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On Investigating Pollution of Groundwater from Atenda Abattoir Wastes, Ogbomoso, Nigeria

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ABSTRACT

The incidence of waterborne diseases arising from pollution of shallow wells in abattoir environment has been on the increase in Ogbomoso community. This project work was carried out in order to examine the geochemical constituents of water samples taken from selected wells in Atenda abattoir environment, Ogbomoso, Oyo State, Nigeria. The effect of abattoir wastes on the groundwater samples and geotechnical analyses of soil samples taken from two points around the abattoir waste dump, and another sample from a control point free from pollution and far away from where the first two samples were taken, were also carried out. Geophysical investigation of the Atenda area was carried out using Vertical Electrical Sounding (VES) of Electrical Resistivity Method (ERM), Electrical Resistivity Tomography (ERT), and also, Very Low Frequency (VLF) electromagnetic method. The geophysical investigation was carried out to determine the lithology of the study area, track the contaminant plume view and compute the depth to bedrock in the study area. It was observed that a strong correlation exist between leachates from the Atenda abattoir location and sampled wells in the immediate environment. A groundwater monitoring programme to determine groundwater quality status of wells in the neighbourhood of abattoirs is recommended for implementation to safeguard the health of innocent residents in the vicinity.

Keywords: *Abattoir Environment, Pollution, Contaminant Plume, Sampled Wells*

1. INTRODUCTION

Abattoir is a slaughter house derived from the French word “abattre” meaning ‘to strike down. It is a place where animals such as cow, cattle, goats, and so on are killed, dressed and distributed for consumption and other industrial purposes. Abattoir operation produces a characteristic highly organic waste with relatively high levels of suspended solid, liquid, and fat. According to Meadows (1995), while the slaughtering of animals result in meat supply and useful by-products, like leather and skin, livestock waste spills can introduce enteric pathogens and excess nutrients into surface waters, and can also contaminate groundwater.

These leachates, as observed by Ifeadi (1982), consist largely of solids, microbial organisms and in special situations chemicals and shallow wells like hand-dug wells are more dangerously polluted. The solid waste includes condemned meat, undigested ingesta, bones, horns, hairs, aborted fetuses and feaces. The liquid waste is usually composed of dissolved solids, blood, gut contents, urine and water. As population grows and urbanization increases, more water is required and greater demand is made on ground and surface water and an even greater amount of organic and inorganic wastes are speared back into water sources so that less potable water becomes available (Amuda and Odubella, 1991).

Water is regarded as being polluted when it is unfit for its intended use. The self-purification process of ground water is a function of the depth of the soil and the concentration of the pollutant in the percolating water [Ifeadi, 1982]. The water used for cleaning procedures must meet drinking water standards and potable water is one that does not contain chemical substances or microorganisms in amounts that could cause hazards to health (Alonge, 1991; Ifeadi, 1982).

Adesemoye et al (2006) opined that the continuous drive to increase meat production for the protein needs of the ever increasing world population has some pollution problems attached. In many countries, according to the author, pollution arises from activities in meat production as a result of failure in adhering to Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP).

Consideration is hardly given to safety practices during animal transport to the abattoir, during slaughter and during dressing. For example, during dressing, the oesophagus of cattle and sheep should be sealed to prevent leakage of animal contents. These ineptitudes often lead to contaminations from hides, hooves and content of alimentary tract during evisceration and negatively impact on the environment, including microbes in the soil and surface and ground water (Hinton et al., 2000; Laukova et al., 2002; Amisu et al., 2003).

Many authors have worked on abattoir wastes and contamination of surface and groundwater sources in several parts of the world. Notable amongst such works are those of Adewoye and Lateef (2004); Adegbola and Ekundayo (2012); Adegbola and Oladeji (2012); Adeyemo (2003); Amisu et al (2003); Madigan et al (2003); McLanghlin and Minea (1995); Shah and Thakur (2002); Inglis and Cohen (2002); Hinton et al (2000) and Efe (2005).

The focus of this investigation, however, is to know the extent of the contamination Atenda abattoir operation has on the groundwater in the immediate environment over the years, and the possible ways to minimize the spread through continuous checking. The aim is to examine the extent of contamination in the subsurface water from wells around the abattoir using appropriate techniques.

The study was carried out in Ogbomoso, Oyo State, Nigeria. Ogbomoso is located in the south western part of Nigeria between the longitudes 08^0 03^1 to 08^0 12^1 and latitudes 04^0 11^1 to 04^0 19^1. Ogbomoso is the administrative headquarters of both Ogbomosho North and South Local Government Areas. It is situated 57 kilometers South-West of Ilorin, the capital of Kwara State; 104 kilometers North of Ibadan and 58 kilometers Northwest of Oshogbo, the capital of Osun state. The popular Atenda abattoir was chosen for the study based on the large expanse of built up area in the immediate environment, comprising low, medium and high housing densities. Majority of residents are civil servants and traders. The abattoir harbours meat shops where slaughtered meat is sold. There are two wells within the slaughter area. The abattoir is surrounded at the south with residential developments and in the north by office complex and west and east by school and shops respectively. The abattoir is about 200meters from the main Ibadan-Ilorin road.

The study area is low lying (low relief) and has a dendritic drainage pattern which is controlled by the topography. Ogbomoso exhibits the typical climate of averagely high temperature, high relative humidity and generally two rainfall maxima regimes during the rainfall period of March to October. The main temperatures are highest at the end of harmattan (averaging 28^0), that is, from the middle of January to the onset of the rains in the middle of March. During the rainfall months, temperature varies between 28^0c and 25^0c, while annual temperature average is about 6^0c. Rainfall varies over the town from an average of 1200mm at the onset of the heavy rains to 1800mm at the peak.

The vegetation of this area is that of the rainforest and derived savannah. The composition is basically the tall crowned trees mixed with thick undergrowth. The trees attain the height of about 20-40m, and grasses are abundant and luxuriant. The typical type of the grass here is that of elephant grass and stubborn grass. The tropical trees are locust beans and most of the trees are deciduous.The climate condition is typical of the south western part of Nigeria whose climate is influenced largely by equatorial maritime air mass. The study area is relatively rugged with undulating topography (Figure 1). The Sunsun and its surrounding environment is exactly 325m and the general elevation varies between 309m and 325m above mean sea level. The average elevation above sea level is about 314m. Figure 2 depicts the graphical details of the study area. The drainage, location and geological maps of the study area are presented in Figures 3, 4 and 5, respectively. Plates 1 and 2 represent the waste dump site of Atenda Abattoir and one of the sampled wells, respectively.

2. METHODOLOGY

The method of investigation adopted in this study includes: reconnaissance survey, geophysical, hydrogeological, and geotechnical mapping of the study area with sampling and analyses. A total of four wells were sampled for analyses within and around the pollution source. Bottles used in the collection of water samples were sterilized in an autoclave at a temperature of120^{o}C for three hours before duplicate samples of 100ml and 2 litres of each of the well water was collected for bacteriological and hydrogeochemical analyses, respectively. The parameters tested for in the water samples include: cyanide, PO_4^-, SO_4^-, Cl^-, NO_3, HCO_3, arsenic, manganese, Fe^{2+} , $NH_{4+,}$ Pb^{2+}, Cd^{2+}, Cu^{2+}, Cr^{2+}, Zn^2, SiO_2, Na, K, Ca, Mg, Nitrate, total suspended solid, dissolved oxygen, and biochemical oxygen demand.

Two Soil samples were collected around the pollution site and another soil sample from a control point far from the pollution source at a depth of about more than 1 metre. These samples were labeled in order to avoid mix-up and were taken to the laboratory for grain size and consistency limit analyses. The electrical resistivity method, which utilizes direct currents or low frequency alternating currents, was used to investigate the electrical properties (resistivity) of the subsurface materials. A reconnaissance survey of the study area was carried out to give a real time site assessment and also to acquire information about the township which may not readily be available in the topography map.

The physical parameters tested include: total solids, turbidity, pH, conductivity, total dissolved solid, alkalinity and total hardness. The laboratory analyses of the water samples were carried out in Kappa Biotechnology, Ibadan, Oyo State, Nigeria. The source and site description for the sampling points are presented in Table 1.

3. RESULTS AND DISCUSSION

The result of the physicochemical parameters obtained from four hand dug wells and that of three samples from upstream, downstream and midstream at Atenda abattoir environment are presented in Table 2. Tables 3 and 4 present the coefficient of correlation of parameters and grain size distribution parameters, respectively.

The pH of the well surrounding the abattoir ranges between 5.7 -- 6.7. When compared with the recommended World Health Organization (WHO) Standards value of 6.5- 8.5, it can be deduced that the sample from well 3 is slightly acidic. The pH for the stream ranges between 6.3 – 6.6 and this falls within the recommended WHO value. The total solids value ranges between 1243.4- 2550 for all the water samples. ATDS has the highest value of TDS; this might be due to the fact that solid wastes were much in the water discharged into the stream. Total suspended solids ranges between 1163.3 – 2550. TSS values were strongly correlated with TS (0.74). (Table 3). This shows proportional increase in TSS as TS value increases. The reason for increased value of TSS might be the same with that of TS.

From the analysis of the water samples, the value for the total viable count for the entire wells ranges between 4.1 x 10^4 to 8.5 x 10^5. These values are higher than the recommended value of 0 -- 10 cfus by WHO. Water samples with total viable count above the standard indicate waterborne diseases such as intestinal infection, cholera and typhoid fever. The total colliform count from all the water samples ranges between 1.1 x 10^4 to 5.4 x 10^4 .These values exceed the recommended range by WHO which is 100cfu for drinking water. The presence of high colliform count in a water system can result in some water borne diseases such as: cholera and typhoid fever.

It can be deduced from Table 3, that the following parameters have a strong or direct correlation, viz: pH and colour (0.94), TSS and colour (0.7), $P0^4$ and colour (0.76), CL^- and colour (0.76), TVC and colour (0.94), TCC and colour (0.84), PO^4 and pH (0.84), ^{TVC} and pH (0.72), TCC and pH(0.74), TDS and conductivity (0.9), BOD and conductivity (0.78), CL^- and conductivity (0.84), Fe^{++} and conductivity (0.87), Na^+ and conductivity (0.98), K^+ and conductivity (0.81), TS and TSS (0.74), TDS and BOD (0.82), TDS and Alkalinity (0.73), TDS and Cl^- (0.81), TDS and Fe^{++} (0.84), TDS and Na^+ (0.95), TDS and K^+ (0.77), TSS and Fe^+ (0.91), TSS and TVC (0.91), BOD and Na^+ (0.73), TH and Alkalinity (0.77), Alkalinity and Ca^+ (0.88), Cu^{++} and TH (0.85), Ca^+ and TH (0.97), PO^4 AND Cu^+ (0.81), PO^4 and Na^+ (0.94), PO^4 and Mg^+ (0.81), PO^4 and TCC (0.87), Fe^+ and Cl^- (0.99), Na^+ and Cl^- (0.82), K^+ and Cl^- (0.99), Fe^+ and Na^+ (0.84), Fe^+ and K^+ (0.98), Cu^+ and Ca^+ (0.72), Cu^+ and Mg^+ (0.86), Na^+ and K^+ (0.81), Mg^+ and TCC (0.84), and TVC and TCC (0.91). The strong or direct correlation indicates, approximately equal levels of increase between the parameters, for example, between TVC and NO^3, indicating that the two parameters are increasing at the same rate and also that these parameters are presumed to be from the same hydrochemical source.

The weak correlation exist between the following set of parameters: BOD and Alkalinity (0.67), Alkalinity and Fe^+ (0.6), NO^3 and Mg^+ (0.6), NO^3 and TVC (0.57), NO^3 and TCC (0.56), Mg^+ and TVC (0.58). The weak indirect correlation indicates that one of the parameters is not increasing as much as the other, which means the rate of increase of either of the two parameters is greater than the other and also that both parameter are presumed not to be from the same hydrochemical source.

Grain size distribution is the amount of different sized particles present in soil sample. The character of a soil is established from its grain size composition. The dominant grain size group naturally establishes the behaviour pattern, depending on the quantities of the other group sizes present. The results of the analysis of the grain size distribution of the three soil samples obtained from three pits and grading curves are presented respectively in Table 4 and Figures 6, 7 and 8. According to the unified soil classification system, sample 1 has its Cu to be 6.8 and Cc to be 1.1. Both values meet the requirements of a well graded soil. Therefore, since the total percentage of sand is more than that of gravel, it is a well graded gravelly-sandy soil. Sample 2 can also be said to be well graded since both criteria are met. Therefore, it is is a well graded sandy-gravelly soil.

Sample 3 is a poorly graded soil, because it has its Cu to be 4.7 and Cc to be 1.0 and these values meet the requirement for a poorly graded soil. It can be seen from the above values that the total value of sand is higher than that of the gravel, hence sample 3 is a poorly graded gravelly-sandy soil. A well graded soil is a soil that has a good distribution of sizes in a wide range, where smaller grains fill the voids created by the larger grains thus producing a dense packing. The grain size distribution curves for such soils would generally be smooth and concave. In poorly graded soil (uniform), the grains are about the same size. Based on grain size distribution, soil A and B, which are well-graded, contain enough smaller particles to pack around the big ones and fill the voids, resulting in low water flow, while soil C, that is poorly graded, will result in high water flow. Soil C, therefore, will allow for high accumulation of contaminants into the subsurface strata, and in extension, the groundwater.

The results of the interpreted VES curves (Figures 9, 10 and 11) were used to draw 2D geoelectric sections along profiles 1--4 (Transverse one), 5--7 (Transverse two), 8-11 (Transverse Three), to show the vertical distribution of resistivities within the volume of the earth in the investigated area. The sections consist of sequence of uniform horizontal (or slightly inclined) layers (horizons). Each layer (horizon) in a geo-electrical section may completely be characterized by its thickness and true resistivity. The geoelectric sections show both vertical and lateral variations in layer resistivity.

The V L F data were collected along the three traverses at the study area and 1 traverse at a control point about 500 meters form the pollution site. Data collected were recorded on ABEM WADI survey field data sheet, depicting the followings: Current Strength, Raw Real, Filter Real, Raw imaginary (RI), Filter Imaginary (FI). Graphs of RR versus Position (m) and FR versus Position (m), were plotted for each of the traverses. Figures 12--15 show the images for raw real and filtered real, with their interpretation for all the four profiles.

In Profile One/Figure 12, two high positive peaks were observed between 50-60m and between 80-100m. These high positive peaks correspond to regions of high conductivities characterized by weak zones. The lateral spread is approximately 10m to 20m, respectively. A very high positive peak is observed along this traverse between the distance of 10m and 30m. This weak zone is a fractured zone of possible contaminated water.(Figure 13). In Profile Three/Figure 14, two peaks of relatively medium and high values were observed along this profile between the distance of 20-40m and 40- 60m respectively, which indicate a possible presence of fractured zone, filled with contaminated water. **A**long traverse four, there exist a high peak of positive value and another positive value of relatively low value. These zones contain fractures but not in appreciable quantities that is enough to provide seepage of leachate into the groundwater. From these interpretation, traverse (Figures) 12 – 14 indicate the presence of high fractured zones which can constitute seepage paths for pollutants to migrate into groundwater.

This survey was carried out along three traverses as for VLF survey.The collected geoelectrical data were processed by means of the RES2DINV (Loke, 1997) modelling software in other to perform 2D geoelectrical data inversion.

The 2D Inverse Model Resistivity Section Profile 1 – 3, using the ERT, is presented in Figure 16. In Profile 1, a well pronounced low resistivity zone could be seen along this profile which constitutes a conductive zone (the contaminated zone) at a very deep depth of about 6.5m. At a distance of 24m and 72m, this low resistivity is well pronounced. In Profile 2, a well defined low resistivity value could also be seen along this traverse at a depth ranging from 3.82m to 7.46m and at a distance of 24.0m, This distance when correlated with the first traverse can be observed to be similar. This zone can be interpreted to be a plume of conductive leachate which has made its way to the groundwater aquifer as a result of its very low resistivity value. In Profile 3, this profile indicates low resistivity value at distance ranging from 9m to 75m along the profile and at depths ranging from 3.82m to 7.46m. This low resistivity indicates conductive zones which is suspected to contain water.

4. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are drawn from the investigation:

- A strong correlation exist between leachates from the Atenda abattoir location and parameters from sampled wells in the immediate environment.

- The total colliform count from all the water samples ranged from 1.1 x 10^4 to 5.4 x 10^4 .These values exceeded the recommended range by WHO which is 100cfu for drinking water. The presence of high colliform count in the water system of the immediate environment of Atenda Abattoir is concluded to be responsible for the rising incidence of water borne diseases in the area.

- Based on grain size distribution, soil A and B, which are well-graded, contain enough smaller particles to pack around the big ones and fill the voids, resulting in low water flow, while soil C, that is poorly graded, will result in high water flow. Soil C, therefore, will assumably allow high accumulation of contaminants into the subsurface strata, and in extension, the groundwater.

- Traverse (Figures) 12 – 14, across the study area, indicated the presence of high fractured zones which could constitute seepage paths for pollutants to migrate into groundwater.

It is recommended that a groundwater monitoring programme to determine groundwater quality status of wells in the neighbourhood of abattoirs be implemented by stakeholders to safeguard the health of innocent residents.

ACKNOWLEDGEMENT

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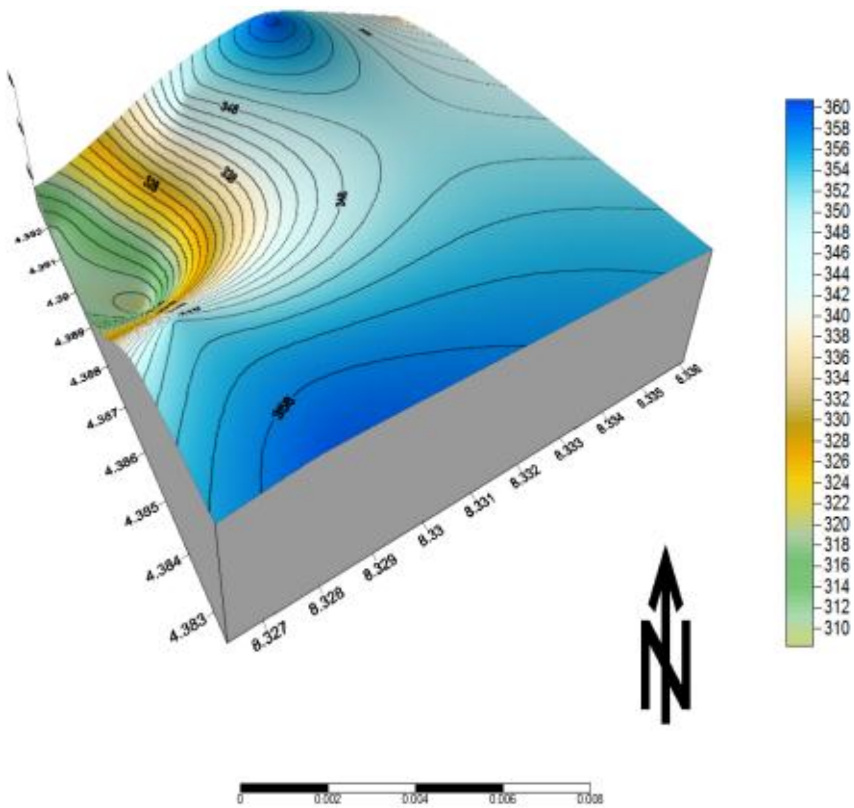


Figure 1: Topographical Map of the Study Area

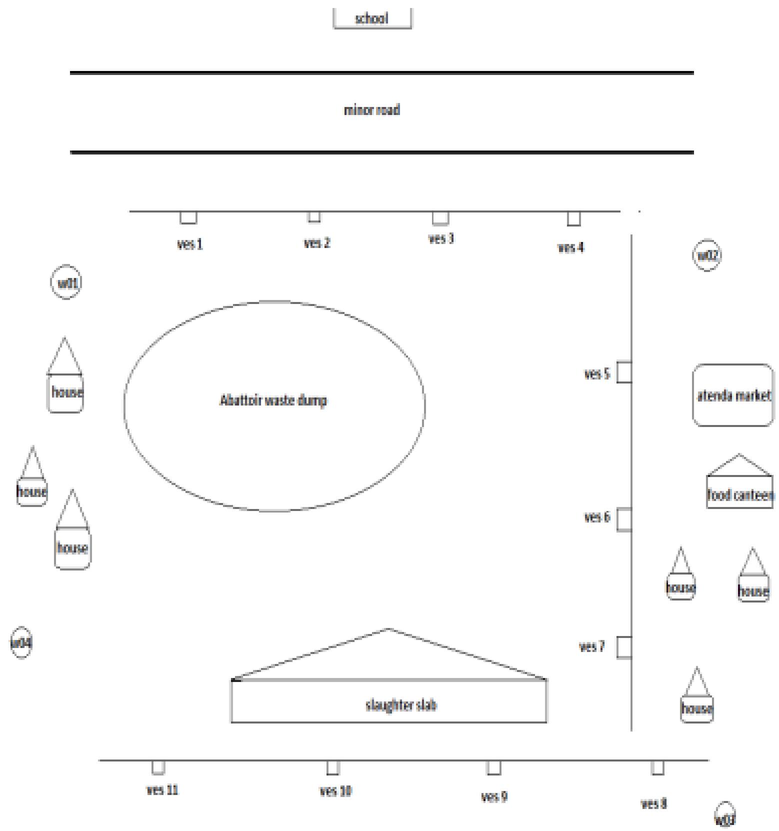


Figure 2: Graphical Details of the Study Area and its Environment

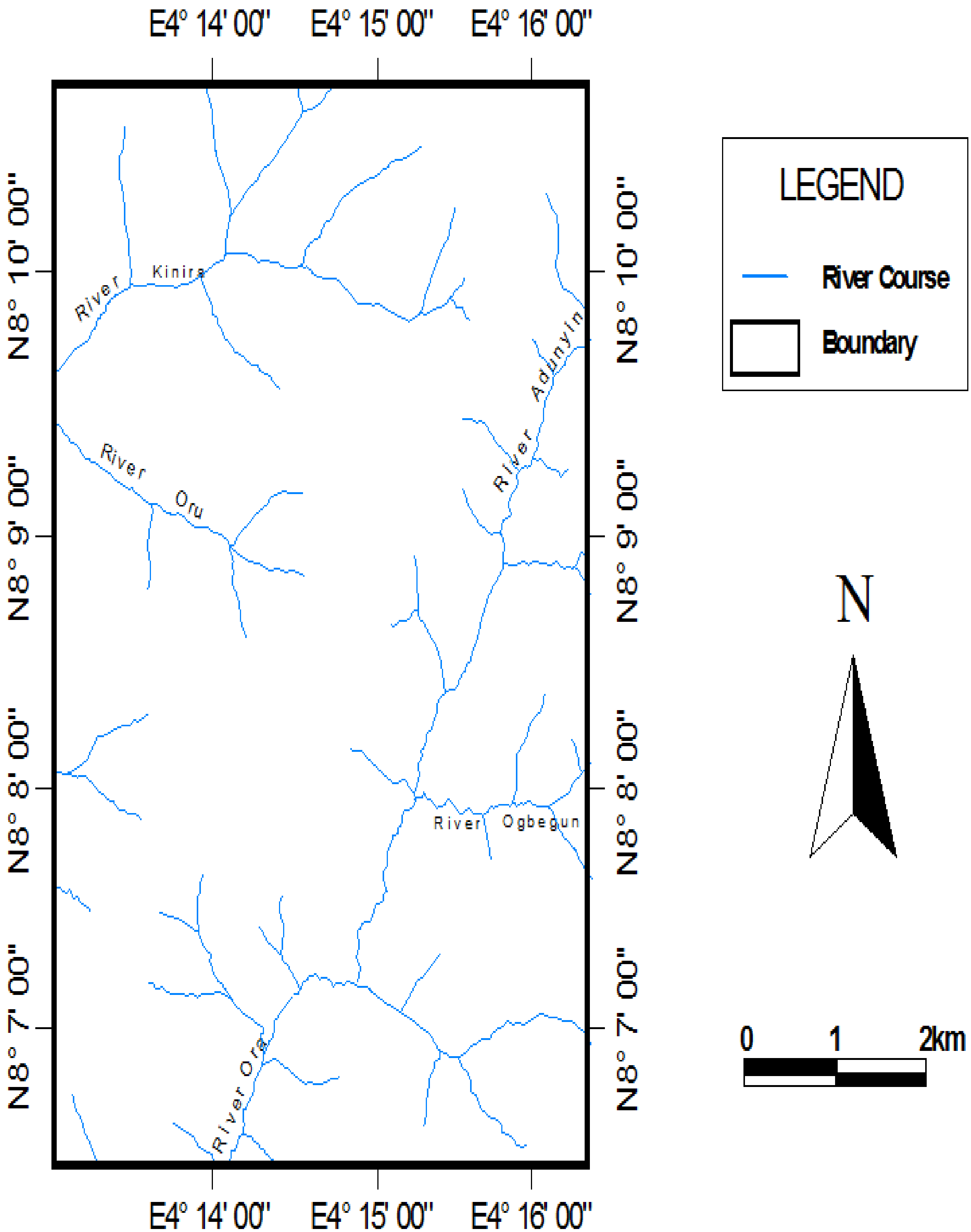

E4° 14' 00"
E4° 15' 00"
E4° 16' 00"
N8° 10' 00"
N8° 9' 00"
N8° 8' 00"
N8° 7' 00"
River Kinira
River Oru
River Adunyin
River Ogbegun
River Ora
LEGEND
River Course
Boundary
N
0
1
2km

Figure 3: Drainage Map of the Study Area

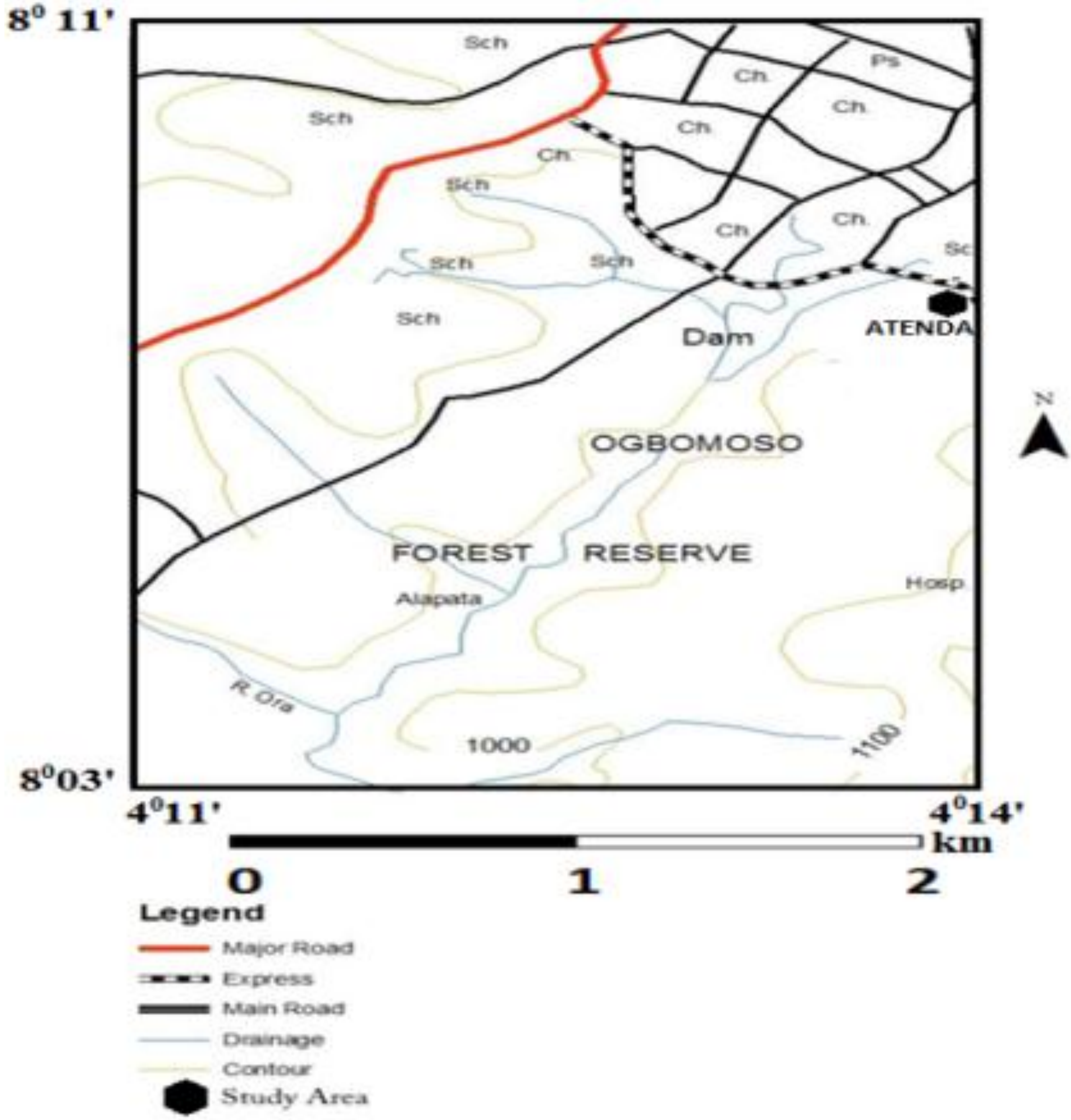


Figure 4: Location Map of the Study Area

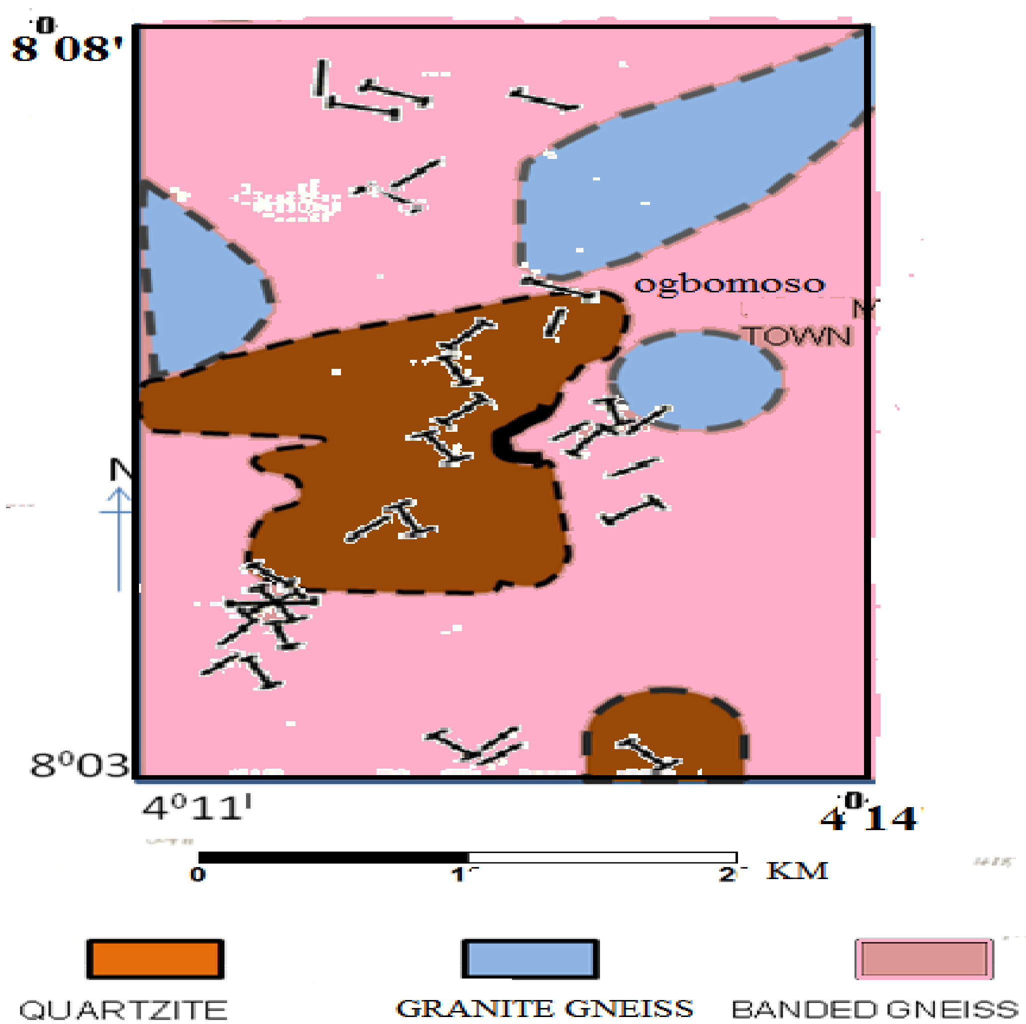


Figure 5: Geological Map of the Study Area

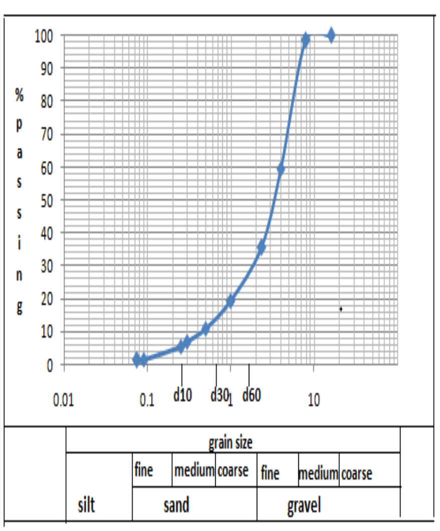


Figure 6: Graph Of Particle Size And Percentage Finer Than d For Sample

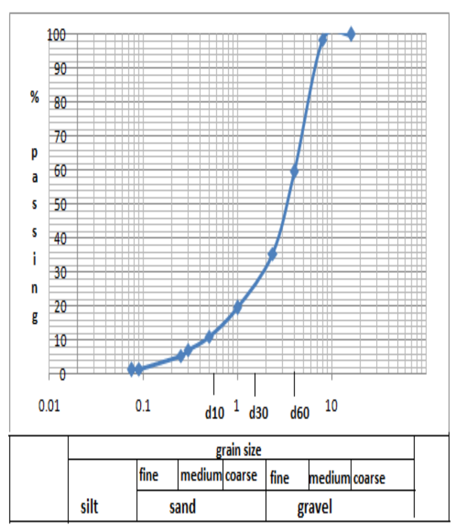


Figure 7: Graph Of Particle Size and Percentage Finer Than d For Sample 2

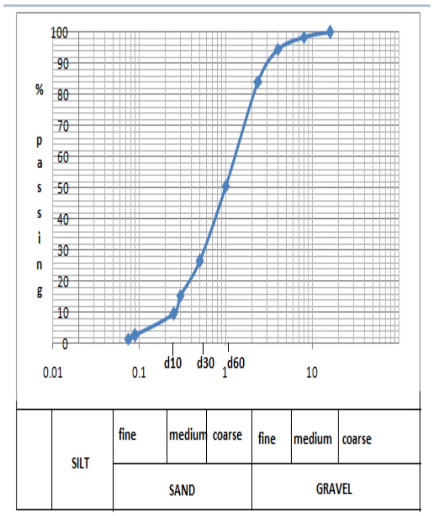


Figure 8: Graph Of Particle Size And Percentage Finer Than d For Sample 3

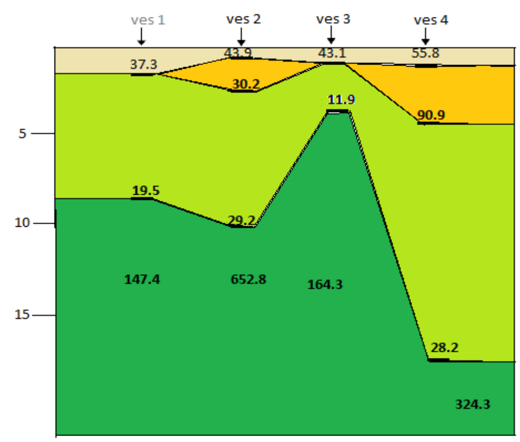


Figure 9: Geoelectric Section for VES 1-4

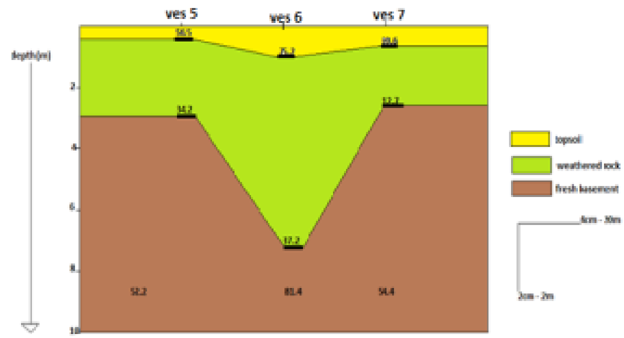


Figure 10: Geoelectric Section For VES 5- 7

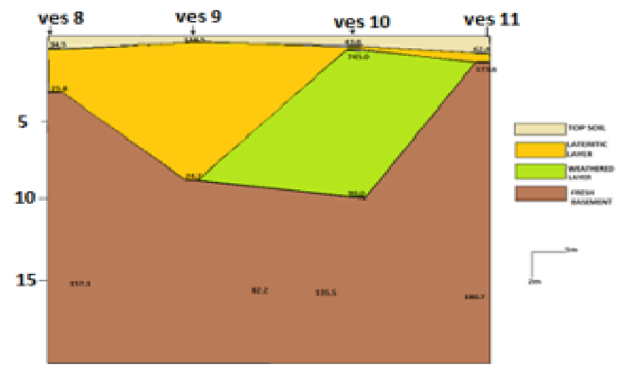


Figure 11: Geoelectric Section For VES 8-11

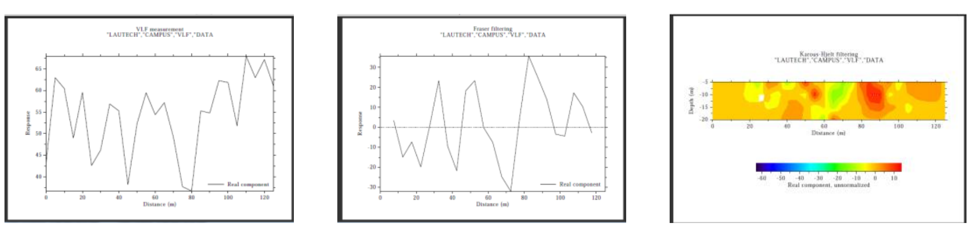


Figure 12: Image of VLF Interpretation For Profile 1

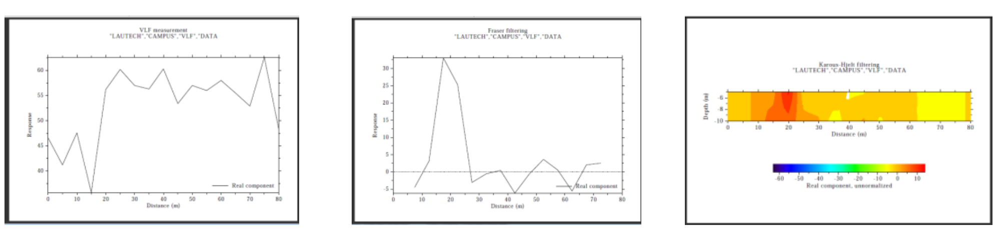


Figure 13: Image Of VLF Interpretation For Profile 2

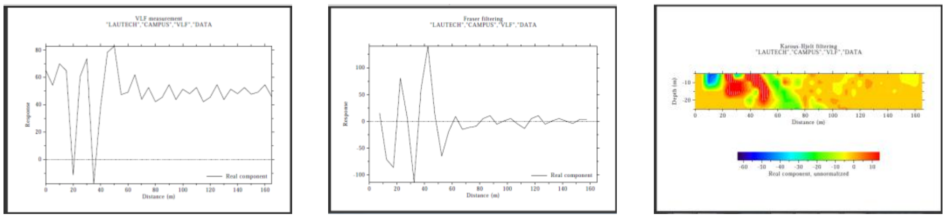


Figure 14: Image Of VLF Interpretation For Profile 3

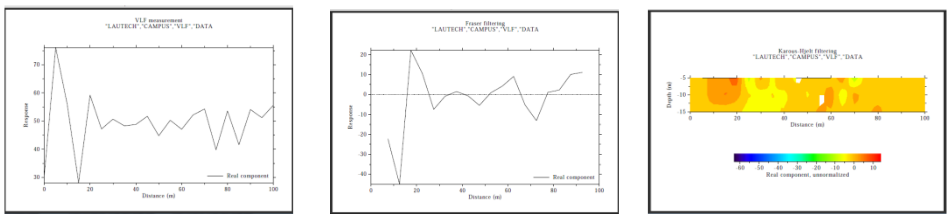
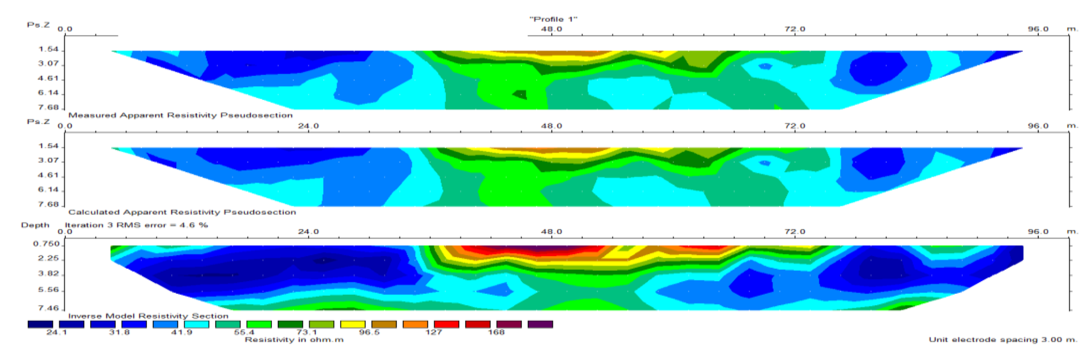
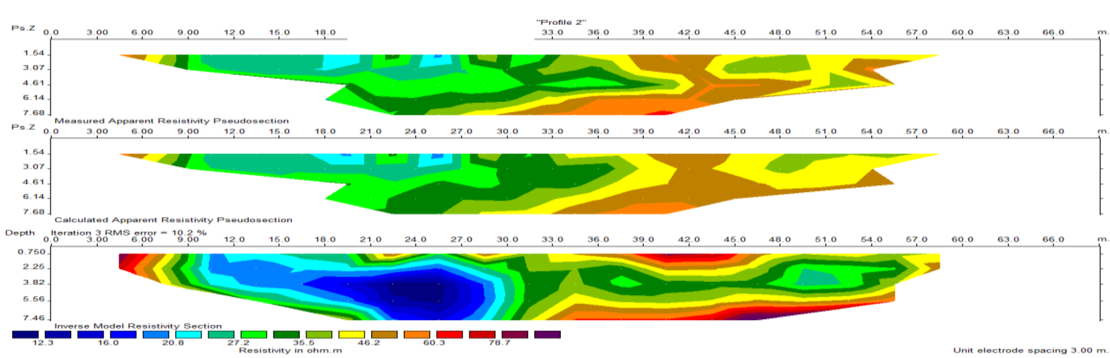


Figure 15: Image Of VLF Interpretation For Profile 4

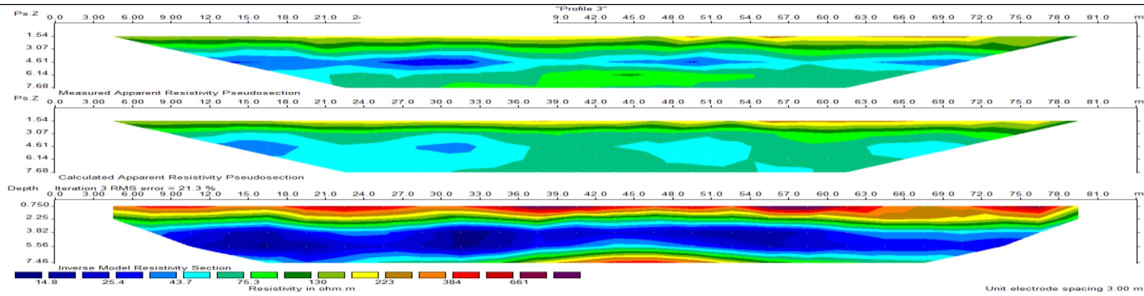
ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT)



PROFILE 1



PROFILE 2



PROFILE 3

Figure 16: 2D Inverse Model Resistivity Section Profile 1 – 3

Plate 1: Waste Dump Of Atenda Abattoir, Ogbomoso

Plate 2: One Of The Sampled Well At Atenda Abattoir

Table 1: Source and Site Description for Sampling Points

Sampling point	Description	Surrounding Activities
W 01	The well serves as source of water for butchers for washing meat	Waste dump of the abattoir and also a market where meat are sold
W 02	The well serves as drinking water for the residential houses around and also for the food canteen around	A food canteen and some residential houses and shops.
W 03	It serves as a source of drinking water for residential houses	Drainage, faeces along foot path, residential houses
W 04	The water provide water for the immediate needs of people around	Residential house ,church and a school
ATUP	The upstream Serves a as wash area for the butchers, also close to a mechanic wash area.	Residential houses and also a bridge
ATMD	The midstream is the waste water directly coming from the slaughter house	Residential houses, shops, minor road.

ATDS	The point at which the midstream open into a canal, there are extensions of sewage pipes from the surrounding houses along the path	Residential houses, a bridge across the minor road.

Table 2: Result of the Physicochemical Parameters of Water surrounding Abattoir Environment in Atenda.

Parameter	W 01	W 02	W03	W04	ATUP	ATMD	ATDS
P^H	6.5	6.7	5.7	6.4	6.6	6.4	6.3
Total solids	2413.3	1933.3	2143.3	1933	1243.4	2130	2550
Total Suspended Solids	1921.6	1675	1491.6	1356.6	1163.3	1980	2550
Nitrate	0.5	0.5	0.5	0.3	0	0.3	0.3
Phosphate	0.3	0.5	0.2	0.3	0.1	0.6	0.6
Chloride	4.56	4.43	7.03	8.26	4.5	6.5	7.2

All parameters in mg/l except pH.

Table 4: Grain Size Distribution of Parameters

Sample Number	**% Sand**			**% Gravel**			**Specific Gravity**	**D10**	**D30**	**D60**	**Cc**	**Cu**
	% Fine	% Med	% Coarse	% Fine	% Med	% Coarse						
Atenda 1	8%	20.5%	39%	29.5%	3%	0%	2.68	0.25	0.68	1.70	1.1	6.8
Atenda 2	4.5%	8%	21.5%	53%	13%	0%	2.64	0.46	1.70	4.0	1.6	8.6
Atenda 3	8%	22%	49%	19%	1%	0%	2.63	0.25	0.55	1.18	1.0	4.7

Table 3: Coefficient of Correlation of Parameters

	COL	*Ph*	*COND*	*TS*	*TDS*	*TSS*	*DS*	*BOD*	*ALK*	*TH*	*PO4*	*CL-*	*NO3*	*FE*	*Cu*	*Na*	*K*	*Ca*	*Mg*	*TVC*	*TCC*
Col	**1**																				
Ph	**0.94**	**1**																			
cond	**-0.96**	**-0.9**	**1**																		
TS	**0.15**	**-0.16**	**-0.04**	**1**																	
TDS	**-0.99**	**-0.93**	**0.99**	**-0.06**	**1**																
TSS	**0.7**	**0.42**	**-0.67**	**0.74**	**-0.68**	**1**															
DS	**0.45**	**0.43**	**-0.19**	**0.46**	**-0.29**	**0.33**	**1**														
BOD	**-0.85**	**-0.98**	**0.78**	**0.29**	**0.82**	**-0.24**	**-0.48**	**1**													
ALK	**-0.84**	**-0.73**	**0.67**	**-0.51**	**0.73**	**-0.73**	**-0.84**	**0.67**	**1**												
T H	**-0.3**	**-0.15**	**0.06**	**-0.77**	**0.13**	**-0.5**	**-0.91**	**0.15**	**0.77**	**1**											
PO4	**0.76**	**0.84**	**-0.887**	**-0.44**	**-0.85**	**0.27**	**-0.14**	**-0.78**	**-0.3**	**0.38**	**1**										
CL-	**0.76**	**-0.53**	**0.84**	**-0.41**	**0.81**	**-0.9**	**0**	**0.34**	**0.53**	**0.09**	**-0.6**	**1**									
NO3	**0.17**	**-0.11**	**-0.32**	**0.51**	**-0.26**	**0.7**	**-0.41**	**0.33**	**-0.01**	**0.11**	**0.13**	**-0.77**	**1**								
FE++	**-0.8**	**-0.59**	**0.87**	**-0.41**	**0.84**	**0.91**	**-0.06**	**0.4**	**0.6**	**0.14**	**-0.16**	**0.99**	**-0.73**	**1**							

CU++	**0.24**	**0.38**	**-0.46**	**-0.74**	**-0.4**	**-0.16**	**-0.66**	**-0.34**	**0.32**	**0.85**	**0.81**	**-0.29**	**0.15**	**-0.26**	**1**						
Na+	**-0.88**	**-0.84**	**0.98**	**0.12**	**0.95**	**-0.56**	**0.02**	**0.73**	**0.48**	**-0.17**	**0.94**	**0.82**	**-0.37**	**0.84**	**-0.64**	**1**					
K+	**-0.71**	**-0.49**	**0.81**	**-0.39**	**0.77**	**-0.88**	**0.08**	**0.28**	**0.46**	**0.03**	**-0.59**	**0.99**	**-0.81**	**0.988**	**-0.32**	**0.81**	**1**				
Ca+	**-5**	**-0.32**	**0.28**	**-0.8**	**0.35**	**-0.68**	**-0.9**	**0.28**	**0.88**	**0.97**	**0.18**	**0.32**	**-0.03**	**0.37**	**0.72**	**0.06**	**0.26**	**1**			
Mg+	**0.44**	**0.4**	**-0.67**	**-0.2981**	**-0.6**	**0.32**	**-0.6**	**-0.27**	**0.08**	**0.63**	**0.81**	**-0.7**	**0.6**	**-0.68**	**0.86**	**-0.81**	**-0.73**	**0.43**	**1**		
TVC	**0.9**	**0.72**	**-0.93**	**0.4**	**-0.92**	**0.91**	**0.24**	**-0.55**	**-0.73**	**-0.26**	**0.65**	**-0.96**	**0.57**	**-0.98**	**0.2**	**-0.86**	**-0.93**	**-0.48**	**0.58**	**1**	
TCC	**0.84**	**0.74**	**-0.95**	**0.02**	**-0.92**	**0.68**	**-0.09**	**-0.58**	**-0.45**	**0.15**	**0.87**	**-0.91**	**0.56**	**-0.92**	**0.59**	**-0.98**	**-0.91**	**-0.08**	**0.84**	**0.91**	**1**