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Geophysical Investigation of Sewage Contamination on Portable Water Supply in Warri Metropolis

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ABSTRACT
Geophysical methods, when integrated with hydrochemical analysis, can be used to investigate groundwater contamination. Direct current (DC) resistivity geo-electrical sounding data were collected within Warri area and used for investigation. The groundwater at shallow depths in alluvium, which is composed of gravel, sand and clay, were suspected to be contaminated with sewage seepage. Two geoelectric section were generated across the investigated area. A total of five subsurface geologic layer were delineated. These are the top soil, clayey sand, sand, coarse sand and fractured basement. Apparent resistivity values delineated were between 6 Ωm and 245 Ωm for the first layer; 9 Ωm and 2191.0 Ωm for the second layer; 39.1Ωm and 764.1 Ωm for the third layer; and 358Ωm and 1057.0 Ωm for the fourth layer the fifth layer which is coarsed sand have resistivity range from 40739 to infinity. Furthermore, the ranges of the thickness of the layers were found to be 0.2 m and 1.1 m for the first layer; 0.3 m and 47.9 m for the second layer; and 0.2 m and 1.1 m for the third layer. The depths of water table in the area were estimated to range between 0.2 and 35 m. The parameters used in characterizing the aquifer protective capacity of the overburden units were layer thickness and their corresponding resistivity values. Accordingly, the total longitudinal layer conductance of the overburden of the area was generally found to be high, implying that the aquifer protective capacity of the area is high. Areas with high hydraulic conductivity are most likely to allow fluid movement within the aquifer, which could potentially enhance the migration and circulation of contaminant in the aquifer system and hence the high (0.004 – 0.005 m/day) and the very high (0.004 – 0.005 m/day) values of hydraulic conductivity constitute the potential vulnerability zones in the study area. The area seem to be very porous and can be regarded as the contaminated zone, compared to other end of the profile which has highly compacted soil with high resistivity values ranging between 500Ωm to 10000Ωm. The water analysis result indicates slight contamination thus confirmed by the confining layer that may have protected the acquifer.
Keywords: Electrical resistivity; Groundwater; Contamination; Vertical electrical sounding; Apparent resistivity; Aquifer

1.0 INTRODUCTION

Water which is one major source of livelihood is a mineral that cannot be avoided from day to day consumption. This water can be obtained from several sources such as rain water, groundwater, well water, river water, borehole water and so on. Warri area which a town in Delta state, Nigeria is faced with so many activities that in one way or the other tempers with the sources of water thereby lowering the quality of the water bodies. Some of such activities are industrial waste oil, or industrial waste chemicals that are not properly disposed that flows into water bodies, indiscriminate disposal of refuse that leashes into water bodies and the closeness of damaged sewage septic tanks that are sited side by side with borehole and well water systems. All of these are the possible sources that lower the quality of drinking water in this locality. The lithological bodies act as natural filter to percolating fluids; therefore, its ability to retard and filter gradually through the porous ground surface reducing the flow of

polluting fluids is a measure of its protective capacity (Ogungbemi et al, 2013). The aquifer which is usually shallow in the basement complex terrains is sometimes usually exposed to surface and near-surface contaminations (Aweto, 2011). It has been asserted that once an aquifer is excessively depleted or contaminated, the damage is essentially permanent and efforts to reduce the contamination are extremely costly (Jegede et al., 2013). In the study area and the surrounding neighborhood, there are tangible concerns over remediation costs in the event of complete contamination since groundwater tapped from hand dug wells and boreholes at depths that are sometimes as shallow as 6 m is the main source of water used for domestic, agricultural and industrial activities in the area (Omeje et al.,2013)

When the water collected for consumption is below the standard of required for human consumption by the World Health Organization (WHO), it is termed unfit for drinking or contaminated. Some of the possible ways of lowering the quality of consumable water are from the overflow of sewage, septic tanks, leaking sewer lines, land application of sludge and partially treated waste water. Sewage, which is the focus of this investigation is a complex mixture containing many types of contaminants. Some of these pose serious threats to our water resources. Examples of the type of contaminant include bacteria, trace quantities of toxic materials, nitrates, metals, and salts. Seepage overflow into drinking water sources can cause disease from the ingestion of micro-organisms such as *E coli*, *Giardia*, Cryptosporidium, Hepatitis A, and helminths.(Khan et al., 2017)

Due to improper disposal/evacuation of sewage water and the damage/mismanagement of sewage facilities in our communities, 80 percent of our local inhabitants are prone to drinking of sewage contaminated water and thus there is the need to properly investigate this trend and carry out an awareness campaign to correct this mistake in our environment. This research intends to carry out geo-electric investigation within the area, determine the acquifer, determine if the acquifer is prone to contamination, test the water samples from various boreholes to identify the contaminated ones and carry out awareness symposium on the dangers of consuming sewage contaminated water.

2. Location of study Area

The study area is Warri metropolis located at the southern part of Delta state, Nigera with coordinates 5°31'N 5° 45'E/ 5.517°N 5.750°E/ 5,517;5.750 see Figure 2.1

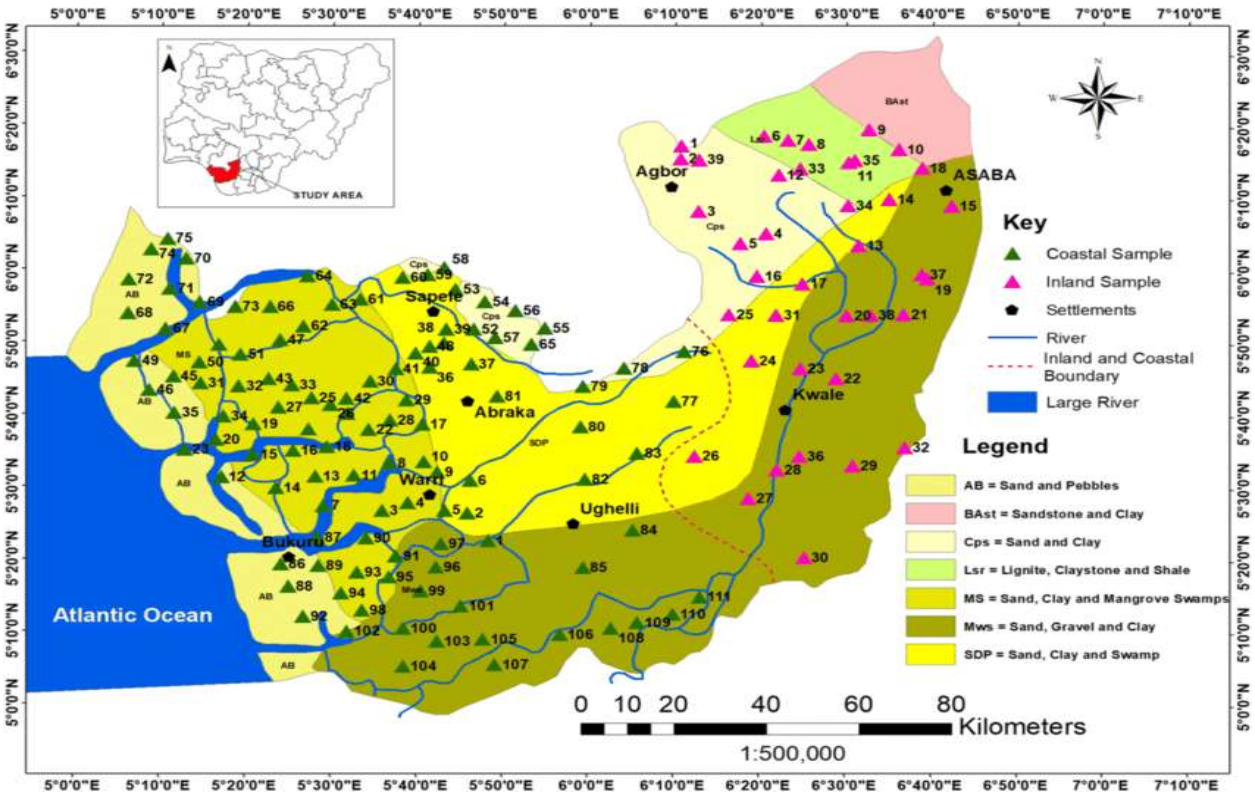

Figure 2.1 Geological Map of Western Delta Showing Location of Study Warri (Owoyemi et al. 2019)

Figure 2.2 Location picture of Field Investigation

2.2 Geology of study area

The subsurface geology of Warri area is within the Niger Delta Basin that is well established (Short and Stauble 1967; Asseez 1989). Three formations namely the Benin, Agbada and Akata Formations make up this basin, from the youngest to oldest respectively. The continental Miocene–Recent Benin Formation conformably overlies the Agbada Formation. The lithological composition is 90% sand and about 10% shale/clays (Short and Stauble 1967). The sands range in size from gravelly, coarse to fine-grained. They are also poorly-sorted, sub-angular to well-rounded, and bear lignite streaks and wood fragments. Its porosity, which decreases with depth, ranges from 15 to 31% in the basin (Tamunositki et al., 2014). It is made up of numerous aquifers. The Agbada Formation conformably overlies the Akata Formation in the subsurface. It is a parallic sequence of alternating shale and sandstone with a variable age ranging from Eocene to Pliocene/Pleistocene and Recent in the Delta surface. The Akata Formation, also known as marine shale ranges from p of the Delta sequence. The shale is believed to be over pressured and highly compacted (Murat, 1970).

3.0 METHODOLOGY

Geo-electric investigation involves electrical sounding Methods where the electrical properties of the subsurface of the earth would be obtained. In this research, vertical electrical soundings (VES) techniques were used. According to standard procedure in the Schlumberger configuration, the electrodes were moved in steps further out from a fixed center in order to achieve greater current penetration into the ground. The Abem SAS 1000 Terrameter and its accessories were used in acquiring the field data with a maximum current electrode spacing of 180 m. A total of twelve (12) Vertical Electical Soundings (VES) were carried out at different sites within Effurun – Warri area as shown in the data acquisition map (Figure 1.1). The results obtained were processed using Resist software. Isopach maps and 3D map were further generated (Figures 3.1 and 3.2) and the geo-electric section (Figures 3.3 and 3.4). After geo-electric investigation, samples of water were collected from some boreholes around the places where the sounding was done for chemical analysis.

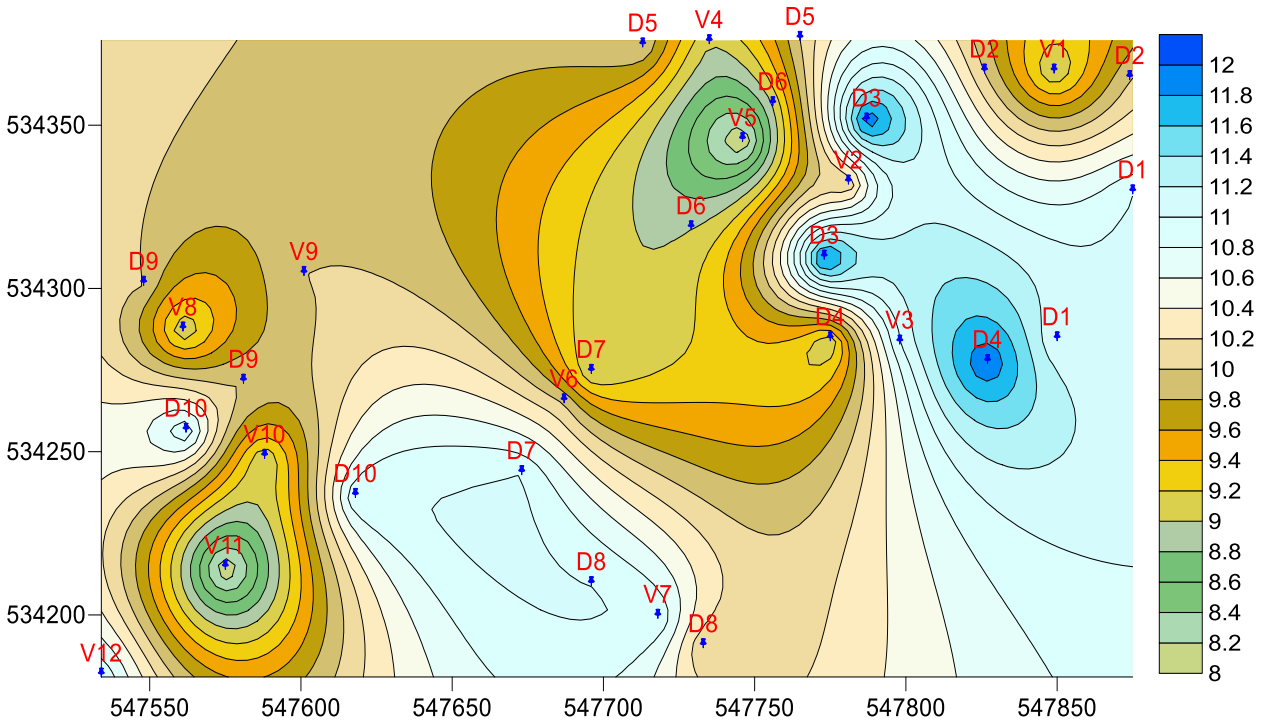

Figure 3. 1 ISOPACH MAP of location of Investigation

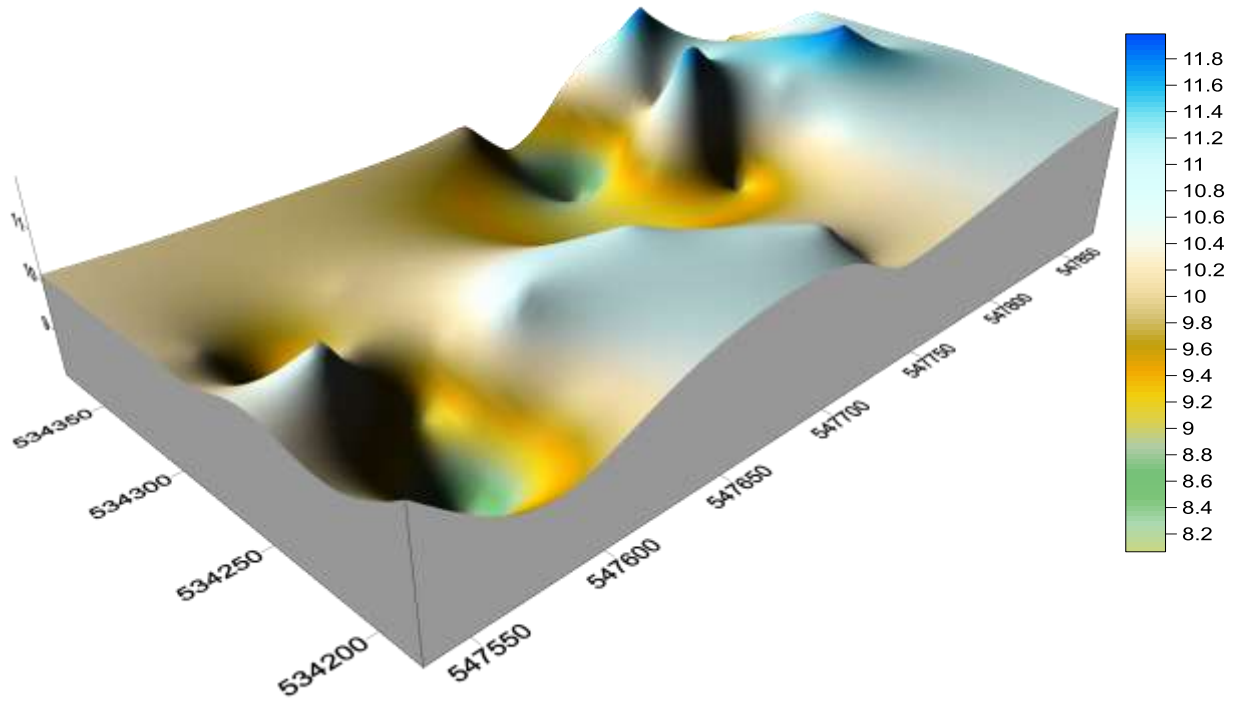

Figure 3.2 Showing 3D Map of Location

4 .0 RESULT AND DISCUSSION

Typical depth sounding curves obtained from the study area are shown in Figures 4.1 and 4.2 below. In the study area, the resistivity type curves obtained vary from 3-layers to 4-layers types. These include 3-layers (A) and 4-layers (AK and KH) types. The A-type is the dominant type curve in the study area with the highest frequency of 8 and percentage occurrence of 66%. The AK and KH type curves respectively has frequency values of 2 and 2 while the percentage occurrence accounted for 17% and 17%respectively of the total sounding curves. Two geoelectric section were generated across the investigated area. A total of five subsurface geologic layer were delineated. These are the top soil, clayey sand, sand, coarse sand and fractured basement. The first layer is the topsoil. The resistivity values generally ranges from 6 – 245 Ωm. The thickness values vary from 0.2 – 1.1 m. The second layer is clayey sand with resistivity values generally ranges from 9 – 2191 Ωm. The thickness values vary from 0.3 – 47.9 m. The third layer is the sand. The resistivity values generally ranges from 6 – 245 Ωm. The thickness values vary from 0.2 – 1.1 m. The fourth layer is the fractured basement. The resistivity values ranges from 358 – 1057 Ωm. The thickness values vary from 0.2 – 35 m. The fifth layer is the coarse sand. The resistivity values generally ranges from 40739 – ∞ Ωm.

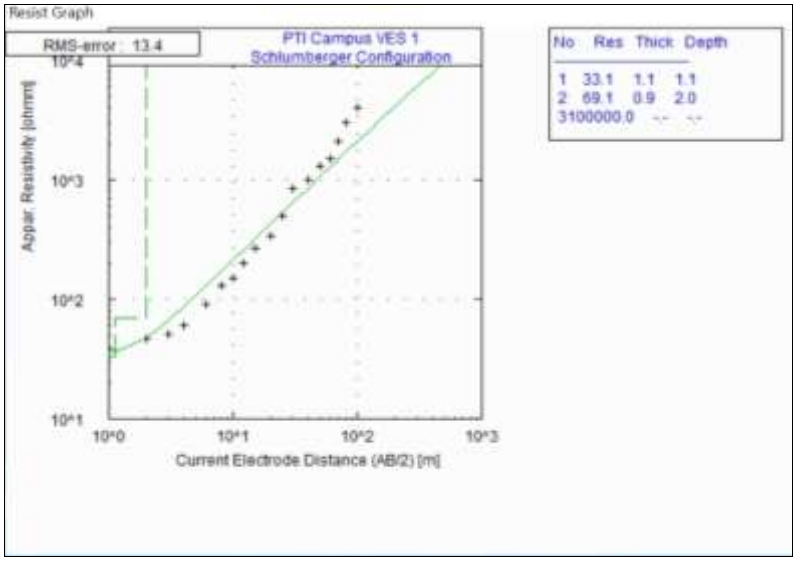

Figure 4.1 A-Type Curve

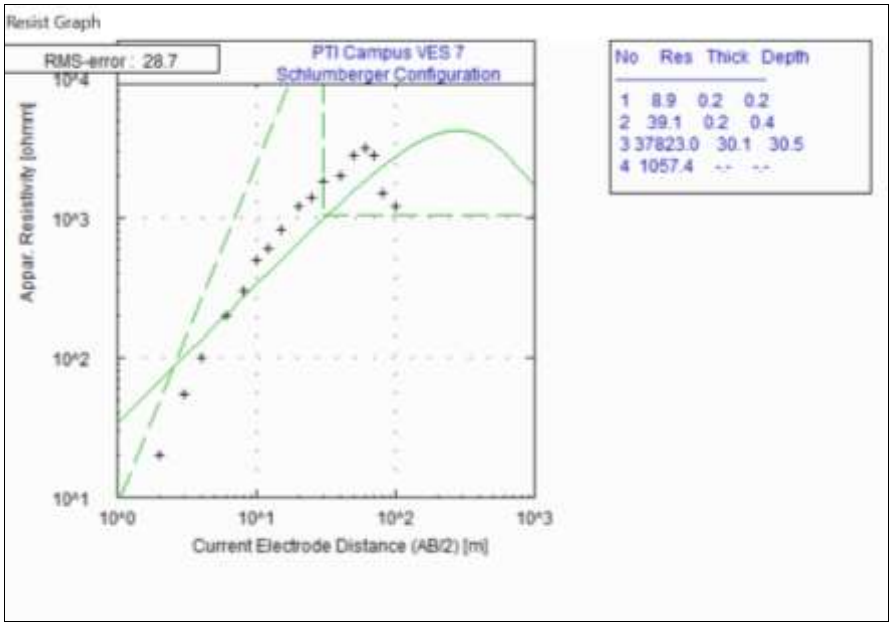

Figure 4.2 AK-Type Curve

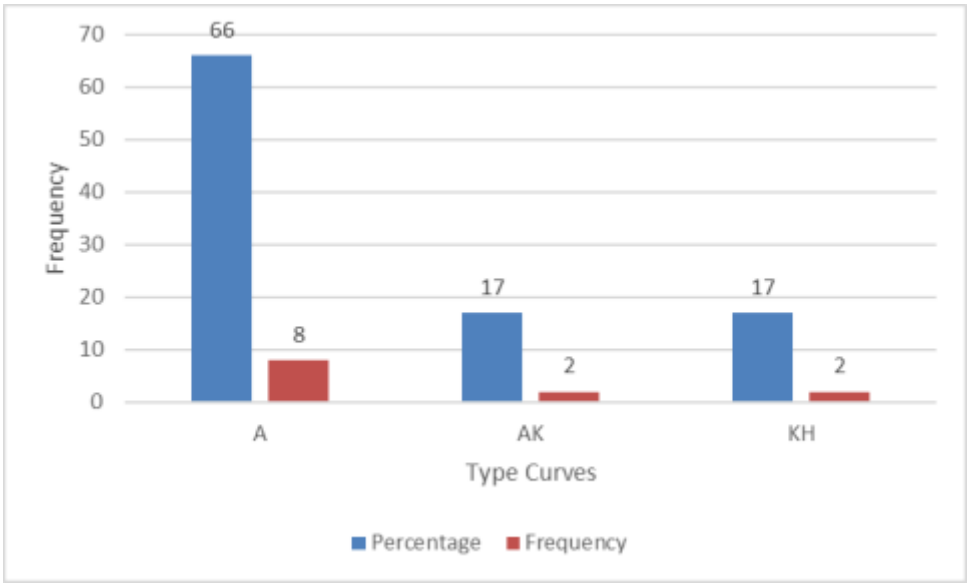

Figure 4:3 Bar Charts Showing the Percentage and Frequency of Occurrence of the Type Curve

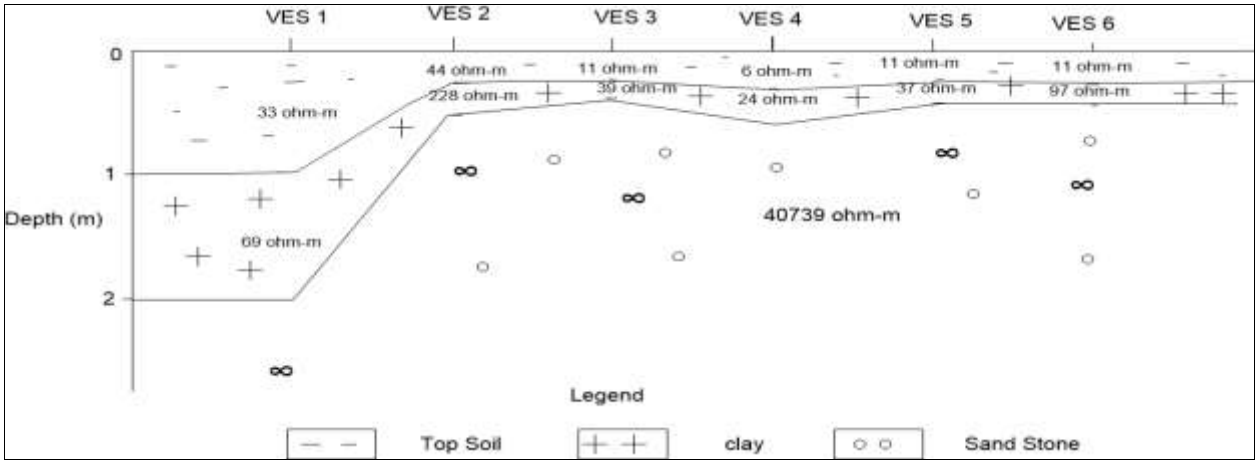

Figure 4.4 Geo-electric Section of Subsurface investigation

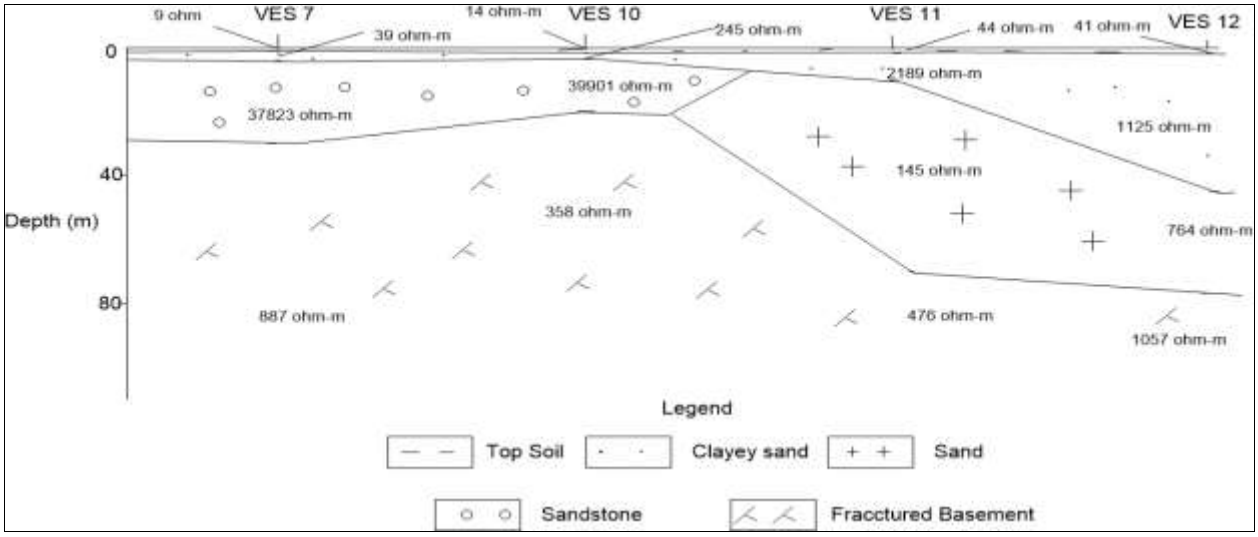

Figure 4.5 Geo-electric Section of investigated area

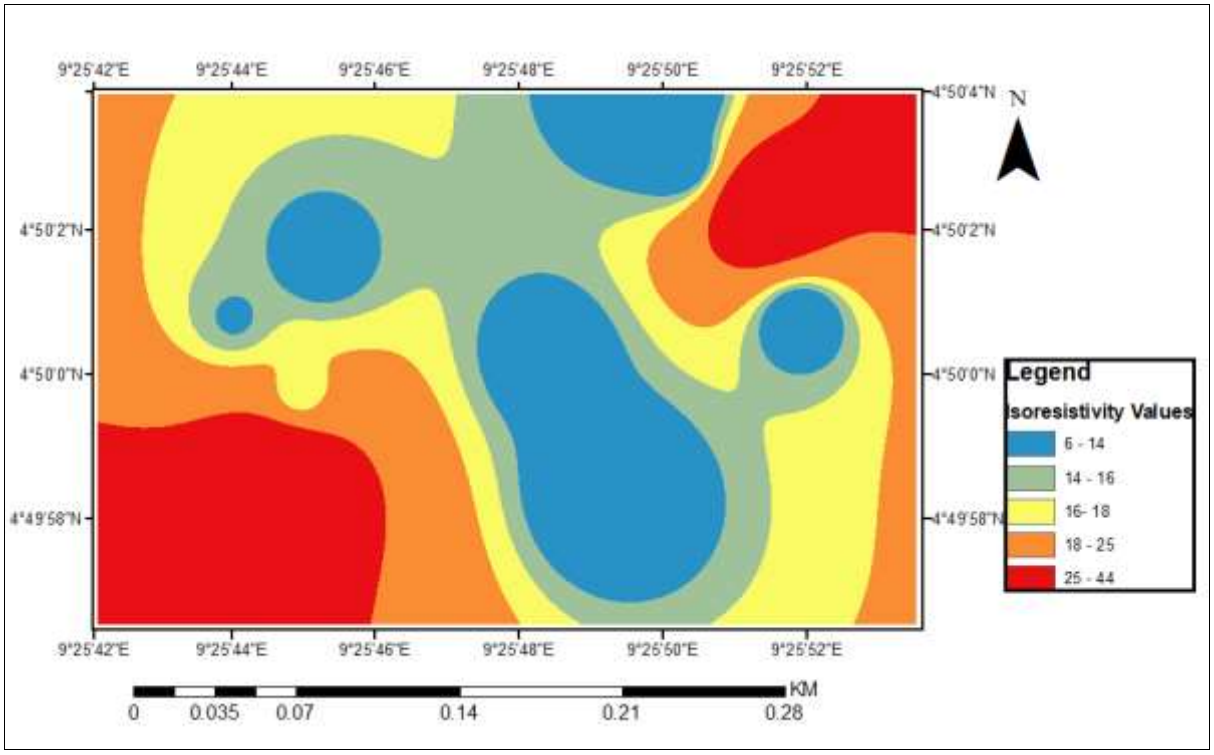

Figure 4.6 Isoresistivity of the top soil

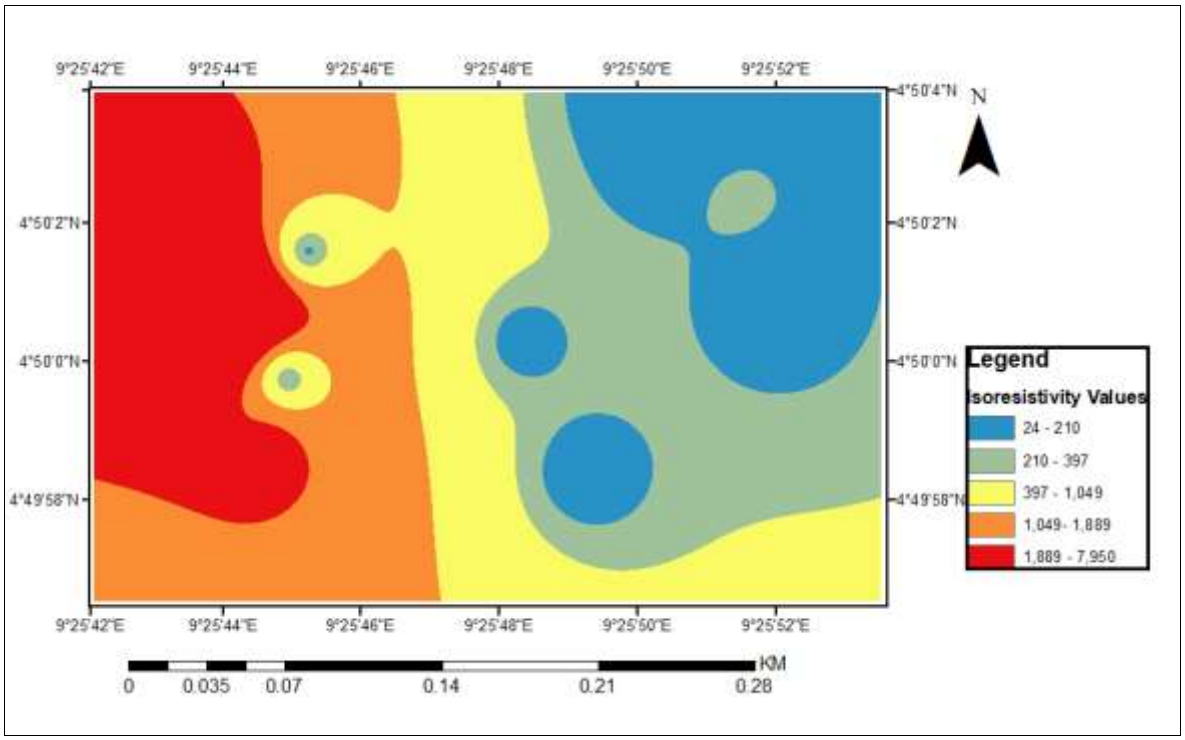

Figure 4.7 Isoresistivity values of the weathered soil

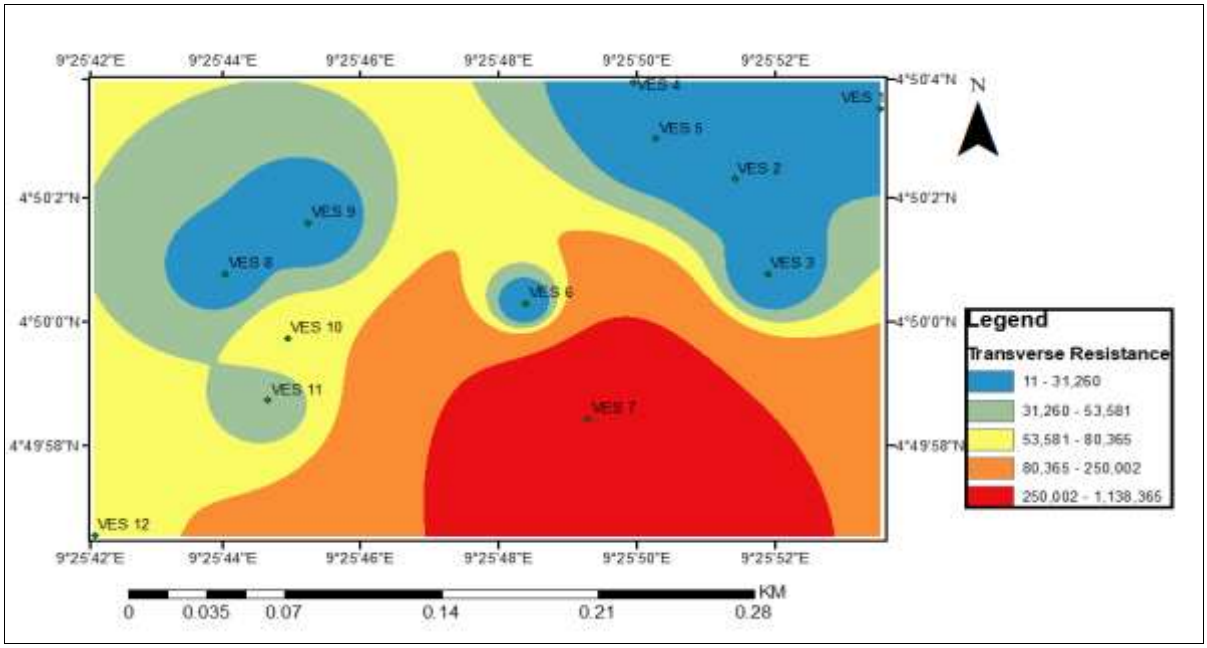

Figure 4.8 Transverse Resistance of the Study Area

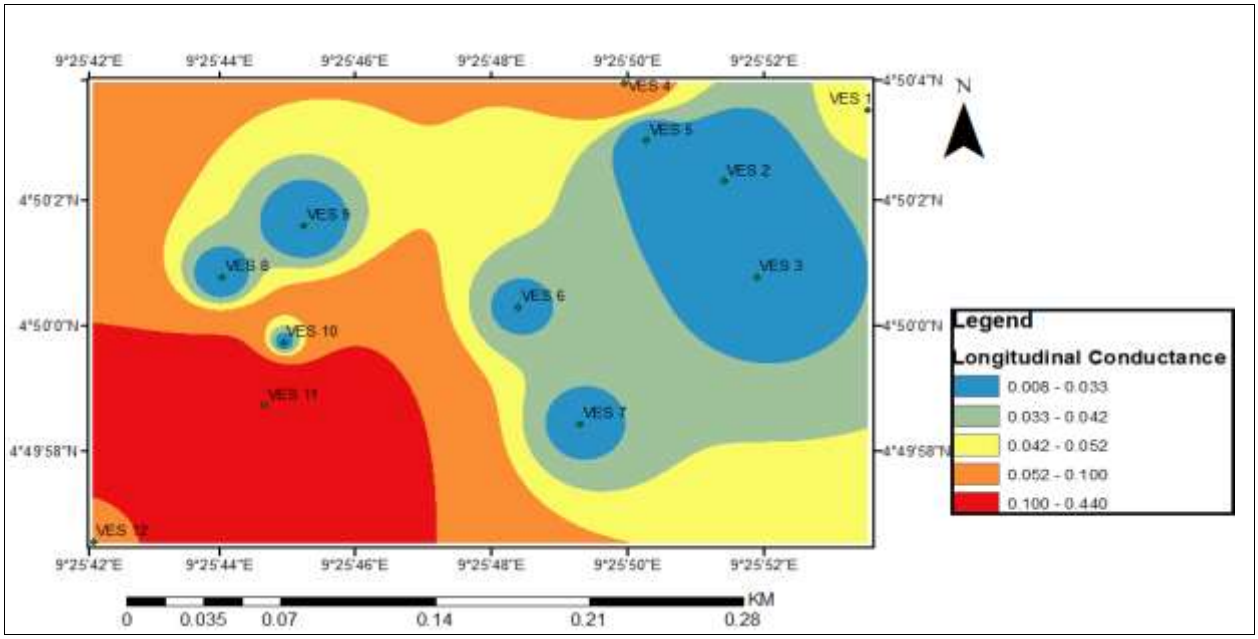

Figure 4. 9 Longitudinal Conductance of the Study Area

Table 4.1 Longitudinal conductance/protective capacity rating (Oladapo and Akintorinwa, 2004)

Total Longitudinal Unit (mhos)	Overburden Protective Capacity Rating
< 0.10	Poor
0.1 – 0.19	Weak
0.2 – 0.69	Moderate
0.7 – 4.9	Good
5 -10	Very good
> 10	Excellent

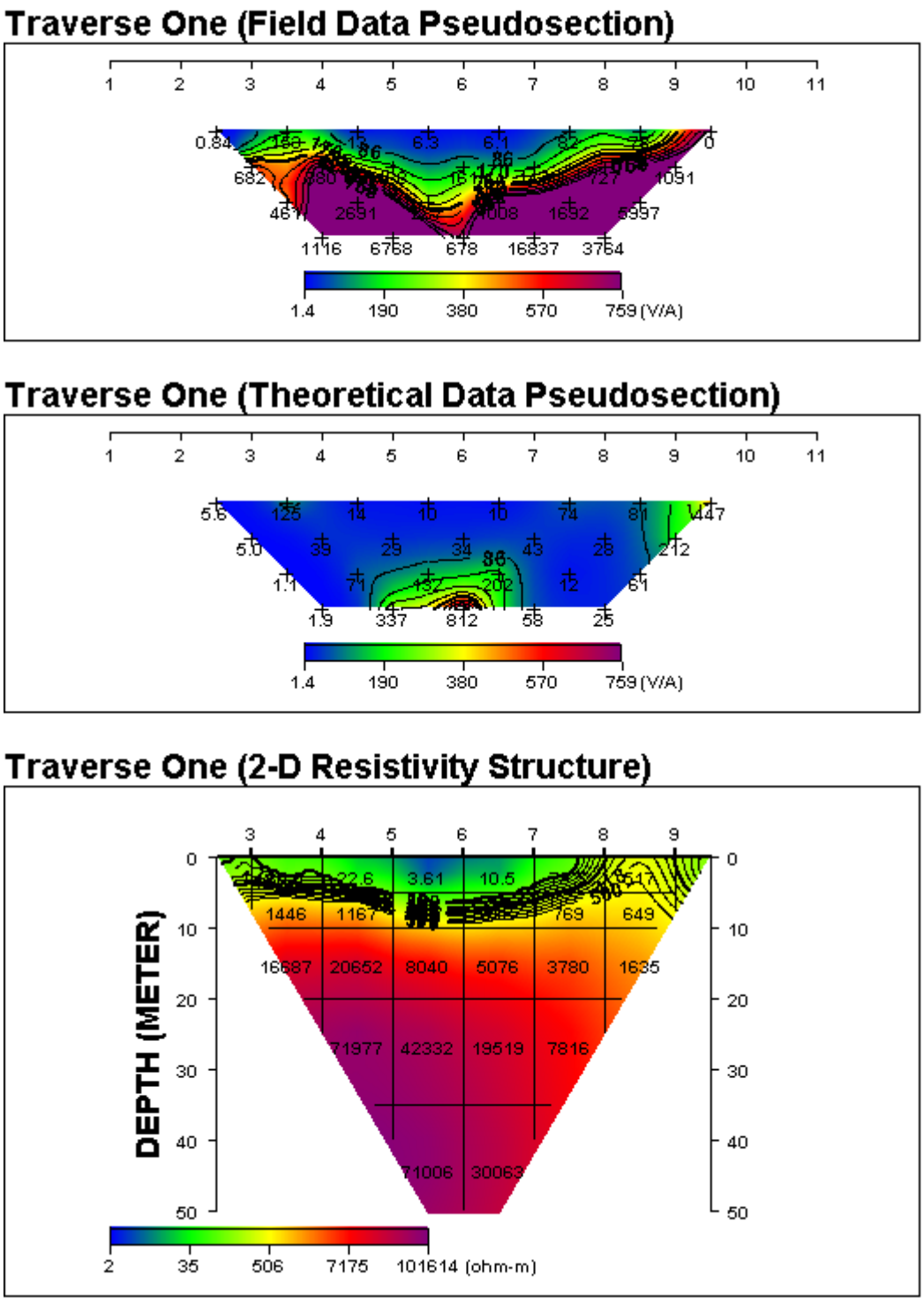

Figure 4.10 Psuedosection of investigation done within Effurun

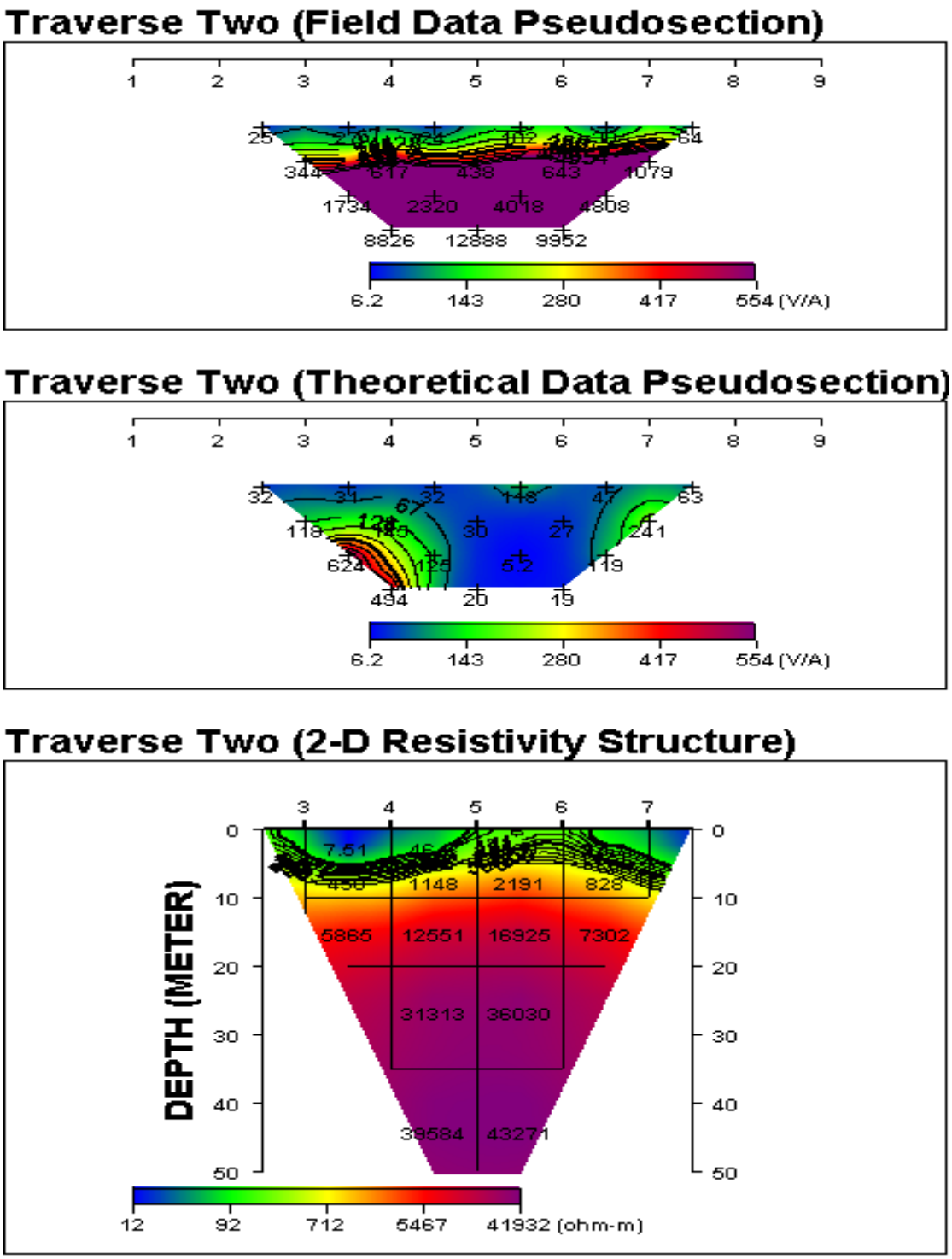

Figure 4.11 Psuedosection of investigation done within Effurun

Table 4.2 Showing result of chemical analysis of water samples

Parameter	Unit	Requirements	Text Result	Methods
Physical & Chemical				
Colour	Pt. Co scale	14	3	Colorimetric
Odour	Pt. Co scale	Odourless	negative	Organoleptic
pH	Pt. Co scale	6.5-8.5	6.50	Electrometric
Test	Pt. Co scale	Tasteless	Normal	Organoleptic
Turbidity	FTU	5	1	Turbidity
Aluminium	Mg/l	0.20	Below 0.2	AAS
Copper	Mg/l	0.1	0.03	AAS
Iron Total	Mg/l	0.3	0.4	AAS
Manganese	Mg/l	0,1	0.06	AAS
Sodium	Mg/l	200	96.93	AAS
Zinc	Mg/l	5	0.047	AAS
Chloride	Mg/l	250	0140.42	Argentometric
Flouride	Mg/l	1.50	0.094	Colorimetric
Nitrate	Mg/l	10	Below 0.110	Colorimetric
Nitrite	Mg/l	1	0.96	Colorimetric
Sulphate	Mg/l	400	Below 0.94	Turbidimetric
Arsenic	Mg/l	0.05	Below 0.001	AAS
Barium	Mg/l	1	Below 0.10	AAS
Cadmium	Mg/l	0.005	Below 0.005	Colorimetric
Cyanide	Mg/l	0.1	Below 0.1	Colormetric
Chrom Hexavalent	Mg/l	0.05	Below 0.006	AAS
Lead	Mg/l	0.05	Below 0.01	AAS
Mercury	Mg/l	0.001	Below 0.001	AAS
Selenium Organic $KMnO_4$	Mg/l	0.1	3.06	Permanganantometric
Dissolved Solid	Mg/l	1000	431	AAS
H_2S	Mg/l	0.05	Below 0.01	AAS
Total Hardness	Mg CaCO3	500	95.49	AAS
Bacteriological				
Total Bacteria	Per ml	1.0×10^2	6.9×10^2	Pour Plate
Coliform	Per 100 ml	Nil	Nil	Filtration
E-Coli	Per 100 ml	Nil	Nil	Filtration
Salmonella sp	Per 100 ml	Negative	negative	Filtration

CONCLUSIONS

From the geophysical investigation of the study area, geoelectric and second order Dar Zarrouk parameters were obtained and plotted as maps. The results show that the study area is vulnerable to contamination because of low to very low longitudinal conductance, high coefficient of anisotropy and also the highly resistive data value obtained in the weathered layer and fractured bedrock can be as a result of some form of contamination. In other to confirm the presence if the type of contamination is from sewage, geochemical analysis has to be combined with hydrochemical analysis.

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