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Geoelectrical study for ground water in waste dump sites: A case study of Warri and its environ, Delta State, Nigeria.

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Abstract

The existing waste dump sites in Delta State were investigated for ground water potential without soil disturbance by using the Schlumberger vertical electrical sounding (VES) with half current electrode spacing in the range 1-147m at six point per decade.The results revealed that the soil overlying the aquifer at Ovwian-Aladja dump site has resistivity values, 11.84-85.50 Ohm-m, thicknesses,21.10-31.83m, at Warri it has resistivity values, 160-1074 Ohm-m, thicknesses, 1.53-7.87m. The results also revealed that the aquifer at Warri dump site has no sealing overburden while that at DSC waste site has a thick clay soil overlying it.

Keywords: Schlumberger Vertical Electrical Sounding - waste dump sites - thick clay-above quifer-contamination.

1.0 Introduction:

The ability of the resistivity method to furnish information on the subsurface geology unobtainable by other methods in ground studies was reported [1,2,3,4,5,6,7,8,9]. The location of the dumps and the high quality of sealing is a guarantee of low or negligible contamination of the geological environment especially of groundwater [10]. Moreover, the use of geoelectrical survey in sensing buried waste and waste migration has been documented[11,12,13,14]. The mapping of the configuration of underlying clay layers as well as the near surface discontinuities of landfills and buried disposal trenches has been reported [15].

The earlier workers including [16,17] mainly used the screening body and profiling tecniques, and geoelectric(VES) as a method was only used for locating buried waste trenches and checking of foil quality of the dumps immediately after construction and during the operation of the foil sealing system which is a down hole method. Also non of the researchers considered the VES method for searching dump sites suitable for water borehole location. Hence,where dump sites are most geographically and socially favoured water borehole locations for efficient water distribution, less favoured locations are chosen due to lack of the awareness created by this work. Therefore, it is the aim of this study to locate sites where water sources are sealed from the contaminants of the wastes in a dump site (a condition which permits the siting of waste dump and water borehole in the same location) using the geoelectrical technique.

2.0 Brief geology of the study area

The Warri and Delta Steel Company Ltd waste dump sites are located within Delta State in ($5^{0.}20$'N; $5^{0}43$'E) and ($5^{0}00$'N; $5^{0}46$'E) respectively. These areas and environs (Figure 2.1) are underlain by quaternary sands belonging to the Sombreiro Deltaic Plain of the Niger Delta Basin and comprises chiefly of sands and clays [18]. Other geological characteristics of these areas have earlier been described by [19]. The typical tropical climate, consisting of dry and rainy seasons is governed by the northeastern and southwestern winds which generally influence the climate of Nigeria [20]. The area lies within the rainforest region of the Niger Delta [21].

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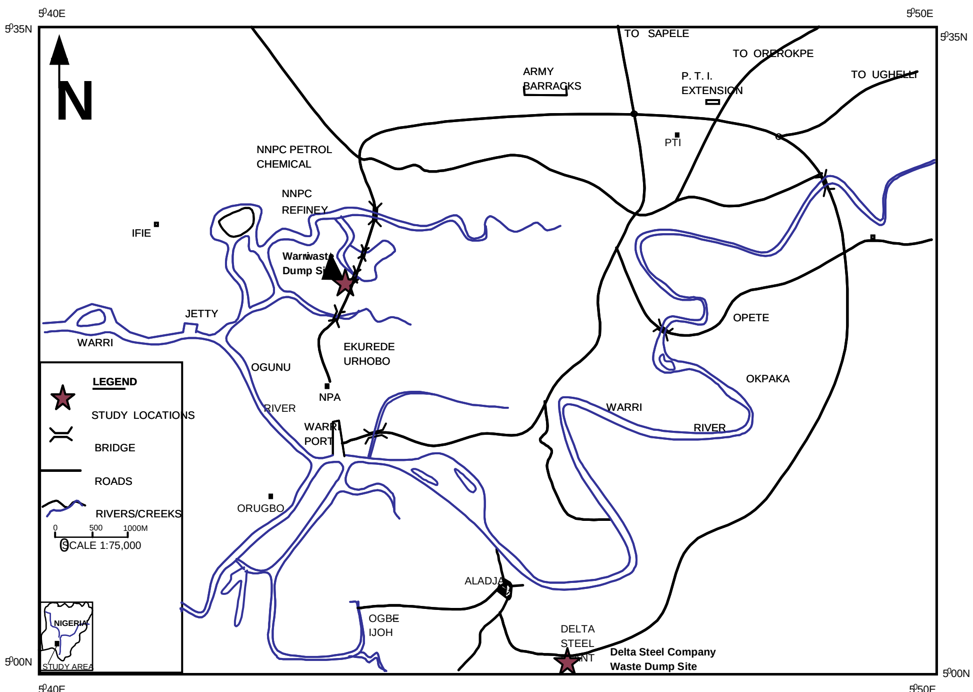

Figure 2.1 Map of Warri and DSC waste dump site

3.0 Theory

For resistivity measurements several types of electrode arrangements can be applied. However, when the earth could be approximated to be composed of horizontally stratified isotropic, and homogeneous media in such a way that the change of resistivity is a function of depth, the Schlumberger configuration is the most widely used array which could provide useful information in solving hydrogeological problems. An important aspect of the Schlumberger is the less sensitivity of this array to the influence of near surface lateral heterogeneities and easy recognition of their effects [22,23,24,25]. Besides smoothing interpretation techniques are much more developed for the Schlumberger array.

In resistivity sounding, four electrodes are earthed along a straight line in the order AMNB (with AB as current electrodes and MN as potential electrodes). The apparent resistivity for Schlumberger array is calculated according to:

$$\lambda_a = \pi\left(\frac{a^2}{b} - \frac{b}{4}\right)\cdot\frac{\Delta v}{I} \qquad (3.1)$$

where a = half current electrodes spacing
b = half potential electrodes spacing,

ΔV and I represent the potential difference in milliVolts and current intensity in milli Amperes respectively.

The technique of data interpretation used involves seeking a solution to the inverse problem namely the determination of the subsurface resistivity distribution from surface measurements.

A very good solution to the inverse problem is the kernel function. It is used in interpreting apparent resistivity measurements in terms of lithology variation with depth. The function assumes the earth to be locally stratified, inhomogeneous and isotropic layers, and unlike apparent resistivity function, it is independent of electrode configuration. It cannot be measured in the field but has to be obtained from the transformation of measured apparent resistivities. The kernel function utilized in this work is derived after [26, 27], if the observed apparent resistivity is given by

$$\lambda_a(r) = r^2 \int_0^\infty \lambda T(\lambda) J_1(\lambda r)\, d\lambda \qquad (3.2)$$

then the kernel function is given by [27] as:

$$T(\lambda) = \int_0^\infty \frac{1}{r} \lambda_a(r) J_1(\lambda r)\, dr \qquad (3.3)$$

where J_1 is the first order Bessel function of the first kind and T(λ) is the transformed resistivity data.

4.0 Methods

Vertical electrical sounding was carried out in the dump sites with an ABEM Terrameter SAS 300C with a booster SAS 2000 to enhance current penetration. The survey was completed with 14 sounding stations in dry season of 2004 using the Schlumberger array with a maximum current electrode spacing (AB) of 294m.The field data acquisition was generally carried out by moving two (current electrodes) or four of the electrodes used between each measurements along a straight path and level ground to avoid lateral inhomogeneity. Details of the method have been documented [28].

The VES curves were obtained by plotting the calculated apparent resistivity against electrode spacing. The curves were interpreted by the well-known method of curve matching and the results were subjected to computer assisted iterative interpretation. The computation employs a 9-point digital linear filters [29]. The resulting sets of layer parameters were interpreted in terms of their lithologic equivalents called geoelectric sections.

5.0 Results and discussion

Table 5.1: Measured apparent resistivity values in Warri (VES 1 and 5) and Delta Steel Company (VES 8 and 13) waste dump sites.

AB/2 (Current Electrode Spacing)	**Apparent Resistivity (Ohm-m)**			
(*m*)	VES 1	VES 5	VES 8	VES 13
1.00	230.00	406.00	58.00	89.00
1.47	220.00	462.00	67.00	55.00
2.15	240.00	465.00	70.00	37.00
3.16	306.00	423.00	63.00	25.00
4.64	372.00	351.00	49.00	18.00
6.81	455.00	293.00	34.00	12.00
10.00	534.00	284.00	24.00	10.00
14.70	576.00	373.00	17.00	10.30
21.50	618.00	553.00	16.50	11.50
31.60	586.00	760.00	20.00	14.00
46.40	555.00	917.00	27.00	19.00
68.10	515.00	912.00	36.00	27.00
100.00	423.00	810.00	45.00	39.00
147.00		675.00	48.00	

Table 5.2; Derived Geoelectric section in Warri waste dump site (VES 1and 5).

Geoelectric Layer	**VES 1**	**VES 5**	**Derived lithology**

	App.Resist (Ohm-m)	Thickness (m)	App.Resist (Ohm-m)	Thickness (m)	Top soil (sand)
1	240.00	0.85	358.00	0.90	sand
2	160.00	0.68	1074.00	1.35	sand
3	760.00	7.65	206.13	5.52	sand
4	672.00	28.88	920.80	24.00	sand
5	263.14	-	613.80	17.50	sand
6			405.68	-	sand

Table 5.3: Derived geoelectric section in Delta Steel Company Ovwian-Aladja waste dump site (VES 8 and 13).

Geoelectric Layer	VES 8		VES13		Derived lithology
	App.Resist (Ohm-m)	Thickness (m)	App.Resist (Ohm-m)	Thickness (m)	Top soil (sand)
1	57.00	0.80	85.00	0.80	clay
2	85.50	1.60	17.00	2.40	clay
3	15.00	19.50	11.84	7.00	clay
4	85.00	-	19.83	14.43	clay.
5			135.00	-	sand

Table 5.4: Summary of the results of VES in Delta State [4,5,6,7,9,31].

Location	Depth to clayey soil(m)	Thickness of clayey soil(m)	Depths to the recommended aquifer(m)
Escravos	15.2	6.1	80.0-151.0
Okpoko	0.1	5.0	6.0-8.0
Ekakpamre	3.0	5.2	8.5-11.0
Effurun-Otor	2.0	20.0	23.0-26.0
Agbarha-Otor	4.0	8.3	12.0-14.0
Ologbo	1.5	5.0	7.0-10.0
Anieze	4.5	6.9	11.0-15.0
Jeddo	5.2	6.6	11.0-15.0
Ugbokodo	3.8	5.0	9.0-14.0
Egbokodo	5.0	7.3	10.0-13.0
Omadino	4.8	27.0	33.0-38.0
Ugbisi	50.0	12.0	65.0-71.0
Delta Steel Company Dump Site	2.0	21..5	23.0-27.0
Warri Dump Site	Nil	Nil	6.5-8.0

Table 5.1 shows that the measured apparent resistivity values for Warri dump site are higher than 100 Ohm-m (representing areas without thick near surface clay) and those for Delta Steel Company dump site (representing areas with thick near surface clay) are lower than 100 Ohm-m. Also the apparent resistivity values for the derived geoelectric sections for Warri dump site(VES1 and 5) are above 100 Ohm-m (Table 5.2) and those for the geoelectric sections in Delta Steel Company (VES8 and 13) are below 100 Ohm-m (Table 5.3)

Table 5.4 shows the locations in Delta State where clayey soil (including its thickness and depth) have been found above the aquifer with the depths to the aquifer inclusive [4,5,6,7,9,31]

Figure 5.1 shows that the field curves for Warri waste dump site (VES1 and 5) have a bell shape at the right most segment and an ascending left most segment. Also shown in Figure 5.1 are the field curves for Delta Steel Company waste dump site (VES8 &13) which have a middle bowl section, a descending left most and an ascending right most segments.

The apparent resistivity values of over 100 (160-1074) Ohm-m (Tables1 and 2) confirmed by the bell shapes with ascending left most segments in the field curves for VES1 and VES5 (Figure 5.1) indicate the presence of sandy soil (permeable soil) above the near surface aquifer in Warri waste dump site. However, the left most descending and the middle bowl segments of VES8 and VES13 in Figure 5.1 is an indication of the low apparent resistivity values (less than 100 Ohm-m) as shown in Tables 5.1 and 5.3, this means that a thick clayey (impermeable) soil is present above the aquifer in Delta Steel Company waste dump site.

However, the presence of 4.5m thick horizontal impermeable (clay) layer above an aquifer can limit the danger of contamination of the aquifer [30,31]. Therefore, the clay of thicknesses, 21.10-24.83m, above the aquifer in the Delta Steel Company waste site which is within the ranges of 0-27m determined in Delta State by earlier workers is capable of protecting the aquifer from contamination by contaminants from the waste above it and this makes the aquifer in this site a source of potable water. Moreover, in [32] resistivity values above 100 Ohm-m indicate the presence of a sandy subsurface, therefore, the Warri dump site (like other parts of Delta State excluded in Table 5.4) where the resistivity values are above 100 Ohm-m there is no thick near surface clay, has an aquifer (water) that

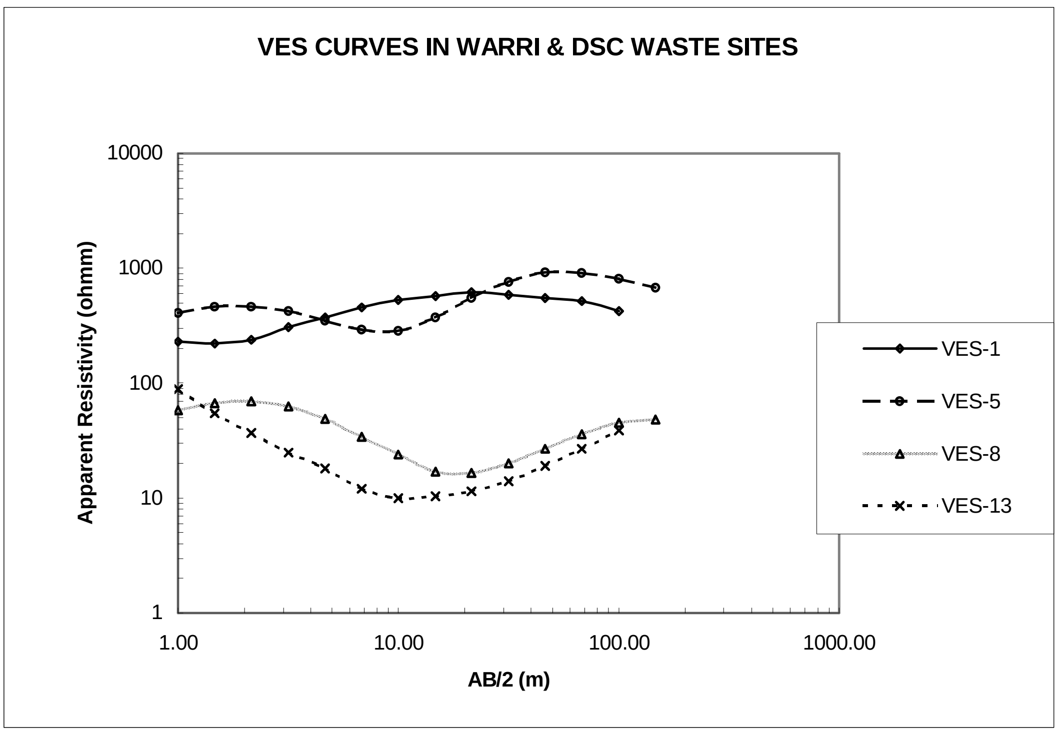

Figure 5.1: Shape of VES Curves in Warri (VES1 and 5) and Delta Steel Company (VES8 and 13) waste dump sites.

is overlain by sands and it is therefore exposed to contamination. Also, Table 5.4 shows that the depths to the aquifer in Warri and Delta Steel Company dump sites are 6.5-8.0m and 23-27m respectively which are within the ranges of 6-151m determined by previous workers for Delta State.

6.0 Conclusion

The results have revealed that only aquifers bellow a thick clay layer are sealed from contamination and should be considered for exploitation. Therefore, the locations shown in Table 5.4 are suitable sites for the dual purposes of water borehole and waste dump. It is mandatory to establish the presence of thick clay above the aquifer before using any site for waste dump because apart from considering such sites for water borehole in the future the aquifer of nearby water boreholes can be contaminated through vertical and horizontal flow of contaminants [31]. And all existing waste dump sites in Nigeria should be investigated using VES, and the usage of any site without clay of at least 4.5m thick above the aquifer must be discouraged. This work is hereby recommending that both waste dump and potable water borehole can be located in the same site if a clay of thickness above 5m exist above the aquifer.

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