Appendix 4.1: METHODOLOGY

Appendix 4.1.1: Meteorology
Data for this study was acquired via field work measurement (microclimatic data) for a period of 24 hours and long term data (macroclimatic data) from the Nigerian Meteorological Agency Oshodi, Lagos state. During the course of fieldwork, a weather station was set up in an open ground, latitude 04° 41.910’ and longitude 007° 09.313’ and allowed to run for a minimum of 24 hours in order to establish a microclimatic baseline of the study area. All precautions usually taken when setting up a weather station were observed for the onsite measurements according to the World Meteorological Organization (WMO) standard. These include setting up the weather station away from obstacles like buildings and tall vegetation, using an instrument shelter to display all temperature sensitive gadgets, orienting the instrument shelter so that the sun’s radiation does not fall directly on the instrument during reading and setting up the weather station in an area representative of the study area’s totality. The parameters monitored and method of measurement and instrumentation are summarized in Table 4.1 A.

Table 4.1A. Instrumentation and Method of Observation

<table>
<thead>
<tr>
<th>Climatic Variable</th>
<th>Instrumentation</th>
<th>Onsite</th>
<th>Synoptic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature</td>
<td>Dry bulb thermometer</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>Psychrometer/hygrometer</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Wind speed</td>
<td>Anemometer/Beaufort scale</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Wind direction</td>
<td>Wind vane</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Cloud cover</td>
<td>Direct observation</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Rainfall</td>
<td>Rain gauge</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Pressure</td>
<td>Barometer</td>
<td>√</td>
<td>-</td>
</tr>
</tbody>
</table>

Appendix 4.1.2 : AIR QUALITY
Sampling was for a period of eight hours per day with readings of all the parameters determined every hour. The following parameters were monitored during the study exercise.

- Sulphur dioxide (SO₂)
- Nitrogen dioxide (NO₂)
- Ammonia (NH₃)
- Carbon monoxide (CO)
- Hydrogen sulphide (H₂S)
- Hydrocarbon (CxHy)
- Suspended particulate matter (SPM)
- Noise
- Heavy metals in Ambient Air.

A portable gaseous emission analyzer, the TESTO 350-XL, from Testo Inc. (Testo,2009), collects and stores data independently. It measures O₂, CO, NOₓ, NO, NO₂, SO₂, HC, and H₂S. Features include a menu driven user interface and LCD display. Auto calibration and probe blow back is offered. Flow rate and sensor temperature monitoring for US EPA CTM-030, -034 and ASTM D6522 requirements. Simple on-site sensor calibration capability including diagnostics and sensor output (0 – 100%).

1
Gaseous Pollutants are monitored continuously by pulsed fluorescence. In this method, air is drawn through a sample chamber where it is irradiated with pulses of ultra-violet light. Any specified gas of interest in the sample is excited to a higher energy level and upon returning to its original state, light or fluorescence is released. The amount of fluorescence measured is proportional to the gas concentration.

### Table 4.2B: Measurement range for parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Accuracy</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>0 to 10,000 ppm H2 comp.</td>
<td>&lt; 5 ppm, 0 to 99 ppm, &lt; 5% of m.v., 100 to 2,000 ppm &lt; 10% of m.v., 2,001 to 10,000 ppm</td>
<td>1 ppm</td>
</tr>
<tr>
<td>NO₂</td>
<td>0 to 500 ppm</td>
<td>&lt; 5 ppm, 0 to 99 ppm, &lt; 5% of m.v., 500 ppm</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>SO₂</td>
<td>0 to 5,000 ppm</td>
<td>&lt; 5 ppm, 0 to 99 ppm, &lt; 5% of m.v., 100 to 2,000 ppm &lt; 10% of m.v., 2,001 to 5,000 ppm</td>
<td>1 ppm</td>
</tr>
<tr>
<td>H₂S</td>
<td>0 to 300 ppm</td>
<td>&lt; 2 ppm, 0 to 39.9 ppm, &lt; 5% of m.v., 40 to 300 ppm</td>
<td>0.1 ppm</td>
</tr>
</tbody>
</table>

**Total Suspended Particulate Matter (TSPM)**

A Met One Instrument Aerosol Mass Monitor meter and an Air metrics Minivol instrument was used to measure Total Suspended Particulate Matter and heavy metals. MiniVol Portable Air Sampler manufactured by Airmetrics is a portable ambient air sampler for particulate (PM₁₀, PM₂.₅ and SPM).

The sampler consists of a vacuum system and filter housed in a shelter and operates on the same principle as a vacuum cleaner. A known volume of air is drawn through a pre-weighed filter for a 8-hour period. The filter is then re-weighed to determine the mass of the particles collected. The digested filter paper is then analyzed for trace metal concentrations.

#### 4.1.3 NOISE

A ExTech Model sound level meter was used to measure noise levels in each location. Noise Level at each point is measured with a pre-calibrated digital readout. The equipment measures noise via microphone probe that generates signals appropriately proportional to sound waves. The sensor of the noise meter was directed upwards and the average reading over a period of two minutes was taken to be the Noise-level at each point. The noise levels were measured in decibels (dBA).

**Table 4.1 C: Sound Meter Properties**

<table>
<thead>
<tr>
<th>Measuring range:</th>
<th>30~130dBA,</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy:</td>
<td>+/- 1.5dB</td>
</tr>
<tr>
<td>Resolution:</td>
<td>0.1dBA</td>
</tr>
<tr>
<td>Frequency range</td>
<td>31.5Hz to 8.5KHz;</td>
</tr>
</tbody>
</table>

#### 4.1.4 VEGETATION

The plant community within each delineated transect was assessed using the segmented transect sampling technique (Oosting 1956; Odu et al 1985; Okpon et al 1998), to ensure maximum chances of finding and recording most of the component species in the area. In the process blocks of 5m x 5m in size were laid on a randomly chosen side of the transect, for detailed studies. Such alternately spaced observation points which cover the entire study area as demarcated by these transects are generally considered more efficient statistically than the contiguous or 100 percent assessment of a smaller length of transect (Odu et al 1985).
Among the parameters investigated in each transect were floristic composition, community structure, numerical abundance, percentage frequency of occurrence, maximum tree height (using an altimeter), stocking density and percentage litter cover. After the general physiognomy of the vegetation, all the plant species were identified to possible taxonomic levels and listed on the field. Taxonomically difficult forms that could not be identified with certainty were collected with a secateurs (including the twig, flower, fruits, etc), properly pressed and labeled, and subsequently taken to the Herbarium, Rivers State University of Science & Technology (RSUST), Port Harcourt for further keying and identification. All identification followed the keys of Hutchinson and Dalziel (1968) and Keay et al (1964) for trees; and Akobundu and Agyakwa (1998) for weeds.

**Phytopathology**

Investigations on the pathological conditions of plants were carried out by physical examination of individual plants/crops for signs of infection (Hill and Waller 1982) within the transects and neighborhood and randomly in all directions. When symptoms of diseases were detected, the number of diseased plants in each transect was recorded and used to calculate the transect disease incidence, using the formula:

\[
\text{Disease Incidence} = \frac{\text{Number of diseased plants}}{\text{Total number of plants examined}} \times 100
\]

Thereafter, samples of diseased plant parts were collected asceptically (using a pair of forceps dipped in absolute alcohol) and immediately transferred into properly labeled sterile bottles / vials. The samples were subsequently transported to the Plant Pathology Research Lab., RSUST, Port Harcourt for culturing and diagnosis. The degree of each infection was rated using a pathological severity indices or categories:

1 = mild infection; 2 = moderate infection and 3 = severe infection

**Phytochemical Analysis**

Leaves of four herbaceous species, commonly found in three sites (Gbarantoru, Zarama and Kaiama), namely *Amaranthus spinosus*, *Ageratum conyzoides*, *Mimosa pudica*, *Phyllanthus amarus* were selected for phytochemistry. The ethanol extracts of the leaves were filtered through 110 mm Whatman filter paper, followed by Thin Layer Chromatography (TLC) run on silica gel 254 and eluted with 4 toluene:1 ethyl acetate. Each of the extracts were tested for the presence of secondary metabolites such as Alkaloids, flavonoids, tannins, glycosides, phenols and steroids in the way of Harbone (1984), and Jack and Okorosaye-Orubite (2008), and Nwokocha et al (2011) methods.

4.1.5 WILDLIFE

This involved various conventional techniques, both direct and indirect methods (Moshby 1974; Dasmann 1964; Sutherland 2000; Davies 2002, Akani et al 1999, 2008 etc ), since the major objectives were to produce a comprehensive checklist of the fauna, determine their distribution and conservation status, against which future changes and magnitude of change in wildlife population would be detected. Several wildlife ecologists of the Niger Delta region have successfully adopted these methods (Anadu and Oates 1982; Happold, 1987; Anadu and Green 1990; AA.VV 1997, 1998; Powell 1998; Angelici 1998; Angelici et al 1999, Akani 1999, 2008). Considering the dependence of wildlife on vegetation for shelter, food, nesting site, etc, sampling stations were same as vegetation transects.
Within each transect and nearby footpaths, farmlands, streams, wildlife physical presence and evidence of occupation (footprints, trails, burrows, fecal droppings, sloughed skin, carcass, food remains, playground, etc) were searched for, while walking at a rate of 1km/hr. Stopovers were made at intervals to listen to animal vocalizations or calls, and high power binoculars (Fujiyama Model) were used to screen trees for arboreal forms like squirrels, snakes, birds, etc, and when necessary photographic documentation was done using a high resolution digital camera. Each transect was sampled twice during the period.

Critical habitats and microhabitats such as logs, litter, forest undergrowth, crevices and burrows were ransacked with the aid of 1m long stick to dislodge any hiding herpetofauna and mammals. To increase the chances of sighting more animals or their evidence of presence, the search was carried out radially along the northern, southern, eastern and western axis of each transect. Pit fall traps were also established in some transects to trap ground running or crawling animals such as amphibians, snakes, skinks, rats, etc (Akani, 2008).

All dislodged and sighted animal were identified to possible taxonomic levels, using the exquisite field guides and keys of Happold (1987), Kingdon (19970, and Powell (1995) for mammals; Peterson (1980) and Borrow and Demey (2001) for birds; Branch (1995) for reptiles; Schiotz (1963, 1969) and Rodel(2000) for amphibians.

Further information concerning the wildlife of the area were collected from literature data from tertiary institutions, forestry departments of Bayelsa State, and interviews with groups of bushmeat sellers at Gbarantoru, Zarama and Kaiama and hunters who assisted us as field guides or escorts. Each group consisted of 10 bushmeat dealers and hunters, and only those information for which there was ≥ 50% consensus of opinion was taken as correct (Akani, 2008). At their homes, hunters were urged to present for examination and identification any preserved animal remains or trophies such as – skin, skull/skeleton, horn, hoof, scale, shell, etc caught in the area, as well as say the last time they sighted or killed each animal discussed. Interviewing of locals as adopted in this study has been acknowledged by several ecologists (Gadgil 1992, Akani, et al 1999; Akani 2008, Greengrass 2009) as a veritable source of information for the habitat history and land-use of any place.

4.1.6 SOIL STUDIES

Soil samples were collected using a stainless steel soil auger. Systematic sampling design (systematic line transect) is employed to collect soil by establishing plots across the sampled area Soil samples were collected at depths of 0-15cm (surface/topsoil) and 15-30cm (subsurface/bottom).

**Sampling tools**
- **Soil auger:** Auger was made of stainless steel, and is capable of retrieving a cylindrical plug of soil 2 inches in diameter and 2 inches deep.
- **Trowels:** used for extruding soil sample from the auger and the use of chrome plated trowels was avoided because samples were to be analyzed for trace metals, as they may interfere with the analysis.

**Collection containers:** The following sub-samples were taken for each depth, namely;
- Samples for physico-chemical parameters which were put into polythene bags;
- Samples for hydrocarbon analysis which were put into glass bottles;
- Samples for hydrocarbon and microbiological analysis collected McCartney bottles were stored in ice-packed coolers

**Gloves:** for personal protection and to prevent cross-contamination of samples. May be plastic or latex; should be disposable and powder less.

**Field notebook** : a bound book used to record progress of sampling effort and record any problems and field observations during sampling.

**Measuring tape or pocket ruler:** used to measure the length of soil core in the soil coring device.
Sample Containers And Labeling
Soil borings will be collected directly into sample containers, and transported in an iced cooler to the participating laboratory. For each soil core, sample identification labels are required. A label is affixed to the sample container.
Sample labeling will occur as prescribed below:
1) pre-printed label onto the sample container.
2) Repeat for each soil core collected using clean sample containers and unique sample ID numbers. Do not allow samples to freeze; place all samples directly onto wet ice (4°C). Samples are transported under a chain of custody, protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Particle Size Matrix
A soil texture triangle (Toogood, 1958) is used to classify the texture class

4.1.7 Surface water
Sampling was designed to describe the existing characteristics of the study environment that constitute reliable measurable indices in natural environmental status. Thus, any change caused by the proposed project can be effectively identified. The following precautions were taken to ensure validity of results of in-situ measurements:

- Instrument was calibrated before use and was standardized using known standards,
- Measurements were taken more than once to ensure data were within confidence limits,
- Electrodes were rinsed with distilled water, then with sample of interest before measurement, to avoid interference.
- Instruments were adjusted to the observed temperature for temperature dependent parameters such as pH, DO and Conductivity.
All samples were preserved in ice chest (coolers) prior to transportation to the laboratory for analysis. Unstable physicochemical parameters of the water such as pH, DO, temperature, salinity, turbidity and conductivity, were measured in-situ, using pre-calibrated portable digital meters.

Table 4.1 D  Specific Analytical Methods for physicochemical parameters.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Parameters</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>ASTMD 1259 - 99</td>
</tr>
<tr>
<td>2</td>
<td>Temperature (°C)</td>
<td>API-RP 45</td>
</tr>
<tr>
<td>3</td>
<td>Conductivity (µs/cm)</td>
<td>APHA 2510 A</td>
</tr>
<tr>
<td>4</td>
<td>Turbidity (NTU)</td>
<td>APHA 2130</td>
</tr>
<tr>
<td>5</td>
<td>Total Dissolved Solids (mg/l)</td>
<td>ASTM D 1868</td>
</tr>
<tr>
<td>6</td>
<td>Biological Oxygen Demand (mg/l)</td>
<td>APHA 5210-B</td>
</tr>
<tr>
<td>7</td>
<td>Chemical Oxygen Demand (mg/l)</td>
<td>APHA 5220-B</td>
</tr>
<tr>
<td>8</td>
<td>Total Suspended Solids (mg/l)</td>
<td>ASTM D 1868</td>
</tr>
<tr>
<td>9</td>
<td>Sulphate (mg/l)</td>
<td>APHA 2320-B</td>
</tr>
<tr>
<td>10</td>
<td>Nitrate (mg/l)</td>
<td>ASTM D 512-89</td>
</tr>
<tr>
<td>11</td>
<td>Phosphate (mg/l)</td>
<td>APHA 4500 P045</td>
</tr>
<tr>
<td>12</td>
<td>Total Hardness (mg/l)</td>
<td>ASTM D 1868</td>
</tr>
<tr>
<td>13</td>
<td>Magnesium Hardness (Mg) (mg/l)</td>
<td>APHA 3111B</td>
</tr>
<tr>
<td>14</td>
<td>Calcium Hardness (Ca) (mg/l)</td>
<td>APHA 3111B</td>
</tr>
<tr>
<td>15</td>
<td>Mercury (Hg) (mg/l)</td>
<td>ASTM D 3228 - 95</td>
</tr>
<tr>
<td>16</td>
<td>Copper (Cu) (mg/l)</td>
<td>ASTM D 1688 - 95</td>
</tr>
<tr>
<td>17</td>
<td>Lead (Pb) (mg/l)</td>
<td>ASTM D 3559-96</td>
</tr>
<tr>
<td>18</td>
<td>Zinc (Zn) (mg/l)</td>
<td>ASTM D 1691 -95</td>
</tr>
<tr>
<td>19</td>
<td>Iron (Fe) (mg/l)</td>
<td>APHA 3111B</td>
</tr>
<tr>
<td>20</td>
<td>Cadmium (Cd) (mg/l)</td>
<td>ASTM D 3866 - 92</td>
</tr>
<tr>
<td>21</td>
<td>Arsenic (As) (mg/l)</td>
<td>ASTM D 3228 - 95</td>
</tr>
<tr>
<td>22</td>
<td>Nickel Ni (mg/l)</td>
<td>ASTM D 1886 - 94</td>
</tr>
<tr>
<td>23</td>
<td>Chromium Cr (mg/l)</td>
<td>ASTM D 1687-92</td>
</tr>
</tbody>
</table>

4.1.8 SEDIMENTS
Sediment samples from bottom of the water body were collected using a mechanized grab sampler (Ekman grab). A successful grab was obtained at each of the sampled stations. The content of the sampled was prepared for physico-chemical analysis as well as other parameters including microbiology and hydrocarbon analyses.
Sediment samples for hydrocarbon analysis were collected in glass bottles and stored in the coolers for onward transfer to the laboratory. Samples for physico-chemical analysis were collected in the same manner while samples for microbiological analysis were collected in sterilized plastic bottles and stored in the ice chest.
The quality control measures also included avoiding samples contamination and deterioration as sampling tools and containers were pre-sterilized, pre-treated and preserved on transit in ice-cooled chest (<40°C) and transported to the laboratory. All samples were immediately and effectively labelled with tags and ineffaceable markers. Samples were stored in refrigerator pending subsequent analyses especially for parameters having short holding times such as total hydrocarbon, microbiological and heavy metal analyses. The following parameters were analysed in the laboratory using the accompanying methods.

4.1.9 Microbiology
Heterotrophic bacterial and total fungal counts were enumerated by inoculating plates in duplicate with 0.1ml aliquot of serially diluted sample in peptone water. 1ml was transferred into 9ml sterile peptone water to make a 10 fold dilution. Inoculum was taken from the 10^-3 dilution.
Sterile molten nutrient agar was aseptically poured into the bacteria plates to support bacterial growth while sterile molten sabouraud dextrose agar was aseptically poured into the fungi plates to support fungal growth. The plates were incubated at 28°C for 24h.
Hydrocarbon utilizing bacteria and fungi were enumerated by inoculating plates in duplicate with 0.1ml aliquot of serially diluted sample in peptone water. 0.1ml solution of tetracycline was added into the fungi plates to inhibit bacterial growth while 0.1ml solution of flagyl was added into bacterial plates to inhibit fungi growth.
Sterile molten mineral salt agar of Mills et al. (1978) was aseptically poured into all the plates. The hydrocarbon source was supplied through the vapour phase by placing filter papers (Whatman No 1) impregnated with 1ml of filter sterilized Bonny light crude oil on the lids of the plates. The plates were incubated at 30°C for 7 days.
The laboratory methods used in the analysis of bottom samples are the same as the one used for surface water samples. APHA (1985), Allison (1965) and Bray & Kurtz (1945).

Total Heterotrophic Bacteria and Fungi
Heterotrophic bacteria and fungi were estimated by aerobic standard plate count (Pour Plate technique). Serial dilutions of the samples were performed using sterile peptone water as diluent. Sample (1.0 ml) was transferred aseptically into 9.0ml sterile peptone water to give a 10-fold dilution (10^-1). Bottle containing peptone water and sample was vigorously shaken and allowed to stand for a minimum of 5mins. Further dilutions were carried out until a desired dilution factor (10^-3) was achieved which depends on the source of the sample.

Aliquot (0.1ml) of the dilution fold of 10^-3 was used to inoculate sterile Petri dishes in triplicates. Sterile molten nutrient agar was then aseptically poured (Pour Plate Method) into sterile plate to support bacterial growth while Sabouraud dextrose agar was used for fungi growth with addition of acid. Culture plate were allowed to solidify and then inverted, followed by incubation at 28°C ± 2.0°C for 24h. Sabouraud dextrose agar plates were incubated at same temperature for 3 days.
After incubation, culture plates were counted (Total Viable Count (TVC) and results calculated thus:
fu/ml = \frac{\text{TVC} \times \text{dilution factor}}{\text{Inoculum vol.}}
Final results obtained were expressed in cfu/ml for surface water.

Hydrocarbon Utilising Bacteria and Fungi

The vapour-phase method (Mills et al. 1978) was employed for determination of hydrocarbon utilizing bacteria and fungi. Aliquots (0.1ml) of serially diluted sample in peptone water was inoculated into a sterile Petri-dish in duplicates for both bacteria and fungi culture. Tetracycline solution (0.1ml) of 50mg/l was added to the fungi plates to suppress bacterial growth while flagyl solution (0.1ml) of 50mg/l was added to bacterial plates to inhibit fungal growth.

A sterile molten mineral salt agar [NaCl (10g/l); MgSO₄·7H₂O (0.42g/l); KCl (0.2g/l); KH₂PO₄ (0.83g/l); Na₂HPO₄; NaNO₃ (0.42g/l); Agar Power (20g/l); Crude Oil (1%v/v) and Distilled Water(1000ml)] to which trace metals of specific volume had been added (usually 2ml/l) was then poured aseptically into all inoculated plates. The plates were allowed to stand for solidification after which they were inverted. A piece of Whatmann filter paper which had been previously soaked in Bonny light Crude oil was then picked using a forceps and placed in the lid of each Petri-dish. Culture plates were incubated in inverted position at 30°C for 7 days for Hydrocarbon Utilizing Bacteria and 14 days for hydrocarbon utilizing fungi.

Total and fecal coliform

Total and fecal coliform bacteria were determined using Multiple Tube Fermentation Technique expressed as Most Probable Number (MPN) APHA 9222C.

Presumptive Coliform Test

A 10ml water sample was dispensed into 10ml sterile double strength Mac Conkey broth in test tubes containing inverted Durham tubes for gas collection. A 1ml water sample was also dispensed into 5ml single strength Mac Conkey broth (sterile) in test tubes incorporated with inverted Durham tubes. To another three (3) set of test tube containing 5ml sterile single strength Mac Conkey broth to which inverted Durham tubes had been incorporated, was 0.1ml of the water sample dispensed.

All tubes were incubated at 37°C for 24hours. The numbers of coliform organisms present were determined by the presence of gas and acid using the most probable number table. Results were expressed in MPN/100ml.

Confirmation Test

To confirm that the gas forming organism in the sample is *E. coli*, the 24-hour culture was streaked unto to an Eosin–Methylene Blue (EMB) plate and incubated for 24 hours. *E. coli* grown on EMB gives a characteristic colony with a metallic sheen. The presence of such colonies was taken as a positive confirmed test.

Completed Test

A loop from the positive tubes in the differential coliform test was cultured into sterile single Mac Conkey broth in test tubes containing inverted Durham tubes for the collection of gas. All test tubes were incubated at 44°C for 24hr for feacal coliforms and 37°C for total coliforms. Test tubes showing the production of gas and acid indicate the presence of *E. coli*. Quantitative estimation of the number of *E. coli* present was then recorded using the MPN Table. Results were expressed in MPN/100ml.
4.1.10 HYDROBIOLOGY

Phytoplankton

Phytoplankton samples were obtained by the direct method where a sample of surface water (1 litre) was collected in opaque plastic containers and fixed with 5% formalin-water mixture. In the laboratory, the organisms were identified with the aid of a binocular microscope using appropriate keys (Durans and Leveque, 1980; Kadiri, 1988).

Zooplankton

Zooplankton samples were collected with the aid of plankton net. This was done by sieving a known volume of water through plankton net and the materials in the collection bottle were then transferred into sample containers and preserved in 5% formaldehyde-water mixture. In the laboratory, few drops of laboratory prepared lugols iodine were added to the samples to aid the identification process. Identification keys from Barnes, (1980), Newell and Newell, (1977) were used as guide for the zooplankton identification and classification.

Benthos

An Ekman grab was used for the collection of sediment / benthos samples and emptied into a plastic bucket. This was washed through a 0.5 mm mesh size sieve and the materials retained in the sieve put into a plastic container and fixed with 10% formalin-water mixture and carefully packaged for laboratory analysis. In the laboratory, the organisms were sorted, identified and classified using appropriate keys (Fauchald, 1977 & 1979).

4.1.11 Fisheries

Data were collected by means of a structured interview schedule on fisher folks, consultations and literature review were also used to obtain information on species diversity, relative abundance of fish species in the study area, their seasonality of abundance and sizes. Furthermore, fishes were caught using the services of local fishermen and supplemented by observations of fishing gears and crafts. Fish samples were collected and transported to the laboratory in polythene bags containing ice blocks to prevent spoilage and then stored in a deep freezer to avert posthumous deterioration.

In the laboratory, fish samples were identified using reliable identification keys compiled by Holdeen and Reed (1972), Reed et al. (1967), sorted into species and families, and each fish weighed to the nearest 0.1g using the Citizen Electronic balance and also determined for condition factors, Total Length (TL) and Weight Measurements.

Condition Factor

The condition factor (kF), an index of the well being of the fish was computed using the formula.

\[ kF = \frac{100W}{L^3} \]

Where,

- \( W \) = weight of fish in grams
- \( L \) = standard length of fish in centimetre

Total Length (TL) and Weight Measurements

Fish total length (cm) was measured using a measuring board as described by Lagler (1970), while weight was measured using the Citizen Electronic balance with sensitivity of 0.1g after identification of the sampled species.
Fish Tissue Metal Analysis
Samples of gills, Spleen, liver, gonads and Kidneys of *Oreochromis niloticus*, *Parachana obscura* and *Clarias gariepinus* were rinsed with distilled water and oven dried at 105°C. The dried fish was crushed and powdered in an agate mortar, and kept in polyethylene bottles for analysis. One (1) gram portions of fish tissues were digested and analysed using a GBC Avanta AAS (Model number: A6600)

4.1.12 HYDROGEOLOGY
Auger drilling method was used throughout. This involved driving a 5-inch auger into the ground and adding the drill stems continuously until the desired depth was reached. The auger did the drilling and was also used to bail out soil samples for lithologic/stratigraphic log description and sieve analysis. The boreholes were screened, gravel-packed and developed until there was clean water before sampling. PVC materials were used to construct the boreholes. This drilling method ensured the collection of representative samples from the boreholes as no chemicals were used.

Lithologic sampling
Lithologic samples were collected from the auger as the boreholes were being drilled.

Groundwater Sampling
Borehole water samples were collected from the 5 boreholes drilled. The water samples were taken with an ISCO bailer from the boreholes drilled in clean 1.5-litre plastic bottles after rinsing each bottle with the sample to be collected. The bottles were filled to the brim to expel oxygen which could trigger reactions and falsify results. The water samples were stored in ice-packed coolers and transported to the laboratory for analysis within 48 hours.

Determination of groundwater flow direction
Groundwater flow direction was determined using BH1, BH2, and BH3. The positions of these boreholes were transferred to the map and their elevations above mean sea level measured with the GPS. The depth to water (SWL) in each of the three boreholes was also measured. For each borehole, the SWL measured was subtracted from the borehole elevation to obtain hydraulic head. The hydraulic head values so determined for the three boreholes were used to draw equipotential lines. Perpendicular lines drawn to these equipotential lines in the direction of lower hydraulic heads gave the groundwater flow direction in the area.

Determination of permeability of soil materials
The permeability of the sands was estimated from Hazen’s Formula. The sands were sieved through a stack of sieves, the data generated were plotted on a semi-log paper (Appendix 1), $d_{10}$ values were obtained from the plot, and used to calculate the permeability from Hazen’s Formula as follows:

\[ K = C d_{10}^2 \]

Where

- \( K \) = Permeability
- \( C \) = constant. For \( K \) in cm/s and \( d_{10} \) in mm, \( C = 1 \) (Freeze and Cherry, 1979)
- \( d_{10} \) = effective diameter, mm defined as diameter such that that 10 % by weight of the porous matrix consists of grains smaller than it.

The permeability of the clays was calculated from consolidation test using the formula:

\[ K = c_v m w c_w = c_v a v w / 1 + e_0 \]

Where \( K \) = permeability
CV = coefficient of consolidation
m_v = coefficient of volume compressibility
\( \gamma_w \) = unit weight of water
a_v = coefficient of compression, and
e_o = void ratio

These parameters were obtained from the consolidation test results.

4.1.13 Social Impact Assessment
Data collection relied on a largely pre-coded household questionnaire administered face-to-face to a probability sample of household respondents at one point in time by trained assistants; discussions with Focus Groups (especially occupational sub-groups); interview of Key Informants (knowledgeable persons within the community); observations and measurements of key community features undertaken by trained assistants; as well as photography. Data analysis mainly entailed use of univariate summary statistics and population projection models. The study belongs to the class described as “passive-observational”, in the sense that subjects were studied in situ, without any form of experimental manipulation. Social Impact Assessment was carried out, using the Hazards and Effects Management Process (HEMP) developed by Shell and internationally utilised.

Use of a Matrix
A matrix of sensitivities (social environmental attributes) against hazards (sources of effects) was used to identify impacts, by noting the nature of interaction between the hazards and sensitivities.

Impact Qualification
Impact qualification was based on the effect of a hazard on a social sensitivity, with reference to the following aspects: positive or negative; direct or indirect; short term/temporary or long-term/permanent; reversible/irreversible; phase of occurrence (mobilization, construction, operations, or decommissioning and abandonment); local and/or regional, and/or national, and/or global; and incremental/non-incremental.

Significance Rating
This entailed the use of a Risk Assessment Matrix (RAM) is employed with likelihood of occurrence of the impact plotted on the y-axis and its consequence on the x-axis. The cells of this matrix, representing possible combinations of likelihood and consequence, give the levels of impact significance as judged by experts. For instance, an impact adjudged to have a low likelihood of occurrence but of great potential consequence will have a minor significance rating.

4.1.14 HEALTH STUDY

Primary Data
Primary data was collected by means of Household Survey, Focus Group Discussions, Key Informant Interviews (KII), Indept interviews and Nutritional Assessment of children below the age of five years and Environmental Health Survey.

Household Survey
Information was collected from a sample of households' representatives in the five communities with an approved standard HIA structured questionnaire. The questionnaire sought information on demographic and other socio-economic characteristics of the households as well as respondents' perception of prevalent illness, causes of death and their determinants. In addition, other pieces of information were obtained on drug and alcohol use, sexual behaviour including commercial sex work, patronage of orthodox and traditional practitioners, immunization

Focus Group Discussion (FGD)
Focus Group Discussions (FGD) were held to mainstream views and input of specific sub-groups that might not have been adequately captured during the Household Survey. Thus, FGDs were held with Youths, Men, Women, Teachers, clergymen and the Elderly following standard procedures for conducting FGDs.
The discussions sought additional qualitative information on all issues raised during household survey with the aim of clarifying and obtaining consensus opinions and explanations.

**Key Informant Interviews**
Certain specialized social and health information were captured through interviews of key informants, such as opinion leaders, traditional rulers, community leaders, workers in-charge of health facilities, Traditional Birth Attendants (TBAs), teachers, health workers, etc. From these informants, information was obtained about cultural practices, living conditions in the communities, presence of health related risk factors as well as health seeking behaviour, available health facilities (orthodox and traditional) and their utilization pattern; opinion about common disease and health concerns as well as expectations from the project implementation. All interviews were conducted in an environment that guaranteed valid responses.

**Nutritional Assessment of Under-fives**
Anthropometric measurement (weight and height) of children were taken to enable an assessment of their nutritional status. In addition, they were examined for overt signs of malnutrition.

**Environmental Health Survey**
This consisted of walk through surveys using prepared checklist in order to identify environmental health issues such as types and quality of houses, water supply, level of sanitation, waste disposal practices, and the availability of health and health related facilities. Furthermore, the available health facilities were visited.