5.5	31.9	2.34	0.12	4.5	0.102	0.054	2.852	0.978	17.6	0.23	0.14	2.40	1.20	0.20	0	4.17	95.2
SS 15 (0-20)	6.0	70.5	2.08	0.12	3.1	0.061	0.015	0.292	2.070	35.5	0.32	0.26	6.48	1.12	0.10	0	8.28	98.8
SS 16 (20-30)	5.8	125.3	1.03	0.08	7.5	0.053	0.039	6.288	1.150	35.4	0.42	0.30	5.52	2.16	0.10	0	8.50	98.8
SS 17 (0-30)	7.1	365.0	1.89	0.17	7.9	0.026	0.028	0.073	2.875	35.5	0.21	0.11	4.00	1.20	0.10	0	5.62	98.2
SS 18 (0-30)	6.4	53.6	2.72	0.12	14.3	0.18	0.018	0.292	0.748	17.8	0.37	0.28	4.64	2.48	0.10	0	8.52	98.8
SS 19 (0-30)	5.8	55.5	1.34	0.10	11.1	0.036	0.021	0.073	3.680	17.7	0.34	0.27	5.68	2.56	0.10	0	8.95	98.9
SS 20 (0-30)	5.6	127.7	2.82	0.15	9.3	0.027	0.019	4.387	0.575	17.8	0.17	0.09	4.56	1.04	0.10	0	5.59	98.3
SS 21 (0-30)	6.5	76.8	3.68	0.20	17.9	0.072	0.017	7.165	2.415	17.7	0.33	0.26	8.16	2.40	0.10	0	11.25	99.1
SS 22 (0-30)	6.0	65.1	1.31	0.15	57.0	0.051	0.037	0.658	1.130	17.8	0.32	0.26	10.88	4.08	0.10	0	15.64	99.4
SS 23 (0-30)	6.2	77.5	2.59	0.14	46.4	0.076	0.046	15.940	2.300	35.5	0.17	0.10	2.40	1.44	0.10	0	4.27	96.3
SS 24 (0-30)	6.3	79.7	2.72	0.14	5.1	0.130	0.029	10.310	0.978	35.6	0.19	0.13	4.40	1.20	0.50	0	6.42	92.2
SS 25 (0-30)	6.4	79.9	1.60	0.17	9.7	0.064	0.004	8.116	5.290	35.5	0.24	0.17	6.48	3.76	0.30	0	10.95	97.3
SS 26 (0-30)	6.0	78.9	4.19	0.15	11.3	0.046	0.009	10.529	2.530	35.5	0.35	0.26	3.84	0.96	0.10	0	5.51	98.2
SS 27 (0-30)	5.6	26.3	1.47	0.15	14.3	0.056	0.056	10.456	3.335	17.8	0.43	0.34	6.64	4.16	0.10	0	11.67	99.1

Appendix 4.3a (Contd)

Codes	pH	EC	C	N	Av.P	NO_3	NO_2	NH_4	SO_4	Cl	Na	K	Ca	Mg	H^+	Al^{3+}	ECEC	B.Sat
	H_2O	µS	%	%	Ppm					Meq/100g soil								%
SS 28 (0-30)	6.2	95.7	2.56	0.15	21.3	0.087	0.021	11.552	1.093	17.7	0.19	0.12	2.56	0.24	0.10	0	3.21	96.9
SS 29 (0-30)	5.6	37.5	0.86	0.10	2.9	0.039	0.014	6.288	3.680	35.6	0.51	0.41	11.68	3.20	0.10	0	20.72	99.4
SS 30 (0-30)	5.7	49.6	0.64	0.04	22.1	0.063	0.066	17.183	2.070	17.8	0.44	0.34	10.88	8.96	0.10	0	20.72	99.5
SS 31 (0-30)	6.0	4.8.0	0.80	0.05	14.2	0.045	0.028	8.116	2.875	35.5	0.16	0.08	2.40	1.04	0.10	0	3.78	97.4
SS 32 (0-30)	5.5	103.8	1.12	0.09	4.3	0.054	0.006	3.802	0.690	35.5	0.14	0.03	2.48	0.88	0.10	0	3.63	97.2
SS 33 (0-30)	6.4	88.0	0.64	0.06	3.7	0.028	0.101	4.460	3.738	35.5	0.12	0.07	1.92	0.96	0.10	0	3.17	96.8
SS 34 (0-30)	6.2	193.7	1.22	0.10	7.5	0.041	0.149	4.095	0.280	53.3	0.13	0.05	2.88	1.04	0.10	0	4.20	97.6
SS 34 (30-60)	5.8	123.0	1.89	0.05	7.5	0.061	0.149	3.437	3.220	53.3	0.11	0.02	1.52	0.56	0.10	0	2.31	99.9
NRS 1	5.9	107.7	2.50	0.10	3.9	0.043	0.149	1.974	0.633	35.5	0.37	0.27	3.68	1.44	0.10	0	5.86	98.3
NRS 3	6.2	172.1	1.38	0.06	5.5	0.056	0.207	13.678	1.955	35.5	0.40	0.32	8.56	2.48	0.10	0	11.86	99.2
NRS 4	6.5	180.0	0.80	0.04	12.1	0.081	0.189	1.828	1.840	35.5	0.53	0.45	8.48	1.28	0.10	0	10.84	99.1
NRS 6	5.6	45.5	1.92	0.06	6.9	0.045	0.245	9.067	4.313	17.8	0.20	0.11	2.16	0.64	0.10	0	3.21	96.9
NRS 8	6.0	60.3	1.32	0.04	4.3	0.072	0.207	2.120	1.610	35.6	0.20	0.14	2.40	0.56	0.10	0	3.40	97.1
NRS 9	6.2	119.6	1.44	0.06	4.8	0.061	0.206	8.189	3.795	17.7	0.41	0.32	8.40	0.72	0.10	0	9.95	99.0
NRS 10	6.2	117.7	0.90	0.90	6.9	0.026	0.261	5.118	2.300	35.5	0.19	0.10	2.24	0.56	0.10	0	3.19	96.9
NRS 11	6.2	253.0	0.93	0.06	2.1	0.029	0.192	3.217	2.530	17.8	0.24	0.18	2.00	0.37	0.10	0	2.89	96.5
NRS 12	6.0	23.8	0.96	0.08	5.7	0.053	0.229	0.439	1.495	71.0	0.29	0.20	7.92	1.52	0.10	0	1.03	99.0
NRS 13	6.0	251.0	1.06	0.11	2.7	0.072	0.190	2.560	1.380	35.6	0.19	0.11	3.28	0.48	0.10	0	4.16	97.6
NRS 14	6.4	208.0	1.12	0.10	0.8	0.081	0.197	0.073	3.623	35.5	0.15	0.10	2.72	0.48	0.60	0	4.06	97.3
NRS 16	6.0	66.9	1.41	0.16	0.6	0.067	0.224	0.804	1.035	17.8	0.31	0.20	4.56	0.48	0.10	0	5.56	98.2
PF 1 (0-30)	6.1	60.37	1.06	0.10	7.7	0.056	0.201	4.095	1.035	35.7	0.36	0.26	4.96	0.56	0.10	0	6.24	98.4
PF 1 (30-60)	6.2	102.2	1.22	0.11	13.7	0.037	0.181	2.120	1.380	17.4	0.12	0.06	1.84	0.32	0.10	0	2.44	95.9
PF 2 (30-60)	6.0	94.2	0.64	0.07	3.2	0.102	0.259	1.682	2.300	35.5	0.18	0.11	2.00	0.32	0.30	0	2.91	89.7

Appendix 4.3b: Texture, heavy metals and THC concentrations of soils along the proposed gas pipeline route (May 2001, Dry Season)

codes	Clay %	Silt %	Sand %	Fe	Mn	Zn	Cu	Cr	Cd	Ni	V	Pb	Hg	THC
SS 1 (0-15)	18.0	13.7	68.3	0.2	0.1	0.27	0.19	0	0	0.47	0	0.09	0	2.9
SS2 (15-30)	4.0	7.7	88.3	28.2	5.6	5.66	1.05	0	0	0	0	0.91	0	1.3
SS 2 (0-30)	3.0	9.2	87.8	54.6	10.9	5.11	0.62	0.38	0	0	0.02	0.64	0	2.8
SS 4 (0-30)	5.5	4.2	90.3	329.3	65.9	3.89	1.55	0.26	0.04	0	0.04	0.19	0	1.8
SS 6 (0-30)	5.0	6.7	88.3	37.9	7.6	3.98	0.82	0.02	0	0	0	1.77	0	3.2
SS 7 (0-30)	5.0	9.7	85.3	37.3	7.5	7.08	0.94	0.04	0	0.04	0	0.68	0	3.6
SS 7 (0-30)	3.0	8.7	88.3	257.4	51.5	0.23	0.97	0.36	0	0	0.08	7.32	0	2.4
SS 8 (0-30)		5.2	90.3	0	0	1.56	0.17	0	0	0	0	1.61	0	3.3
SS 9 (0-30)	2.5	7.2	90.3	20.9	4.18	2.39	0.60	0.16	0	0.42	0	0	0	1.8
SS 10 (30-60)	2.5	8.2	89.3	38.7	7.74	2.04	0.54	0	0	0.12	0	0	0	1.5
SS 11 (0-30)	2.5	10.2	87.3	241.6	48.3	4.15	0.63	0.21	0	0	0	0.15	0	2.9
SS 12 (0-30)	2.5	6.2	91.3	19.9	4.0	8.79	0.36	0.82	0.08	0	0.12	4.64	0	1.6
SS 13 (0-20)	2.5	7.2	90.3	398.6	79.7	10.18	1.75	1.26	0.04	0	0.36	0	0	12.0
SS 15 (20-30)	5.0	16.7	78.3	422.8	84.6	9.33	2.06	0.17	0.06	0.31	0	1.03	0	4.1
SS 15 (0-20)	4.0	6.7	89.3	140.3	28.1	25.93	0.82	0.29	0.05	0	0	1.45	0.001	1.6
SS 16 (20-30)	6.0	12.7	92.3	423.5	84.7	5.61	1.19	0.23	0	0	0	1.01	0	1.0
SS 17 (0-30)	9.0	13.7	77.3	14.3	2.9	7.64	0.39	0.85	0	0.06	0.28	0	0	4.5
SS 18 (0-30)	2.5	3.2	94.3	26.8	5.4	10.84	0.57	0.13	0.10	0	0	11.68	0	3.0
SS 19 (0-30)	2.5	7.2	90.3	91.2	18.2	13.06	0.68	0.24	0	0	0.22	0	0	2.3
SS 20 (0-30)	5.0	8.7	86.3	20.5	4.1	1.80	0.25	0	0	0	0	0	0	1.9
SS 21 (0-30)	2.5	5.2	92.3	33.74	6.75	19.14	0.57	0	0	0.04	0	0	0	1.9
SS 22 (0-30)	5.0	13.7	81.3	20.28	4.06	14.18	0.38	0	0	0	0	0	0	2.3

Appendix 4.3b (Contd)

Codes	Clay %	Silt %	Sand %	Fe	Mn	Zn	Cu	Cr	Cd	Ni	V	Pb	Hg	THC
SS 23 (0-30)	4.0	13.0	81.3	97.88	19.58	4.07	1.02	0.16	0	0	0	0	0	1.4
SS 24 (0-30)	14.0	11.7	74.3	35.58	7.17	5.98	0.75	0.18	0	0	0	0	0	1.9
SS 25 (0-30)	9.0	12.7	68.3	50.98	10.20	7.67	0.73	0.26	0	0.26	0.08	0	0	9.5
SS 26 (0-30)	4.0	12.7	68.3	236.40	47.28	0.31	0.86	0.67	0.02	0.03	0.32	0	0	18.6
SS 27 (0-30)	5.0	12.7	68.3	95.98	19.20	6.72	0.93	0.13	0	0.05	0	0.02	0	2.4
SS 28 (0-30)	3.0	23.7	73.3	150.00	30.00	31.51	0.97	0.81	0.06	0	0.36	0	0	2.8
SS 29 (0-30)	14.0	14.7	71.3	144.00	28.80	21.32	0.34	0.67	0.03	0.27	0.26	0	0	13.1
SS 30 (0-30)	4.0	17.7	78.3	135.36	27.07	5.16	0.82	0	0	1.08	0	0.05	0	7.7
SS 31 (0-30)	3.0	24.7	72.3	57.31	11.46	18.81	0.14	0	0	0	0	1.97	0	4.4
SS 32 (0-30)	7.0	6.7	86.3	33.30	6.66	0.11	0.69	0.12	0	0	0.04	0.05	0	4.9
SS 33 (0-30)	2.5	14.2	83.3	72.86	14.57	4.46	0.52	0.19	0.03	0	0.02	1.38	0	8.5
SS 34 (0-30)	2.5	7.2	90.3	45.22	9.04	11.83	0.49	0.87	0	0.02	0.21	0.02	0	3.5
SS 34 (30-60)	2.5	12.2	85.3	73.60	14.72	12.26	0.77	0.96	0	0	0.08	0.35	0	3.0
NRS 1	4.0	6.7	89.3	155.40	31.08	11.14	1.19	0.12	0	0	0	0.95	0	5.8
NRS 3	3.0	9.7	87.3	247.92	49.58	12.20	1.17	0.05	0.05	1.39	0	0.82	0	3.6
NRS 4	7.0	11.7	81.3	76.85	15.37	32.70	0.66	0.44	0	0.03	0	0.01	0	25.9
NRS 6	4.0	10.7	85.3	445.80	89.16	11.44	1.02	0.56	0.02	0.04	0	4.13	0	2.4
NRS 8	4.0	7.7	88.3	104.52	20.90	9.91	0.60	0.25	0	0	0	0.02	0	3.1
NRS 9	3.0	4.7	92.3	272.28	54.46	8.85	1.01	0.25	0	0.03	0	0.02	0	5.6
NRS 10	8.0	7.7	84.3	443.16	88.63	18.96	1.46	0.84	0.11	0.04	0.25	2.14	0	2.3
NRS 11	3.0	7.7	89.3	68.02	13.60	29.99	0.58	0.87	0.02	0	0.36	0	0	5.6
NRS 12	3.0	6.7	90.3	89.98	18.00	12.39	1.19	0.62	0.11	0.19	0.28	1.07	0	10.6
NRS 13	3.0	6.7	90.3	47.40	9.48	1.09	0.89	0.59	0	0	0.25	0.38	0	5.2
NRS 14	3.0	8.7	88.3	402.36	80.47	3.35	2.74	0.51	0.08	0.58	0.19	1.81	0	4.8
NRS 16	7.0	8.7	84.8	44.74	8.95	1.63	0.64	0	0	0.04	0.08	0.01	0	1.8
PF 1 (0-30)	3.0	6.7	90.3	53.34	10.67	2.22	1.25	0.23	0	0.07	0	1.34	0	1.8
PF 1 (30-60)	3.0	6.7	90.3	34.51	6.90	0.03	0.20	0	0	0	0	2.07	0	3.3
PF 2 (30-60)	2.5	3.2	94.3	358.44	71.69	0.09	1.37	0.12	0.02	0	0.02	0.52	0	3.4

Appendix 4.3c: Chemical Characteristics of soils along the proposed gas pipeline route (October 2001 Wet Season)

Codes	pH	EC	C	N	Av.P	NO_3	NO_2	NH_4	SO_4	Cl	Na	K	Ca	Mg	H^+	Al^{3+}	ECEC	B.Sat
	H_2O	µS	%	%	Ppm					Meq/100g soil								%
SS 1 (0-30)	7.6	464	1.28	0.07	14.5	0.024	0.021	81.646	2.366	17.7	0.28	0.16	4.00	1.68	0.40	0	6.52	93.9
SS2 (0-15)	6.6	66.9	0.96	0.07	4.9	0.041	0.010	3.583	0.460	35.5	0.19	0.14	3.20	1.60	0.10	0	5.23	98.1
SS 2 (15-30)	6.3	15.3	1.38	0.07	1.3	0.033	0.001	0.877	2.128	53.3	0.13	0.07	1.28	0.72	0.10	0	2.30	95.7
SS 4 (0-30)	6.2	45.3	2.30	0.12	5.1	0.051	0.006	0.073	0.460	53.3	0.23	0.12	4.00	2.24	0.10	0	6.69	98.5
SS 6 (0-30)	6.3	48.4	2.24	0.12	1.6	0.060	0.009	9.140	2.013	35.4	0.45	0.26	7.36	4.88	0.10	0	13.05	99.2
SS 7 (0-30)	6.1	52.6	1.06	0.08	10.6	0.027	0.022	0.658	1.438	35.6	0.27	0.20	6.64	2.40	0.10	0	9.61	99.0
SS 7 (0-30)	6.2	51.8	1.22	0.07	6.7	0.031	0.006	9.140	2.645	35.5	0.16	0.11	3.60	1.20	0.10	0	5.17	98.1
SS 8 (0-30)	6.2	44.7	1.92	0.09	3.6	0.042	0.003	0.219	0.633	35.5	0.17	0.14	3.20	1.44	0.10	0	5.05	98.0
SS 9 (0-30)	6.1	90.2	2.14	0.16	2.3	0.024	0.005	0.951	2.875	17.6	0.21	0.14	6.40	1.92	0.10	0	8.77	98.9
SS 10 (0-30)	6.0	59.2	1.27	0.08	48.3	0.034	0.018	4.607	1.265	53.4	0.23	0.16	3.92	1.92	0.10	0	6.33	98.4
SS 11 (0-30)	6.0	21.0	1.70	0.08	4.5	0.071	0.023	4.022	2.128	35.4	0.15	0.06	1.60	0.32	0.20	0	2.33	91.4
SS 12 (0-30)	6.0	96.8	1.54	0.12	6.2	0.043	0.026	0.877	1.323	35.4	0.28	0.25	4.48	1.60	0.10	0	6.71	98.5
SS 13 (0-30)	5.9	36.8	1.12	0.10	8.2	0.025	0.022	3.802	3.680	17.8	0.30	0.22	2.40	0.96	0.30	0	4.18	92.8
SS 15 (0-20)	6.0	70.5	2.08	0.12	3.1	0.061	0.015	0.292	2.070	35.5	0.32	0.26	6.48	1.12	0.10	0	8.28	98.8
SS 15 (20-30)	5.5	31.9	2.34	0.12	4.5	0.102	0.054	2.852	0.978	17.6	0.23	0.14	2.40	1.20	0.20	0	4.17	95.2
SS 16 (20-30)	5.8	125.3	1.03	0.08	7.5	0.053	0.039	6.288	1.150	35.4	0.42	0.30	5.52	2.16	0.10	0	8.50	98.8
SS 17 (0-30)	7.1	365.0	1.89	0.17	7.9	0.026	0.028	0.073	2.875	35.5	0.21	0.11	4.00	1.20	0.10	0	5.62	98.2
SS 18 (0-30)	6.4	53.6	2.72	0.12	14.3	0.18	0.018	0.292	0.748	17.8	0.37	0.28	4.64	2.48	0.10	0	8.52	98.8
SS 19 (0-30)	5.8	55.5	1.34	0.10	11.1	0.036	0.021	0.073	3.680	17.7	0.34	0.27	5.68	2.56	0.10	0	8.95	98.9
SS 20 (0-30)	5.6	127.7	2.82	0.15	9.3	0.027	0.019	4.387	0.575	17.8	0.17	0.09	4.56	1.04	0.10	0	5.59	98.3
SS 21 (0-30)	6.5	76.8	3.68	0.20	17.9	0.072	0.017	7.165	2.415	17.7	0.33	0.26	8.16	2.40	0.10	0	11.25	99.1
SS 22 (0-30)	6.0	65.1	1.31	0.15	57.0	0.051	0.037	0.658	1.130	17.8	0.32	0.26	10.88	4.08	0.10	0	15.64	99.4
SS 23 (0-30)	6.2	77.5	2.59	0.14	46.4	0.076	0.046	15.940	2.300	35.5	0.17	0.10	2.40	1.44	0.10	0	4.27	96.3
SS 24 (0-30)	6.3	79.7	2.72	0.14	5.1	0.130	0.029	10.310	0.978	35.6	0.19	0.13	4.40	1.20	0.50	0	6.42	92.2
SS 25 (0-30)	6.4	79.9	1.60	0.17	9.7	0.064	0.004	8.116	5.290	35.5	0.24	0.17	6.48	3.76	0.30	0	10.95	97.3
SS 26 (0-30)	6.0	78.9	4.19	0.15	11.3	0.046	0.009	10.529	2.530	35.5	0.35	0.26	3.84	0.96	0.10	0	5.51	98.2
SS 27 (0-30)	5.6	26.3	1.47	0.15	14.3	0.056	0.056	10.456	3.335	17.8	0.43	0.34	6.64	4.16	0.10	0	11.67	99.1

Appendix 4.3c (Contd)

Codes	pH	EC	C	N	Av.P	NO_3	NO_2	NH_4	SO_4	Cl	Na	K	Ca	Mg	H^+	Al^{3+}	ECEC	B.Sat
	H_2O	µS	%	%	Ppm					Meq/100g soil								%
SS 28 (0-30)	6.2	95.7	2.56	0.15	21.3	0.087	0.021	11.552	1.093	17.7	0.19	0.12	2.56	0.24	0.10	0	3.21	96.9
SS 29 (0-30)	5.6	37.5	0.86	0.10	2.9	0.039	0.014	6.288	3.680	35.6	0.51	0.41	11.68	3.20	0.10	0	20.72	99.4
SS 30 (0-30)	5.7	49.6	0.64	0.04	22.1	0.063	0.066	17.183	2.070	17.8	0.44	0.34	10.88	8.96	0.10	0	20.72	99.5
SS 31 (0-30)	6.0	48.0	0.80	0.05	14.2	0.045	0.028	8.116	2.875	35.5	0.16	0.08	2.40	1.04	0.10	0	3.78	97.4
SS 32 (0-30)	5.5	103.8	1.12	0.09	4.3	0.054	0.006	3.802	0.690	35.5	0.14	0.03	2.48	0.88	0.10	0	3.63	97.2
SS 33 (0-30)	6.4	88.0	0.64	0.06	3.7	0.028	0.101	4.460	3.738	35.5	0.12	0.07	1.92	0.96	0.10	0	3.17	96.8
SS 34 (0-30)	6.2	193.7	1.22	0.10	7.5	0.041	0.149	4.095	0.280	53.3	0.13	0.05	2.88	1.04	0.10	0	4.20	97.6
SS 34 (30-60)	5.8	123.0	1.89	0.05	7.5	0.061	0.149	3.437	3.220	53.3	0.11	0.02	1.52	0.56	0.10	0	2.31	99.9
NRS 1	5.9	107.7	2.50	0.10	3.9	0.043	0.149	1.974	0.633	35.5	0.37	0.27	3.68	1.44	0.10	0	5.86	98.3
NRS 3	6.2	172.1	1.38	0.06	5.5	0.056	0.207	13.678	1.955	35.5	0.40	0.32	8.56	2.48	0.10	0	11.86	99.2
NRS 4	6.5	180.0	0.80	0.04	12.1	0.081	0.189	1.828	1.840	35.5	0.53	0.45	8.48	1.28	0.10	0	10.84	99.1
NRS 6	5.6	45.5	1.92	0.06	6.9	0.045	0.245	9.067	4.313	17.8	0.20	0.11	2.16	0.64	0.10	0	3.21	96.9
NRS 8	6.0	60.3	1.32	0.04	4.3	0.072	0.207	2.120	1.610	35.6	0.20	0.14	2.40	0.56	0.10	0	3.40	97.1
NRS 9	6.2	119.6	1.44	0.06	4.8	0.061	0.206	8.189	3.795	17.7	0.41	0.32	8.40	0.72	0.10	0	9.95	99.0
NRS 10	6.2	117.7	0.90	0.90	6.9	0.026	0.261	5.118	2.300	35.5	0.19	0.10	2.24	0.56	0.10	0	3.19	96.9
NRS 11	6.2	253.0	0.93	0.06	2.1	0.029	0.192	3.217	2.530	17.8	0.24	0.18	2.00	0.37	0.10	0	2.89	96.5
NRS 12	6.0	23.8	0.96	0.08	5.7	0.053	0.229	0.439	1.495	71.0	0.29	0.20	7.92	1.52	0.10	0	1.03	99.0
NRS 13	6.0	251.0	1.06	0.11	2.7	0.072	0.190	2.560	1.380	35.6	0.19	0.11	3.28	0.48	0.10	0	4.16	97.6
NRS 14	6.4	208.0	1.12	0.10	0.8	0.081	0.197	0.073	3.623	35.5	0.15	0.10	2.72	0.48	0.60	0	4.06	97.3
NRS 16	6.0	66.9	1.41	0.16	0.6	0.067	0.224	0.804	1.035	17.8	0.31	0.20	4.56	0.48	0.10	0	5.56	98.2
PF 1 (0-30)	6.1	60.37	1.06	0.10	7.7	0.056	0.201	4.095	1.035	35.7	0.36	0.26	4.96	0.56	0.10	0	6.24	98.4
PF 1 (30-60)	6.2	102.2	1.22	0.11	13.7	0.037	0.181	2.120	1.380	17.4	0.12	0.06	1.84	0.32	0.10	0	2.44	95.9
PF 2 (30-60)	6.0	94.2	0.64	0.07	3.2	0.102	0.259	1.682	2.300	35.5	0.18	0.11	2.00	0.32	0.30	0	2.91	89.7

Appendix 4.3d: Texture, heavy metals and THC concentrations of soils along the proposed gas pipeline route (October 2001, Wet Season)

Codes	Clay %	Silt %	Sand %	Fe	Mn	Zn	Cu	Cr	Cd	Ni	V	Pb	Hg	THC
SS 1 (0-15)	18.0	13.7	68.3	0.2	0.1	0.27	0.19	0	0	0.47	0	0.09	0	2.9
SS2 (15-30)	4.0	7.7	88.3	28.2	5.6	5.66	1.05	0	0	0	0	0.91	0	1.3
SS 2 (0-30)	3.0	9.2	87.8	54.6	10.9	5.11	0.62	0.38	0	0	0.02	0.64	0	2.8
SS 4 (0-30)	5.5	4.2	90.3	329.3	65.9	3.89	1.55	0.26	0.04	0	0.04	0.19	0	1.8
SS 6 (0-30)	5.0	6.7	88.3	37.9	7.6	3.98	0.82	0.02	0	0	0	1.77	0	3.2
SS 7 (0-30)	5.0	9.7	85.3	37.3	7.5	7.08	0.94	0.04	0	0.04	0	0.68	0	3.6
SS 7 (0-30)	3.0	8.7	88.3	257.4	51.5	0.23	0.97	0.36	0	0	0.08	7.32	0	2.4
SS 8 (0-30)		5.2	90.3	0	0	1.56	0.17	0	0	0	0	1.61	0	3.3
SS 9 (0-30)	2.5	7.2	90.3	20.9	4.18	2.39	0.60	0.16	0	0.42	0	0	0	1.8
SS 10 (30-60)	2.5	8.2	89.3	38.7	7.74	2.04	0.54	0	0	0.12	0	0	0	1.5
SS 11 (0-30)	2.5	10.2	87.3	241.6	48.3	4.15	0.63	0.21	0	0	0	0.15	0	2.9
SS 12 (0-30)	2.5	6.2	91.3	19.9	4.0	8.79	0.36	0.82	0.08	0	0.12	4.64	0	1.6
SS 13 (0-20)	2.5	7.2	90.3	398.6	79.7	10.18	1.75	1.26	0.04	0	0.36	0	0	12.0
SS 15 (20-30)	5.0	16.7	78.3	422.8	84.6	9.33	2.06	0.17	0.06	0.31	0	1.03	0	4.1
SS 15 (0-20)	4.0	6.7	89.3	140.3	28.1	25.93	0.82	0.29	0.05	0	0	1.45	0.001	1.6
SS 16 (20-30)	6.0	12.7	92.3	423.5	84.7	5.61	1.19	0.23	0	0	0	1.01	0	1.0
SS 17 (0-30)	9.0	13.7	77.3	14.3	2.9	7.64	0.39	0.85	0	0.06	0.28	0	0	4.5
SS 18 (0-30)	2.5	3.2	94.3	26.8	5.4	10.84	0.57	0.13	0.10	0	0	11.68	0	3.0
SS 19 (0-30)	2.5	7.2	90.3	91.2	18.2	13.06	0.68	0.24	0	0	0.22	0	0	2.3
SS 20 (0-30)	5.0	8.7	86.3	20.5	4.1	1.80	0.25	0	0	0	0	0	0	1.9
SS 21 (0-30)	2.5	5.2	92.3	33.74	6.75	19.14	0.57	0	0	0.04	0	0	0	1.9
SS 22 (0-30)	5.0	13.7	81.3	20.28	4.06	14.18	0.38	0	0	0	0	0	0	2.3

Appendix 4.3d (Contd)

Codes	Clay %	Silt %	Sand %	Fe	Mn	Zn	Cu	Cr	Cd	Ni	V	Pb	Hg	THC
SS 23 (0-30)	4.0	13.0	81.3	97.88	19.58	4.07	1.02	0.16	0	0	0	0	0	1.4
SS 24 (0-30)	14.0	11.7	74.3	35.58	7.17	5.98	0.75	0.18	0	0	0	0	0	1.9
SS 25 (0-30)	9.0	12.7	68.3	50.98	10.20	7.67	0.73	0.26	0	0.26	0.08	0	0	9.5
SS 26 (0-30)	4.0	12.7	68.3	236.40	47.28	0.31	0.86	0.67	0.02	0.03	0.32	0	0	18.6
SS 27 (0-30)	5.0	12.7	68.3	95.98	19.20	6.72	0.93	0.13	0	0.05	0	0.02	0	2.4
SS 28 (0-30)	3.0	23.7	73.3	150.00	30.00	31.51	0.97	0.81	0.06	0	0.36	0	0	2.8
SS 29 (0-30)	14.0	14.7	71.3	144.00	28.80	21.32	0.34	0.67	0.03	0.27	0.26	0	0	13.1
SS 30 (0-30)	4.0	17.7	78.3	135.36	27.07	5.16	0.82	0	0	1.08	0	0.05	0	7.7
SS 31 (0-30)	3.0	24.7	72.3	57.31	11.46	18.81	0.14	0	0	0	0	1.97	0	4.4
SS 32 (0-30)	7.0	6.7	86.3	33.30	6.66	0.11	0.69	0.12	0	0	0.04	0.05	0	4.9
SS 33 (0-30)	2.5	14.2	83.3	72.86	14.57	4.46	0.52	0.19	0.03	0	0.02	1.38	0	8.5
SS 34 (0-30)	2.5	7.2	90.3	45.22	9.04	11.83	0.49	0.87	0	0.02	0.21	0.02	0	3.5
SS 34 (30-60)	2.5	12.2	85.3	73.60	14.72	12.26	0.77	0.96	0	0	0.08	0.35	0	3.0
NRS 1	4.0	6.7	89.3	155.40	31.08	11.14	1.19	0.12	0	0	0	0.95	0	5.8
NRS 3	3.0	9.7	87.3	247.92	49.58	12.20	1.17	0.05	0.05	1.39	0	0.82	0	3.6
NRS 4	7.0	11.7	81.3	76.85	15.37	32.70	0.66	0.44	0	0.03	0	0.01	0	25.9
NRS 6	4.0	10.7	85.3	445.80	89.16	11.44	1.02	0.56	0.02	0.04	0	4.13	0	2.4
NRS 8	4.0	7.7	88.3	104.52	20.90	9.91	0.60	0.25	0	0	0	0.02	0	3.1
NRS 9	3.0	4.7	92.3	272.28	54.46	8.85	1.01	0.25	0	0.03	0	0.02	0	5.6
NRS 10	8.0	7.7	84.3	443.16	88.63	18.96	1.46	0.84	0.11	0.04	0.25	2.14	0	2.3
NRS 11	3.0	7.7	89.3	68.02	13.60	29.99	0.58	0.87	0.02	0	0.36	0	0	5.6
NRS 12	3.0	6.7	90.3	89.98	18.00	12.39	1.19	0.62	0.11	0.19	0.28	1.07	0	10.6
NRS 13	3.0	6.7	90.3	47.40	9.48	1.09	0.89	0.59	0	0	0.25	0.38	0	5.2
NRS 14	3.0	8.7	88.3	402.36	80.47	3.35	2.74	0.51	0.08	0.58	0.19	1.81	0	4.8
NRS 16	7.0	8.7	84.8	44.74	8.95	1.63	0.64	0	0	0.04	0.08	0.01	0	1.8
PF 1 (0-30)	3.0	6.7	90.3	53.34	10.67	2.22	1.25	0.23	0	0.07	0	1.34	0	1.8
PF 1 (30-60)	3.0	6.7	90.3	34.51	6.90	0.03	0.20	0	0	0	0	2.07	0	3.3
PF 2 (30-60)	2.5	3.2	94.3	358.44	71.69	0.09	1.37	0.12	0.02	0	0.02	0.52	0	3.4

Appendix 4.4a: Plant species composition and frequency of occurrence along the proposed pipeline route (May 2001 Dry season)

S/no	Plant Species			% Frequency of Occurrence
	Scientific Name	Family/Sub family	Common Name	
	Trees/Shrubs			
1	*Daniellia oliveri*	Caesalpiniaceae	African copaiba balsam, Ilorin balsam	100
2	*Lophira lanceolata*	Ochnaceae	Ibo: Okopia	100
3	*Piliostigma thonningii*	Caesalpiniaceae	Thonning's piliostigma	88
4	*Cochlospermum planchoni*	Cochlopermaceae	-	76
5	*Combretum hispidum*	Combretaceae	Combretum	18
6	*Uapaca togoensis*	Euphorbiaceae	Hausa: Kafafago	6
7	*Annona senegalensis*	Annonaceae	Custard apple	62
8	*Borassus aethiopum*	Palmae	Borassus palm	29
9	*Syzygium guineense*	Myrtaceae	Yoruba: adere	12
10	*Antidesma venosum*	Euphorbiaceae	Ibo: okoloto	6
11	*Ficus exasperata*	Moraceae	Sandpaper plant	18
12	*Ficus sycomorus*	Moraceae	Tiv: hirkar	24
13	*Bridelia scleroneura*	Euphorbiaceae	Hausa: Kisni	12
14	*Vitex doniana*	Verbanaceae	Yoruba: Orinla	59
15	*Terminalia avicennioides*	Combretaceae	Hausa: baushe	41
16	*Chromolaeria odorata*	Asteraceae	Siam weed	41
17	*Parkia clappertoniana*	Mimosaceae	Tiv: nune; African locust bean.	82
18	*Calotropis procera*	Asclepiadaceae	Clotropis	48
19	*Elaeis guineensis*	Palmae	Oil palm	12
20	*Anacardium occidentale*	Anacardiaceae	Cashew	42
21	*Ricinus communis*	Euphorbiaceae	Castor oil	24
22	*Cassia siamea*	Caesalpiniaceae	Cassia	18
23	*Mangifera indica*	Anacardiaceae	Mango	29
24	*Azadirachta indica*	Meliaceae	Neem	35
25	*Bombax costatium*	Bombaceae	Hausa: Kurya	6
	Herbs/Vines			
26	*Aspilia africana*	Asteraceae	Haemorrhage plant	52
27	*Crotalaria retusa*	Papilionaceae	Rattlebox	29
28	*Cleome viscose*	Cleomaceae	Consumption weed or spider plant	88
29	*Centrosema pubescens*	Papilionaceae	Centrosema	48
30	*Calopogonium sp*	Fabaceae	Calopogonium	59
31	*Phyllanthus amarus*	Euphorbiaceae	Phyllanthus	65
32	*Tridax procumbens*	Asteraceae	Tridax, coat buttons	59
33	*Ipomoea ascarifolia*	Convolvulaceae	-	24
34	*Commelina benghalensis*	Commelinanceae	Wandering jew, tropical spiderwort	18
35	*Euphorbia heterophylla*	Euphorbiaceae	Spurge weed	65
36	*Euphorbia hirta*	Euphorbiaceae	Snake weed	82
37	*Anchomanes welwitschii*	Araceae	Savanna woodland araceae	24
38	*Hyptis suavotens*	Lamiaceae	Bush tea	88
39	*Urena lobata*	Malvaceae	Hibiscusbur	81
40	*Boerhavia erecta*	Nyctaginaceae	Red spiderling	35
41	*Cassia mimosoides*	Caesalpiniaceae	Japanese tea	29
42	*Smilax kraussiana*	Smilaceae	West African sarsaparilla	24
	Grasses/Sedges			
43	*Rottboellia cochinchinensis*	Poaceae	Itchgrass	48
44	*Andropogon gayanus*	Poaceae	Ganbagrass	94
45	*Brachiaria lata*	Poaceae	Brachiaria	82
46	*Imperata cylindrica*	Poaceae	Speargrass	65
47	*Hyparrhenia involucrata*	Poaceae	Roofing grass	88
48	*Hyparrhemia rufa*	Poaceae	Roofing grass	76
49	*Mariscus alternifolius*	Cyperaceae	Sedge	12
50	*Cynodon dactyton*	Poaceae	Bahama grass	24
51	*Panicum rapens*	Poaceae	Couch panicum	18
52	*Sporobolus pyramidalis*	Poaceae	Cat's tailgrass	76
53	*Setaria pallide-fusca*	Poaceae	Cattail grass	18
54	Setaria longiseta	Poaceae	Foxtail	12
56	*Rhynchelytrum rapens*	Poaceae	Blanket grass	35
57	*Cenchrus biflorus*	Poaceae	Hedgehog grass	29
58	*Pennisetum pohystachion*	Poaceae	Feathery pennisetum	53
59	*Cymbopogon citratrus*	Poaceae	Lemon grass	12

Appendix 4.4b: Plant species composition and frequency of occurrence along the proposed pipeline route (October 2001)

S/no	Plant Species			% Frequency of Occurrence
	Scientific Name	Family/Sub family	Common Name	
	Trees/Shrubs			
1	*Daniellia oliveri*	Caesalpiniaceae	African copaiba balsam, Ilorin balsam	100
2	*Lophira lanceolata*	Ochnaceae	Ibo: Okopia	100
3	*Piliostigma thonningii*	Caesalpiniaceae	Thonning's piliostigma	88
4	*Cochlospermum planchoni*	Cochlopermaceae	-	76
5	*Combretum hispidum*	Combretaceae	Combretum	18
6	*Uapaca togoensis*	Euphorbiaceae	Hausa: Kafafago	6
7	*Annona senegalensis*	Annonaceae	Custard apple	62
8	*Borassus aethiopum*	Palmae	Borassus palm	29
9	*Syzygium guineense*	Myrtaceae	Yoruba: adere	12
10	*Antidesma venosum*	Euphorbiaceae	Ibo: okoloto	6
11	*Ficus exasperata*	Moraceae	Sandpaper plant	18
12	*Ficus sycomorus*	Moraceae	Tiv: hirkar	24
13	*Bridelia scleroneura*	Euphorbiaceae	Hausa: Kisni	12
14	*Vitex doniana*	Verbanaceae	Yoruba: Orinla	59
15	*Terminalia avicennioides*	Combretaceae	Hausa: baushe	41
16	*Chromolaeria odorata*	Asteraceae	Siam weed	41
17	*Parkia clappertoniana*	Mimosaceae	Tiv: nune; African locust bean.	82
18	*Calotropis procera*	Asclepiadaceae	Clotropis	48
19	*Elaeis guineensis*	Palmae	Oil palm	12
20	*Anacardium occidentale*	Anacardiaceae	Cashew	42
21	*Ricinus communis*	Euphorbiaceae	Castor oil	24
22	*Cassia siamea*	Caesalpiniaceae	Cassia	18
23	*Mangifera indica*	Anacardiaceae	Mango	29
24	*Azadirachta indica*	Meliaceae	Neem	35
25	*Bombax costatium*	Bombaceae	Hausa: Kurya	6
	Herbs/Vines			
26	*Aspilia africana*	Asteraceae	Haemorrhage plant	52
27	*Crotalaria retusa*	Papilionaceae	Rattlebox	29
28	*Cleome viscose*	Cleomaceae	Consumption weed or spider plant	88
29	*Centrosema pubescens*	Papilionaceae	Centrosema	48
30	*Calopogonium sp*	Fabaceae	calopogonium	59
31	*Phyllanthus amarus*	Euphorbiaceae	Phyllanthus	65
32	*Tridax procumbens*	Asteraceae	Tridax, coat buttons	59
33	*Ipomoea ascarifolia*	Convolvulaceae	-	24
34	*Commelina benghalensis*	Commelinanceae	Wandering jew, tropical spiderwort	18
35	*Euphorbia heterophylla*	Euphorbiaceae	Spurge weed	65
36	*Euphorbia hirta*	Euphorbiaceae	Snake weed	82
37	*Anchomanes welwitschii*	Araceae	Savanna woodland araceae	24
38	*Hyptis suavotens*	Lamiaceae	Bush tea	88
39	*Urena lobata*	Malvaceae	Hibiscusbur	81
40	*Boerhavia erecta*	Nyctaginaceae	Red spiderling	35
41	*Cassia mimosoides*	Caesalpiniaceae	Japanese tea	29
42	*Smilax kraussiana*	Smilaceae	West African sarsaparilla	24
	Grasses/Sedges			
43	*Rottboellia cochinchinensis*	Poaceae	Itchgrass	48
44	*Andropogon gayanus*	Poaceae	Ganbagrass	94
45	*Brachiaria lata*	Poaceae	Brachiaria	82
46	*Imperata cylindrica*	Poaceae	Speargrass	65
47	*Hyparrhenia involucrata*	Poaceae	Roofing grass	88
48	*Hyparrhemia rufa*	Poaceae	Roofing grass	76
49	*Mariscus alternifolius*	Cyperaceae	Sedge	12
50	*Cynodon dactyton*	Poaceae	Bahama grass	24
51	*Panicum rapens*	Poaceae	Couch panicum	18
52	*Sporobolus pyramidalis*	Poaceae	Cat's tailgrass	76
53	*Setaria pallide-fusca*	Poaceae	Cattail grass	18
54	Setaria longiseta	Poaceae	Foxtail	12
56	*Rhynchelytrum rapens*	Poaceae	Blanket grass	35
57	*Cenchrus biflorus*	Poaceae	Hedgehog grass	29
58	*Pennisetum pohystachion*	Poaceae	Feathery pennisetum	53
59	*Cymbopogon citratrus*	Poaceae	Lemon grass	12

Appendix 4.4c: Taxonomic list of plants in streams/rivers and vegetation supported by wetlands along pipeline routes (May 2001 Dry season).

i) Free-floating or submerged communities
Ceratophyllaceae: *Ceratophyllum demersum*
Lemnaceae : *Lemna pausicostata*
Nymphaeceae: *Nymphaea lotus; N. maculata*
Araceae: *Pistia stratiotes*
Pontederiaceae: *Eichlomaea ceassipes*

ii) Macrophytes at edges of swamp or between pools of stagnant/still water/dry swamp.

a) Grasses & Sedges
Cyperaceae: *Cyperus iria, fuirena, umbellate, Elaeocharis sp*
Ponceae: *Echinolcloa pyranidalis, Paspalum polystachyum vossia cuspidate*

b) Herbs.
Amaranthaceae: *Alternanthera sessilis*
Fabaceae: *Aeschynomene indica*
Onagraceae: *Ludwigia decurrens*
Polygonaceae: *Polygonium salicifolium*
Convulvulaceae: *Ipomoea ascarifolia, I. Aquatica*

Appendix 4.4d: Taxonomic list of plants in streams/rivers and vegetation supported by wetlands along pipeline routes. (wet season)

i) Free-floating or submerged communities
Ceratophyllaceae: *Ceratophyllum demersum*
Lemnaceae : *Lemna pausicostata*
Nymphaeceae: *Nymphaea lotus; N. maculata*
Araceae: *Pistia stratiotes*
Pontederiaceae: *Eichlomaea ceassipes*

ii) Macrophytes at edges of swamp or between pools of stagnant/still water/dry swamp.
a) Grasses & Sedges
Cyperaceae: *Cyperus iria, fuirena, umbellate, Elaeocharis sp*
Ponceae: *Echinolcloa pyranidalis, Paspalum polystachyum vossia cuspidate*

b) Herbs.
Amaranthaceae: *Alternanthera sessilis*
Fabaceae: *Aeschynomene indica*
Onagraceae: *Ludwigia decurrens*
Polygonaceae: *Polygonium salicifolium*
Convulvulaceae: *Ipomoea ascarifolia, I. aquatica*

Appendix 4.4e: Plants tissue (nature leaves) elemental composition of commonest plant species along the proposed pipeline route (May 2001)

S/N	Plant Species/Sampling Location	N	P	K	Na	Ca %	Mg	Fe	Mn	Zn	Cu ppm	Cr	Cd	Ni	V	Pb	Hg
1	Phase 1 SS14 Perkia	1.269	0.026	0.05	0.023	0.641	0.193	1.34	1.2	173.1	34.5	0.6	0	0	0	57.8	0
2	***Phase 1 SS17 Aropogon***	0.771	0.035	0.13	0.045	0.640	0.097	1.07	0.6	0.4	32.3	0.6	0	0	0	0.1	0
3	Phase 1 SS18 Cassava	2.504	0.047	0.11	0.052	0.802	0.290	5.47	0.1	0.3	26.5	0	0	0	0	0.1	0
4	Phase 1 SS22 Hyperrhinia	1.163	0.053	0.06	0.034	0.962	0.580	14.42	0.1	0.3	5.82	6.5	0	0	2.3	0.1	0
5	Phase 1 SS20 Mimosa	2.340	0.043	0.09	0.033	0.481	0.097	8.54	0.1	0.3	0.03	2.6	0	0	1.2	0.1	0
6	Phase 1 SS24 Cassava	1.897	0.046	0.09	0.044	0.804	0.193	16.82	0.2	0.4	17.51	2.6	0	0	0.8	0	0
7	Phase 1 SS26 Poliostigma	1.437	0.049	0.09	0.045	0.483	0.193	14.02	0.1	0.2	36.04	0	0	0	0	44.7	0
8	Phase 1 SS23 Calapogonium	1.700	0.046	0.11	0.051	0.481	0.193	18.02	0.1	0.2	12.13	7.9	0	1.0	0	0.1	0
9	Phase 1 SS34 Daniellia	0.611	0.051	0.07	0.032	0.643	0.193	8.28	0.2	0.2	4.06	2.9	0	0	0.8	0	0
10	Phase 1 SS8 Hyptis Suavolens	0.819	0.044	0.12	0.049	0.484	0.097	14.69	0.2	0.2	30.52	3.2	0	0	0.2	0	0

Table 4.4f: Plants tissue (nature leaves) elemental composition of commonest plant species along the proposed pipeline route (October 2001)

S/N	Plant Species/Sampling Location	N	P	K	Na	Ca %	Mg	Fe	Mn	Zn	Cu ppm	Cr	Cd	Ni	V	Pb	Hg
1	Phase 1 SS14 Perkia	1.269	0.026	0.05	0.023	0.641	0.193	1.34	1.2	173.1	34.5	0.6	0	0	0	57.8	0
2	***Phase 1 SS17 Aropogon***	0.771	0.035	0.13	0.045	0.640	0.097	1.07	0.6	0.4	32.3	0.6	0	0	0	0.1	0
3	Phase 1 SS18 Cassava	2.504	0.047	0.11	0.052	0.802	0.290	5.47	0.1	0.3	26.5	0	0	0	0	0.1	0
4	Phase 1 SS22 Hyperrhinia	1.163	0.053	0.06	0.034	0.962	0.580	14.42	0.1	0.3	5.82	6.5	0	0	2.3	0.1	0
5	Phase 1 SS20 Mimosa	2.340	0.043	0.09	0.033	0.481	0.097	8.54	0.1	0.3	0.03	2.6	0	0	1.2	0.1	0
6	Phase 1 SS24 Cassava	1.897	0.046	0.09	0.044	0.804	0.193	16.82	0.2	0.4	17.51	2.6	0	0	0.8	0	0
7	Phase 1 SS26 Poliostigma	1.437	0.049	0.09	0.045	0.483	0.193	14.02	0.1	0.2	36.04	0	0	0	0	44.7	0
8	Phase 1 SS23 Calapogonium	1.700	0.046	0.11	0.051	0.481	0.193	18.02	0.1	0.2	12.13	7.9	0	1.0	0	0.1	0
9	Phase 1 SS34 Daniellia	0.611	0.051	0.07	0.032	0.643	0.193	8.28	0.2	0.2	4.06	2.9	0	0	0.8	0	0
10	Phase 1 SS8 Hyptis Suavolens	0.819	0.044	0.12	0.049	0.484	0.097	14.69	0.2	0.2	30.52	3.2	0	0	0.2	0	0

Appendix 4.5a: Physicochemical Characteristics of Surface water from the rivers/streams in the study area (May, 2001)

S/No.	Location	pH	EC µS	TDS (mg/l)	TSS (mg/l)	COLOR (PtCo)	TRUB (HTU)	COD	CO_3	HCO_3	P	NH_4	NO_3	NO_2	SO_4	Cl	Na	K	Ca
1.	WS 1	7.7	266.0	134.0	15	47	4	6.00	0	134.2	0.078	0.411	0.051	0.007	0.109	28.4	5.10	8.75	19.24
2.	WS 3	7.8	90.6	44.8	76	338	109	4.60	0	61.0	0.235	0.512	0.001	0.059	0.779	35.5	1.98	2.50	22.44
3.	WS 4	7.7	75.4	37.4	23	162	42	16.60	0	91.5	0.111	0.265	0.007	0.028	0.394	21.3	2.29	2.19	9.62
4.	WS 5	7.6	81.0	40.3	13	96	16	7.40	0	103.7	0.033	0.027	0.003	0.002	0.247	35.5	2.29	2.40	6.41
5.	WS 6	7.6	70.4	35.1	22	105	28	8.00	0	67.1	0.061	0.064	0.014	0.042	0.247	14.7	2.19	2.29	9.62
6.	WS 7	7.6	65.6	32.8	15	92	16	4.20	0	73.2	0.051	0.110	0.004	0.061	0.224	49.7	1.98	1.88	14.43
7.	WS 8	7.4	87.1	43.6	22	142	23	2.40	0	61.0	0.103	0.247	0.003	0.056	0.187	21.3	2.81	3.54	12.83
8.	WS 9	7.6	67.8	33.9	21	110	34	10.20	0	67.1	0.141	0.457	0.003	0.015	0.359	35.5	2.19	3.13	8.02
9.	WS 10	7.1	72.1	36.1	17	110	25	2.60	0	54.9	0.125	0.411	0.006	0.015	0.262	35.5	2.29	3.23	11.22
10.	WS 11	7.3	67.0	33.5	17	112	24	7.60	0	61.0	0.183	0.165	0.004	0.009	0.256	28.4	2.19	3.02	8.02
11.	WS 12	7.2	45.2	22.6	66	520	131	9.60	0	54.9	0.289	0.192	0.007	0.003	1.189	21.3	1.66	2.40	6.41
12.	WS 13	7.2	57.7	28.8	35	183	45	5.60	0	54.9	0.087	0.064	0.001	0.042	0.414	35.0	1.66	2.19	9.62
13.	WS 14	6.9	49.9	25.0	17	41	9	13.0	0	54.9	0.033	0.229	0.025	0.098	0.144	14.2	2.08	2.40	6.41
14.	WS 15	6.5	69.8	34.9	14	54	10	14.40	0	54.9	0.059	0.521	0.034	0.132	0.069	35.6	2.19	3.44	9.60

Appendix 4.5a Contd.

Location	Mg	Fe	Mn	Cu	Cr	Cd	Ni	V	Pb	Hg	THC
WS 1	12.57	0.049	0.021	0.562	0.045	0.002	0.026	0.014	2.956	0	1.1
WS 3	0.97	0.101	0.105	0.406	0.056	0	0.164	0.135	0.117	0	8.0
WS 4	3.87	0.070	0.055	0.018	0.044	0	0.064	0.058	0.044	0	4.2
WS 5	1.93	0.036	0.002	0.125	0.035	0	0.001	0.056	0.030	0	1.2
WS 6	1.93	0.035	0.026	0.006	0.038	0.003	0.174	0.031	0.029	0	2.3
WS 7	1.93	0.031	0.031	0.018	0.091	0.001	0.003	0.052	0.023	0	1.2
WS 8	0.97	0.044	0.005	0.024	0.039	0.001	0.042	0.053	0.005	0	2.1
WS 9	4.83	0.049	0.005	0.018	0.052	0	0.029	0.031	0.044	0	5.2
WS 10	2.90	0.033	0.005	0.018	0.039	0	0.026	0.023	0.023	0	3.1
WS 11	1.93	0.059	0.002	0.006	0.038	0	0.001	0.041	0.042	0	4.0
WS 12	3.87	0.160	0.224	0.078	0.044	0	.0235	0.206	0.161	0	4.1
WS 13	3.87	0.051	0.021	0.119	0.036	0	0.026	0.070	0.067	0	17.0
WS 14	0.96	0.013	0.002	0.029	0.040	0	0.100	0.019	0.016	0	7.1
WS 15	1.94	0.004	0.019	0.042	0.049	0	0.003	0.025	0.001	0	0

Appendix 4.5b: Physicochemical Characteristics of Surface water from the rivers/streams in the study area (October 2001)

Location	Temp	pH	EC µS	TDS (mg/l)	TSS (mg/l)	COLOR (PtCo)	TRUB (NTU)	DO (mg/l)	O_2 sat %	BOD (mg/l)	COD	CO_3	HCO_3	P	NH_4	NO_3	NO_2	SO_4	Cl
WS 1	31.3	6.9	244	134.0	15	47	10.0	4.5	60.9	4.4	6.00	0	134.2	0.078	0.411	0.051	0.007	0.109	28.4
WS 3	36.0	6.8	84	44.8	76	338	103.0	3.8	54.5	2.5	4.60	0	61.0	0.235	0.512	0.001	0.059	0.779	35.5
WS 4	30.9	6.8	68	37.4	23	162	60.5	4.5	62.8	2.7	16.60	0	91.5	0.111	0.265	0.007	0.028	0.394	21.3
WS 5	28.8	6.8	61	40.3	13	96	38.8	4.4	57.0	1.6	7.40	0	103.7	0.033	0.027	0.003	0.002	0.247	35.5
WS 6	28.8	6.8	62	35.1	22	105	37.8	4.5	58.0	3.2	8.00	0	67.1	0.061	0.064	0.014	0.042	0.247	14.7
WS 7	29.6	6.8	64	32.8	15	92	40.3	5.0	66.2	2.2	4.20	0	73.2	0.051	0.110	0.004	0.061	0.224	49.7
WS 8	29.1	6.9	65	43.6	22	142	47.0	4.6	59.3	3.8	2.40	0	61.0	0.103	0.247	0.003	0.056	0.187	21.3
WS 9	28.5	6.9	63	33.9	21	110	55.0	4.5	58.6	3.1	10.20	0	67.1	0.141	0.457	0.003	0.015	0.359	35.5
WS 10	31.1	6.9	61	36.1	17	110	30.7	4.6	62.4	3.2	2.60	0	54.9	0.125	0.411	0.006	0.015	0.262	35.5
WS 11	29.7	6.9	61	33.5	17	112	32.7	4.7	62.2	1.4	7.60	0	61.0	0.183	0.165	0.004	0.009	0.256	28.4
WS 12	26.5	6.9	38	22.6	66	520	116.7	5.0	63.1	2.7	9.60	0	54.9	0.289	0.192	0.007	0.003	1.189	21.3
WS 13	27.8	6.9	51	28.8	35	183	116.0	5.2	66.8	0.5	5.60	0	54.9	0.087	0.064	0.001	0.042	0.414	35.0
WS 14	27.9	6.9	33	25.0	17	41	11167.7	5.3	66.1	4.4	13.0	0	54.9	0.033	0.229	0.025	0.098	0.144	14.2
WS 15	27.8	6.9	45	34.9	14	54	87.5	5.1	65.5	4.5	14.40	0	54.9	0.059	0.521	0.034	0.132	0.069	35.6

Appendix 4.5b: Contd.

Location	Na	K	Ca	Mg	Fe	Mn	Cu	Cr	Cd	Ni	V	Pb	Hg	THC
WS 1	5.10	8.75	19.24	12.57	0.049	0.021	0.562	0.045	0.002	0.026	0.014	2.956	0	1.1
WS 3	1.98	2.50	22.44	0.97	0.101	0.105	0.406	0.056	0	0.164	0.135	0.117	0	8.0
WS 4	2.29	2.19	9.62	3.87	0.070	0.055	0.018	0.044	0	0.064	0.058	0.044	0	4.2
WS 5	2.29	2.40	6.41	1.93	0.036	0.002	0.125	0.035	0	0.001	0.056	0.030	0	1.2
WS 6	2.19	2.29	9.62	1.93	0.035	0.026	0.006	0.038	0.003	0.174	0.031	0.029	0	2.3
WS 7	1.98	1.88	14.43	1.93	0.031	0.031	0.018	0.091	0.001	0.003	0.052	0.023	0	1.2
WS 8	2.81	3.54	12.83	0.97	0.044	0.005	0.024	0.039	0.001	0.042	0.053	0.005	0	2.1
WS 9	2.19	3.13	8.02	4.83	0.049	0.005	0.018	0.052	0	0.029	0.031	0.044	0	5.2
WS 10	2.29	3.23	11.22	2.90	0.033	0.005	0.018	0.039	0	0.026	0.023	0.023	0	3.1
WS 11	2.19	3.02	8.02	1.93	0.059	0.002	0.006	0.038	0	0.001	0.041	0.042	0	4.0
WS 12	1.66	2.40	6.41	3.87	0.160	0.224	0.078	0.044	0	.0235	0.206	0.161	0	4.1
WS 13	1.66	2.19	9.62	3.87	0.051	0.021	0.119	0.036	0	0.026	0.070	0.067	0	17.0
WS 14	2.08	2.40	6.41	0.96	0.013	0.002	0.029	0.040	0	0.100	0.019	0.016	0	7.1
WS 15	2.19	3.44	9.60	1.94	0.004	0.019	0.042	0.049	0	0.003	0.025	0.001	0	0

Appendix 4.6a: Physico-chemical characteristics of Sediments of some of the rivers in the study area (May 2001)

Location	pH	EC	C	N	Av.P	NO_3	NO_2	NH_4	SO_4	Cl	Na	K	Ca	Mg	H^+	Al^{3+}	ECEC	B.Sat
	H_2O	µS	%	%	Ppm					Meq/100g soil								%
BS 3	7.9	61.8	0.32	0.04	3.0	0.047	0.002	6.58	2.59	35.5	0.25	0.10	0.96	1.60	0.20	0	3.11	93.6
BS 4	7.2	89.3	0.16	0.01	6.9	0.041	0.004	2.74	3.40	53.2	0.24	0.09	1.76	1.84	0.20	0	4.13	95.2
BS 5	6.0	83.7	0.96	0.09	7.5	0.057	0.005	9.05	4.66	35.6	0.79	0.62	15.44	7.76	0.20	0	24.81	99.2
BS 6	6.2	35.3	0.42	0.05	8.3	0.062	0.002	4.02	4.38	35.5	0.29	0.14	1.76	4.32	0.20	0	6.71	97.0
BS 7	6.1	52.3	0.54	0.05	14.4	0.038	0.008	6.67	2.19	71.2	0.19	0.12	2.08	0.64	0.10	0	3.13	96.8
BS 8	4.4	68.4	1.15	0.10	2.6	0.051	0.016	6.99	4.49	71.0	0.50	0.31	4.88	5.04	0.60	0	11.33	94.7
BS 9	4.3	79.8	1.25	0.05	17.2	0.071	0.016	0.91	4.38	35.5	0.52	0.26	1.68	1.04	0.50	0	4.70	74.5
BS 10	4.2	77.2	1.82	0.12	2.6	0.062	0.119	174.03	119.69	35.7	0.69	0.55	10.72	2.00	0.40	0	14.56	95.9
BS 11	4.5	54.0	1.50	0.15	6.9	0.090	0.015	6.76	3.34	35.6	0.66	0.44	4.48	3.04	0.40	0	9.02	95.6
BS 12	5.1	36.0	1.02	0.13	6.3	0.038	0.017	7.84	1.44	35.5	0.19	0.12	2.00	1.36	0.20	0	3.87	94.8
BS 13	4.9	42.5	1.22	0.12	6.2	0.061	0.006	7.13	6.05	35.5	0.25	0.13	1.52	1.44	0.20	0	3.54	94.4
BS 14	5.2	17.3	0.64	0.04	16.3	0.073	0.002	4.20	1.84	35.4	0.17	0.06	1.28	1.52	0.30	0	3.33	91.0
BS 15	5.2	32.7	0.80	0.06	7.3	0.051	0.002	10.42	6.05	35.5	0.13	0.05	0.72	25.68	0.10	0	26.68	99.6

Appendix 4.6b: Physico-chemical characteristics of Sediments of some of the rivers in the study area (October 2001)

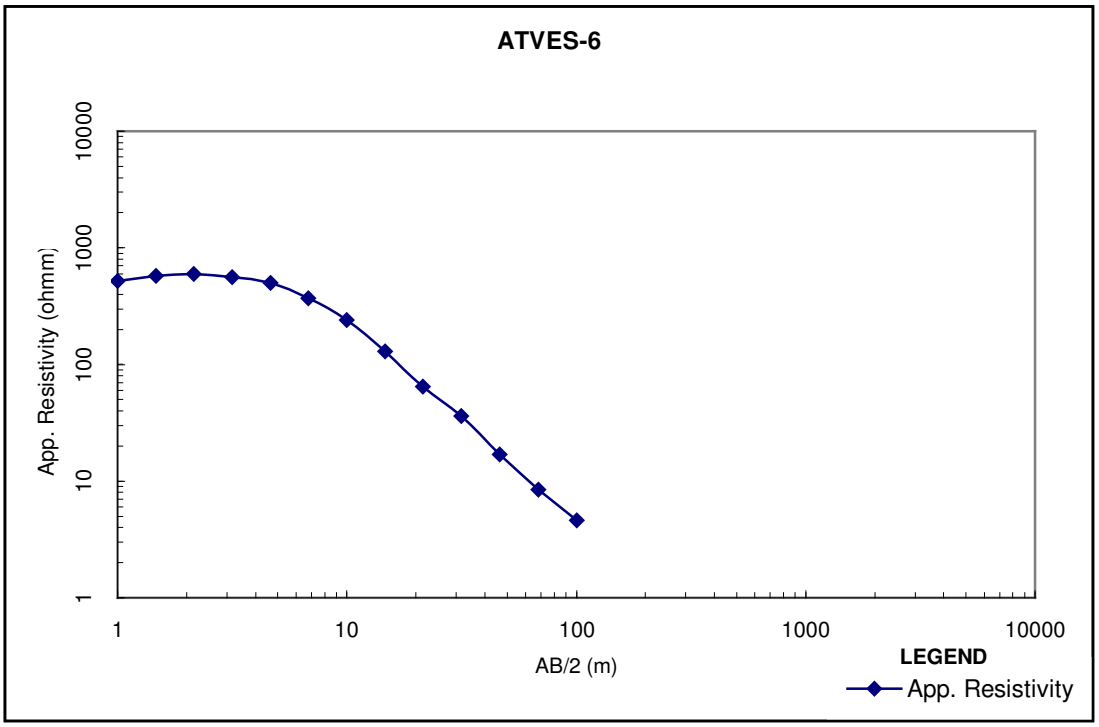
Location	pH	EC	C	N	Av.P	NO_3	NO_2	NH_4	SO_4	Cl	Na	K	Ca	Mg	H^+	Al^{3+}	ECEC	B.Sat
	H_2O	µS	%	%	Ppm					Meq/100g soil								%
BS 3	7.9	61.8	0.32	0.04	3.0	0.047	0.002	6.58	2.59	35.5	0.25	0.10	0.96	1.60	0.20	0	3.11	93.6
BS 4	7.2	89.3	0.16	0.01	6.9	0.041	0.004	2.74	3.40	53.2	0.24	0.09	1.76	1.84	0.20	0	4.13	95.2
BS 5	6.0	83.7	0.96	0.09	7.5	0.057	0.005	9.05	4.66	35.6	0.79	0.62	15.44	7.76	0.20	0	24.81	99.2
BS 6	6.2	35.3	0.42	0.05	8.3	0.062	0.002	4.02	4.38	35.5	0.29	0.14	1.76	4.32	0.20	0	6.71	97.0
BS 7	6.1	52.3	0.54	0.05	14.4	0.038	0.008	6.67	2.19	71.2	0.19	0.12	2.08	0.64	0.10	0	3.13	96.8
BS 8	4.4	68.4	1.15	0.10	2.6	0.051	0.016	6.99	4.49	71.0	0.50	0.31	4.88	5.04	0.60	0	11.33	94.7
BS 9	4.3	79.8	1.25	0.05	17.2	0.071	0.016	0.91	4.38	35.5	0.52	0.26	1.68	1.04	0.50	0	4.70	74.5
BS 10	4.2	77.2	1.82	0.12	2.6	0.062	0.119	174.03	119.69	35.7	0.69	0.55	10.72	2.00	0.40	0	14.56	95.9
BS 11	4.5	54.0	1.50	0.15	6.9	0.090	0.015	6.76	3.34	35.6	0.66	0.44	4.48	3.04	0.40	0	9.02	95.6
BS 12	5.1	36.0	1.02	0.13	6.3	0.038	0.017	7.84	1.44	35.5	0.19	0.12	2.00	1.36	0.20	0	3.87	94.8
BS 13	4.9	42.5	1.22	0.12	6.2	0.061	0.006	7.13	6.05	35.5	0.25	0.13	1.52	1.44	0.20	0	3.54	94.4
BS 14	5.2	17.3	0.64	0.04	16.3	0.073	0.002	4.20	1.84	35.4	0.17	0.06	1.28	1.52	0.30	0	3.33	91.0
BS 15	5.2	32.7	0.80	0.06	7.3	0.051	0.002	10.42	6.05	35.5	0.13	0.05	0.72	25.68	0.10	0	26.68	99.6

Appendix 4.6c: Texture, heavy metals and THC Concentrations of Sediments of some of the rivers in the study area (May 2001)

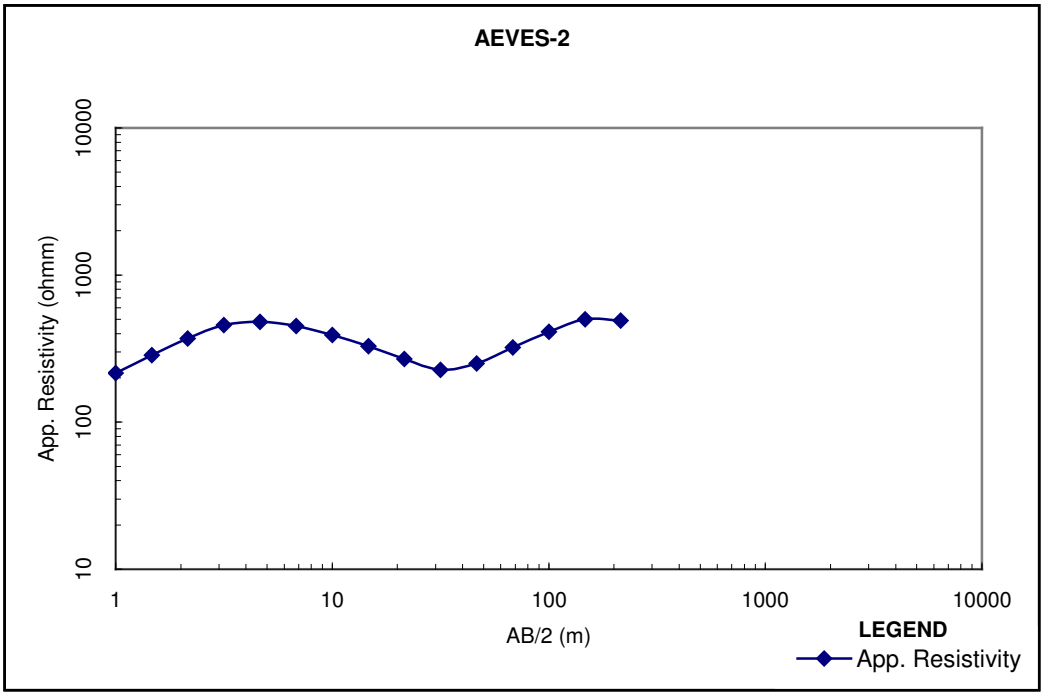
Location	Clay	Silt	Sand	Fe	Mn	Zn	Cu	Cr	Cd	Ni	V	Pb	Hg	THC
BS3	0	0	100.0	54.64	10.93	2.33	0.16	0	0	0	0	0		
BS4	0	0	100.0	131.64	26.33	3.19	0.32	0	0	0	0	0		
BS5	13.0	10.7	76.3	289.44	57.89	2.36	1.43	0.12	0.01	0.06	0	0		
BS6	0	0	100.0	218.16	43.63	0.06	0.36	0	0	0	0	0		
BS7	2.0	1.7	96.3	278.04	55.61	10.97	0.54	0.02	0	0	0	0	1.5	
BS8	12.0	7.7	80.3	382.92	76.58	3.73	1.02	0.08	0.06	0.05	0	0	1.2	
BS9	7.0	11.7	81.3	388.32	77.66	9.09	0.09	0.26	0.06	0.03	0	0	1.7	
BS10	21.0	10.7	68.3	449.76	89.95	58.71	4.68	0.12	0.12	0.15	0	0	1.2	
BS11	7.0	9.7	83.3	453.84	90.77	7.81	3.00	0.38	0	0	0	0	1.7	
BS12	4.0	9.7	86.3	421.44	84.29	7.16	1.37	0.40	0	0.02	0	0	1.7	
BS13	4.0	1.7	94.3	433.80	86.76	13.81	2.46	0.55	0	0	0	0	1.6	
BS14	3.0	10.7	86.8	390.36	78.07	4.33	1.58	0	0	0	0	0	2.6	
BS15	0	0	100.0	262.92	52.58	0.65	0.19	0.12	0	0	0	0	1.7	

Appendix 4.6d: Texture, heavy metals and THC Concentrations of Sediments of some of the rivers in the study area (October 2001)

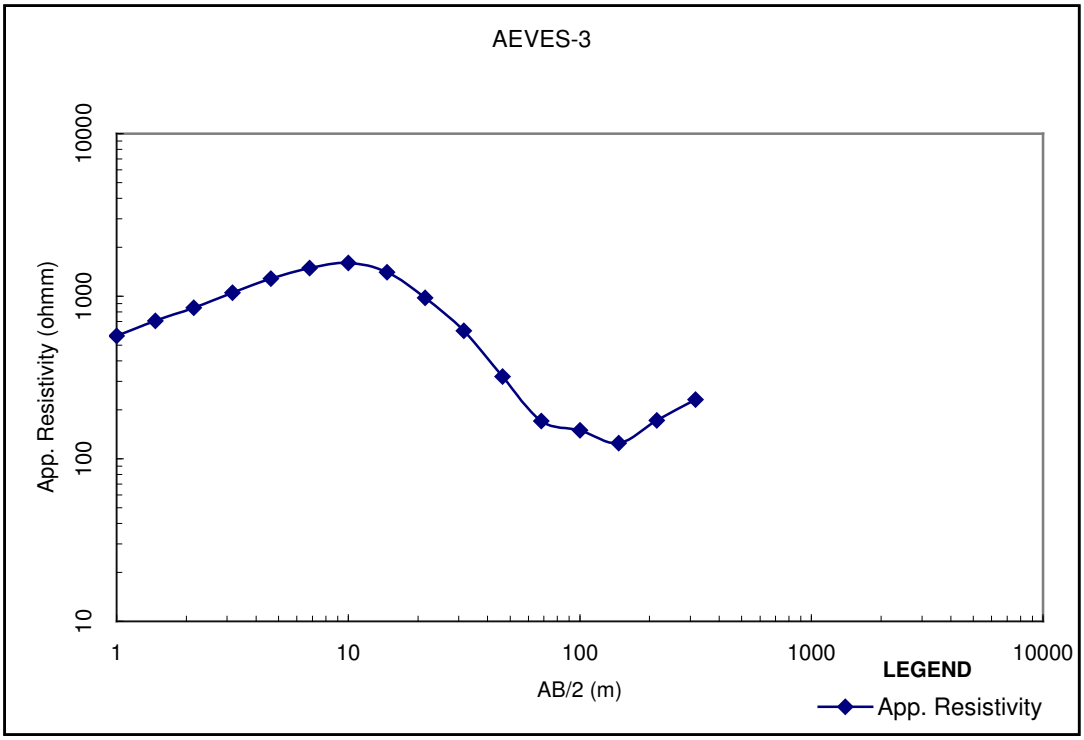
Location	Clay	Silt	Sand	Fe	Mn	Zn	Cu	Cr	Cd	Ni	V	Pb	Hg	THC
BS3	0	0	100.0	54.64	10.93	2.33	0.16	0	0	0	0	0	0	0.9
BS4	0	0	100.0	131.64	26.33	3.19	0.32	0	0	0	0	0	0	1.3
BS5	13.0	10.7	76.3	289.44	57.89	2.36	1.43	0.12	0.01	0.06	0	0	0	1.6
BS6	0	0	100.0	218.16	43.63	0.06	0.36	0	0	0	0	0	0	1.7
BS7	2.0	1.7	96.3	278.04	55.61	10.97	0.54	0.02	0	0	0	0	0	1.5
BS8	12.0	7.7	80.3	382.92	76.58	3.73	1.02	0.08	0.06	0.05	0	0	0	1.2
BS9	7.0	11.7	81.3	388.32	77.66	9.09	0.09	0.26	0.06	0.03	0	0	0	1.7
BS10	21.0	10.7	68.3	449.76	89.95	58.71	4.68	0.12	0.12	0.15	0	0	0	1.2
BS11	7.0	9.7	83.3	453.84	90.77	7.81	3.00	0.38	0	0	0	0	0	1.7
BS12	4.0	9.7	86.3	421.44	84.29	7.16	1.37	0.40	0	0.02	0	0	0	1.7
BS13	4.0	1.7	94.3	433.80	86.76	13.81	2.46	0.55	0	0	0	0	0	1.6
BS14	3.0	10.7	86.8	390.36	78.07	4.33	1.58	0	0	0	0	0	0	2.6
BS15	0	0	100.0	262.92	52.58	0.65	0.19	0.12	0	0	0	0	0	1.7



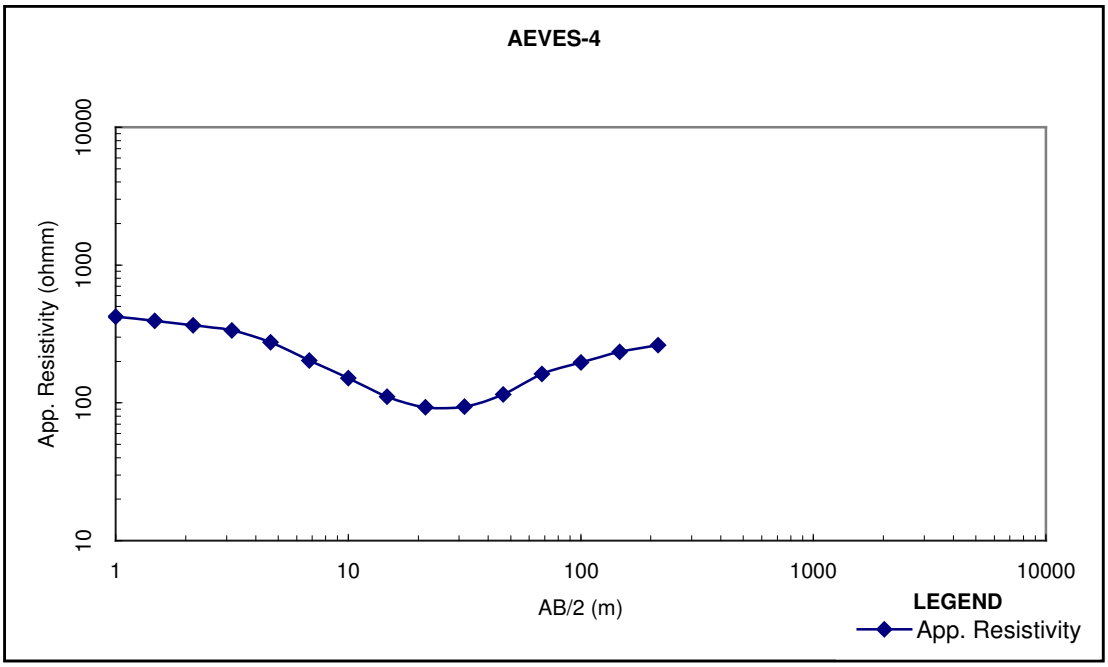
Appendix 4.7a: Response Curve for AEVES-1



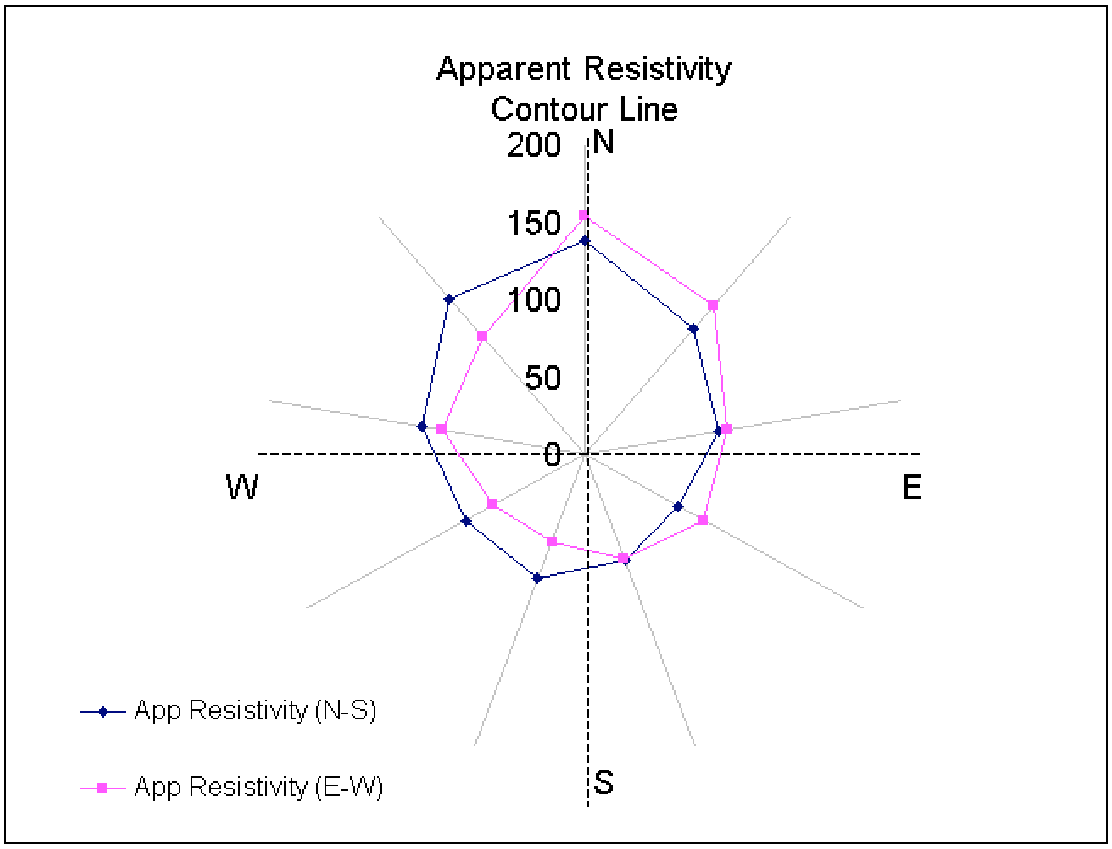
Appendix 4.7b: Response Curve for AEVES-2



Appendix 4.7c: Response Curve for AEVES-4



Appendix 4.7d: Response Curve for AEVES-4



APPENDIX 4.8: CONSULTATION LETTERS

Appendix 4.9: SIA and HIA Questionnaires

1. SETTLEMENT CODE

1.1 Date of Interview _____
1.2 Name of Village / Quarter _____
1.3 L.G.A./ _____
1.4 State _____
1.5 Ethnic Group _____

2. RESPONDENT SOCIAL DATA

2.1. Sex
- 2.1.1 Male
- 2.1.2 Female

2.2. Age
- 2.2.1 10 - 20 years
- 2.2.2 21 - 30 years
- 2.2.3 31 - 40 years
- 2.2.4 41 - 50 years
- 2.2.5 51 - 60 years
- 2.2.6 61 and above

2.3 Marital Status
- 2.3.1 Single
- 2.3.2 Married
- 2.3.3 Divorced
- 2.3.4 Widow
- 2.3.5 Widower

2.4 Level of Education
- 2.4.1 Primary School
- 2.4.2 Secondary School
- 2.4.3 Vocational/Technical School
- 2.4.4 Tertiary School
- 2.4.5 No Formal Education

2.5. Employment
- 2.5.1 Farming / Hunting
- 2.5.2 Fishing
- 2.5.3 Technician
- 2.5.4 Trading
- 2.5.5 Business/Contractor
- 2.5.6 Teaching
- 2.5.7 Civil Servant
- 2.5.8 Retired
- 2.5.9 Student / Apprentice
- 2.5.10 Unemployed
- 2.5.11 Others (specify)

2.6 Skills
- 2.6.1 Mason
- 2.6.2 Welder
- 2.6.3 Technician
- 2.6.4 Fisherman
- 2.6.5 Politician
- 2.6.6 Transporter
- 2.6.7 Unskilled

2.7 Length of Service
- 2.7.1 0 - 5 years
- 2.7.2 6 - 10 years
- 2.7.3 11 - 20 years
- 2.7.4 21 - 20 years
- 2.7.5 Above 30 years

2.8 What is your annual income ?
- 2.8.1 □1,000 - □10,000
- 2.8.2 □11,000 - □20,000
- 2.8.3 □21,000 - □30,000

2.8.4 □31,000 - □40,000
2.8.5 □41,000 - □50,000
2.8.6 □51,000 - □60,000
2.8.7 □61,000 - □70,000
2.8.8 □71,000 - □80,000
2.8.9 Above □80,000

2.9 Family Size ?
2.9.1 1 - 3
2.9.2 4 - 6
2.9.3 7 - 10
2.9.4 11 - 15
2.9.5 16 - 20
2.9.6 Above 20

2.10 Age Distribution of household
(Including Parents) ?
xxxxxxxxx MALE Age range FEMALE
2.10.1 0 - 14
2.10.2 15 – 24
2.10.3 25 – 34
2.10.4 35 - 44
2.10.5 45 - 54
2.10.6 Above 55

2.11 Distribution of household occupation
x x x MALE Status FEMALE
2.11.1 Student / Apprentice
2.11.2 Business / Contractor
2.11.3 Technician
2.11.4 Farming/Fishing/Hunting
2.11.5 Teaching
2.11.6 Civil servant
2.11.7 Married / House Wife
2.11.8 Unemployed
2.11.9 Others (Specify)

2.12 How many births in the last 12 months ?
2.12.1 :.....

2.13 How many deaths in the last 12 months ?
2.13.1 :.....

2.14 List the common sickness in the settlement ?
2.14.1 :.....
2.14.2 :.....

2.15 List the Environmental problems in the settlement ?
2.15.1 Soil infertility
2.15.2 Pest attack / invasion
2.15.3 Soil salinity
2.15.4 Erosion
2.15.5 Rain storm / flooding
2.15.6 Others (specify)
2.15.7 No idea

2.16 Status of respondent
2.16.1 Traditional ruler / head of settlement
2.16.2 Church leader
2.16.3 Traditional chief / councilor
2.16.4 Family head
2.16.5 Union leader
2.16.6 Doctor/Nurse/Herbalist
2.16.7 Immigrant / Settler
2.16.8 Visitor
2.16.8 Others (specify)

2.17 Who should speak for your community on oil matters.
2.17.1 Chief
2.17.2 Community chairman
2.17.3 Community secretary

2.17.4 Youth leader
2.17.5 Church leader

2.18 How long have you lived in the settlement
2.18.1 Less than 5 years
2.18.2 6 - 10 years
2.18.3 11 - 15 years
2.18.4 16 - 20 years
2.18.5 Above 20 years
2.18.6 Since birth

2.19 What is your religion ?
2.19.1 Traditional
2.19.2 Islam
2.19.3 Christianity
2.19.4 I worship God
2.19.5 Atheist

2.20 Of what use is the water bodies in your area ?
2.20.1 Fisheries
2.20.2 Irrigation
2.20.3 Domestic
2.20.4 Transportation
2.20.5 Recreation
2.20.6 None
2.20.7 Others (specify)

3. RESPONDENT ECONOMIC DATA

3.1 What type of house do you (own /live in) ?
3.1.1 Thatched
3.1.2 Thatched / wooden
3.1.3 Thatched / mud
3.1.4 Zinc roof / wooden
3.1.5 Zinc roof / mud
3.1.6 Zinc roof / block

3.2 Do you own
3.2.1 Canoe
3.2.2 Bicycle
3.2.3 Motor – Cycle
3.2.4 Car / Lorry
3.2.5 Engine boat
3.2.6 Fish pond
3.2.7 Other (specify)

3.3 What other properties do you own ?
3.3.1 Rubber plantation
3.3.2 Palm plantation
3.3.3 Cocoa plantation
3.3.4 Forestry / Raffia palm
3.3.5 Farm land
3.3.6 Poultry (specify)
3.3.7 None
3.3.8 Others (specify)

3.4 Rank order of pattern of land ownership ?
3.4.1 Inheritance (Patrilineal/Matrilineal)
3.4.2 Tenant / lease
3.4.3 Family
3.4.4 Outright purchase
3.4.5 Communal
3.4.6 Other (specify)

3.5 What is the total size of your land in hectares ?
3.5.1 0 - 5 (1 = football field)
3.5.2 2 - 3
3.5.3 4 - 5
3.5.4 6 - 7
3.5.5 Above 7
3.5.6 None

3.6 Which is the farming method in this area ?
- 3.6.1 Garden
- 3.6.2 Fallow
- 3.6.3 Shifting cultivation
- 3.6.4 Rotational bush fallow
- 3.6.4 Others (specify)
- 3.6.5 No idea

3.7 What cropping system is common here ?
- 3.7.1 Mono - Cropping
- 3.7.2 Mixed - Cropping
- 3.7.3 Inter - Cropping
- 3.7.4 Others (specify)
- 3.7.5 No idea

3.8 What has been the nature of Agricultural yield ?
- 3.8.1 Increasing
- 3.8.2 Decreasing
- 3.8.3 The same

3.8 Form of farming
- 3.9.1 Net (canoe)
- 3.9.2 Net (Motorised Boat)
- 3.9.3 Hook
- 3.9.4 Trap/Basket
- 3.9.5 Any other (specify)

3.10 What is your usual means of transportation.
- 3.10.1 Canoe
- 3.10.2 Engine Boat
- 3.10.3 Motorcycle
- 3.10.4 Car
- 3.10.5 Bicycle

3.11 Name Sacred sites in your community
- 3.12 …….
- 3.13 …….
- 3.14 …….
- 3.15 …….
- 3.16 …….
- 3.17 …….
- 3.18 …….

4 RESPONDENTS ATTITUDE TO COMPANY /ENVIRONMENT

4.1 Name the companys in this area and state the benefits you have derived from them.....……..?
- 4.1.1 Employment
- 4.1.2 Scholarship
- 4.1.3 Community Project (specify)
- 4.1.4 Skills Acquisition
- 4.1.5 None
- 4.1.6 Negative
- 4.1.7 Name negative effects

4.2 Are you aware of any intended project in the community ? (Yes / No) If yes, What is it ?
- 4.2.1 cement factory
- 4.2.2 gas pipeline
- 4.2.3 Development project (specify)
- 4.2.4 No idea

4.3 What benefit do you expect from this project ?
- 4.3.1 Employment opportunity
- 4.3.2 Economic boom
- 4.3.3 Infrastructural development
- 4.3.4 Scholarship
- 4.3.5 Housing
- 4.3.6 Hospital
- 4.3.7 Others (specify)

4.4 What is your attitude to this project ?
- 4.4.1 Support the project

4.4.2 Resist the project
4.4.3 No idea
4.4.4 Demand compensation

4.5 What pipeline related social-problems do you have in your area ?
4.5.1 Youth / Juvenile delinquency
4.5.2 Land dispute
4.5.3 Chieftancy tussle
4.5.4 Inter-family problem
4.5.5 Inter-village / Tribal conflict
4.5.6 Acute unemployment
4.5.7 Child abuse/ Infant pregnancy
4.5.8 Alcoholism, Prostitution
4.5.8 Other (specify)

4.6 What are your fears on the proposed project in order of importance
4.6.1 Loss of land (acquisition/deforestation)
4.6.2 Damage to farmland
4.6.3 Pollution of air/waterways
4.6.4 Health problems
4.6.5 Socio-cultural inter ference
4.6.6 High cost of living
4.6.7 Increased population
4.6.8 Soil infertility
4.6.9 Social disorder
4.6.10 Frequent death
4.6.11 Others (specify)
4.6.12 Explain your fears in details
4.6.13 …….
4.6.14 …….
4.6.15 …….

4.7 Give general comment on activities of Dangote any other company in this community ?
4.7.1 .....
4.7.2 .....
4.7.3 .....
4.7.4 ……
4.7.5 ……

4.8 What pipeline induced problem have you experienced, when and where ?
4.8.1 .....
4.8.2 .....
4.8.3 .....
4.8.4 …….
4.8.5 …….

4.9 Type of waste discharge system
4.9.1 Water System
4.9.2 Pit system
4.9.3 Bucket system
4.9.4 River
4.9.5 Bush/swamp
4.9.6 Others (specify).....

4.10 Source of water supply
4.10.1 .....
4.10.3 .....
4.10.3 .....

4.11 Do you have the following in the river/creek ?
4.11.1 Shrimps/prawns
4.11.2 Oysters
4.11.3 Thias
4.11.4 Periwinkles
4.11.5 Scallops
4.11.6 Carbs
4.11.7 Others (specify).....

4.12 Types of wild life in the area
4.12.1 .....
4.12.2 .....

4.12.3 .....

4.13 List in order of importance what you expect from oil company
4.13.1 ……
4.13.2 ……
4.13.3 ……
4.13.4 ……
4.13.5 ……
4.13.6 ……

4.14 Which group(s) in your community suffers most from industrial activities
4.14.1 ……..
4.14.2 ……..
4.14.3 ……..
4.14.4 ……..
4.14.5 ……..

QUESTIONNAIRE FOR COMMUNITY HEALTH SURVEY (HIA)

A) SOCIO-DEMOGRAPHIC VARIABLES

1. Name of Town/village_____
2. House Hold No. (District/settlement/house no.)_____
3. Age (Last birthday)_____
4. Sex: (a) Male (b) Female
5. Marital Status: (a) Married (b) Single (c) Divorced (d) Separated
6. What is the highest level of education you attained?
7 Occupation _____
8. Income per Month (for Adults only): _____
9. Ethnic Group: _____

B) LIFE STYLE / HABITS

1. Common food/preparations taken in the community

   _____

   _____

   _____

2. During the last 4 weeks how often have you had drinks containing alcohol? Would you say:
   - Every day
   - At least once a week
   - Less than once a week
   - None at all (don't take alcohol)

3. Smoking (Yes / No)
   If yes, how many sticks per day?…….

4. Use of Tobacco (Yes / No)

5. Exercise (Yes / No)
   Type ……. (b) How often …….

C) COMMON HEALTH HAZARDS IN THE COMMUNITY

1. During the last 12 months have you been admitted into a hospital on account of ill health? (Yes / No)

2. If yes for which condition?

3. List all illness episodes in the last 12 months:

   _____

_____

4. Which disease conditions in your opinion poses the greatest health threat to the community: (in order of priority)

_____

5. How many people on the average died in your community within the last 12 months: Adults ---------- Under 5 ---------- Less than one year ----------

6. What in your opinion is the most important cause of death in the community?
   (a) Amongst children under one year _____
   (b) Amongst children under 5 years _____
   (c) Amongst adults _____

D) **IMMUNISATION STATUS (CHILDREN)**

Have you received any of the following vaccines?
(i) DPT (Yes / No)
(ii) BCG (Yes / No)
(iii) Oral Polio Vaccine (OPV) (Yes / No)
(iv) Typhoid
(v) Yellow Fever
(vi) Tetanus Toxoid
(vii) Small Pox
(viii) Hepatitis Vaccine
(ix) Others (Specify)

E **KAP REGARDING SEXUALLY TRANSMITTED INFECTIONS**

1. Have you ever heard of diseases that can be transmitted through sexual intercourse?

Yes	No

2. Can you describe any symptoms of sexually transmitted diseases in women?
1. Abdominal pains
   - Genital discharge
   - Burning pain on urination
   - Genital ulcers/sores
   - Itching
   - Swelling in the groin+-
   - Others

3. Can you describe any symptoms of sexually transmitted disease in men?
   - Genital discharge
   - Burning pain on urination
   - Genital ulcers/sores
   - Itching
   - Swelling in the groin
   - Others

Yes	No

4 Have you heard of HIV/AIDS

5 Do you have a close friend or close relative who is infected with HIV or who has died of AIDS?

- Yes a close relative
- Yes a close friend
- No
- No response

6 In your opinion, can people protect themselves from contracting sexually transmitted diseases or HIV/AIDS?

If yes by what means _____

7 Do you think this project will increase or decrease the chances of people contracting sexually transmitted diseases and HIV/AIDS? | YES | No |

- o Yes will increase chances
- o Yes will decrease chances
- o No difference
- o Don't know

8 If yes, how _____

9 What do you think can be done to prevent people from contracting sexually transmitted diseases and HIV/AIDS during this project? _____

F **COMMUNITY HEALTH NEEDS**

1 What in your opinion are the most important health needs of your Community. (Score in order of priority 1 – 5)

- Safe drinking water
- Food
- Health services / clinics
- Electricity
- Good toilet system
- Waste disposal
- Others (Specify)

2 In order of preference, what do think should be done to improve the Health Services in your community?

(i) _____

(ii) _____

(iii) _____

3 What Health problems do you think may arise because of this project in your Community?

(i) _____

(ii) _____

(iii) _____

(iv) _____

4. In order of preference what do you think should be done to minimize these anticipated health problems?

(i) _____

(ii) _____

(iii) _____

(iv) _____

G) **ENVIRONMENTAL HEALTH**

1. What is the source of your drinking water?

- Tap
- Well
- Stream
- Other (Specify)

2. How do you dispose your faeces?

(a) Bucket System
(b) Pit latrine
(c) Water System
(d) Bush
(e) Into River/Stream
(f) others (specify)

3. How do you dispose your house refuse?

(a) Dustbin
(b) Open dumping on land / creeks
(c) Composting
(d) Incineration

(e) Others (specify).

(H) **OCCUPATIONAL EXPOSURES**

(a) Have you been exposed to any of the following (Explain possible sources)

- Asbestos
- Lead
- Benzene
- Coal dust
- Loud noise (over a long period of time)
- Others (name them)

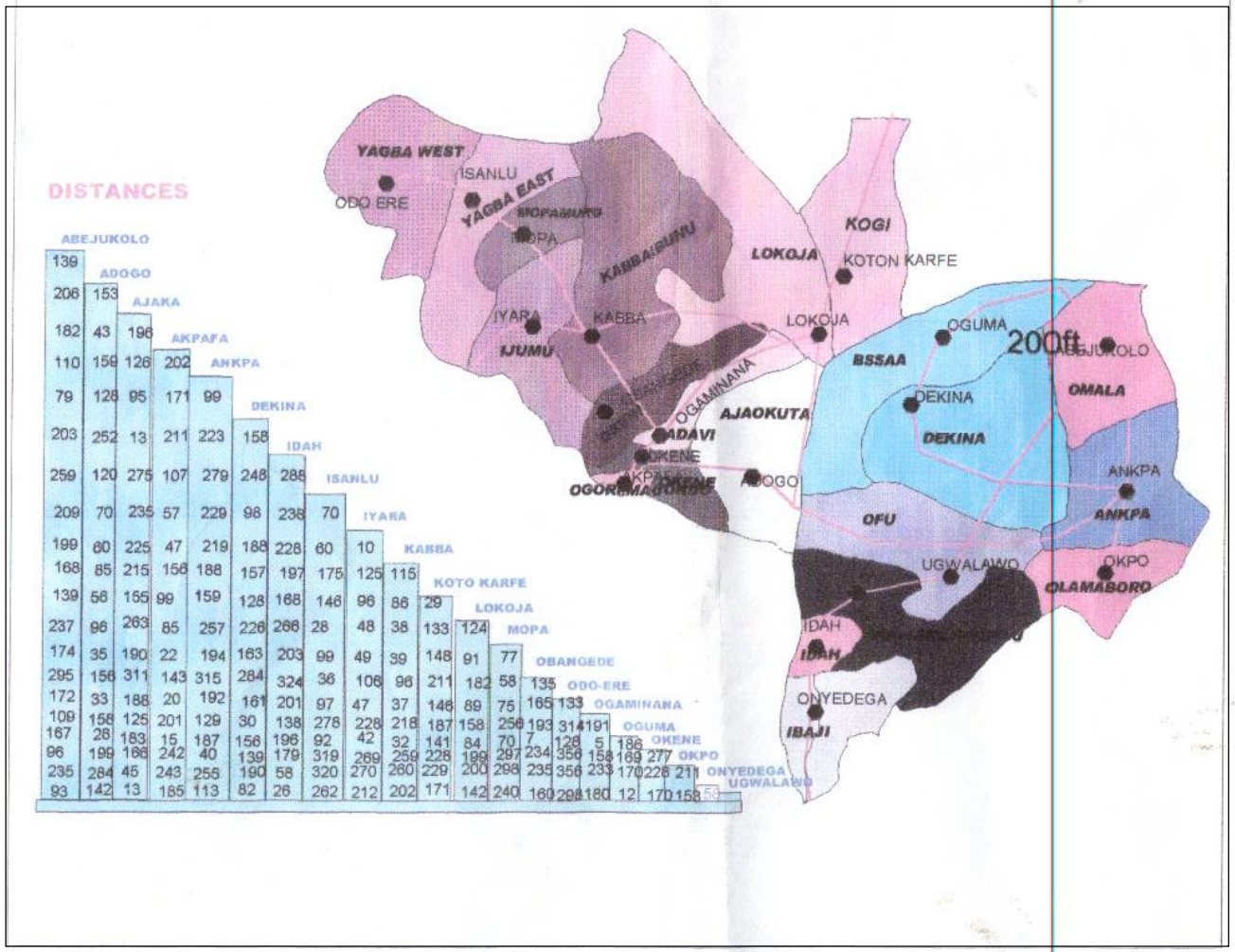
(b) Have you had any of the following occupational illnesses: (Explain symptoms)

- Respiratory diseases
- Skin diseases
- Upper limb and neck disorder
- Cancer and malignant blood disease
- Poisoning
- Noise induced hearing loss
- Infectious diseases
- Mental ill-health

Thanks a lot for your patience and co-operation.

APPENDIX 4.1a: TERMS OF REFERENCE APPROVAL LETTER FROM FMENV

Administrative Map of Kogi State Showing LGAs.



N

W E

S

LEGEND

- Lgahq.shp
- Kmapshape.shp
  - ADAVI
  - AJAOKUTA
  - ANKPA
  - BASSA
  - DEKINA
  - IBAJI
  - IDAH
  - IGALAMELA/ODOLU
  - IJUMU
  - KABBA/BUNU
  - KOGI
  - LOKOJA
  - MOPAMURO
  - OFU
  - OGORI
  - OKEHI
  - OKENE
  - OLAMABORO
  - OMALA
  - YAGBA EAST
  - YAGBA WEST

SCALE

9000 0 9000 18000 27000 Meters

DATA SOURCES:
NIGERIA SHEET 10 (1964);
KABBA PROVINCE MAP (1968);
KOGI STATE ADMINISTRATIVE MAP (1993)
AND POLITICAL MAP OF KOGI STATE (2001).

BOUNDARY NOTE

THE POSITION OF STATE AND LOCAL GOVERNMENT BOUNDARIES ARE NOT ACCURATE
THEY HAVE BEEN PHOTO REDUCED FROM EXISTING MAPS AS INDICATED IN THE DATA SOURCE

COMPILED AND PRODUCED BY:
SOVOD DIGITAL MAPPING AND COMPUTER SERVICES
OPPOSITE FEDERAL MEDICAL CENTRE LOKOJA KOGI STATE NIGERIA