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Geophysical Investigation around an Active Landfill Site in Ilokun, Ado-Ekiti, Southwestern Nigeria

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Abstract:
Integrated surface geophysical surveys were carried out in the vicinity of an active waste dumpsite in Ilokun Ado-Ekiti. This was with a view to generating a subsurface model and hence determine its suitability, or otherwise, for landfill. It was also meant to determine its impact, if any, on the groundwater.
Seismic refraction survey was executed along three (3) traverses while six (6) vertical electrical soundings were done with a maximum current electrode spread of 100 meters.
Both geophysical techniques revealed overburden thickness of over 10m, the bulk of which is aquiferous. The clayey nature of the unsaturated zone indicates presence of seal that can prevent pollution of groundwater by leachate from the waste. Besides, there is no evidence of fractures below weathered zone.
Increase in resistivity of the water bearing zone with distance from dumpsite is indicative of pollution by the waste.

Keywords: *surface geophysical surveys, landfill, overburden thickness, pollution, weathered zone.*

1. Introduction

Huge volume of solid waste is generated on daily basis in most parts of Ado-Ekiti as is the case with most rapidly developing state capitals in Nigeria. However, the waste is often dumped without any regard to its detrimental effect on the environment. Figure 1 shows the project site. A serious negative impact of waste on the environment is the pollution of shallow groundwater, arguably the main source of water in most parts of Nigeria. Poor management of solid wastes greatly affects the environment, thereby resulting to public health hazards such as periodic epidemics and communicable diseases (Fasunwon, 2010). Landfills, most of which are open dumpsites are the commonest waste disposal systems in Nigeria. However, most of the landfills are improperly designed, if at all, due to low capital investment and lack of geoscientific investigation prior to their utilization as waste dumpsites.

Figure 1: The Plate Showing the Project Site at Ekiti State Waste Dump Site along Ilokun-Iworoko Road, Ado Ekiti, Ekiti State

2. The Study Area

Ado-Ekiti, the capital of Ekiti sate lies between latitude $7\,^{0}31^{1}$ and $7\,^{0}49\,^{1}$ North of the equator and longitude $5\,^{0}7^{1}$ and $5\,^{0}27\,^{1}$ East of the Greenwich Meridian (Fig. 2). The relief low with isolated hills and inselbergs that are dome-shaped. The major river draining the area is Ireje River which flows south-east, it is associated with simple form of tributaries. The river is seasonal with reduction in volume of its water or total dry up in case of extreme drought. (Ebisemyu, 1989).

The town is underlain by Pre- Cambrian Basement Complex rocks which include coarse grained charnokite, medium grained granite and porphyrite biotite hornblende granite (Fig. 2). Field relationship of the rocks is indicative of common age (Omotoyinbo, 1994). Rocks which constitute the Basement Complex of Southwestern Nigeria are known to be overlain by thick overburden. Oyawoye (1964), Rahaman (1973, 1976, 1988), Odeyemi (1978) and many others to carry out an extensive study of the rocks of the Precambrian Basement Complex of Nigeria

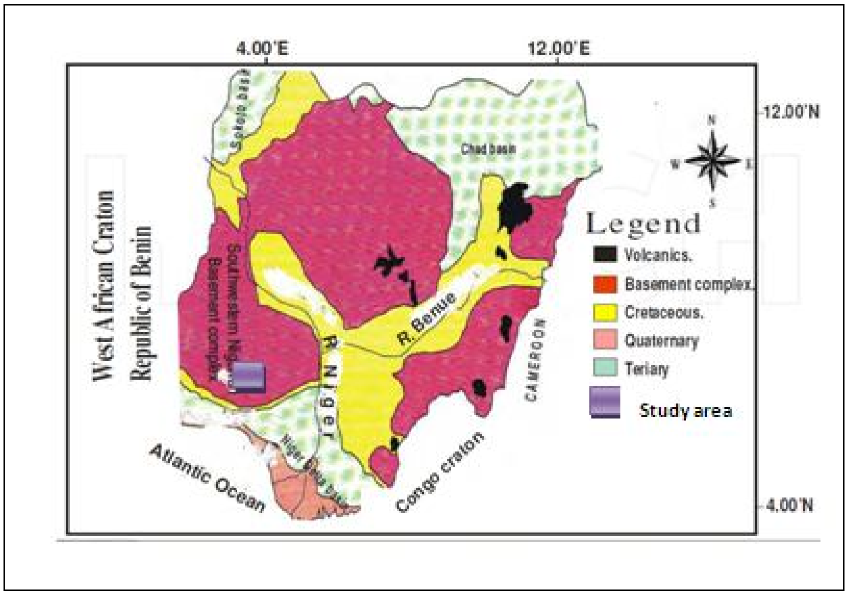

Figure 2: Map of Nigeria showing Southwestern Basement Complex and the location of study area (modified fron Elueze, 1982)

3. Methods of Study

The two surface geophysical techniques employed in the study were the electrical resistivity and seismic refraction surveys. The methods have over the years gained wide application in many parts of the world for characterization of the subsurface.

A total of six vertical electrical sounding (VES) were carried out with a maximum current electrode spacing of 100 meters. Schlumberger array was employed. The apparent resistivity data obtained from the VES survey were presented as depth sounding curves by plotting the apparent resistivities along the ordinate axis and the half current electrode spacing (AB/2) along the abscissa. The results of the VES curves (Figs. 3 to 8) obtained from the partial curve matching were then used to constrain the interpretation by the computer using iteration software known as WINRESIST. This invariably reduces overestimation of depths.

Seismic refraction survey was carried out along three traverses in the vicinity of the dumpsite. For this project, an array of 12 geophones was used. On and Reverse shootings were also done, with offsets of 2 m along both shooting. The seismic data were analyzed using SeisImager software (Pickwin95, and Plotrefa). Figures 9 to 14 show the travel time curves and the tomographic models for the three traverse occupied.

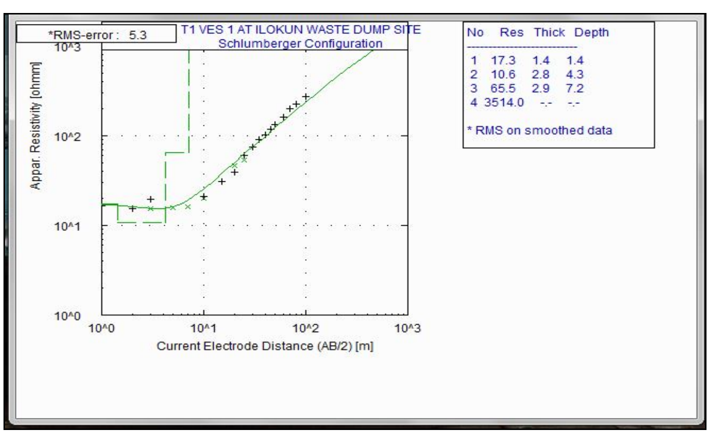

Figure 3: Depth Sounding Curve for VES 1

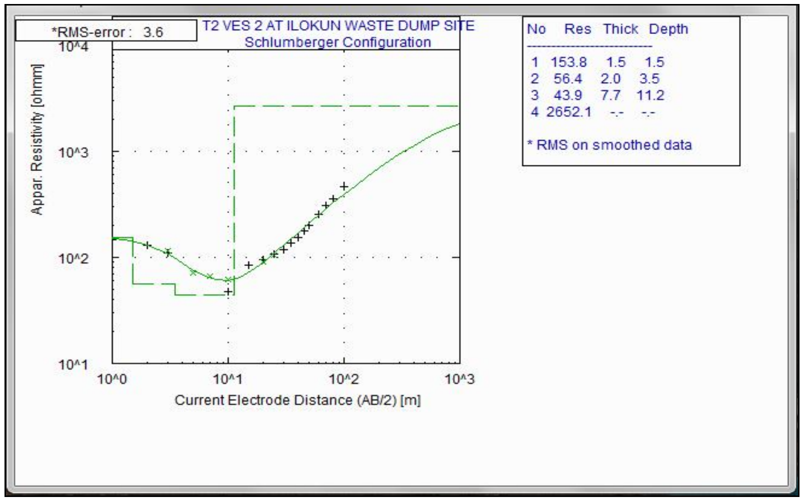

Figure 4: Depth Sounding Curve for VES 2

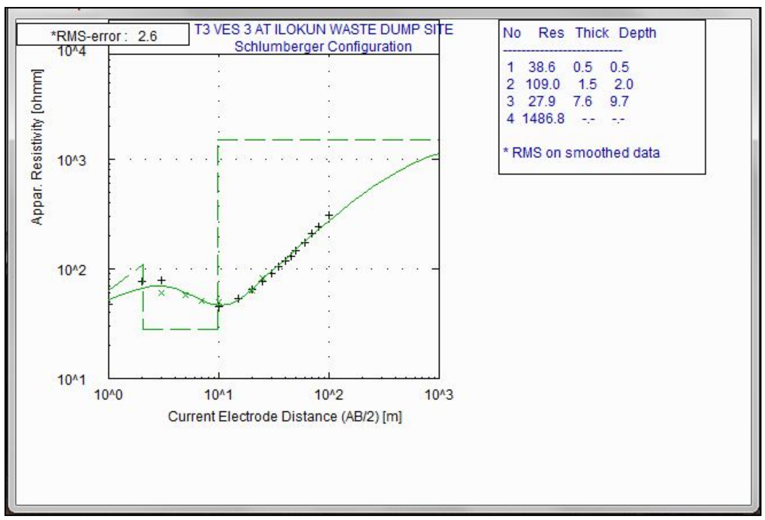

Figure 5: Depth Sounding Curve for VES 3

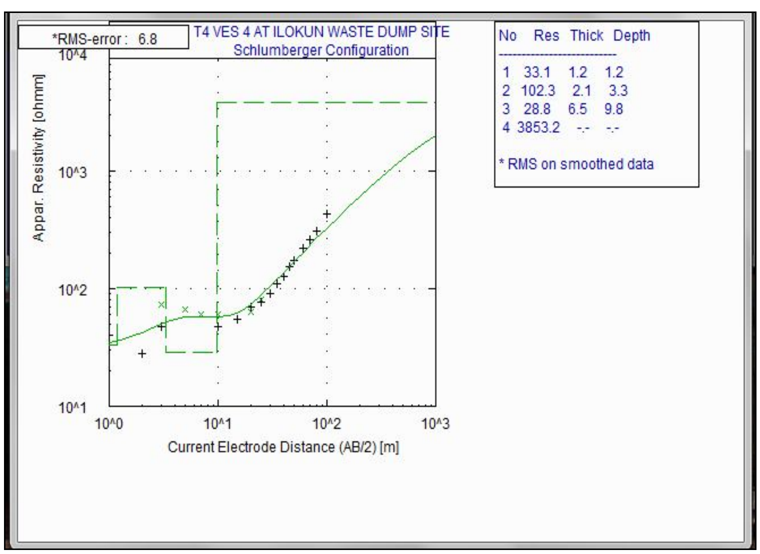

Figure 6: Depth Sounding Curve for VES 4

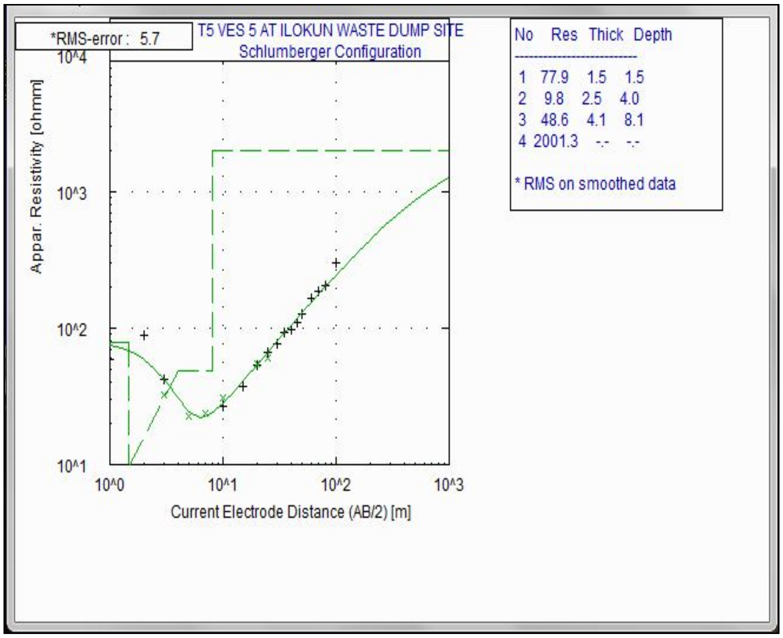

Figure 7: Depth Sounding Curve for VES 5

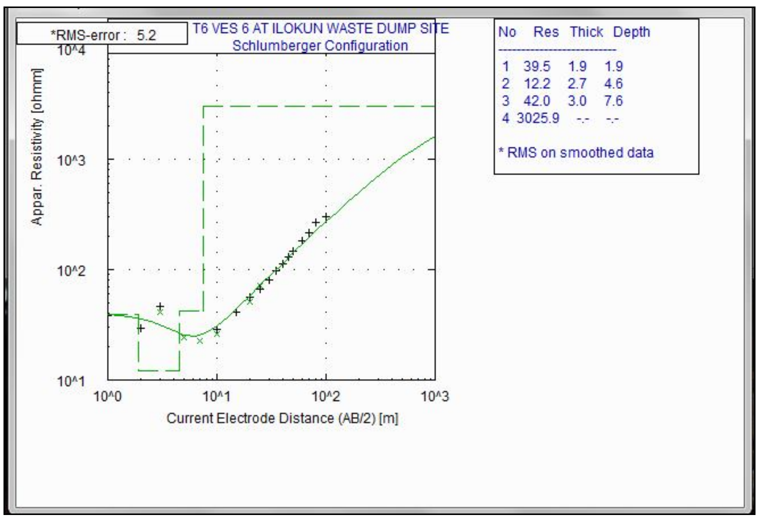

Figure 8: Depth Sounding Curve for VES 6

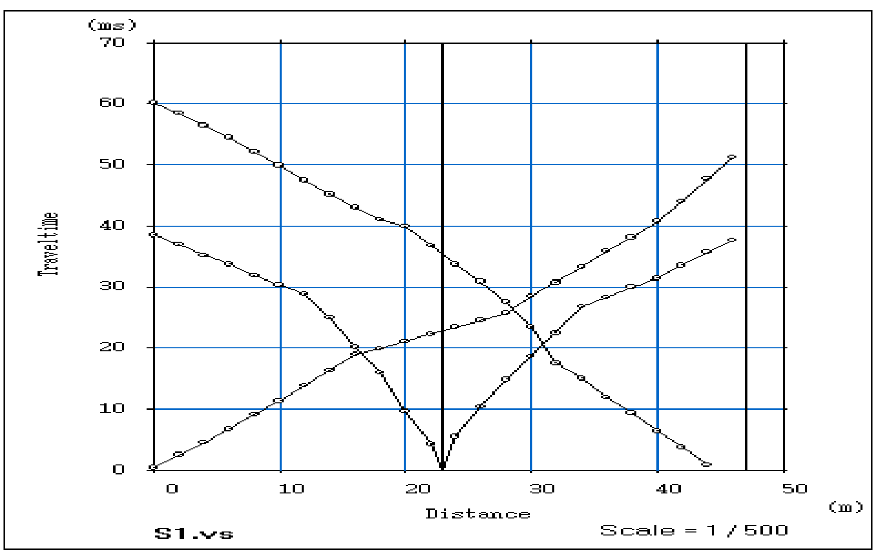

Figure 9: Travel Time Curve Interpretation of Profile 1.

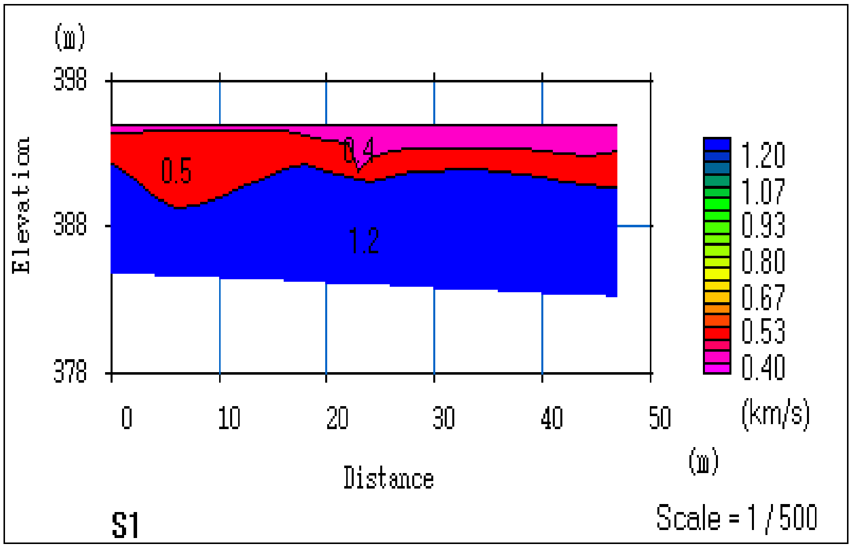

Figure10: Tomographic Model Interpretation of Profile1.

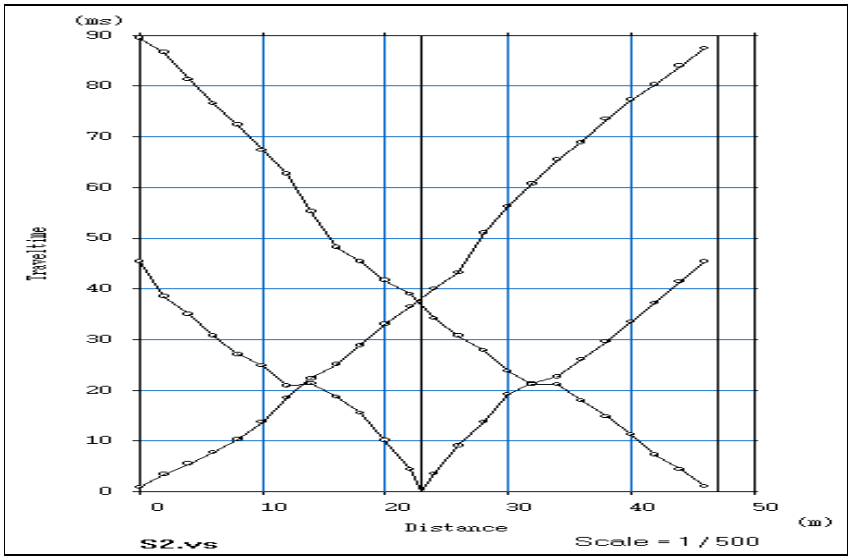

Figure11: Travel time curve interpretation of profile 2.

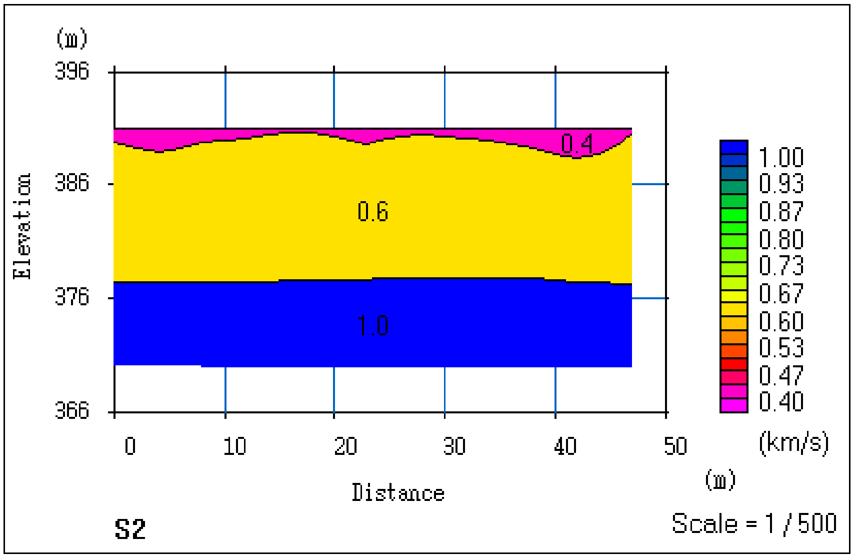

Figure 12: Tomographic Model Interpretation of Profile 2.

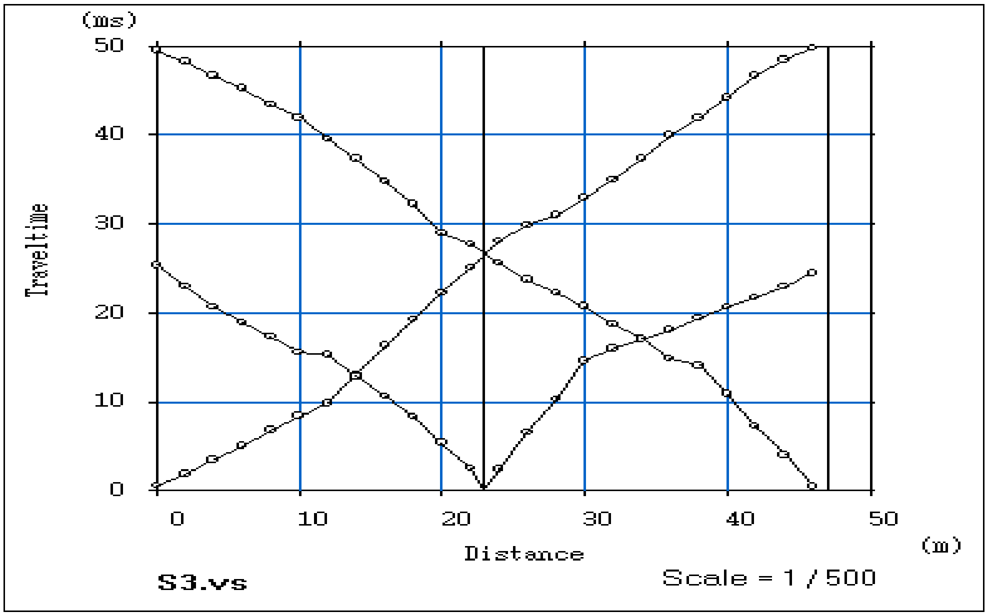

Figure 13: Travel time curve interpretation of profile 3.

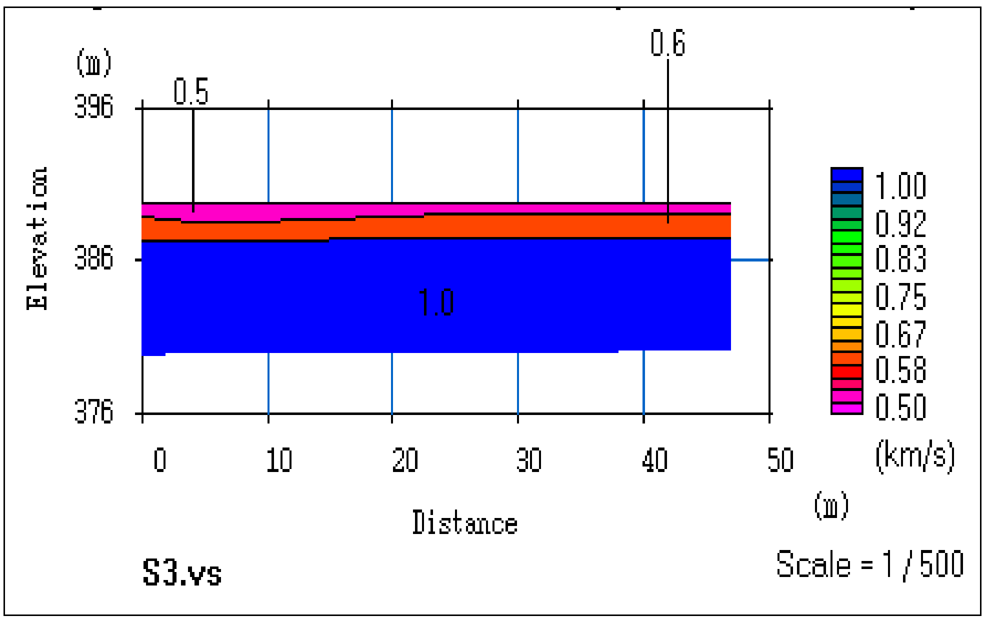

Figure 14: Tomographic Model Interpretation of Profile 3

4. Results and Discussions

Majority of the VES curves are KH types. Tables 1 to 6 summarise the results of the resistivity survey. The tables reveal thick overburden (about 3m to 8m) which aquiferous. The computed generally high reflection coefficient (0.95 – 0.99) indicate absence of any fracture of hydrogeological significance in the underlying bedrock. Therefore, the only promising water bearing horizon is the weathered zone. However, increase in the resistivity of water bearing horizon away from the dumpsite is indicative of pollution of groundwater by leachates from the dumped waste. Two geoelectric sections were drawn as shown in Figures 15 and 16. The geoelectric sections show four distinct layers, namely topsoil, lateritic clay, weathered layers and fresh basement. The topsoil had resistivities ranging from 17.3 Ωm- 153.8 Ωm to a depth of 0.5 m-1.9 m. The second layer characterized by lateritic clay had resistivities ranging from 9.8 Ωm- 109 Ωm to a depth of 2.0 m-4.6 m. The weathered layer had resistivities ranging from 27.9 Ωm-65.5 Ωm to a depth of 7.2 m- 11.2 m and the fresh bedrock had resistivities ranging from 1486.8 Ωm- ∞.

The results of the seismic survey are summarized in Tables 7 to 9. The Tables reveal thick overburden (about 14 m to 16 m) out of which about 6 m to 12 m is water bearing weathered zone. Seismic wave velocity is also seen to increase with distance from waste dump. This implies that the pollution of groundwater by leachates decreases away from the waste dump.

Layer	Resistivity (ohm-m)	Thickness(m)	Depth(m)	Probable Lithology
1	17.3	1.4	1.4	Topsoil
2	10.6	2.8	4.3	Lateritic Clay
3	65.5	2.9	7.2	Weathered Rock
4	3514.0	infinite	infinite	Fresh Basement

Table 1: Summary of VES 1 Interpretation

Layer	Resistivity (ohm-m)	Thickness(m)	Depth(m)	Probable Lithology
1	153.8	1.5	1.5	Topsoil
2	56.4	2.0	3.5	Lateritic Clay
3	43.9	7.7	11.2	Weathered Rock
4	2652.1	infinite	Infinite	Fresh Basement

Table 2: Summary of VES 2 Interpretation

Layer	Resistivity (ohm-m)	Thickness(m)	Depth(m)	Probable Lithology
1	38.6	0.5	0.5	Topsoil
2	109.0	1.5	2.0	Lateritic Clay
3	27.9	7.6	9.7	Weathered Rock
4	1486.8	infinite	Infinite	Fresh Basement

Table 3: Summary of VES 3 Interpretation

Layer	Resistivity (ohm-m)	Thickness(m)	Depth(m)	Probable Lithology
1	33.1	1.2	1.2	Topsoil
2	102.3	2.1	3.3	Lateritic Clay
3	28.8	6.5	9.8	Weathered Rock
4	3853.2	infinite	Infinite	Fresh Basement

Table 4: Summary of VES 4 Interpretation

Layer	Resistivity (ohm-m)	Thickness(m)	Depth(m)	Probable Lithology
1	77.9	1.5	1.5	Topsoil
2	9.8	2.5	4.0	Lateritic Clay
3	48.6	4.1	8.1	Weathered Rock
4	2001.3	infinite	Infinite	Fresh Basement

Table 5: Summary of VES 5 Interpretation

Layer	Resistivity (ohm-m)	Thickness(m)	Depth(m)	Probable Lithology
1	39.5	1.9	1.9	Topsoil
2	12.2	2.7	4.6	Lateritic Clay
3	42.0	3.0	7.6	Weathered Rock
4	3025.9	infinite	Infinite	Fresh Basement

Table 6: Summary of VES 6 Interpretation

Layer	V(m/s)	Depth (m)	Material
1	400	2	top soil
2	500	5	Sand
3	1200	9	Weathered rock

Table 7: Summary of Profile 1 Seismic Refraction Data

Layer	V(m/s)	Depth (m)	Material
1	500	1.5	top soil
2	600	8	Sand
3	1000	5.5	Weathered rock

Table 8: Summary of Profile 2 Seismic Refraction Data

Layer	Velocity (m/s)	Depth (m)	Material
1	500	1	top soil
2	600	1	Sand
3	1000	11.5	Weathered rock

Table 9: Summary of Profile 3Seismic Refraction Data

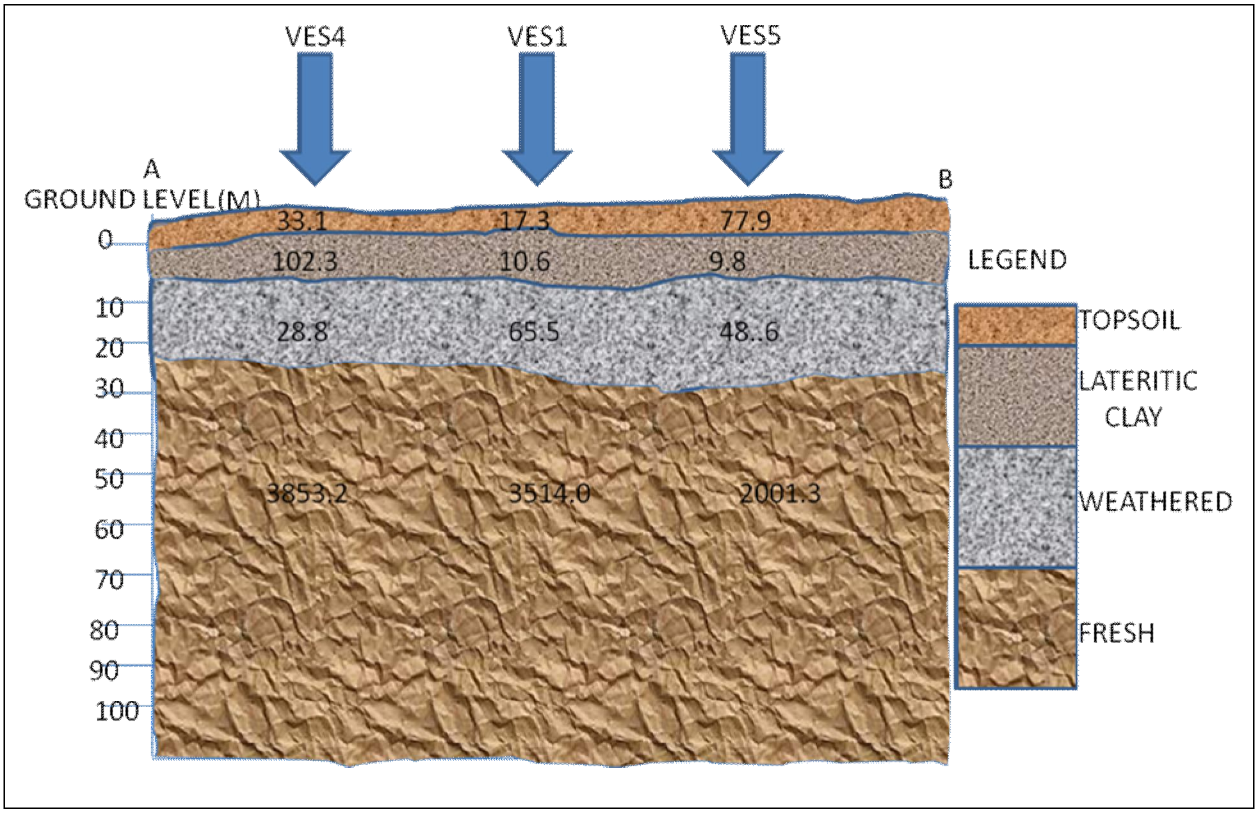

Figure 15: Geoelectric Section Showing Variation of Resistivity with Depth along VES 4, VES 1 and VES 5.

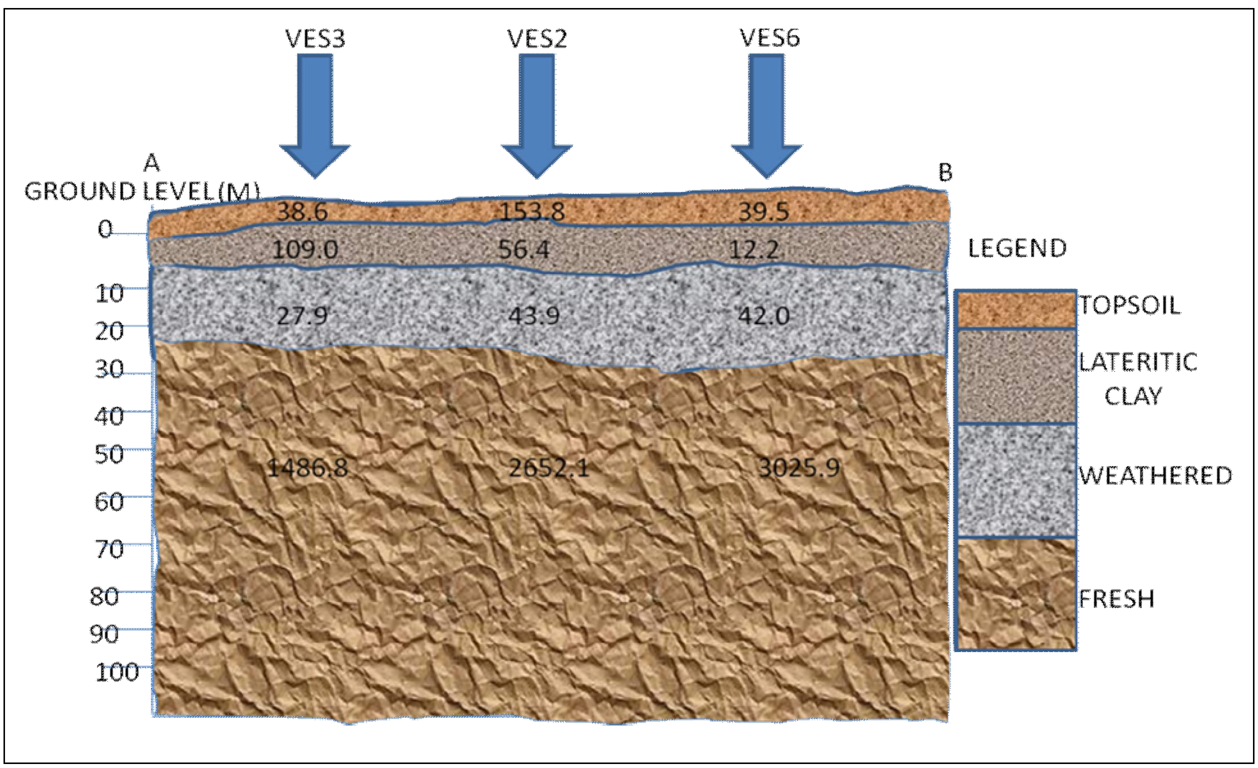

Figure 16: Geoelectric Section Showing Variation of Resistivity with Depth along VES 4, VES 1 And VES 5 .

5. Conclusions

Integrated geophysical methods have been successfully employed to understand the subsurface condition in the active dump site environment. A fairly thick weathered zone is the only important water bearing horizon in the study area because there is no evidence of fracture in the underlying bedrock.

Leachates from the waste have been found to have polluted the groundwater and confirmed by the increase in resistivity of the water bearing weathered zone away from the dumpsite.

6. Acknowledgements
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