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Environmental Baseline Characteristics for a Pilot Project Site for Integrated Solid Waste Management in Makurdi, Nigeria

[1]S.V. Irtwange and [2]R. Sha'Ato
[1]Department of Agricultural and Environmental Engineering, University of Agriculture, Makurdi
[2]Department of Chemistry, University of agriculture, Makurdi

Abstract: The study of the pilot project site for integrated solid waste management in Makurdi, Nigeria was conducted to establish the environmental baseline characteristics as part of an Environmental Impact Assessment (EIA) process. Survey of literature was conducted to generate information on climate, geology, and the general physical, chemical and biological status of the environment as well as identify information gaps. This was achieved through the consultation of existing studies/survey reports, technical publications, textbooks, etc. Field data gathering exercise was conducted to fill information gap identified from desk survey and also to validate existing information. It entailed visual observation, interviews, on-site measurements and collection of samples for laboratory analysis and testing. The study covered terrain/topography, climate and meteorology, land ownership, land use and zoning, soil quality, geological formations underneath the project site, hydrology and water quality, groundwater geophysical survey, hydro geology, ambient air quality, ecology of the project site and surroundings, baseline noise levels and public consultation. The results of the study indicates that the environmental components of the site were within natural background levels of the environment except the outcrops of the Makurdi sandstone in the designated land fill areas having served as a road construction excavation site in the past. The study also shows that apart from the nearby stream, there are no existing environmental stresses or pollution within the area.

Key words: Environmental baseline characteristics, EIA, integrated solid waste management, Makurdi and Nigeria

INTRODUCTION

The Department for International Development (DFID) funded State and Local Government Programme (SLGP) is assisting the Benue State Government towards governance reform. The State's governance programme is aimed at achieving long-term sustainable reforms that will enhance the capacity and effectiveness of State and Local Governments to formulate policy, manage resources and support service delivery in the interests of the poor people. In 2002 up to early 2004, the SLGP assisted in a number of studies and diagnostic survey activities (Barrat *et al*., 2002; Bdliya, and Lyam, 2002; Sha'Ato and Ikor, 2003; Whiteman *et al*., 2003; Sha'Ato *et al*., 2003; Lyam, 2003; Barrat and Sha'Ato, 2004; Crawhurst, 2004) and spearheaded the establishment of a number of Steering Committees. One of these, the Environmental Management Steering Committee (EMSC), is focusing on environmental management particularly solid waste. The EMSC has one working group, known as the Solid Waste Technical Working Group (TWG). A Secretariat has also been established within the Ministry of Water Resources and Environment (MWRE) to assist with implementation, monitoring and administration of the pilot project. The EMSC and TWG have initiated a pilot project for integrated solid waste management in Makurdi. This pilot project will test and demonstrate service-oriented governance through implementing new and improved solid waste management services. The pilot project is intended as a basis for improvement of solid waste management services throughout other parts of Makurdi and other towns in Benue State, Nigeria.

An Integrated Waste Treatment Facility (IWTF) will be constructed as part of this pilot project. The IWTF will consist of a combination of composting, recycling and sanitary landfill. An Environmental Impact Assessment (EIA) of the proposed IWTF is required to be carried out as an integral part of the detailed design, planning and approval process. The TWG carried out a field evaluation of a long list of 9 potential sites and an evaluation matrix used to rank the sites in relation to a range of key suitability criteria (Whiteman *et al*., 2004). The outcome of this exercise was that the present site selected for the EIA scored significantly higher than the other potential sites. Following the conclusion of the site selection exercise, the study area for the IWTF has been determined by the EMSC and TWG. The study area includes the land to potentially be used for the facility and the immediate surrounding area. Benue State Government (BNSG) officials indicate that the land is fully owned by State Government and no land ownership or acquisition issues

Corresponding Author: S.V. Irtwange, Department of Agricultural and Environmental Engineering, University of Agriculture, Makurdi, Nigeria

are foreseen. The purpose of this study is therefore to establish the environmental baseline characteristics of the selected site as part of the EIA process.

MATERIALS AND METHODS

The survey of literature was undertaken to identify gaps and understand features peculiar to the project environment. This involved research into relevant data on climate and meteorology, geology, hydrogeology, etc. Field work acquisition was conducted between July 13-August 24, 2004 and involved

- Meeting with subject matter specialist for briefing and assignment of responsibilities
- Meeting with TWG for consultations on key operational and design aspects of the IWTF
- Reconnaissance of the project area to delineate and physically overview the IWTF site and the 1km radius for public consultation
- Environmental sensitivity mapping and
- Commencement of survey work and ecological and socio-economic data collection

Sampling Design: The ecological components collected were surface water, groundwater, soils and vegetation. Surface water samples were collected from river Jamo, groundwater collection was from boreholes sunk within the study area and surrounding neighbouring communities while soil samples were collected across the project site. Socio economic studies of the host communities were conducted using standard methods.

In order to comprehensively capture all the ecological and socio-economic components peculiar to the project area, sampling was designed to involve the following

- Surface water collection at 3 locations from river Jamo and data collection at one hydrometric point
- Groundwater collection from one borehole sunk within the project area
- Soil sample collection at 8 locations and 2 profile pits designated randomly within the project area
- Measurement of field permeameter at 3 locations
- Biodiversity studies across the project area
- Noise measurements at 5 locations across the project area
- Air quality measurements at one location outside the project area
- Ecological studies involving 4 sampled plots within the facility and 4 eco-control plots outside the facility each measuring 10m x 10m
- Socio-economic study of the immediate host communities within 1km radius of the project site

Field/Experimental Procedures: The methodology for sampling/analysis and associated health and safety pep talks and precautionary measures to avoid contamination, in addition to sampling points distribution have been presented in this study:

Terrain/Topography: The study of the terrain/topography of the project site and the immediate surrounding area was conducted by production of a topographic plan showing contours at 1m interval, boundary stations, access roads and settlement at the scale of 1:1000. The slope in any direction was obtained by the difference in height between the first and last contours in that direction divided by the horizontal distance between the points.

Climate and Meteorology: Climate and meteorology covering location, rainfall, temperature, humidity and wind was through survey of literature (desk study).

Land Ownership, Land Use and Zoning: Land Ownership, Land Use and Zoning was carried out through study visit, questionnaire and fieldwork acquisition of data by a team of experts.

Soil Quality: Soils are the ultimate recipients of waste and other material deposits. It is therefore imperative to have some baseline soil data in order to effectively monitor the environmental impact of the IWTF. Soil investigations were therefore carried out both in the field and in the laboratory. Filed investigations involved the collection of surface soil samples (0-15cm) from 8 points based on topographical, vegetative and observable surface soil characteristics. In addition, two profile pits were sunk and described using soil survey manual (Soil Survey Staff, 1994). The two points were located at the lower slope positions relative to the landfills and dumping bays for reasons of direction of flow of effluents. The location of the two profile pits and the 8 sampling points is shown in Fig. 1. Standard routine methods were employed in the laboratory investigation after pre-analysis treatments of drying, crushing and sieving. The 8 surface soil samples were analysed for pH, organic carbon, total nitrogen, available phosphorus, CEC, and exchangeable cations. Only the A and the Btg horizons of the two profile pits were analysed for heavy metals (Zn, Cd, and Pb). These metals are required by plants in small quantities. They become toxic above certain critical levels. Some sources of heavy metal accumulation in soil are sewage and industrial bye products.

Geological Formations Underneath the Project Site: The investigations of the geological formations under the site of IWTF gives insight into the underlying bearing capacity of the rock units and subsequently determine the structural stability of the structures that will be erected for the use of IWTF project. The degree of weathering and fracturing of the rock units determines the groundwater potential and the natural fertility of the soils that can be derived from them. The geological mapping was carried out by compass and traverse method. Available footpaths were used as traverses whereby rock out crops were

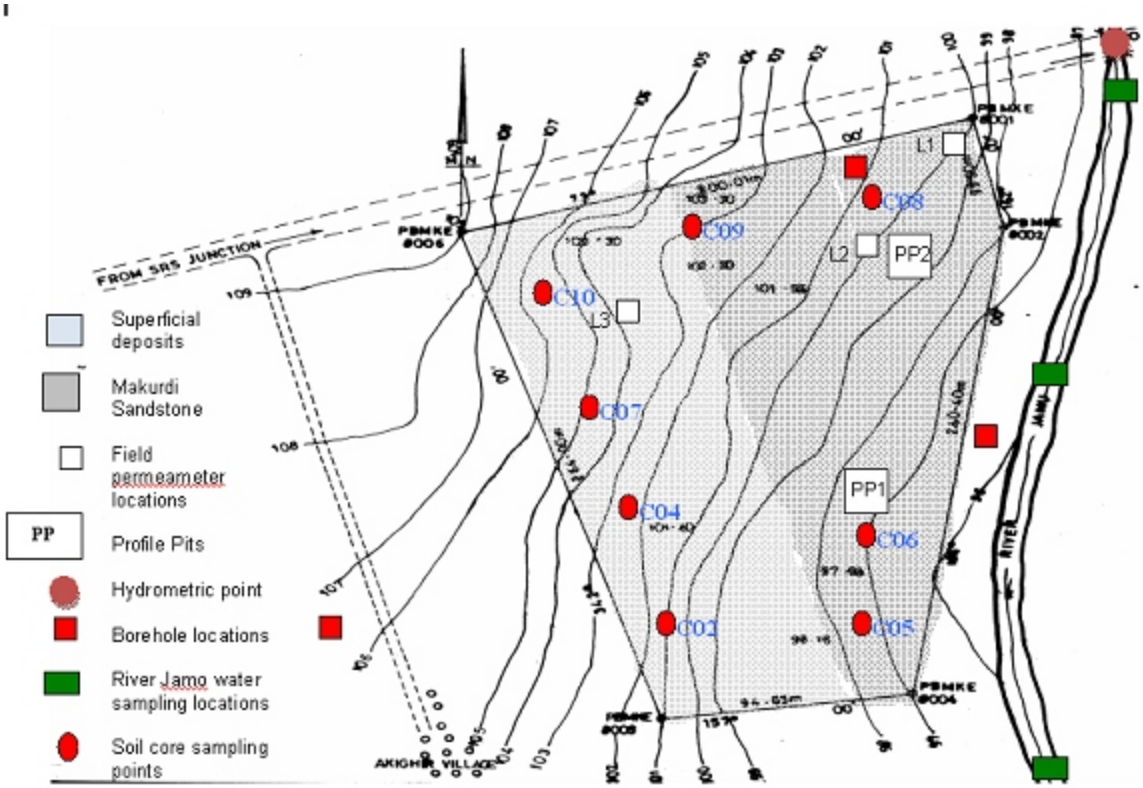

Fig. 1: A topographic plan of the project site showing geological map of the IWTF site, field permeameter locations, profile pits, hydrometric point, monitoring/mitigation borehole locations, water sampling locations and soil core sampling points

observed megascopically and their locations were plotted on the base map, subsequently geological map of the proposed site was produced. Field permeameter of dimensions 10cm by 10cm by 10cm were established to determine the coefficient of permeability of soil lithology within the IWTF site. Some quantity of water was poured into the field permeameter pit and time taken for this quantity of water to infiltrate completely into the subsurface soil lithology was noted and recorded. Cumulative volume of water and cumulative time taken for the water to infiltrate completely into the soil lithology was calculated. Darcy formula was used to compute the coefficient of permeabiulity of soil/lithology. Darcy (1856) stated that the rate of discharge of water through soil/lithology is given as Q = KIA where Q = rate of discharge of waters (m^3/s); K=coefficient of permeability (m/day); I = hydraulic gradient (dimensionless); A = cross sectional area of the field permeameter pit (m^2). Therefore, K = Q/IA = Q/A assuming I=1 (one).

Hydrology and Water Quality: Hydrology is mainly the study of surface water incorporating the fields of fluid mechanics. Both surface water and groundwater are interdependent on each other. Water is a universal solvent that can dissolve most substances hence the need to study the present state of the stream(s) that drain the IWTF site. The state of surface water will enable assessment of the impact of the waste treatment facility on the quality especially chemical quality for appropriate mitigation(s) measures to be carried out. River Jamo is the main river that drains the study area. River Jamo is a tributary of River Benue. River Jamo is a seasonal stream. The water sampling locations of the river are as shown in Fig. 1. Discharge measurement of river Jamo was carried out. Velocity of flow was determined at the bridge on river Jamo along the University of Agriculture road. The width and depth of the river were also determined to compute the cross sectional area of river Jamo. The product of velocity of flow of the river (V) and cross sectional area of the river (A) gives the discharge of the river (Q): V (m/s) x A (m^2) = Q (m^3/s). The gage height hydrograph of River Benue at Makurdi bridge was plotted from the guage readings from the Benue State Water Board Headquarters, Makurdi. The hydrograph separation was used to assess the relative abundance of groundwater over surface water.

To determine the chemical parameters of water, field water sampling was carried out at the upstream, midstream and down stream of River Jamo. pH and temperatures of the water samples were taken at the field. Subsequently, the water samples were carried to the laboratory for chemical analysis. Three water samples were collected along the course of river Jamo, which is adjacent to the study site. The first sample labeled RW1

was down stream at the project site. The second sample (RW2) was midstream while the third sample (RW3) was taken 100m from the point where the river empties into River Benue. Sample BW1 was from one of the boreholes on the project site (Plate 2). Each sample was analyzed for pH, colour, odour, alkalinity, acidity, total hardness, Mg^{2+} and Ca^{2+} hardness, chloride (Cl^{-}), total solids, total dissolved solid, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and sulphates, using standard methods for water analysis. Other parameters analyzed were NH_3–N, PO_4^{3-} and metals (Pb^{2+}, Hg^{2+}, Cd^{2+}, Fe^{2+} / Fe^{3+}, Zn^{2+}, Ni^{2+} and Cu^{2+}).

Groundwater Geophysical Survey: Incidences of abortive wells world over are on the increase because information about the subsurface geology and its groundwater potential in particular is insufficient. In Makurdi, groundwater is not readily available for exploitation due to unfavourable geologic conditions, thus making its development somewhat difficult. This exigency inspired the need for careful hydrological and geophysical assessments of the proposed integrated waste treatment site for appropriate siting of monitoring and mitigation wells. To this end therefore, the development of modern technology like the geophysical technique helps greatly in reducing groundwater exploration problems. In pursuant of the same objective, a geophysical survey team headed by a Chartered Geologist was commissioned to carry out a pre-drilling feasibility study. The field work lasted two (2) days (i.e 14th and 27th of July, 2004), at the end of which the data processing, analysis, and interpretation as well as the compilation of the survey report commenced. The final recommendations were based on the result of reconnaissance, geologic, and hydro-geologic observations, and to a greater extent on the result of the geophysical measurements made on the ground surface at the site. The locations of the survey areas were the Benue State IWTF site at KM 2.4 University of Agriculture road, and the immediate vicinity all in the North Bank area of Makurdi.

Vertical Electrical Sounding (VES) probe was carried out in this study using the schlumberger configuration. The primary objective of this survey was to verify the geologic successions and water bearing potentials in the areas. In all, vertical electrical soundings were conduced at three (3) strategically designated locations. An ultra modern McOhm resistivity meter, was employed in generating the field data. Soundings were conducted with a maximum half-electrode spread of 75 metres and a minimum of 55 metres at some points corresponding to desired depths of geologic probe. Good quality data with smooth field-and –calculated curves showing defined geo-electric layers were obtained. The true resistivity values were derived from the apparent readings through the process of curve matching by the auxiliary point method. The final recommendation regarding the suitability of drilling productive boreholes in the areas was based on the outcome of the direct current electro-resistivity measurements made on the ground surface, as well as the geological and hydrological conditions prevalent in the area.

Hydrogeology: Hydrogeology is the study of ground water incorporating the fields of geology and fluid mechanics. It involves the study of groundwater and its relationship with the host rock. Both surface water and groundwater are interdependent on each other. Water is a universal solvent that can dissolve most substances. Groundwater is always hydraulically connected with surface water; the state of groundwater will enable one to assess the impact of the waste treatment facility on the quality especially chemical quality of groundwater; for appropriate mitigation(s) measures to be carried out. Drilling operations by rotary drilling and hammer drilling were used to drill the boreholes; during which the cuttings from the boreholes were analysed for texture and groundwater potential. Depths to water table measurements in the boreholes were carried out.

Ambient Air Quality: The sampling/monitoring for ambient air quality was carried out continuously (24-hour averaging time) for three consecutive days, from 13 to 15 August, 2004. The monitoring station was at the Federal Housing Estate, a distance of about one kilometer from the IWTF site. The residential area was purposely chosen, for it is located downwind of the project site. It also has the same weather conditions and topographic features. Again, since the long-term aim is to, among others, investigate the impacts of the pollutants on human health, animal husbandry and crop yields, it is logical that the preliminary investigation for air quality baseline be done among the people, their domestic animals and economic trees. Major pollutants, suspended particulate matter (SPM), respirable suspended particulate matter (PM_{10}), ammonia (NH_3), hydrogen sulphide (H_2S), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2), were identified, monitored and analyzed. Both the particulate matter and the gaseous pollutants were sampled simultaneously by using an Indian made Respirable Dust Sampler-Envirotech Model APM460 (NL)–S/N50DATE/E2002. The machine was mounted at the height of 1.2m, for weather and meteorological homogeneity.

The PM_{10} in air stream were sampled by gravimetric techniques on 24 hourly basis by collecting the particles on pre-weighed What man Glass Micro fibre Filters (GF/A – England), 20.3 ´ 25.4 cm, size (Cat. No. 1820 866). Though the filters were non-hygroscopic, they were still equilibrated in conditioned environment (Descicator) for 2 hours before and after sampling to minimize errors due to humidity and material loss. The average flow rate was 1.2 m^3/min, and the sampling frequency was 8 hourly, such that 3 samples were obtained per day. The SPM from the segregated cyclone mechanism were collected on the pre-weighed serially numbered collection cups attached at the bottom of the sampler. The flow rate

and the sampling frequency were the same with that of the PM_{10}. Both the filters and the cups were taken to the laboratory and reweighed, and the mass concentrations were calculated according to the procedures given by EPA (1973), Katz (1977) and Shah *et al.* (1997).

The gaseous pollutants, NH_3, H_2S, SO_2 and NO_2, were monitored simultaneously through the specially attached gaseous equipment, on 24 hourly basis for three days. The flow rate, as read from the rotameter was 0.5 liters/min, and the sampling frequency was 4 hourly. That is, a total of 6 gaseous samples were obtained for 24 hourly sampling. The gases were passed through 4 serially numbered midget impingers, each containing 20 ml of the appropriate absorbing medium. The samples were taken to the laboratory and analyzed within 24 hours. The preparation of the media and the analysis for NH_3, H_2S, SO_2 and NO_2 were done in accordance with the modified Methylene Blue, Nessier's reagent, Jacobs & Hochhesier and West & Gaeke methods (Stern, 1976; Katz, 1977; Rao and Rao, 1989). The transmittance (T%) for the gases, obtained by using the spectrophotometer were compared with the NEERI (2000) standard calibration curve to obtain mass concentrations of the gases.

Ecology of the Project Site and Surroundings: The survey of the flora and fauna (micro- and macro-) in the project area was undertaken. The study involved an inventory of these environmental components in the terrestrial and aquatic ecosystems including any sensitive habitats and endangered species. The investigation employed the services of experienced botanists, taxonomists, ecologists, microbiologists, local hunters, fishermen and traditional medicine practitioners.

Investigation of the floristic composition was carried out to generate information on plant distribution, abundance, economic importance/values, among others of the site and the surrounding area. This study enhances knowledge of the plants and their contributions to the community and possible impact during the pre-operational and operational periods. Eight quadrats with four each within and outside the proposed project site were employed (Fig. 2). For impact monitoring, the study used pairs of "reference" and "treatment" location methods located outside and within the project site respectively. Statistically significant change in the proportional abundance of organisms at reference and treatment locations between pre-operational and operational periods will be regarded as impacts. The quadrats size was determined and species-area curve for several quadrats sizes were plotted and $10m^2$ was adjudged the best. The method of Onyekwelu and Okafor (1979) was employed in laying the quadrat. In each quadrat, all the plant species were identified and listed. Those plant species that cannot be identified on the spot were taken to the Herbarium of the Department of Biological Sciences, University of Agriculture, Makurdi for further analysis and identification. Identification was carried out according to the Flora of West Tropical Africa. For ethnobotanical study, oral questionnaire technique was employed. This involved collection of medicinal plants by the traditional medicinal healers and identification of the respective plants and recording. Recipes were described and recorded. Although the efficacy of the description was not tested, but the fact that the members of the community have relied on them over the decades for their health care delivery is enough justification for note to be taken of them.

The disposal of refuse by microorganisms is one of the oldest biological waste treatment systems. Man has buried unwanted refuse for centuries and the microorganism have broken the complex organic compounds into simple compounds which have been reused by higher plants. Today, there are two classes of refuse disposal by microorganisms. Sanitary landfill and composting. In either case, the operation relies partly on microbial activities to transform the waste materials. One major problem in handling the municipal waste is that microbial activities are well advanced before the materials reach the composting area. Thus, the waste materials constitute a potential source of pathogenic and non-pathogenic organisms. When rain water hits the ground, a portion of it runs off below and above the ground surface. It picks up many substances as it flows into river, stream or ponds, microorganisms, organic matter and minerals. Being rich in nutrients, it becomes a perfect medium for the growth of all types of microorganisms. Water has long served as a mode of transmission of diseases. The common human pathogenic bacteria and protozoa found in water include *Salmonella* spp*., Shigella dysenteriae, Vibro comma Entamoeba histolytica a*nd viruses. It is therefore necessary to investigate the microbial status of the soil of the site and the microbial status of the water of River Jamo that borders it.

Soil samples were collected from the quadrats as with flora evaluation. Samples were also taken from within the project site and reference plots/quadrats herein referred to as Eco-Control. Each of the samples wrapped in aluminum foil were taken to the laboratory and analysed by serial dilution method. The samples were inoculated on nutrient agar and potato-dextrose agar for fungi and bacteria respectively. The emerging colonies after three days of incubation were counted and recorded. The colonies were also examined individually by biochemical tests to identify the species of the organisms. Samples of water were collected from different locations along River Jamo. Five locations at 100m interval were collected from up and down the River Jamo across the Bridge on University of Agriculture, Makurdi Road. Samples were thoroughly homogenized by mixing them in order to get adequate representation of the water. Samples were tested immediately after collection to avoid contamination. The multiple tube fermentation method using the most probable number (MPN) for coliform bacteria was adopted in the analyses. Prior to sample collection, sterile broth was prepared using McConkey broth in

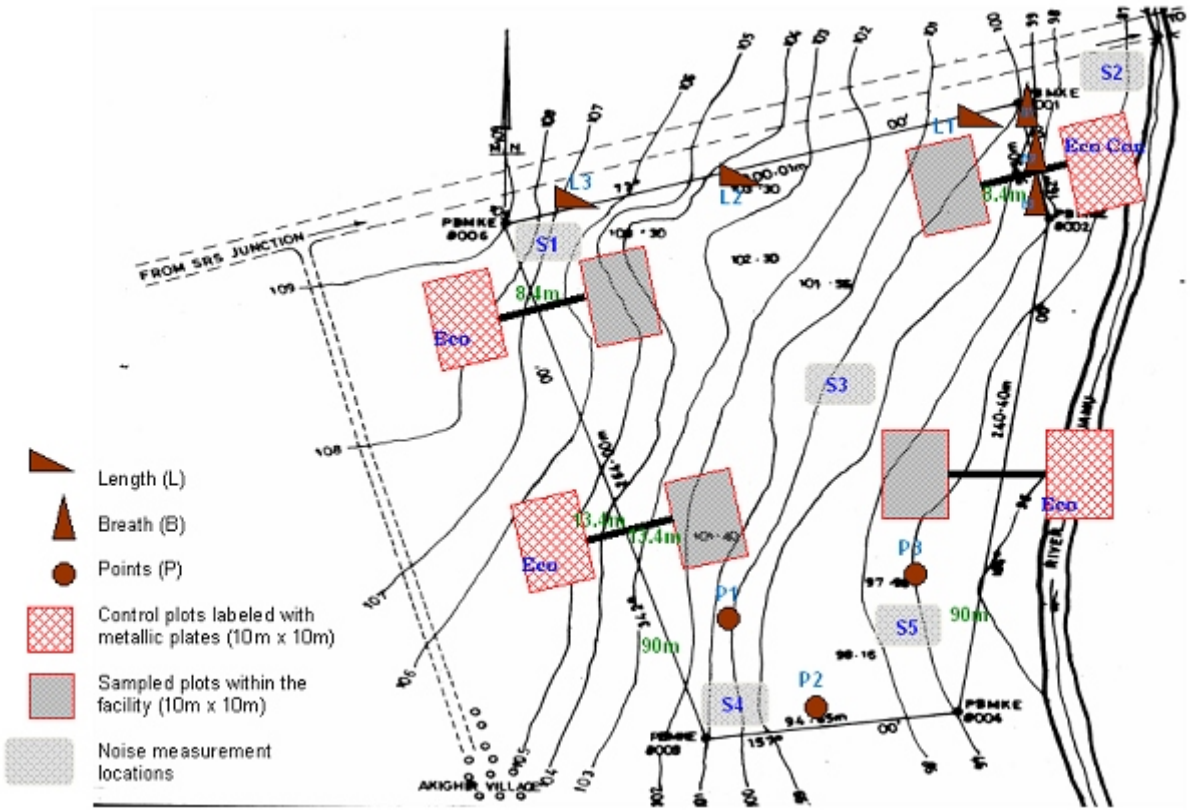

Fig. 2: Plot layout of vegetation analyses and location of the noise measurements

fermentation tubes. The tubes were then inoculated with the samples and incubated at 35ºC for 48 hrs for total coliform bacteria. By use of sterile loop, new broth in fermentation tubes were again inoculated from the previous inoculated tubes showing positive growth of coliform bacteria. These were incubated at 44ºC in the incubator to obtain results for fecal coliform bacteria.

Baseline Noise Level: For a better spread and statistical distribution of the measured data, five measurement sites were selected and coded S_1, S_2, S_3, S_4, and S_5. Six measurements for each site were taken hourly for a period of 10 hours (i.e 7:00am-4:00pm) on 9th August 2004. The locations of the measurement sites are as indicated in Fig. 2. A total of 300 data points were generated for the site using Piezonoise Digital Meter built and calibrated in accordance with the IEC-651,BS-5969 and ANSI-S1.4 standards, serial PG/3383 (1998), Nigeria make.

Public Consultation: Consultation is the process of soliciting people's views on proposed actions and engaging them in meaningful dialogue. It is an iterative, continuous process, with each step building upon that of the previous stages and allowing time for learning. The socio-economic conditions of a community change from time to time. Even though one may be dealing with the same communities, reactions to situations are not bound to be the same always. They vary from year to year and decade to decade. In order to carry out the task properly, dialogue with the traditional leadership of the people became imperative. Courtesy calls were made. Various consultations were also made at small group meetings with the traditional leadership the subject being introduced at higher levels. Participatory approach technique was used so that the community could be adequately reached. A semi workshop/meeting was finally held at Akir village where the closest stake holders to the project site live.

The objectives of the public consultation were as follows:

- To create awareness in the local community at a radius of 1km distance from the IWTF
- To sensitize the community about the functions of IWTF and the benefits they could derive from such a facility
- To appraise the reaction of the community to the facility which is to be situated in their land
- To identify stake holders and investigate their livelihood strategies.
- To convey findings about the feelings of the immediate community about the IWTF facility to

Environmental Management Steering Committee (EMSC)

The process was as follows:

- Identification of the communities covered by 1km radius of the site
- Preliminary courtesy calls were made to the traditional rulers in the area and five preliminary consultation meetings were held.
- A meeting was held at Akir village where the closest stake holders to the project were present both the youth and elders. The village head, Elder Ugobi was present.
- A bigger meeting/workshop was arranged for the community chiefs and elders of Mbagune community. Youth and women were also part of the meeting. During the meeting a visit was made to the project site by the community together with the members of EIA team, for mutual inspection of the land involved.
- There was a detailed dialogue between the Public Consultation team and the community concerning the scope of the EIA and subsequently the establishment of IWTF. The community was sensitized during the ward meeting/workshop. Objectives of the EIA were also made clear to the community. The benefits that were due to the community were also discussed at length. Small groups were interviewed; question and answer method was used.
- Stakeholders were identified and their livelihood strategies were carried out. Other pieces of information were also derived like the expectations of the stakeholders concerning the IWTF project.
- A social map of the area was also produced using the community members.

RESULTS AND DISCUSSION

Terrain-Topography: A topographic plan of the project site and the immediate surrounding area shows contours at 1m interval, boundary stations, access roads and settlement at the scale of 1:1000 (Fig. 1). The total land area is 4.42 ha. The site is about 40m east of Akir village. There is a stream on the eastern side of the site which drains into the River Benue. The River Benue itself is about 5km south of this site. Much of the stream dries up during the dry season but for about eight months of the year, it provides water to the neighbouring villages for almost all of their domestic use. This site is also bounded on the northern side by the road that leads to the University of Agriculture, College of Advanced and Professional Studies and Government Science Secondary School, all in Makurdi. The lowest contour is that of 96m which is close to river Jamo and which touches the boundary line PBMKE 8002-PBMKE 8003 near PBMKE 8003. The highest contour is 109m and it passes through point PBMKE 8005. As can be seen from the contours, which are lines passing through places of equal height above datum, the land slopes eastward towards river Jamo and southwards along the river. It also slopes from PBMKE 8005 to PBMKE 8004. The slope along the main road or line PBMKE 8004 to PBMKE 8001 is (109-100)/200.01 ≈ 1:1800. Also the slope along the river is (97-96)/(240.4+5.5) ≈ 1:300. In the southern direction along the line PBMKE 8005-PBMKE 8004, the slope is (109-101)/264 ≈ 1:2000.

Climate and Meteorology: Makurdi which is located on lat. 7º45'N and long. 8º38'E, experiences tropical wet and dry (Aw) climate, which is characterized by two seasons, the wet and dry seasons. Rainfall is dominantly associated with the southwest monsoon air stream that originates from the St. Helena high pressure cell of the South Atlantic. The dominant rain-producing systems in Makurdi are squall lines, experienced in the months of April/May and thunderstorms in July and August. These contribute significantly to the total rainfall. Makurdi has a mean annual precipitation of 1093mm with the highest rainfall occurring in August. The rainy season normally lasts from April to October. There is hardly any major difference between the rainfall regime of the North Bank the South Bank areas of Makurdi.

Temperature is generally high in Makurdi. The lowest temperatures (about 26ºC) are usually recorded in January while the highest (32ºC) monthly temperatures are recorded in March/April. Like other Aw regions, Makurdi experiences three temperature periods namely:

- The cool dry season between November – January (at the time of the low sun);
- The hot dry season between February – early April (just preceding the rains), and
- The hot wet season between mid April – October (during the rains).

The humidity in Makurdi is closely related to the prevailing wind system. Wind speeds are generally low throughout the year within the range of 29-68 m/s. The air humidity is generally low during the dry season (40%) and increases during the onset of the rainy season with its peak in August (81%). Air humidity is high correlating with the dense cloud cover. Prevailing winds in Makurdi are seasonal. The south west humid winds come during the wet season. This is the time when solid waste dumps can become smelly because of the wetness. Wet winds are also more likely to accommodate more smell and carry it through longer distances. Currently the nearest settlements that could have been easily affected are situated before the treatment site. However, the proposed Gindiri Old Students Association (GOSA) college will be directly affected. On the other hand the dry harmattan winds which reach the treatment site before the settlements do not enhance smelly conditions. They could however blow much of the light waste into the settlements of the site if not properly fenced.

Landownership, Land Use and Zoning: The land on which this site is situated belongs to the Mbagune Community. More specially, the project is on the farm land belonging to Elder Ogobi from Akir village. There are no sites of cultural or archaeological and historical importance within the proposed enclosure of the IWTF. Shrines and graves of relations which could be of historical significance are all located outside this enclosure. At the moment, there is a secondary school development project earmarked within the vicinity of the site by GOSA. It is also note worthy that this site had been earlier quarried for engineering purposes and is in the process of recovery. However, for profitable agricultural purposes therefore, this is almost waste land as far as crop production is concerned. On the periphery of the perimeter however, small corn (maize), yam and guinea corn farms and isolated banana plants surround the site except along the road to University of Agriculture. As at the time of the study visit, short savanna bush and shrubs occupied the greater part of the site with only a lone mature *Daniella oliveri* tree (Chiha in Tiv language) standing by the road. Palm trees found on the site provides high grade palm wine for the drinking pleasure of the community. The University of Agriculture road provides the only access to the site and no other utilities or services are available within the vicinity except the public power supply electric poles carrying light to College of Advanced and Professional Studies, Makurdi (CAPSM) and UAM, two of the four major higher institutions in Makurdi. The land use within the premises does not show any variation. Short savanna bushes and shrubs cover the whole site with small farms flanking it particularly along the eastern and southern side. The lone village nearest to it is found to the west of the site. The Federal Housing Estate is located about three quarters of a kilometer to the West of this site. Plates 1a,b shows representative land use characteristics of the project site.

(a)

(b)

Plate 1: Land use characteristics of the project site (a) a farm; (b) river Jamo-major source of water supply for the community

Soil Quality:

Morphological characteristics of the soils: As observed in Table 1a,b, the soils of the area generally have coarse textured surface and fine textured subsurfaces. The surface soils are loamy sand to sandy loam while the subsurfaces are sandy clay loam to clay loam. These vertical differences in textural classes could be due to the vertical translocation of fine clay particles with percolating water from the surface to the subsurface (eluviations and illuviation). The clay particles are deposited on the indurated and coherent sandstone because the material is impervious to water. Soil colour is very dark brown (10YR2/3) in the A horizons to olive brown (2.5Y4/4) in the Btg horizons. The dark colour of the surface horizon may be due to the accumulation of organic materials on the surface. The grey colouration of the Btg horizons could be due to reduced soil condition because of perched water table. Percolating water accumulates on the sandstone due to the indurated nature of the rock which causes water logging and therefore reduced soil conditions (gleization).

The occurrence of indurated and coherent sandstone within 120 cm of the soil surface is a very striking feature of these soils. In profile 1, it occurs at 120cm depth while in profile 2, it is encountered at 85cm depth. The implication of this phenomenon is that water cannot percolate through these soils beyond these depth/levels. Since the surface horizons are permeable, water can percolate through the surface soils but accumulate at the indurated layers. However, the slopy nature of the land allows for lateral flow within the profile on the indurated surfaces. This means that effluents from the landfills and dumping bays are likely to flow over the indurated layers into River Jamo and finally River Benue. It is therefore very necessary to continually collect soil samples at these depths in order to effectively monitor the impact of the IWTF project on the environment. The lateral flow could

Table 1a: Morphological description of the soils (Profile Pit 1)

Profile Pit 1		
Topography:	Lower slopes 1% slope	
Drainage:	Somewhat poorly drained	
Vegetation:	Imperata cylindrical dominant, fallow.	
Parent materials:	Indurated coherent Makurdi Sandstone	
Remarks:	Soil colours are described under moist conditions	
Horizon	Depth (cm)	Soil Description
A	0 -33	Very dark brown (10YR2/3, moist) loamy sand; moderate fine crumbs; friable moist many fine to medium roots few coarse roots; gradual smooth boundary.
AB	33-65	Dark brown (7.5YR4/4, moist) sandy clay loam; few fine faint strong brown (7.5YR 5/8) mottles; moderate medium sub-angular blocky; sticky and plastic wet; few fine roots; gradual smooth boundary.
Btg	65-120	Olive brown (2.5Y4/4) clay loam few fine faint yellowish brown (10YR 4/6) mottles; strong coarse sub-angular blocky; very sticky and plastic wet; indurated coherent sandstone at 120 cm.

Table 1b: Morphological description of the soils (Profile Pit 2)

Profile Pit 2		
Topography:	Lower slope, 1% slope.	
Drainage:	Somewhat poorly drained.	
Vegetation:	Grasses and shrubs.	
Parent materials:	Indurated coherent Makurdi Sandstone.	
Remarks:	Soil colours are described under moist condition	
Horizon	Depth (cm)	Soil Description
A	0-25	Black (10YR 2/1) Sandy loam tending towards loam; moderate medium sub-angular blocky; slightly sticky and plastic wet; many fine and few coarse roots; gradual smooth boundary.
B	25-50	Brown (10YR 4/4) Sandy clay loam; Moderate medium sub-angular blocky; sticky and plastic wet; common fine roots; abrupt smooth boundary.
CB	50-60	Brown (10 YR 4/4) gravelly clay loam; sticky and plastic wet; few fine roots; abrupt irregular boundary.
Btg	60-85	Greyish brown (2.5Y 5/3) clay loam; few fine faint olive yellow (2.5Y 6/8) mottles; strong coarse sub-angular blocky; very sticky and plastic wet; and coherent sandstone at 85 cm.

Table 2: Soil Chemical Composition of IWTF Site in Makurdi, Benue State

S/N0	Soil Sample No	PH		Organic, Carbon %	Organic Matter %	Total Nitrogen %	Available Phosphorous Ppm	C.E.C Meq/100g Soil	Exchangeable cations Meq/100g soil				Heavy Metals, ppm		
		H_20	KC1						Na	K	Ca	Mg	Zn	Cd	Pb
1	CO2	5.59	5.03	0.958	1.651	0.025	15.60	6.737	2.33	0.44	2.80	1.10	-	-	-
2	CO4	5.27	4.73	0.599	1.032	0.041	13.00	5.183	2.33	0.22	1.40	1.20	-	-	-
3	CO5	6.30	5.61	1.117	1.926	0.018	17.50	6.743	1.40	0.21	3.40	1.70	-	-	-
4	CO6	6.43	5.73	0.738	1.273	0.020	10.50	6.343	1.51	0.30	2.70	1.80	-	-	-
5	CO7	6.26	5.49	1.576	2.717	0.049	36.15	8.693	1.35	0.56	4.40	2.30	-	-	-
6	CO8	5.92	5.14	1.097	1.892	0.029	20.55	7.360	1.58	0.33	4.20	1.20	-	-	-
7	CO9	5.48	4.72	0.578	0.997	0.021	9.85	5.053	0.50	0.27	2.60	1.60	-	-	-
8	C10	5.12	4.28	0.539	0.929	0.019	23.25	5.583	1.20	0.35	2.80	0.60	-	-	-
9	PPIA	-	-	-	-	-	-	-	-	-	-		5.80	0.46	3.80
10	PPIB	-	-	-	-	-	-	-	-	-	-		2.80	0.15	0.68
11	PP2A	-	-	-	-	-	-	-	-	-	-		4.60	0.35	2.60
12	PP2B	-	-	-	-	-	-	-	-	-	-		2.30	0.10	0.84

Key: Soil sample Nos. CO2 – C10 (auger soil samples). Soil Sample Nos. PPIA – PP2B (Profile pit soil samples).

affect the surface water as well as underground water through groundwater movement.

Soil Chemical Properties: Table 2 shows the results of soil analysis for plant nutrients elements and heavy metals of the IWTF site. The results indicate that the soils at the site are weakly acidic (pH 5.12 – 6.43) and the pH is alright for the growth of a wide range of plants as only at about pH values below 4.2 that the H^+ ions in the soil can stop or even reverse cation uptake by roots (Black, 1967). Both organic matter and total nitrogen are below the average level of about 3.0% and 0.19% respectively for tropical soils. Except Ca which is within the average range of about 4.0 meq/100g soil, available P, CEC and other exchangeable cations (Na, K and Mg) are below the critical levels for normal plant growth (Sanchez, 1976). The concentrations of the heavy metals indicate that they are available in far minute quantities to pose any hazard to plants and the environment in general. The critical levels for the metals are: Zinc – 25 ppm, Cadmium – 0.73 ppm and Lead – 20ppm (Pendias and Pendias, 1986). However, expected recharge of heavy metals from the dumped waste materials could pose a danger to the environment with time.

Geological Formations Underneath the Project Site:

Geological Setting of the Site: Fig. 1 shows the geological map of the IWTF site. The site is underlain by Makurdi sandstone and superficial deposits. The Makurdi sandstone is greyish brown in appearance and fine to medium grained texture. The outcrops occurred as low-lying outcrops. Visible minerals are Quartz and feldspar. Makurdi sandstone is Turonian in age, thus, Makurdi sandstone outcrops are found at the anticlines, the younger superficial deposits the synclines. In the two profile pits PP1and PP2, Makurdi sandstone was

Table 3: Field Permeameter Readings

Location	Time (s)	Volume of water (cm^3)	Cumulative Time (s)	Cumulative volume of water (cm^3)	K value
1	600	250	600	250	K= 2.483 m/day
	1140	250	1740	500	medium-grained sand
2	2400	250	2400	250	K=0.9m/day fine-grained clayey sand
3	1800(∞)	250	1800(∞)	250	K=0.00 clay

Table 4: Standard Table for Coefficient of Permeability of Soil/Lithology

Soil/Lithology	Coefficient of Permeability in m/day		
	Maximum	Average	Minimum
Gravel	100	100	100
Grave+ coarse-grained sand	100	40	20
Coarse-grained sand	20	15	10
Medium-grained sand	10	5	2
Fine-grained clayey sand	2	1	0.2
Fine-grained sandy clay	0.2	0.1	0.05
Clay	0.05	0.01	0.005

Table 5: Field Measurement of Discharge of River Jamo

S.No	Velocity of River Jamo in m/s		Width of River Jamo (m)	Depth of River Jamo (m)
	Distance (m)	Time (s)		
1	7.5	120	7.05	0.75
2	7.5	120	7.05	1.125
3	7.5	100	7.05	
4	7.5	96	7.05	
Average	7.5	109	7.05	0.94

Average velocity of flow of River Jamo = 7.5m/109s = 0.07m/s; Average depth = 0.94m; Discharge of River Jamo = average velocity x cross sectional area of the river = 0.07m/s x (7.05m x 0.94m) = 0.464m^3/sec

encountered at depths 120cm and 90cm respectively. The bearing capacity of Makurdi sandstone is quite high. Superficial deposits overlay Makurdi sand stone at the IWTF site. It can be found at the Eastern part of the site. The superficial deposits are found lying conformably on the Makurdi sandstone at depths 120cm and 90cm in PP1 and PP2 respectively. The superficial deposits are clayey and dark grey in appearance, in the South Eastern part of the site and fine to medium grained sand in the North Eastern part of the IWTF.

Coefficient of Permeability of the Soil/Lithology: Table 3 shows the readings of the field permeameters while Table 4 is the standard table for coefficient of permeability of soil/lithology. The value of coefficient of permeability of the soil/lithology in the IWTF site ranges from 0.00 m/day to 2.483m/day corresponding to clay and medium grained soils respectively. The coefficient of permeability in location 3 (L3) is the presence of lateritic clay. When laterite is exposed to the air (atmosphere) it tends to harden up. The high coefficient of permeability of the soil/lithology in location 1 (L1) is due to the presence of sediments deposited by River Jamo when it overflowed its banks.

Hydrology and Water Quality:

Discharge of River Jamo and Gage height hydrograph: Table 5 shows the field measurement of discharge of river Jamo by the bridge at University of Agriculture Makurdi Road. The discharge was determined as 0.464 m^3/sec. This discharge is not enough to cause flooding at IWTF site. Fig. 3 shows the gage height hydrographs of River Benue at Makurdi for 1997/98 hydrogeological year. Surface water accounts for 21.5% and groundwater accounts for 78.5%. There is abundance of groundwater over surface water.

Chemical Parameters of Water: Results of the chemical parameters of water are shown in Table 6.The results indicate that the chemical parameters of the water samples fall within the World Health Organization (WHO) recommended values for domestic, industrial and agricultural uses. Therefore, the water as it is now (both the river samples and the borehole) is completely unpolluted based on stated parameters.

Groundwater Geophysical Survey: The primary objective of the hydro-geophysical survey was to explore the groundwater potentials of the area with the ultimate aim of guiding against drilling abortive wells. The survey promised useful recommendations, such as the estimation of the drilling depth, probable rock types to be encountered during the drilling, and aquiferous zone. The sites were accessible to men all the year round but those outside the IWTF site were found to be inaccessible to rig during rainy season. Benue State is known geologically to consist of (2) main rock types, namely:- the crystalline basement and the sedimentary rocks. The study location is particularly underlain geologically by the cretaceous sedimentary formation of the lower and middle trough which is a continuation of the Gulf of Guinea up to the Chad Basin. The cretaceous sedimentary rocks of the area are considered to be hydro-geologically difficult because

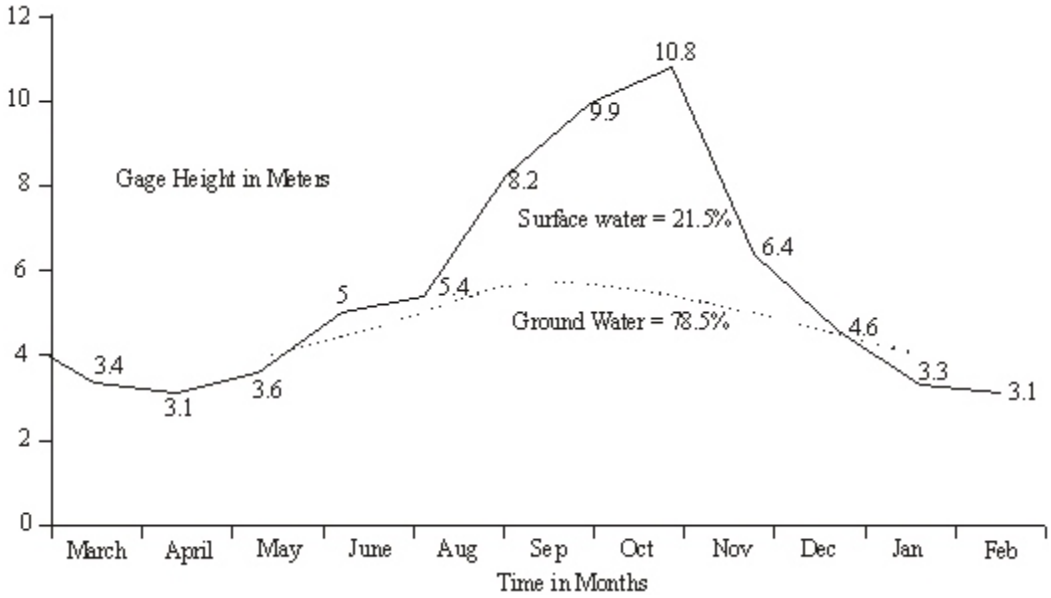

Fig. 3: Gage height hydrograph of river Benue at Makurdi Nigeria for 1997/98 hydro-geological year

Table 6: The Chemical Analysis of the Water Sample from River Jamo and Bore Hole at IWTF Project Site

Parameter	RW1	RW2	RW3	BW1	WHO Max allowed limit
Appearance/Colour	Turbid / light brown	Turbid / light yellow	Turbid / light yellow	Slightly cloudy	-
Odour	Odourless	Odourless	Odourless	Odourless	-
Temperature (°C)	29	29	28	-	-
pH	7.0	8.0	7.5	8.0	6.5-8.5
Alkalinity mg/l	168	164	168	722	-
Acidity mg/l	6.0	4.0	6.0	8.0	-
Total Hardness mg/l	60	64	70	122	100-500
Ca^{2+} mg/l	42	46.2	27.3	8.4	-
Mg^{2+} mg/l	4.39	4.30	10.42	27.72	30-150 (India)
Total Solids mg/l	0.22	0.25	0.20	0.47	500-1500 (India)
TSS Mg/l	0.12	0.12	0.12	0.25	-
Total dissolved solids mg/l	0.10	0.13	0.08	0.22	1000
Cl^- mg/l	30	20	30	60	200-600
SO_4^{2-} mg/l	41.15	37.04	41.15	28.81	200-600
PO_4^{3-} mg/l	nd	nd	nd	nd	-
COD (mg/L)	415.52	493.92	689.92	250.52	-
BOD_5 (mg/L)	175.36	85.76	689.92	250.52	-
Pb^{2+} mg/l	-	0.167	nd	nd	0.1
Zn^{2+} mg/l	nd	0.012	0.033	1.36	5
Na^+ mg/l	36.4	85.2	25.4	200	-
Cd^{2+} mg/l	nd	nd	nd	nd	-
Fe^{2+}mg/l	0.03	0.017	0.025	nd	0.3

Key: RW1 = Water sample at the beginning of river Jamo close to the project site; RW2 = Water sample at the middle of river Jamo; RW3=Water sample at the point (100m) of entering into river Benue; BW1=Borehole water on the project site; nd=Not detected

of their poor hydraulic characteristics. Generally, the sedimentary formation there consists majority of sandy topsoil, sandy-clays, medium grained sand and compact sandstones. Groundwater potential is usually enhanced by rocks with adequate porosity and permeability for the storage and migration water to wells. In Makurdi, groundwater potential is generally low to moderate (and not high) while the quality is generally good for moderately deep boreholes, as very deep ones are prone to pollution through salinization.

The process of drilling productive boreholes has become accurate and cost effective through the employment of various geophysical survey methods. More often than not, successes record in groundwater development through boreholes has been attributed to the invention of modern technology in geophysical prospecting. The importance of pre-drilling geophysical survey cannot therefore be over-emphasized as incidences of abortive wells and associated waste of funds will be reduced. Geophysical prospecting offers in all detailed anomalous signatures leading to the detection of water bearing rock zones in the sub-surface, and has proved successful in this study. Geologically, the area is underlain by various suites of sedimentary rocks including

Table 7: Lithologic projections derived from the geo-electric resistivity values

Borehole Location	VES Number	Estimated Depth (m)	Resistivity (Ohm-m)	Probable Rock Types*
IWTF Site	VES (1)	0-1.4	62	Topsoil
		1.4-4	41	Lateriticsoil
		4-8	15	Sandy clay (wet)
		8-15	< 1	Shale
		15-75	225	Sandstone (hard and saturated)
	VES (2)	0-1.2	28	Topsoil
		1.2-15	7	Laterite, clay, and shale
		15-55	375	Sand, clay, and hard sandstone (fairly saturated)
	VES (3)	0-1.2	210	Topsoil
		1.2-25	11	Laterite, sandy clay, and shale
		25-55	600	Sand, sandstone (hard and poorly saturated)

* Lithologic projections not absolute

Table 8: Drilling recommendations

Borehole Location	Recommended Drilling point	Alternative Drilling Point	Estimated Drilling depth	Recommended Drilling Method	Anticipated yield
IWTF Site	VES (1)	VES (2)	40-50m	Wet Rotary/Air Hammer	Low to Moderate

clay, shale, silt, sand, and sandstone which is more often than not indurated, thus impairing groundwater flow. Hydrologically, rainfall is the dominant factor controlling groundwater infiltration or borehole recharge in the area. Geophysically, all the survey areas revealed three (3) distinct geo-electric groupings, except at VES (1) on the IWTF site near the stream channel where the geo-electric groupings are up to five (5) due to the preservation of shale there (Table 7). The shale is likely to pollute the groundwater through saline intrusion. The VES curves showed relatively resistive bottom layers from average of 15-75 metres indicating the presence of sandstone which may be moderately hard and therefore less saturated. By implication therefore, there is no prolific aquifer in the entire area but moderate quantities of water could be exploited from the well if it penetrates the full length of the aquifer up to a reasonable depth. It must however be emphasized that the overall success of the wells will greatly depend on the use of appropriate drilling method, materials, and accurate well design by a competent site Geologist. For the purpose of drilling, the recommendations presented in Tables 7 and 8 for the survey at the IWTF site are offered based on the result of reconnaissance, geologic, and hydro-geologic observations and to a greater extent on the result of the geophysical measurements made on the ground surface at the survey area. The results for the other two borehole locations showed a similar pattern.

Hydrogeology: Fig. 4 shows the drillers log for one of the boreholes drilled at IWTF site in Makurdi shown as Plate 2. The thickness of the superficial deposits as aquifer is about 9m with texture ranging from fine-grained silty sand to fine to medium grained sand at the IWTF borehole. The thickness of the weathered Makurdi sandstone as aquifer is about 3m which can be found at depths 9-12m. It consists of fine to medium-grained sand with intercalations of cuttings of Makurdi sandstone. The fresh fractured Makurdi sandstone as aquifer is about 3m thick. It is a prolific aquifer as was shown during drilling with hammer and compressor. It can be found at depths 12-15m. The fresh Makurdi sandstone as aquifer is highly

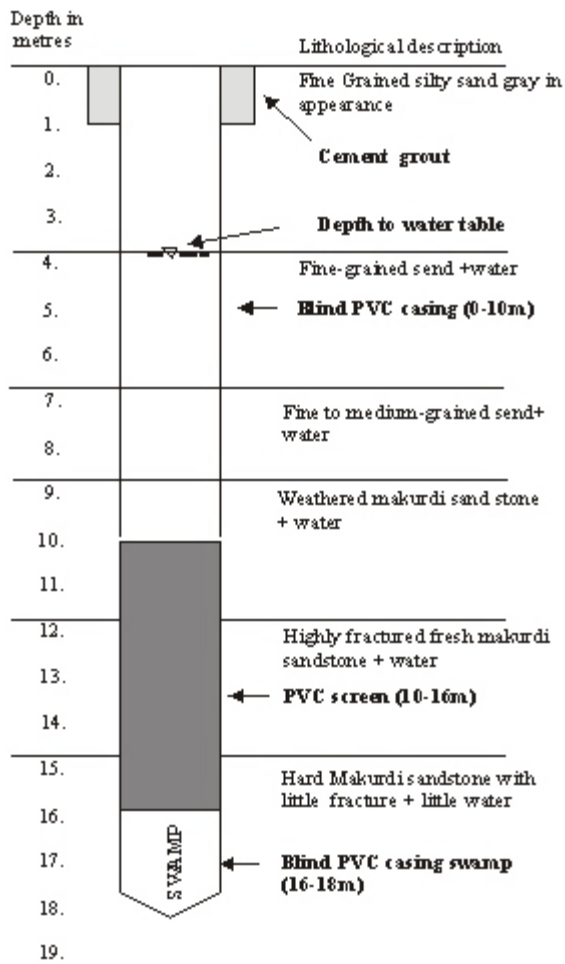

Fig. 4: Standard table for Coefficient of Permeability of Soil/Lithology

Table 9: SPM and PM_{10} concentrations (daily 8 hourly average) and NH_3, H_2S, SO_2 and NO_2 concentrations (daily 4 hourly average)

Week Days	SPM and PM_{10} concentrations, daily 8 hourly average		NH_3, H_2S, SO_2 and NO_2 concentrations, daily 4 hourly average			
	SPM (mg/m^3)	PM_{10} (mg/m^3)	NH_3(mg/m^3)	H_2S(mg/m^3)	SO_2(mg/m^3)	NO_2(mg/m^3)
Friday (13/08/04)	525.58	596.89	14.00	1.00	6.00	8.00
Saturday (14/08/04)	115.37	233.83	5.00	1.00	5.00	8.00
Sunday (15/08/04)	252.57	567.13	26.00	3.00	6.00	11.00
Mean value	297.84	465.92	15.00	1.67	5.60	9.00

Plate 2: Borehole drilled on the project site as part of the EIA process

indurated with little or no cracks. It was highly resistant to hammer drilling during the drilling operation. However a thickness of 3m was achieved during drilling which occurs at depth of 15-18m.

Ambient Air Quality: The prime objective of this short-term ambient air quality sampling/monitoring at the IWTF site is to evaluate the prevailing ambient air quality levels, so as to establish the air quality baseline in the project area. The sources of air pollution identified in and around the project site are mostly area and line sources. These include diesel and gasoline driven vehicles/generators, fuel wood, bush burning, farming/harvesting, food processing and ranching. Others are geophysical sources like cosmic radiation, harmattan winds and some biological sources such as pollens and spores.

The average concentrations (in mg/m^3) for SPM, PM_{10}, NH_3, H_2S, SO_2 and NO_2, obtained from the 'spot' sampling are shown in Table 9. The arithmetic means for SPM and PM_{10} concentrations, for the 3-days sampling, are 297.84 and 465.92 mg/m^3 respectively, while that of the NH_3, H_2S, SO_2 and NO_2 are 15.00, 1.67, 5.60 and 9.00 mg/m^3 respectively. The concentrations of SPM and PM10 are well within the prescribed limits of 24 – hourly annual average concentrations of 200 and 150 mg/m^3 for residential areas respectively (CPCB, 1994; USEPA, 1997). The NH_3, SO_2 and NO_2 concentrations are equally within the allowable levels of the annual average of 0.4mg/m^3 (400), 60 and 80 mg/m^3 concentrations respectively (CPCB, 1994; USEPA, 1997). Most international standard organization for air quality does not give limits for H_2S, but the value obtained appears to be within the allowable limit.

The existing ambient air quality at the IWTF site has therefore been assessed and evaluated, and found to be within the primary ambient air quality standards (that which protects the public health) and the secondary ambient air quality standards (that which protects the public welfare). However, it should be noted that the short period sampling is not used for setting up an air quality standard, and therefore may not yield a qualitative comparison and conclusion. So, a continuous sampling/monitoring of the area for at least 12 months with sampling frequency of twice a week (to obtain annual average) should be carried out for confirmatory results. The sampling was carried out during rainy season. There is need for it to be repeated in dry season.

Ecology of the Project Site and Surroundings:

Floristic Composition: A total of 78 plant species were identified and recorded. Of this total, 23 species were trees, 6 shrubs, 34 herbs, 3 woody climbers, 3 climbers, 2 woody herbs, bryophytes, mushrooms and lichens. The results showed that herbs were more abundant than trees and shrubs. This is a physiognomic feature of Guinea Savanna zone where Makurdi is located. Seven families were conspicuously outstandingly abundant. These include Poaceae, (9 species), followed by Fabaccae (8 species). Others were Euphorbiacaee (6 species), Combretaceae, Compositae and Meliaceae with four species each. The most dominant species *were Rttboellia cochinensis, Sateria ancepts and Tphrosia bracteolate.* A total of 40 plant species with trado-medicinal importance were identified and recorded. Medicinal uses of the respective plants were obtained from oral interview with the community's local medicinal practitioners and the information thereafter were recorded. Details of the dicotyledenous plants, monocotyledonous plants, medicinal plants, specie with food value and faunal species identified on the IWTF site were fully documented.

Microbial Evaluation of Soil and Water: The results of standard plate count from soil samples and presumptive tests are presented in Tables 10 and 11. Differences in soil microbial load are a function of soil fertility resulting from decayed organic matter. The higher the soil microbial count, the more fertile the soil and consequently the higher its potentials for higher agricultural productivity. Thus Eco controls II and plots I and III

Table 10: Results of standard plate count from soil sample

Location of sample	Number of colonies per plate			
	10^{-1}	10^{-2}	10^{-3}	10^{-4}
Point I	90	68	50	15
Point II	180	162	80	30
Point III	85	50	42	22
Breadth I	91	78	38	20
Breadth II	81	55	25	18
Breadth III	87	63	31	15
Length I	89	70	43	20
Length II	195	98	60	29
Length III	108	93	65	40
Reference plots				
Eco Control I	80	50	41	22
Eco Control II	250	120	70	40
Eco Control III	48	30	20	07
Eco Control IV	too crowded	160	85	60
Plot I within site	too crowded	170	91	70
Plot II within site	200	108	70	50
Plot III within site	80	41	30	20

Table 11: Results of Presumptive Test (Using McCrady's Statistical Table)

Location of sample	Description	Number/100ml of water		
		Coliforms	Faecal coliforms	Colonies/plate 10^{-3}
A	Upper part of the River	350	45	236
B	Opposite A	550	60	231
C	Middle	200	45	129
D	Lower Part of the River	550	170	240
E	Opposite D	900	275	230

located outside and within the project site respectively are more fertile and could be used for agricultural purposes. Eco controls II and plots I and III are located within the plains of river Jamo. Sediments carried in suspension and deposited along this plain must have accounted for higher soil fertility nature of these areas.

The microbial status of the water is an indication of polluted water even though the water is adjudged unpolluted in terms of chemical parameters. Total coliforms ranged from 350 – 900; while faecal coliforms ranged between 45 and 275. WHO limits for total coliform (cfu/100ml) and faecal coliform (cfu/100ml) is 0.00.These results indicate high levels of contamination of the water from animal and organic matter and may harbour human pathogenic microorganisms. The organisms identified include:

- Escherichia coli
- Aerobalter aeroginesa
- Faecal Streptococcus
- Bacillus aureus
- Escherichia ferundii
- Salmonella typhosa
- Pseudomonas aerogenosa
- *Aspergillus* spp
- *Penicillium* spp
- Yeasts

Evidences abound from the presence of *salmonella typhosa* in the samples. This is not surprising as most surface water pick up many substances as it flows back to larger water bodies. River Jamo is a tributary of River Benue. River Jamo originates from various erosion outlets.

Baseline Noise Level: The statistical analyses were conducted and the noise spectra for each period were tabulated (Table 12). The plots of the environmental noise level as a function of time for each of the selected sites showed a good base-line noise level within the recommended ambient noise level of 40-55 dB(A) for office buildings (AS/NZS-2107, 2000). There is no exceedent level at any location of the site. It therefore means that the background noise level at the site for IWTF, for a period of 10 hours (7:00am-4:00pm) is 48 dB(A) which is far less than the recommended noise level of 90 dB(A). The background noise level of 48 dB(A) at the site is therefore harmless.

Public Consultation:

Livelihood Strategies of the Communities: The stakeholders of the project are involved in the following for their livelihoods: Agriculture-Crops/livestock and Fisheries; Artisans-Carpentry, Masons, Welders, Painters (house decoration) and Drivers; Civil Service-Teachers; Unemployment and Unspecified Activities. Participatory strategy determinations of the livelihood of the members of the community showed that 63.2% of the people were involved in agriculture. This 63.2% was made up of 32.9% for livestock and crop production while 30.3% are involved in fishing. Among artisans who are 18.5% of the community, the highest score in this group was drivers (6.6%). Others are carpenters (2.6%), masons (5.3%), welders (2.63%) and painters (4%). Teachers only made 1.32%. The unemployed group in the community made up 10.53% and those who were unspecified scored 6.45%.

Table 12: Environmental Noise Measurements

Period	Sites	Measurement (dB)						Mean noise pressure level (dB(A))
		10	20	30	40	50	60	
7:00-8:00am	S_1	44.0	43.0	44.0	48.0	53.0	57.0	S_A
	S_2	41.0	43.0	46.0	40.0	44.0	51.0	
	S_3	39.0	41.0	47.0	41.0	40.0	38.0	46.0
	S_4	42.0	56.0	65.0	39.0	40.0	42.0	
	S_5	47.0	50.0	60.0	39.0	41.0	46.0	
8:00-9:00am	S_1	49.0	48.0	49.0	53.0	58.0	62.0	S_B
	S_2	44.0	46.0	49.0	43.0	47.0	54.0	
	S_3	42.0	44.0	50.0	44.0	43.0	41.0	51.0
	S_4	45.0	59.0	68.0	41.0	43.0	45.0	
	S_5	50.0	53.0	63.0	42.0	44.0	49.0	
9:00-10:00am	S_1	45.0	44.0	45.0	49.0	54.0	58.0	S_c
	S_2	42.0	44.0	47.0	41.0	45.0	52.0	
	S_3	40.0	42.0	48.0	42.0	41.0	39.0	47.0
	S_4	43.0	57.0	65.0	40.0	45.0	41.0	
	S_5	48.0	51.0	61.0	40.0	42.0	47.0	
10:00-11.00am	S_1	46.0	45.0	46.0	50.0	55.0	59.0	S_D
	S_2	43.0	45.0	48.0	42.0	46.0	53.0	
	S_3	41.0	43.0	49.0	43.0	42.0	40.0	48.0
	S_4	44.0	58.0	67.0	40.0	42.0	44.0	
	S_5	49.0	52.0	62.0	41.0	43.0	48.0	
11:00-12:00am	S_1	48.0	46.0	48.0	52.0	57.0	61.0	S_E
	S_2	45.0	47.0	50.0	44.0	48.0	55.0	
	S_3	43.0	45.0	51.0	45.0	44.0	40.0	49.0
	S_4	46.0	60.0	65.0	43.0	44.0	43.0	
	S_5	51.0	54.0	64.0	43.0	45.0	50.0	
12:00-1:00pm	S_1	47.0	52.0	59.0	45.0	52.0	60.0	S_F
	S_2	46.0	49.0	52.0	51.0	57.0	60.0	
	S_3	40.0	47.0	49.0	42.0	52.0	55.0	49.0
	S_4	43.0	53.0	56.0	44.0	46.0	51.0	
	S_5	41.0	43.0	46.0	44.0	48.0	52.0	
1:00-2:00pm	S_1	45.0	50.0	57.0	43.0	50.0	58.0	S_G
	S_2	44.0	47.0	50.0	49.0	55.0	58.0	
	S_3	38..0	45.0	49.0	40.0	50.0	53.0	47.0
	S_4	40.0	51.0	54.0	42.0	44.0	49.0	
	S_5	39.0	41.0	44.0	42.0	46.0	50.0	
2:00-3:00pm	S_1	44.0	49.0	56.0	43.0	49.0	57.0	S_H
	S_2	43.0	46.0	49.0	48.0	54.0	57.0	
	S_3	37.0	44.0	46.0	39.0	49.0	52.0	46.0
	S_4	40.0	50.0	53.0	41.0	43.0	50.0	
	S_5	38.0	40.0	43.0	41.0	45.0	49.0	
2:00-3:00pm	S_1	46.0	51.0	58.0	44.0	51.0	59.0	S_I
	S_2	45.0	48.0	51.0	50.0	56.0	59.0	
	S_3	39.0	46.0	48.0	41.0	51.0	54.0	50.0
	S_4	41.0	52.0	55.0	43.0	45.0	50.0	
	S_5	40.0	42.0	45.0	43.0	47.0	51.0	
3:00-4:00pm	S_1	43.0	48.0	55.0	41.0	48.0	56.0	S_J
	S_2	42.0	45.0	48.0	47.0	53.0	56.0	
	S_3	36.0	43.0	45.0	38.0	48.0	51.0	45.0
	S_4	39.0	49.0	52.0	40.0	42.0	47.0	
	S_5	37.0	39.0	42.0	40.0	44.0	48.0	

Socio-Economic Resources: The IWTF project is sited at the right hand side of the road about 2.4km away from the North Bank Makurdi town and College of Advanced and Professional Studies, Makurdi. This road also leads to University of Agriculture Makurdi Main Campus. The site is close to Jamo stream and the nearest settlement to the site is Akir village. The one kilometre radius starts from the bridge near the Federal Housing and ends at Imande village. The Jamo stream separates Mbagune kindred on the West and Mbaikejor kindred on the East. Within the 1km radius of the site, there is a primary school at Imande, a village along with Roman Catholic Church. Fire wood is sold here daily. On the other side of Jamo stream almost opposite the IWTF there is a site being acquired by Gindiri Old Students Association (GOSA) for the establishment of a secondary school. There is grain grinding mill at Imande. There is in Mbagune kindred another grinding mill. Fire wood is also sold here daily. The women mainly are involved in this industry. Even though there are fishermen etc crops dominates the farm out puts.

Public Concerns and Expectations from the Participating Members of the Community: During the consultations, a score of the expectations of the participants was made. Fifty percent of the participants had not made up their minds about what to expect from the meetings whether pleasant or unpleasant. About 30%

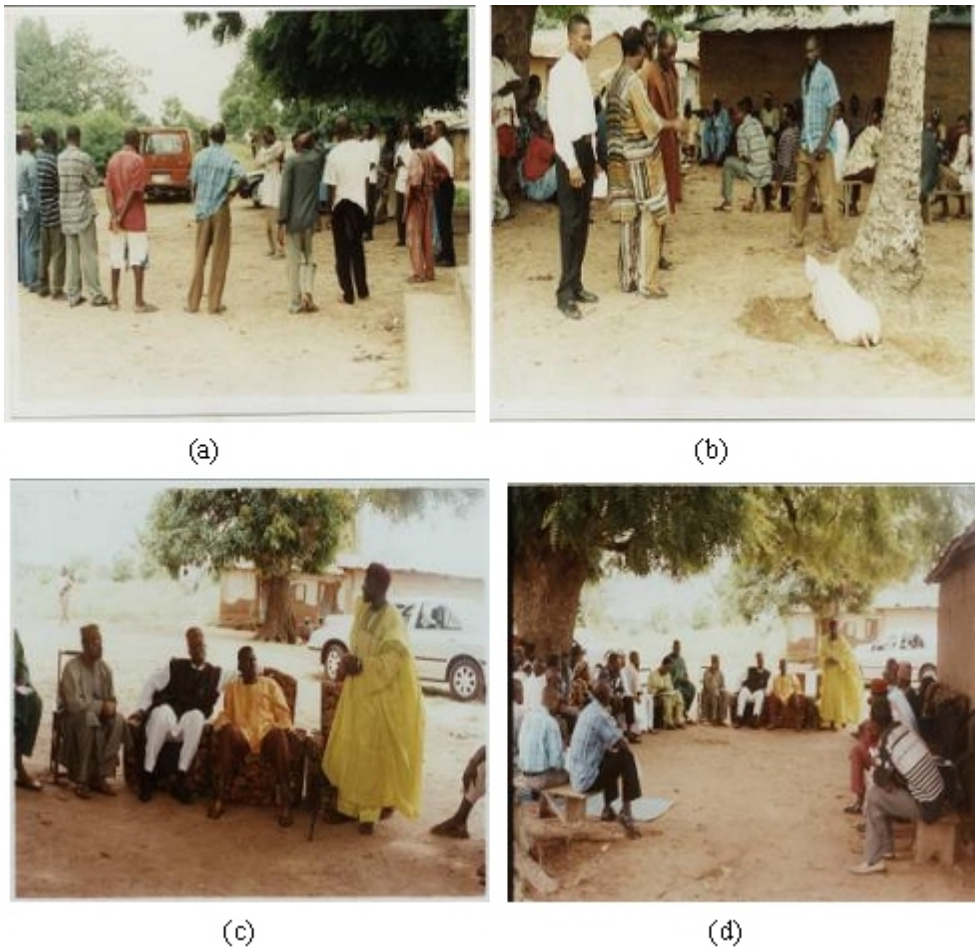

Plate 3: Cross-sections of participants during the public consultations; (a) Breaking the ice; (b) Presentation to Elder Ugobi as part of the consultation process; (c) Ag. Ter Makurdi addressing the consultation meeting (from his right is Hon. Comm. for Lands and Survey; Hon. Comm. for Water Resources and Environment and Chairman, Makurdi LGA) and (d) The Chiefs sitting to the right listening with approval as the Ag. Ter Makurdi speaks their mind.

believed that the workshop/meeting was to discuss the improvement of their welfare in water supply, installation of electricity and employment facilities. A smaller percentage 13.4% said that they were to discuss the project at the meeting and believed that both old and young should have a say whether the project was to be or not to be situated in their community. About 6.6% felt that before the facility was to be sited, compensation must be paid to members of the community. Plates 3 a,b shows cross-sections of participants during the consultations.

Legal Requirements: The EMSC initiated the process to obtain title to the four top ranked sites due to uncertainty over the feasibility of land acquisition to provide an excellent avenue for any future expansion of services(Barrat and Sha'Ato, 2004). Officers of the Benue State Ministry of Land and Survey visited the four sites with the Chairman, TWG on 9th December 2003. While all four sites were said to be available for acquisition, they independently ranked the sites for ease of acquisition and suitability for the purpose requested, the present site for the EIA came first (Whiteman *et al*., 2004). However, EIA public consultation has shown that the process of acquisition of the title to the land did not take into consideration necessary compensations to be paid to the community even though it is claimed that "*the land is fully owned by State Government and no land ownership or acquisition issues are foreseen*". The legal requirement of land acquisition after due process is therefore required by Government for subsequent developments.

By Section 1 of the Nigerian Land Use Act, all land comprised in the territory of each state in the federation are vested in the Governor for that state and such land shall be held in trust and administered for the use and common benefit of all Nigerians in accordance with the provisions of the Act (Land Use Act, 1978). However, ownership of land by the state government under the Act is not absolute. A holder of a right in land be it customary or statutory right is entitled to be compensated according to Section 29 of the Land Use Act 1978. This is the usual

procedure for revocation of customary and statutory right of occupancy for overriding public interest by State Governments.

Outcome of the Major Community Meetings: There was much dialogue between the EIA Public Consultation team and the community. However, at the end of this very important meeting with the chiefs and the community, members were very well aware of what the IWTF project was and what benefits they were to derive from it and though they were very willing to allow the EIA team to carry on with the technical test and assessments, they insisted that compensation must be paid for the piece of land where the project was to be situated. This demand was beyond the scope of the EIA team and as such the issue had to be referred to the MWRE. A meeting was fixed for Wednesday 11th August, 2004 at which the Commissioners for Ministry of Water Resources and Environment and Lands and Survey, Ter Makurdi, Chairman Local Government Council Makurdi, etc were in attendance (see Plate 3c,d). It was resolved that a team for evaluation should be sent by Government to estimate a value for the land preparatory to payment of compensation. In the recent years, the rural communities are becoming aware of their environment and their rights. It has also been noted that youth and women have to be carried along with consultations if lasting results are to be achieved. Generally, the community was very friendly.

CONCLUSIONS

The environmental baseline characteristics of the IWTF project site was established covering terrain/topography, climate and meteorology, land ownership, land use and zoning, soil quality, geological formations underneath the project site, hydrology and water quality, groundwater geophysical survey, hydrogeology, ambient air quality, ecology of the project site and surroundings, baseline noise levels and public consultation. The results of the study provides further basis for EIA and subsequent monitoring of the impacts of the project during construction, operation, closure and aftercare phases.

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