

NIGERIAN JOURNAL OF PHYSICS



June, 2019

Published by
Nigerian Institute of Physics
www.nipng.org

NJP VOLUME 28(1)

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14	A. Jacob, F. O Anjorin, J. Nafinji, Y. A. Ezekiel	OVERVIEW OF AEROSOL LOADING IN THE SAVANNAH BELT OF NIGERIA: An Assessment of Impact of Desertification in the Region.	116
15	Sanda, A. and Yerima, J. B.	FREQUENCY DEPENDENCE OF DIELECTRIC PARAMETERS OF CORN SYRUP SOLUTIONS USING CYLINDRICAL LIQUID TEST CELL.	125
16	A. Ango, N.K. Abdullahi, and M.S.Ahmad	APPLICATION OF 2D AND 3D GEO- ELECTRICAL RESISTIVITY IMAGING FOR HYDROLOGICAL AND ENGINEERING SITE INVESTIGATION IN KADUNA STATE UNIVERSITY, NORTH-WESTERN NIGERIA	136
17	R. O. Agboola, L. A. Sunmonu, S. Olatunji, N.K.Olasunkanmi	INTEGRATED GEOELECTRICAL AND HYDROCHEMICAL ASSESSMENTS OF EYENKORIN MARKET DUMPSITE, ASA I G.A., KWARA STATE, NIGERIA.	145
18	Igbekele O. J., Kwaha, B. J., Ogherohwo E. P and Zhimwang J.T	TRANSMISSION EVALUATION OF MOBILE CELLULAR VOICE AND DATA SERVICES UNDER RAIN CONDITION IN JOS, NIGERIA.	155
19	Dikko A. B.	A METHOD OF ESTIMATION OF THE AMOUNT OF DIESEL AS AN ADULTERANT IN KEROSENE USING A SIMPLE VISCOMETER.	163
20	Joseph, E., Ahmed, Y. A. and Bello, O. M.	INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF ELEMENTS OF INTEREST IN FARMLANDS AT THE CENTRAL AREA OF KATSINA STATE, NIGERIA.	168
21	L. W. Lumbi, A. Lawan, J. I. Kwajighu and E. N Chifu.	REIMANNIAN STUDY ON SOME QUANTIZED PARAMETERS OF A HARMONIC OSCILATOR	177
22	Adamu, A., Ngadda, Y H. and Dikwa, M. K.	THE FINITE SIZE OF AN ELECTRON AND ITS EFFECT ON ATOMIC SPECTRA.	182
23	A.D Bajoga, S. Abdulsalam, H. A. Dala and M. Hussaini	ASSESSMENT OF GEO-ACCUMULATION INDEX IN TOP SOILS OF METAL SCRAP YARDS WITHIN GOMBE METROPOLIS, GOMBE STATE, NIGERIA USING ATOMIC ABSORPTION SPECTROMETRY.	191
24	Dikko, A. B. and Ezike S. C.	SOME ACOUSTIC PARAMETERS AND ULTRASONIC VELOCITY OF QUATERNARY LIQUID MIXTURE OF ETHANOL, METHANOL, BENZENE AND DISTILLED WATER WITH TEMPERATURE VARIATION.	202
25	Abdulsalam, N. N., Maduenyi, C. N. and Coker, J. O.	SPECTRAL DEPTH ESTIMATE OVER PARTS OF MIDDLE BENUE TROUGH NIGERIA USING HIGH RESOLUTION AEROMAGNETIC DATA	207
26	Sivla W.T. and Ogunjobi O.	ON GREAT GEOMAGNETIC STORMS OF SOLAR CYCLE 23: A BRIEF REVIEW	218

INTEGRATED GEOELECTRICAL AND HYDROCHEMICAL ASSESSMENTS OF EYENKORIN MARKET DUMPSITE, ASA L.G.A., KWARA STATE, NIGERIA.

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ABSTRACT

Geophysical and physico-chemical investigations of a waste dumpsite was aimed at assessing the extent of groundwater pollution arising from leachate plume. Very Low Frequency Electromagnetic, Resistivity Profiling and Sounding were employed within the range of 1 to 100 m in NE-SW direction, in discordant with orientation of outcrops in the area. VLF-EM results showed high range values (0 - 10 μ S) of conductivity within a depth range of 5-15 m. Profiling showed low Resistivity value range (3.79 - 11.0 Ω m) within a depth range of 9 - 12 m. The sounding results delineated four - five vertical lithological layers from the geo-electric sections of KII type sounding curves. High conductivity shown by the VLF-EM could be a signature of aquiferous layers in the area. The low resistivity value could be an evidence of dissolved particles from the decaying rubbish in the waste, forming the constituent of the leachate. The hydro-physicochemical analysis showed concentration of Magnesium (6.8-8.4)mg/l, Iron (2.0-3.5)mg/l, Manganese (0.5-0.85)mg/l, Lead (0.5mg/l), Chromium (0.6-0.8)mg/l and Nickel (0.05mg/l) present in the water samples, higher than WHO, 2006 and NSDQW, 2007 standards. Thus, migration of leachate could have posed menace of pollution.

Keywords: leachate plume, heavy metals, sounding curve, health hazard, geophysical

INTRODUCTION

Industrial development and uncontrolled growth of urban waste and population result in the production of toxic and non-toxic wastes which are incessantly disposed in confined or unconfined waste disposal sites (dumpsites). (Fig.1). The decomposition of the refuse lead to the production of leachate which infiltrates the earth in the direction of rainwater percolation to contaminate the groundwater, depending on the topography, hydrology condition, porosity and the rock type within the locality. Leachates can travel several metres of vertical and horizontal distance, thereby polluting soil, rocks, surface water, and groundwater (Bernstone, *et al.*, 2000).

In this study, Electrical Resistivity and Electromagnetic methods were applied as reconnaissance tools to detect and delineate leachate plume from uncontrolled Eyekorin market solid waste dumpsites while

hydrochemical assessment of the well water in the study area was also carried out. The study is aimed at investigating possible Groundwater contaminant signature from open dumpsites in the study area. This becomes necessary as the inhabitants in the study area depend mostly on groundwater for domestic purposes and as such this might have had deleterious effect on human health.

Description and Geology of Study Area

Eyekorin market dumpsite is within the human locality sandwiched between Latitude 8° 23' 25" to 8° 23' 41" N and Longitude 4° 27' 36" to 4° 27' 62" E in Asa Local government areas of Kwara State, South-western, Nigeria. According to (Olaschinde, Virbka and Esan 1998; Rahaman, 1976; Oluyide, 1979), the study area is situated on the undifferentiated Precambrian Basement Complex rocks of granitic Gneisses, Migmatites and metamorphic origin. (Figures 2a and b).

The two main types of aquifer in this area are the weathered basement and jointed/fractured basement aquifers with the

latter usually occurring below the former (Davis and De Wiest, 1966).



Figure 1: Eyekorin-Market dumpsite

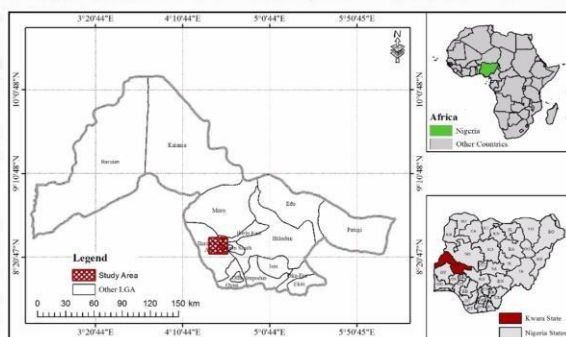


Figure. 2a: Location Map of the study area

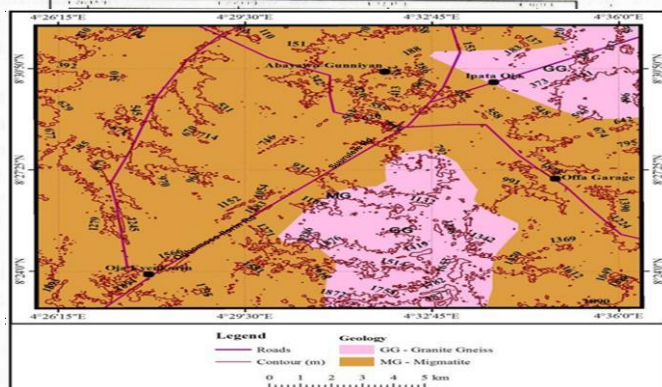


Figure 2b: Geological Map showing the Study Area

METHODOLOGY

Geophysical Techniques

The electrical resistivity techniques adopted were Vertical Electrical Sounding (VES), using Schlumberger electrode configuration, 2-D electrical resistivity profiling using Werner alpha array together with Very Low Frequency Electromagnetic (VLF-EM). In Electrical Resistivity Profiling and Vertical Electrical Sounding (VES) measurement, electric current (I) was introduced into the ground through a pair of electrodes A (C1) and B (C2), while electrodes M (P1) and N (P2) measured the potential difference (ΔV) created in between A and B due to the current pressures in them. This operation is repeated when the distance between current electrodes are increased, together with an increase of the study depth. Values of apparent resistivity (ρ_a) were calculated in each distance AB using

$$\rho_a = \frac{\Delta V}{I} G \quad (1)$$

$G (= \pi \frac{(\frac{AB}{2})^2}{MN})$ is the geometrical factor, determinable from the arrangement of the electrode configuration. The field data were interpreted using *RES2DINV* software. (Loke *et al.*, 1996) and *WINRESIST* modeling software while 1-D electrical resistivity tomograms were generated.

VLF-EM data set was collected using ABEM- WADI VLF equipment to measure the vertical (HZ) (Real) and horizontal (HX) (Imaginary) components of the secondary electromagnetic fields along the established profiles at 5 m and 10 m data intervals. The real component of the data is filtered

following the Fraiser (1966)'s technique. Using the method of Karous and Hjelt (1983), the filtered real component of the data was used to compute current density pseudo-section for each VLF profile. Computation and plotting of current density pseudo-section was done with the aid of KHF-filter inversion software (Pirttijarvi, 2004). The inversion uses skin depth normalization that compensates for the effect of attenuation with depth.

$$\text{Skin depth } (\delta) = \sqrt{2\rho/\omega\mu} \quad (2)$$

Where ω is the angular speed; μ is the magnetic permeability and ρ is the resistivity.

PHYSICO-CHEMICAL ANALYSIS

Water samples were taken from the three available hand dug wells around the dumpsite area by adopting standard method for sample collection and preservations. Field measurements include physicochemical parameters such as temperature, pH and other physical parameters including: water level, depth to bottom of the well, total dissolved solids, colour, odour, taste, and turbidity.. Cations and heavy metals analyses were carried out using Atomic Absorption Spectrophotometer. Sodium and Potassium metal (Na and K) by Flame photometry (Systronics) ,while anion analysis was performed using Iron Chromatographic method (titrimetric method was used for SO_4^{2-} and HCO_3^-). Four anions were quantified, while thirteen metal elements were also quantified.

RESULTS AND DISCUSSION

Results

(i) Very Low Frequency -EM

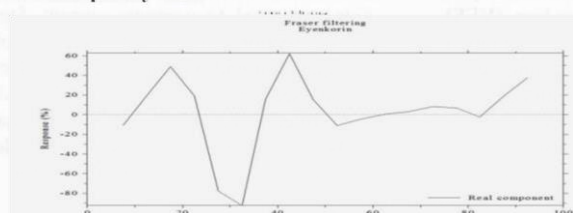


Figure 3a: Filtered In-phase Response of VLF data

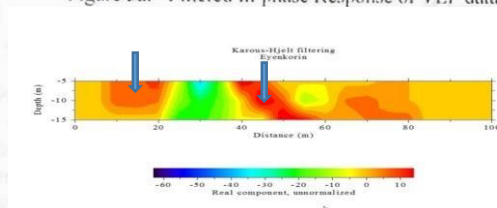


Figure 3b: Current density Equivalent Pseudo-section along VLF profile

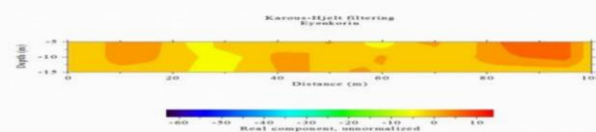
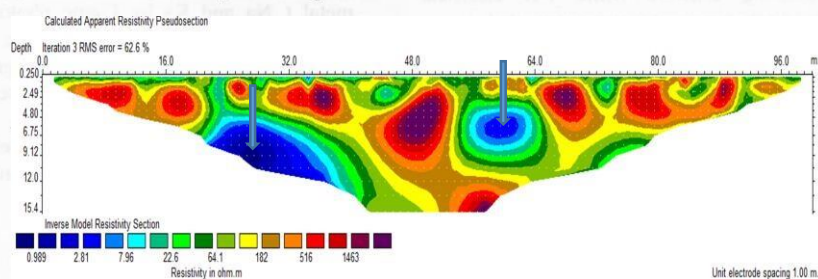


Figure 3c: Current density Equivalent Pseudo-section along VLF profile (Controlled)

(ii) Electrical Resistivity Profiling



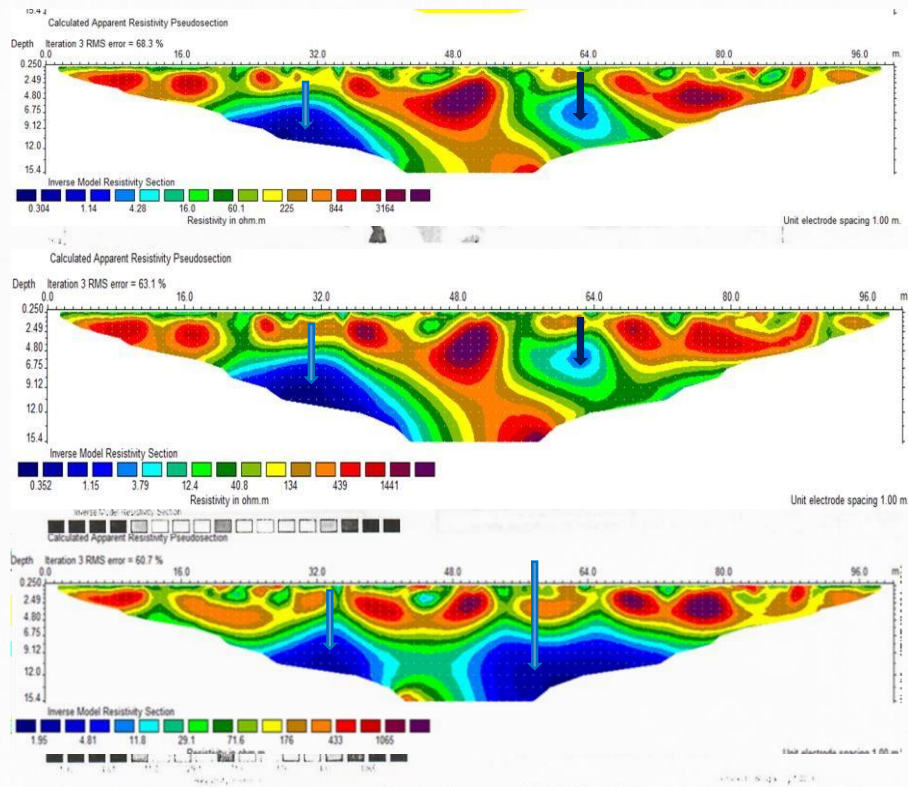
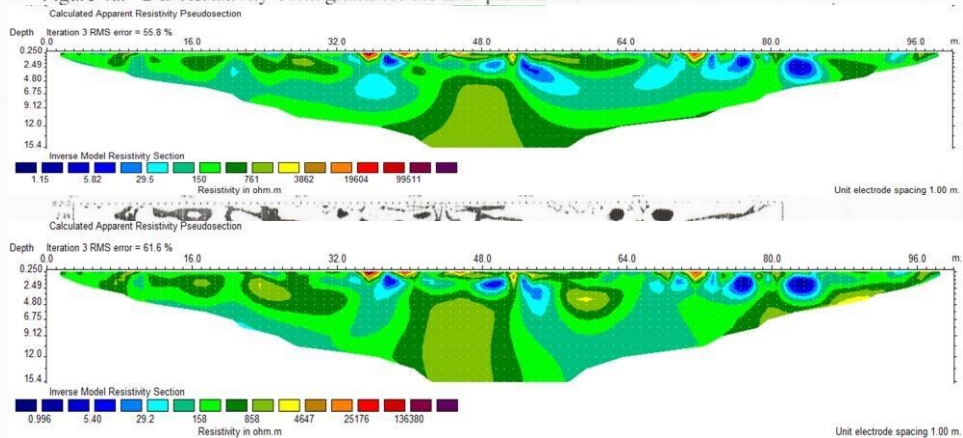


Figure 4a: 2-D Resistivity Tomograms for the ERP profiles NE – SW



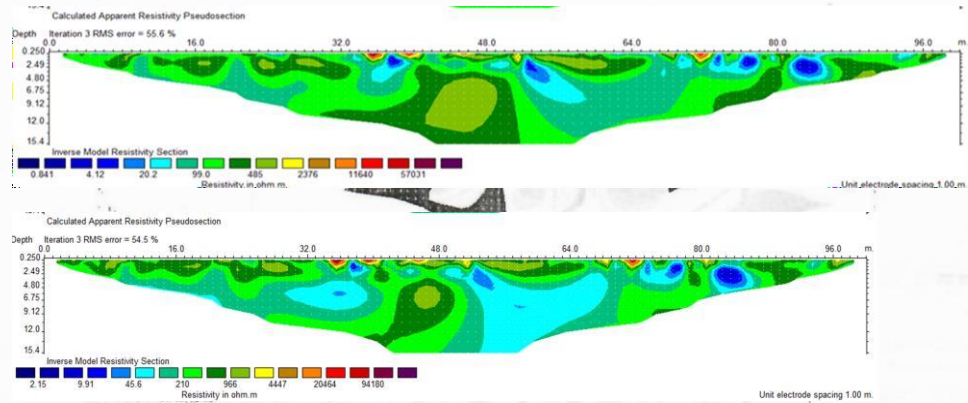
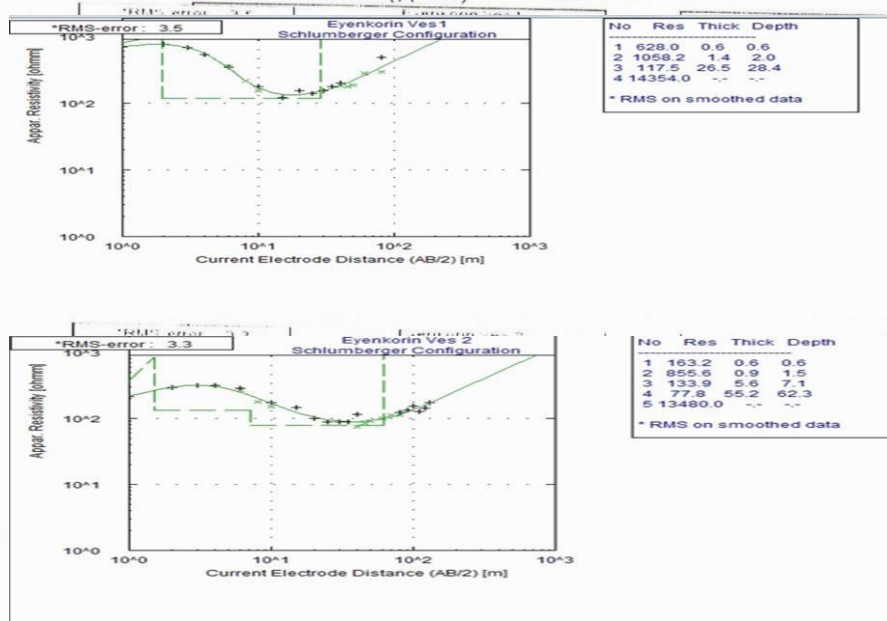


Figure.4b 2-D Resistivity Tomograms for the ERP profiles NE - SW Direction (Control site)

(iii) Vertical Electrical Sounding (VES)



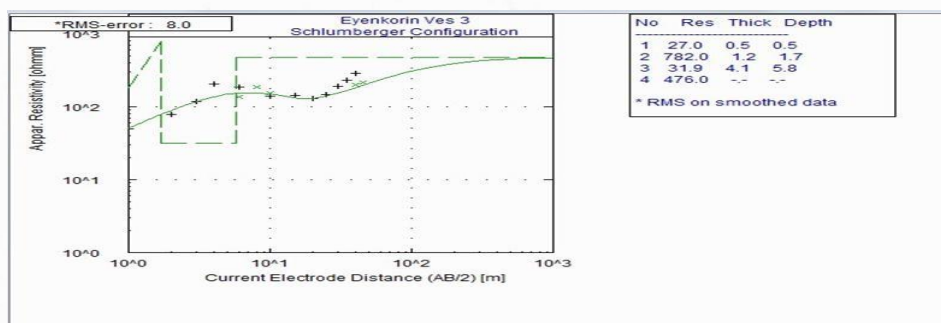


Figure 5: Modeled VES Field curves

Table 1: VES Curves Analysis

LOCATIONS	VES	Layers	Resistivity (Ωm)	Thickness (m)	Depth (m)
Oja/Eyenkorin	VES 1	1	628.0	0.6	.06
		2	1058.2	1.4	2.0
		3	117.5	26.5	28.4
		4	14354.0	-----	-----
	VES 2	1	163.2	0.6	0.6
		2	855.6	0.9	1.5
		3	133.9	5.6	7.1
		4	77.9	55.2	62.3
	VES 3	5	13480.0	-----	-----
		1	27.0	0.5	0.5
		2	782.0	1.2	1.7
		3	31.0	4.1	5.8
		4	476.0	-----	-----

(iv) Physico-Chemical Analysis

Table 2: Comparative analysis between water quality standard and the result of Physico-chemical analysis of hand dug well water samples in the study area

PARAMETERS	WELL A	WELL B	WELL C	NSDWQ (mg/l)	WHO (mg/l)
Depth of wells (m)	13.75	15.40	10.0		
Distance of wells from dumpsite(m)	28.00	24.50	70.00		
Colour	colourless	colourless	colourless	Clear, colourless	Clear, colourless
Taste	tasteless	tasteless	tasteless	Unobjectionable	Unobjectionable
Odour	Repulsive	Repulsive	none		
pH	7.3	7.5	7.88	6.8 - 8.5	6.8 - 8.5
Temperature ($^{\circ}C$)	29.0	29.50	30.0		24.5 - 39.7
Fe ²⁺ (mg/l.)	2.0	3.5	0	0.5	0.5
Pb ²⁺ (mg/l.)	0.5	0.5	0	0.01	0.01
Cu ²⁺ (mg/l.)	0.5	0.7	0	1.0	2.0
Zn ²⁺ (mg/l.)	1.8	2.6	0	3.0	3.0

K ⁺ (mg/L.)	1.3	0.9	2.1		15
Na ⁺ (mg/L.)	2.3	2.3	4.4	200	200
Mg ²⁺ (mg/L.)	6.8	8.4	0	0	0.2
Ca ²⁺ (mg/L.)	14.4	11.2	5.8	75	75
Ni	0.05	0.05	0	0.02	0.02
Cd	0.00	0.0	0	0.003	0.003
Cl ⁻ (mg/L.)	17.0	17.0	34.92	250.0	250.0
Cr ³⁺ (mg/L.)	0.6	0.8	0.0	0.05	0.05
Mn (mg/L.)	0.85	0.5	0.0	0.05	0.4
Co (mg/L.)	-0.01	0.04	0.05		
SO ₄ ²⁻ (ppm)	19.0	22.5	12.74	250.0	100.0
NO ₃ (ppm)	2.5	3.0	2.09		50
PO ₄ (ppm)	0.75	0.8	1.13		250
CN- (mg/L.)	0.0	0.0	0		0.07
TDS (ppm)	174.00	284.00	400.00		1000
DO (mg/L.)	5.40	4.0	4.00	3.0	3.0
BOD (mg/dl)	4.4	3.6	6.30	10	10
COD (mg/dl)	6.2	4.6	5.4	10	10
Turbidity (mg/L.)	7.0	7.5	0.42		5.0

DISCUSSIONS

Contaminant Presence

The Results of the study area as presented in figures 3a and b showed that the observation recorded on the electromagnetic response from the Fraser Filtering graph and current density Pseudo section pattern on the VLF-EM tomograms indicating the locations of high positive current- density anomaly (0 to +10 μ S) of the VLF results representing the area of high conductivity. This indicates the presence of contaminant in the areas under investigation. Places showing high positive current-density anomaly along the VLF profiles on Figures 3a and b are interpreted to be rocks/soil infiltrated by contaminants. Places with low negative - low positive are interpreted to be rocks with low conductivity property. Places with high negative anomaly are interpreted to be crystalline rocks. Crystalline rocks are very resistive because they lack porosity that will permit the infiltration of water or leachate. The VLF-EM profiles located 50 m away from the dumpsite showed lower current density

(Figure 3c) than their corresponding profiles within the dumpsite (Figures 3a and b). This suggests that high current density is due to the presence of leachate.

Similarly, a contaminant leachate plume was delineated in 2-D resistivity sections as low resistivity zones, as presented in figure 4a. The 2-D resistivity imaging was identified as bluish zones of low resistivity range of 3.79 - 11.0 Ω m with the depth ranging of 6 to 12 m. The low resistivity value revealed that the area has been contaminated. Comparing the profile within the dumpsite to the profile 60 m away outside the dumpsite (Figure 4b), it was noted generally that rocks outside the dumpsite are more resistive than those within the dumpsite.

However, the resistivity pattern in the 2-D ERP tomograms is similar to the current density pattern observed in the VLF-EM tomograms in the sense that the contaminated area of low resistivity values on the ERP is correlated to the conductivity structures seen in VLF

tomograms. The Structures suggesting local pool of contaminant are consistent within the vicinity of some of the dumpsites as shown on 2-D ERP tomograms and VLF-EM tomograms. High resistivity signatures on 2-D ERP tomograms suggest the presence of basement rocks that are not permeable to contaminant infiltration.

Interpretation of VES data (Figure 5) shows that the study area revealed four – five geo-electric layers. Based on previous study (Olaschinde and Raji, 2007), the five geo-electric layers are interpreted as: top soil, lateritic layer, weathered rock layer, fractured basement rock and fresh basement rock. Topsoil layer is absent in places interpreted for four geo-electric layers. They were meant to strengthen or substantiate the conductivity and resistivity structures observed in the VLF-EM and ERP results. The analysis carried out on the field data acquired on dumpsite and control revealed 4 -5 layered model with KII and KQH type curve ($\rho_1 < \rho_2 > \rho_3 < \rho_4$, $\rho_1 < \rho_2 > \rho_3 < \rho_4$). In the first and third layer of the VES 3, the resistivity values were 27.0 Ωm and 31.9 Ωm with a relative thickness of 0.5 m and 4.11 m. The second layer has high resistivity value of 782 Ωm with relative thickness of 1.19 m which could be lateritic layer. However, the low resistivity values observed in the first layer (figure.5, VES-3) is assumed due to pollution which resulted from the high porosity and permeability characteristics of the sandy soil encouraging the seepages of the contaminant to a maximum depth of 0.5 m at the subsurface. The fourth layer has high resistivity value of 476 Ωm which indicated the fractured to fresh basement zones. The thickness of this geo-electric layer is to an infinite depth. However, high resistivity values observed in all the layers of the control sites of (figure 5, VES 1 and 2) showed non pollution of the area. The fourth layer with high resistivity

range value of 13642 - 14114 Ωm , indicated the fractured or basement zones (Table 1)

Assessment of Leachates Impact on Surrounding Groundwater Quality shows that all major ions revealed concentration below the acceptable limit of The World Health Organization (WHO,2006) and Nigeria Standard for Drinking Water Quality (NSDWQ,2007) standard guidelines used as standard for assessing the groundwater quality in the research area, except: Iron, Lead, Magnesium, Nickel, Chromium and manganese whose concentrations were slightly above the acceptable standards limit in most of the surface and shallow groundwater downslope of the dumpsite, as presented in Table 2. The levels of pH in majority of ground water samples are in the range of 7.3 - 7.88, this is in conformity with The World Health Organization (WHO,2006) and Nigeria Standard for Drinking Water Quality (NSDWQ,2007) standard. The various parameters tested in the sampled wells show different concentration, the depths of the sampled wells and their various distances from the waste disposal site are presented in Table 2.

CONCLUSION

The study has revealed that the study area have been considerably contaminated due to migration of leachate which could pose some health risks to the residents. This is evident from the high values of conductivity obtained from the results of VLF-EM and Low Resistivity values obtained from the result of the ERT. The hydro geologic features of the study areas showed that contaminants derived from the waste disposal site infiltrate through vulnerable sandy formations and hence to the groundwater flow. The variation in the concentration of some metals and element might have been as a result of the infiltration. It could be concluded from this

study that contaminant is present in the area. However, based on the result of hydro-chemical analysis of the surrounding well water, it could be concluded that the groundwater is mostly unsuitable for human consumption.

However, it is recommended that effective and frequently monitoring of ground water quality will safe guard the health of the public residing in the surroundings of the dump site and an improved waste disposal management system is also necessary.

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