Determination and Delineation of Groundwater pollution from leachate generated from dumpsite, Ijagun community Odogbolu southwestern Nigeria.

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Abstract. The research examined the extent of pollution by leachate generated from Ijagun dumpsite, Odogbolu Area, Southwestern Nigeria, on the groundwater using electrical resistivity method. Four vertical electrical sounding measurements were taken around the dumpsite, Two on the dumpsite (VES 1/ VES 2), and the other two (VES 3 /VES 4) around the dumpsite (serving as control) using schlumberger array technique. The result obtained interpreted both quantitatively and qualitatively, iterated with WINRESIST software. From the computer output, three curve types were obtained from the field survey (A, H, KHA). There is indication of the presence of the contamination in the VES 1 (layer 2) and VES 2 (layer 2) due to their low resistivity values while there are yet no pollution in VES 3/ VES 4 due to their high resistivity values compare to that of VES 1 and VES 2. The stratigraphy at the dumpsite consisting of Sand, Dry sand and Sandstone which shows that the dumpsite is situated on aquiferous materials that is highly porous and permeable and may aid the free flow of leachate into the groundwater. Therefore, there is need for drinking water quality assessment to determine the suitability of the groundwater for human and industrial consumption.

Keywords: aquifer, dumpsite, electrical resistivity, groundwater, leachate, pollution.

1 INTRODUCTION

Nigeria, like most developing countries, is handicapped by serious financial constraints in undertaking a program of providing adequate potable water to all her inhabitants as many depends on pipe borne water, this has made people to resort to groundwater exploration for domestic, agricultural and industrial purposes). Various socio-economically developed activities caused by population pressure with their attendant waste generation and improper management of these wastes continue to threaten water quality (Hussain *et al.,* 1989). Solid waste management has emerged as one of the greatest challenges facing state and local government environmental protection agencies in Nigeria. The volume of solid waste being generated continues to increase at a faster rate than the ability of the agencies to improve on the financial and technical resources needed to parallel this growth. Solid waste management in Nigeria is characterized by inefficient collection methods, insufficient coverage of the collection system and improper disposal of solid waste (Ogwueleka, 2003; Ogwueleka, 2009). As a result, most of these wastes, indiscriminately dumped in dumpsite, find there way into watercourse either through run-offs during rain (into surface water) or by leachate-percolation from the wastes which naturally infiltrates into the groundwater depending on the stratigraphy of the area hence making it unwholesome for its intended use (Turk, 1980, Badmus, *et al.*, 2001).

Refuse disposal is one of the major environmental problems in most of the cities in Nigeria (Agumwamba *et al.,* 2003). Large volume of wastes are generated daily from industries, residential and institutional environments and this can lead to dangerous epidemic diseases if the waste are not properly disposed, improper disposal can lead to groundwater pollution due to contamination by rainwater that leaches into groundwater as leachate from open dumps and sanitary landfills usually contains both biological and chemical constituents (Dauda and Osita, 2003; Slomczynska and Slomczynski, 2004).

The cheapest method use of landfill system according to Schneider (1970) is the sanitary landfill despite its designing and engineering ambiguity. Yet, the system is subject to problems of leaching and seepage of waste substances into the groundwater. More so, the infiltration of this leachate into the underground water depends on the rate and characteristics of leachate production, waste composition, moisture and temperature condition, particle size, degree of compaction, available oxygen and the stratigraphy of the area (Jhamnani and Singh, 2009).

This present study seeks to determine and delineate the extent of pollution of groundwater by leachate generated at municipal dumpsite using electrical resistivity geophysical technique. The depths of aquifer unit, extent of leachate and geo-electric layers of the study area were examined. With particular references to geo-scientific investigations, geophysical techniques are employed because of their ability to combine speed with cost effectiveness in providing information on the depth to bedrock, the extent of saturation and porosity of the materials (Afolayan *et al.,* 2004). Most studies have used contoured apparent resistivity data at a given depth to model plumes of hydrocarbon contamination (Foster, *et al.,* 1987 Benson, *et al.,* 1997; Benson, 1991, Benson, 1992; Burger, 1992; Carderelli and Bernabini 1997; Carpental *et al.,* 1990). Barker, (1990) used resistivity sounding in surveying a landfill and the sounding result across a landfill in Yorkshire in which the landfill is conductive (around 20Ωm or less) over a contaminated substrate of sandstone.

Monier-williams *et al.,* (1990) used Schlumberger sounding to survey around the Novo Horizonte landfill in Brazil. Quantitative analysis of the sounding shows the resistivity values and it revealed significant zones with anomalously low resistivity and these have been interpreted as being contaminant plumes arising from the landfill.

In this study, interpreted resistivity obtained by iterative computer modeling of the apparent resistivity data was employed. Since the apparent resistivity values collected in the field are affected by the thickness and fluid content of each of the subsurface layers. And usually contaminated groundwater, whether affected by leachate from a landfill or by saltwater intrusion, has greater conductivity than ordinary groundwater. Therefore, materials containing contaminated water will possess lower resistivity than materials containing unaffected groundwater (Barker, 1990). So it is possible to map the extent of contamination, if the water table is fairly shallow and the subsurface is relatively homogeneous.

1.2 The study area

The study area lies within the sedimentary terrain of Southwestern Nigeria grouped under the cretaceous sediments of Abeokuta group (Jones and Hockey, 1964) and located between longitude E003^{0} 47'.377" to E003^{0} 47'.483" and latitude N06^{0} 56'.393" to N003^{0} 56'.564" at Ijagun Community , Odogbolu, Ogun State (Fig. 1 and Fig. 2). Ijagun is located along the Sagamu- Benin highway that linked Western and Eastern parts of Nigeria and is also accessible through network of major and minor roads.

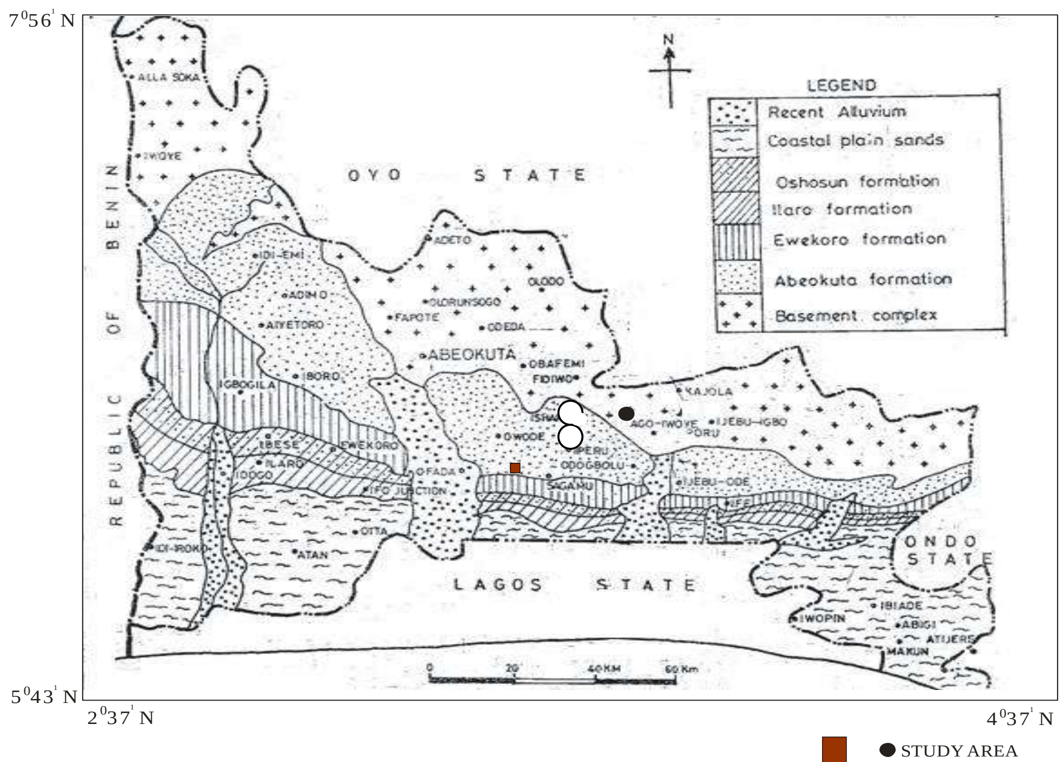


Fig. 1. Map of Ogun State Showing the Study Area (Adapted from Kehinde Philips, 1992)

1.3 Geology of Ogun State, Climate and Vegetation condition of the Study Area

Ogun state is made up of both sedimentary and basement complex rocks; the sedimentary rocks accounts for about 75% of the whole surface area while the rest part of the state contains basement complex rocks. The sedimentary rock of Ogun state consist of Abeokuta groups. Which consist of Araromi formation, Afowo formation and Ise formation. The study area falls under the sedimentary terrain of Abeokuta group.

The study area is located in moderately hot, humid tropical climate zone of southwestern Nigeria, with Rainy season which last from March / April to October / November and dry season which last for the rest of the year October / November. And it is rainforest zone.

Fig.2. Ijagun dumping site

2 MATERIALS AND METHODS

The electrical resistivity method was adopted for the survey because of its responsive to water bearing materials as it indicates the resistivities and conductive nature of underground layer(s). In addition to this, the method is cost efficient.

Four (4) Vertical Electrical Sounding measurements were taken on and around the dumpsite using Schlumberger array (Fig. 3). VES 1 and VES 2 measurements were taken on the dumpsite while VES 3 and VES 4 measurements were taken at about 10m (SW) and 15m (S) of the dumpsite respectively. Field resistance measurements were taken using PASI Terrameter (Model 16-GL Earth Resistivity meter). The instrument is setup at the central line with the current and potential cable connected adjacent to it. The current cable were used to connect current electrodes A and B to the terminal C1 and C2 of the terrameter; potential cables were used to connect potential electrodes M and N to the terminal P1 and P2 and the other ends of the cables are attached with the clips to electrodes which were driven into the ground at measured appropriate distance from the central point. A current is then passed between the two metal electrodes driven into the ground at a known distance by the terrameter. Repeated measurements of current and potential differences are made this same point using a large current separation in each successive electrode probe. The results obtained in form of resistance (Ω) were converted to apparent resistivity (Ωm) by multiplying the resistance value with appropriate geometric factors (K).

The values obtained were first manually plotted against their respective current-electrode spacing values ($^{AB}/_{2}$) on a log-log graph, partially curve-matched and then electronically iterated using WINRESIST computer iteration program to obtain the geo-electric layers which show vertical variation in resistivity values with depth. The interpretation of the sounding curves was done both quantitatively and qualitatively. The qualitative interpretation entails the observation of the sounding curves as observed in the manual plots on the bi-logarithm graph paper. The quantitative interpretation involves the use of partial curve matching.

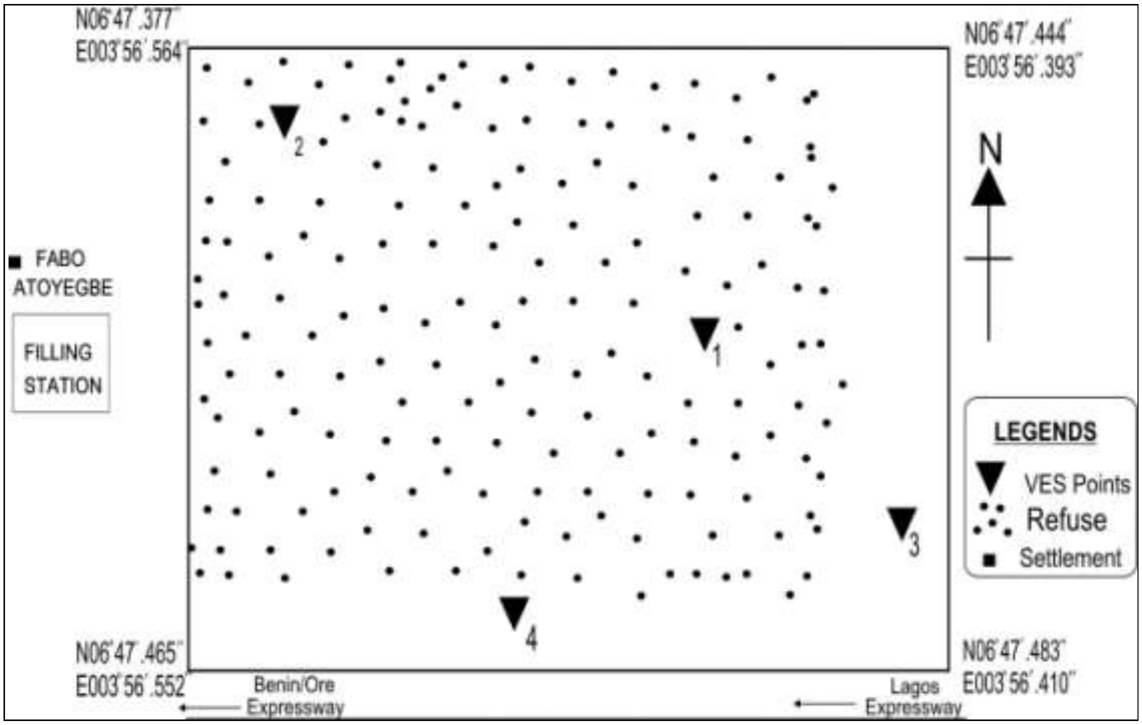


Fig.3. Sketch Map of the Study Area

Table 1. Resistivity Field Record (VES 1-4) – Ijagun Dumping Site

			LAT.	N06° 47'.421"	N06° 47'.380"	N06° 47'.422"	N06° 47'.470"
			LONG.	E003° 56'.489"	E003° 56'.478"	E003° 56'.449"	E003° 56'.514"
S/N	$^{AB}/_{2}$	$^{MN}/_{2}$	VES	VES 1(Ωm)	VES 2(Ωm)	VES 3(Ωm)	VES 4(Ωm)
1.	1	0.2		17.3	628.1	1006.6	486.3
2.	2	0.2		21.3	419.9	1032.5	672.0
3.	3	0.2		25.1	309.6	795.2	654.0
4.	3	0.5		23.8	296.9	700.9	613.1
5.	5	0.5		29.6	77.8	606.5	575.4
6.	8	0.5		38.9	64.1	560.8	601.0
7.	10	0.5		42.6	65.8	595.5	595.3
8.	10	1.0		43.2	63.4	513.2	606.1
9.	15	1.0		59.5	85.2	527.8	669.3
10.	20	1.0		84.6	102.2	616.7	689.4
11.	25	1.0		112.7	135.3	662.6	729.3
12.	25	3.0		104.5	135.8	709.6	774.1
13.	30	3.0		129.7	160.0	746.4	793.1
14.	40	3.0		188.3	180.0	648.1	674.8
15.	50	3.0		196.9	198.3	554.3	587.0
16.	50	5.0		183.4	192.8	530.9	572.1
17.	75	5.0		251.6	255.1	606.9	647.4

18.	100	5.0		310.2	297.7	755.1	718.2
19.	100	7.0		-	-	-	728.4
20.	150	7.0		-	-	-	871.4
21.	200	7.0		-	-	-	636.5

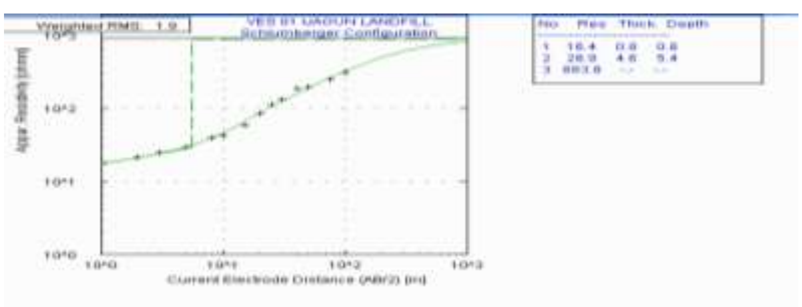
Table 2. Qualitative and Quantitative of VES curve obtained from the Site

VES No	No of layers	Curve type	Resistivity (Ωm)	Thickness (m)	Depth (m)	Geological Implication
1	1 2 3	A $\ell_1 < \ell_2 < \ell_3$	16.4 28.9 883.8	0.8 4.6 -	0.8 5.4 -	Top Soil (clay) Peat (Leachate Contamination) Sandstone
1	1 2 3	H $\ell_1 > \ell_2 < \ell_3$	697.2 36.0 426.0	1.3 5.0 -	1.3 6.3 -	Top Soil (sand) Peat (Leachate Contamination) Sandstone
3	1 2 3 4 5	KHA $\ell_1<\ell_2>\ell_3<\ell_4 < \ell_5$	1047.6 1377.5 450.0 662.8 754.8	0.8 0.5 3.6 25.9 -	0.8 1.3 4.9 30.8 -	Top soil (sand) Laterite Sand Dry Sand Sandstone
4	1 2 3 4 5	KHA $\ell_1<\ell_2>\ell_3<\ell_4 < \ell_5$	307.1 1427.6 368.9 623.8 723.8	0.4 0.7 2.1 17.0 -	0.4 1.1 3.4 20.4 -	Top soil (sand) Laterite Sand Dry Sand Sandstone

3 RESULTS AND DISCUSSION

The result of the resistivity values obtained from the field survey is presented in table 1. The resistivity values obtained ranges from 17.3Ωm to 1032.5Ωm, with VES 3 having the highest resistivity values followed by VES 4, VES 2 and then VES 1.

The qualitative and quantitative analyses of the VES curves are presented in Table 2 and 3. The VES plots obtained from computer iteration of the resistivity values are presented in Fig. 4. Three (3) curve types A, H and KHA were obtained (Table 3). Furthermore, the result of the investigation reveals the presence of three (3) to five (5) layers, with depth ranging from 0.8m to 30.8m.



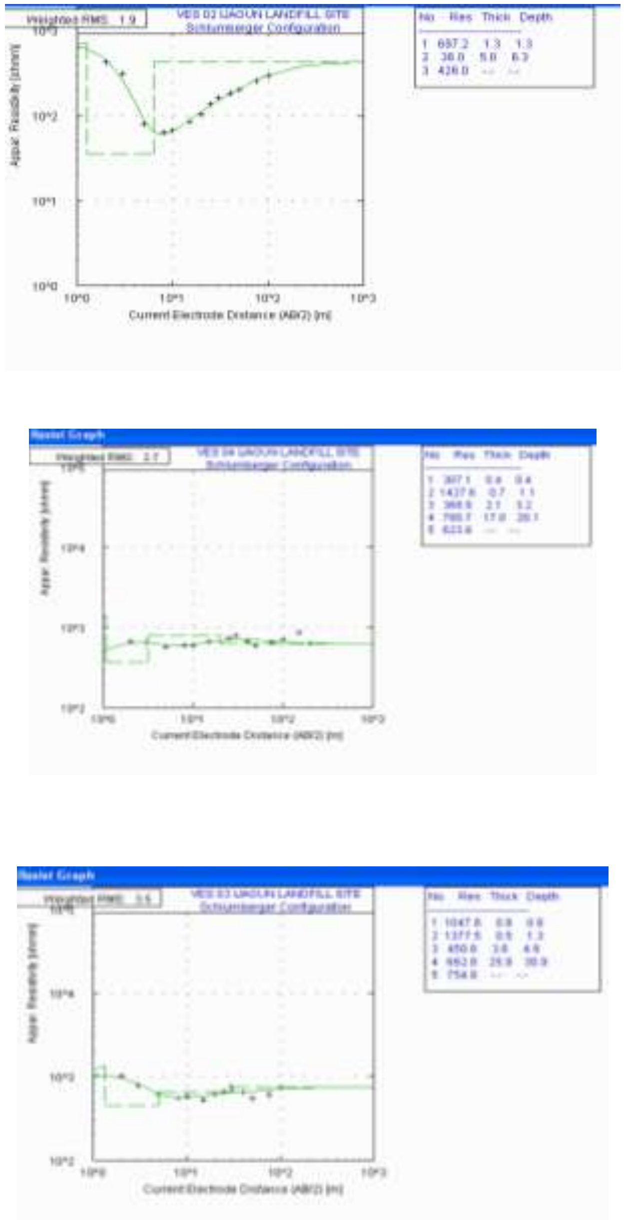


Fig. 4. VES Curves for VES 1 – 4.

Table 3. Showing the Curve types

No of layers	Curve Types	VES Points
3	A	1
3	H	2
5	KHA	3 and 4

The geo-electric section of the study area was generated to show the vertical variation of the materials in relation with their resistivity values. The area composed of topsoil, laterite, Peat, Dry sand and Sandstone (Fig. 5), with three and five layers. The profile one with depth, has topsoil (clay), leachate contamination, and sandstone formation with low resistivity values of 16.4Ωm, 28.9Ωm, 883.8Ωm. It has thicknesses of 0.8m, 4.6m and infinity with depth 0.8m, 5.4m and infinity respectively. The geo-electric section depicts low resistivity values revealing the presence of the leachate pollution in VES 1 (layer 2) which can directly infiltrate into the groundwater through the highly porous and permeable (Aquiferous) sandstone in subsurface layer.

The profile two with depth has top soil, leachate contamination and sandstone formation having respective resistivity values of 697.2Ωm, 36.0Ωm and 426.0Ωm; thicknesses of 1.3m, 5.0m and ∞ with depths of 1.3m, 6.3m and ∞. This also depicts low resistivity values, thus implying the presence of leachate pollution in VES 2 (layer 2) that can infiltrate directly into the groundwater through the highly porous and permeable (Aquiferous) sandstone (as in profile 1 above) thereby causing contamination of the underground water. In profile three, the geo-electric section with depth, indicates that the profile has top soil (sand), laterite, sand, dry sand and sandstone formations with resistivity values of 1047.6Ωm, 1377.5Ωm, 450.6Ωm, 662.8Ωm and 754.8Ωm respectively. The thicknesses of the layers being 0.8m, 0.5m, 3.6m, 25.9m and depths of 0.8m, 1.3m, 4.9m and 30.8m respectively. This result reveals high resistivity values compared to VES 1 and VES 2 implying a temporal absence of pollution but may be present with time due to the stratigraphy of the study area.

The geo-electric section of profile four with depth shows that it has top soil (sand), laterite, sand, dry sand and sandstone formation with resistivity values of 307.1Ωm, 1427.6Ωm, 368.9Ωm, 780.7Ωm and 623.8Ωm respectively, and infinite thicknesses and depths. This reveals high resistivity values compared to VES 1 and VES 2, also implying that pollution is absent but may be present with time due to the stratigraphy of the study area.

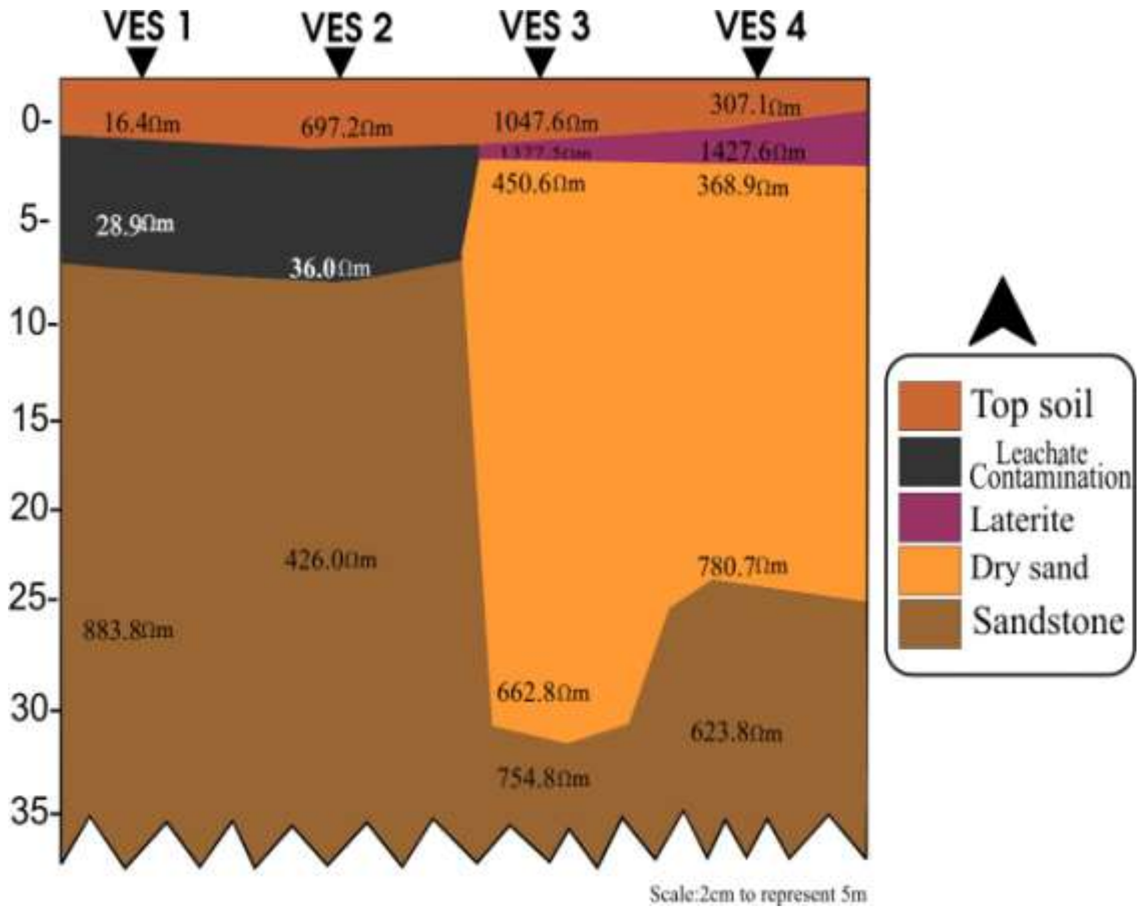


Fig. 5. Geo-electric section relating to VES 1 – 4.

Based on the porosity and permeability condition of the observed geologic materials present (predominantly sand and sandstone) in the study area, the result shows that VES 1 and VES 2 (layer 2) of the area has been polluted by leachate as a result of low resistivity values obtained at these points. As noted by Barker (1990) that materials containing contaminated groundwater will possess lower resistivity than material's containing unaffected groundwater. And if the water table is fairly shallow and the subsurface is relatively homogenous, contamination by leachate pollution will occur easily. This underground source of pollution might result from high concentration of mineral salts based on the geological nature of the study area. VES 3 and VES 4 are yet to show contamination effect as their resistivity values are high compared to VES 1 and VES 2, but may subsequently become contaminated because the underlying layer (which is sandstone formation) is potentially aquiferous (Plummer *et al.*, 2003).

5 CONCLUSION

The study revealed that the dumpsite consists of, topsoil, laterite, Peat, Dry sand and Sandstone indicating that the dumpsite is located on an aquiferous sandstone. The low resisitivities at VES 1 and VES 2 indicated groundwater pollution from the generated leachate occurred to a depth of ∞ on the dumpsite. On the hand the high resisitivities at VES 3 and

VES 4 indicated that groundwater are of high qualities and yet to be contaminated but may become contaminated with time because of their porous geologic materials.

Furthermore, as a result of groundwater dependence among the inhabitants of the study areas; It is recommended that the leachate sample can also be collected to really ascertain the composition of this leachate. Physical, chemical and microbiological assessment can be done to test for the quality of the groundwater in correspondence to the WHO standard.

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