Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.14, 2015

Geophysical and Hydrochemical Investigation of a Municipal Dumpsite in Ibadan, Southwest Nigeria

Tosin, A. Olla, Ayokunle, A. Akinlalu, Gbenga, M Olayanju*, Adebowale, O. Adelusi, Kola, A. Adiat,
Department of Applied Geophysics, Federal University of Technology Akure, Ondo State, Nigeria.

Abstract
Geophysical and hydrochemical investigations have been undertaken within a reclaimed site of municipal dumpsite in Ibadan, southwestern Nigeria with a view of assessing the impact of effluent from the ancient dumpsite on the soil and groundwater sytem. The study area is underlain by precambrian Basement Complex rocks mainly granite gneiss. The geophysical investigation involved electrical resistivity methods using dipole-dipole profiling and Schlumberger Vertical Electrical Sounding (VES), while the hydrochemical investigation involved physical, chemical and microbial analyses of water samples within the reclaimed land and active dumpsite. A total of 175 sampling points were occupied using dipole-dipole profiling, while 29 Schlumberger electrical soundings were carried out. In addition, water samples from available nine wells in the area whose static water levels range between 1.2 m and 7.4 m were analysed. The results from electrical surveys show that the study area is underlain by a maximum of four subsurface layers namely the topsoil, the weathered layer, the partly weathered/fractured basement and the fresh basement whose resistivities values range from 41-495 ohm-m, 13-643 ohm-m, 86-720 ohm-m and 2800 ohm-m and above. Their thickness of the overburden units varies from 0.7- 49.5 m. The partly weathered/fractured basement constitute the main aquifer. The resistivity distribution of the topsoil and weathered layer indicates that parts of these layers have been infiltrated by plumes from the reclaimed land and active dumpsite, especially in areas characterised by low resistivity (<30 Ohm-m). In most cases, the suspected leachates are held within the clayey overburden and are prevented from infiltrating the aquifer by local barriers. There are indications that the leachate migration is topographically controlled. The hydrochemical analysis of samples from the wells show that the concentration of the analysed anions (Cl^-, $S0_4^{2-}$ and $N0_3^-$) and cations (Na^+, Ca^{2+}, Mg^{2+} and Fe^+) are within the World Health Organisation (2004) and Standard Organisation of Nigeria (2007) permissible limits. This indicates that the aquifer system in the area might be free from contamination. However, there is possiblity of future impacts on wells in the area from downwards migration of the effluents from active dumpsite and other anthropogenic activities relating to human impacts on existing geo-environmental systems.
Keywords: effluent, contaminantion, hydrochemical analysis, leachate, aquifer

1. Introduction
Planning and development of effective waste management in a society is very important to healthy living of people in the society. Great amount of annual budgets of governments at all levels are always on sustaining health sectors worldwide. Most of diseases and outbreaks of health related catastrophes can be associated with contaminations from anthropogenic activities relating to human impacts on existing geo-environmental systems. The generation of solid wastes from intrinsic elements associated with human existence as the day to day activities of man cannot be possible without producing unwanted materials or by-products (WHO, 1971). Solid wastes can be grouped into two: (i) Hazardous wastes which include toxic chemicals, radioactive materials, flammable and explosive wastes and (ii) Non –hazardous wastes from agriculture, commercial and industrial wastes that are not lethal by nature or contain toxic materials (Fasunwon *et al*, 2010). Groundwater is of major importance to civilization since it is the largest reserve of potable water in regions where humans live (Alile, *et. al*. 2011). However, maintaining a portable ground water supply that is free from microbial and chemical contaminants is far from reality in most of our urban centers due to poor waste disposal and management practices (Ekeocha, *et. al.* 2012).

Several works have been carried out on the environmental impact of waste dumpsite on the groundwater quality in a typical basement complex terrain of south-western Nigeria (Awoniyi 2013; Lawal *et al*., 2013; Oluwafemi, 2012; Badmus *et al*., 2009; Ehirim *et al*., 2009; Mathias *et al*., 1994). The presence of dumpsite in an area poses a major threat to the quality of water consumed by the people living in that environment. This assertion has led to the reason why impact of leachate has been given much attention in recent years in Nigeria (Ikem *et al.,* 2002; Obase *et al*., 2009; Ojo, *et al*., 2014). Indiscriminate dumping of refuse can create a number of adverse environmental impacts such as wind-blown litter, attraction of vermin and generation of leachate that are impairable to the quality of groundwater (Bayode *et al*, 2011). The biodegradation of these wastes generates leachate that can contain both chemical and biological constituents (Dauda and Osita, 2003, Bayode *et al*, 2012, Slomczynska and Slomczynski, 2004).

The ancient city of Ibadan in the southwestern Nigeria is one of the largest and most densely populated cities in West Africa (Fourchard, 2003). The large population in turn accounts for the huge wastes produced in these cities. Many of the huge wastes produced on daily basis across the ancient City of Ibadan are disposed off in a number of dumpsites across the city, which include Apete, Sango, Challenge, Bashorun and Jenbewon dumpsites (Figure 1).

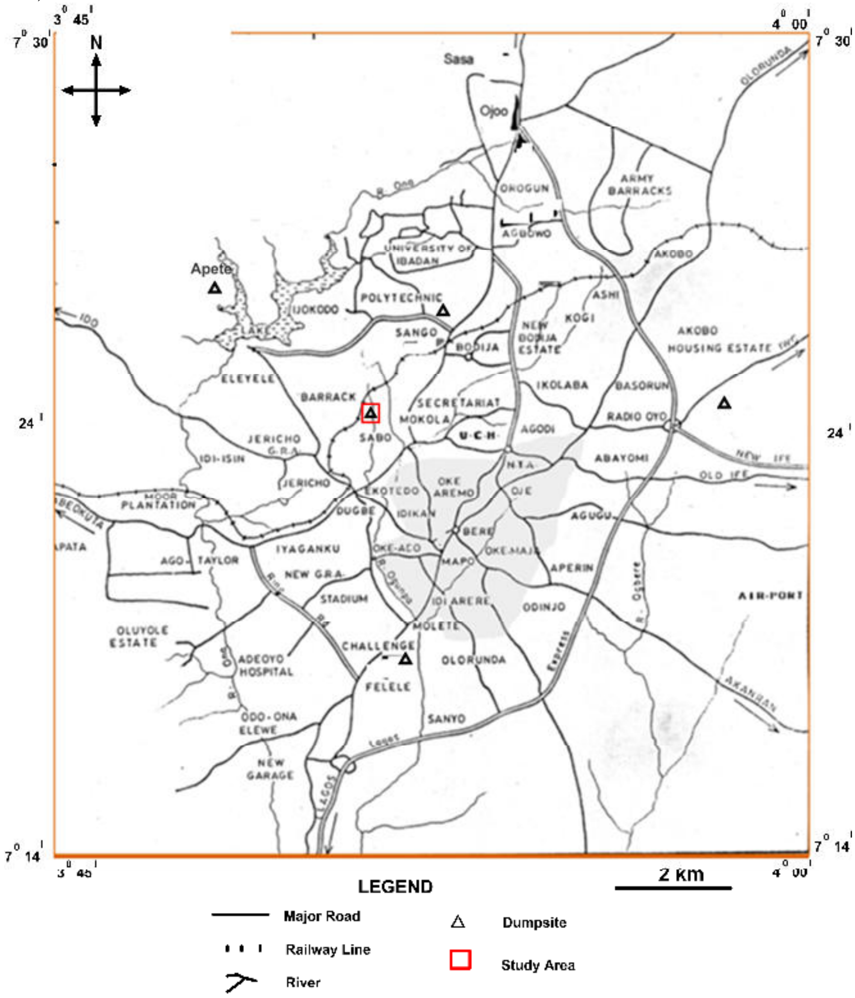

Figure 1: Map of Ibadan, Southwestern Nigeria Showing the Study Area (Modified after Fourchard, 2003).

This paper focused on the impacts of the long existing Jenbewon dumpsite on the geo-environment around its locality. Jenbewon dumpsite is an old dumpsite that was in operation for more than sixty years, which was reclaimed for residential purpose and located within Ibadan metropolis. A portion of the area is kept as active dumpsite (Figure 2), where both degradable and non-degradable materials from the community are being deposited, which can constitute health hazards in feature if no proper waste management program is put in place. In addition, the fact that no previous environmental or geophysical investigations have been conducted in the area, underscore the importance of addressing potential environmental degradation from Jembewon dumpsite. This paper hereby addressed in the detailed study involving geophysical and hydrochemical investigation aimed at characterizing the environmental impacts from effluents associated with the dumpsite.

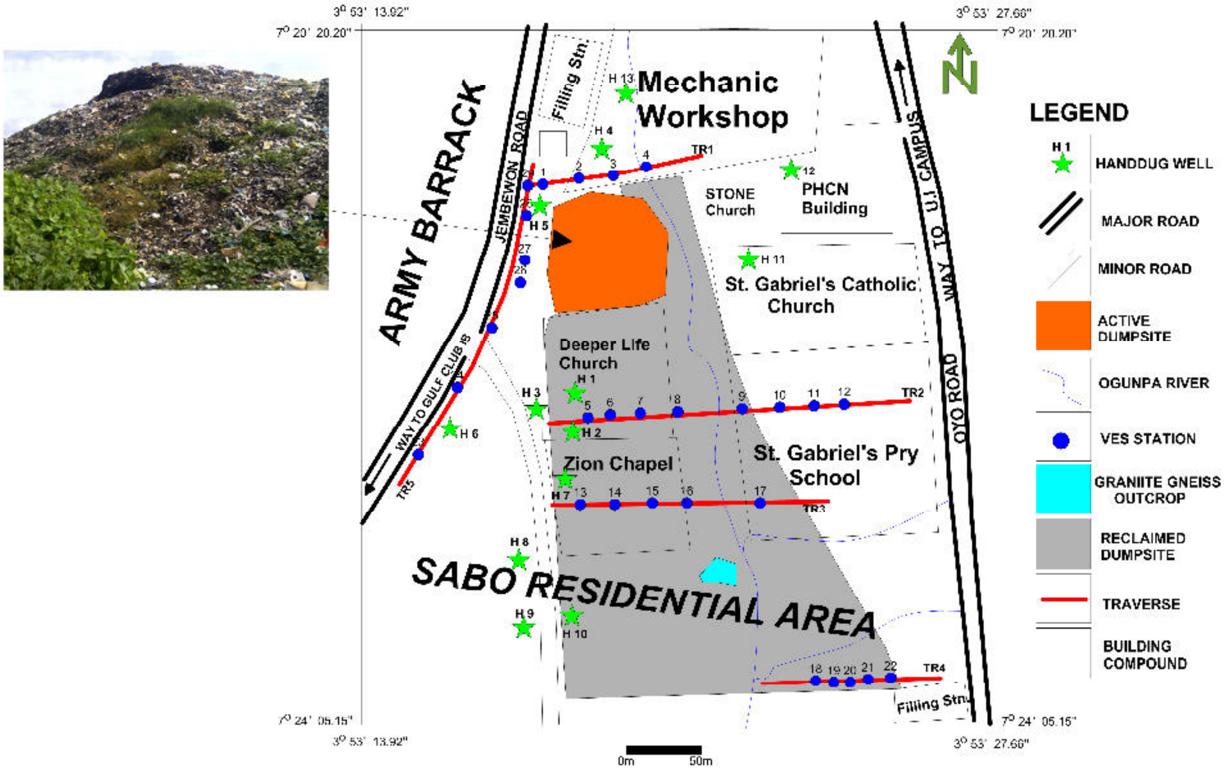

Figure 2: Location map of the study area showing data acquisition layout (inset a photograph showing the dumpsite).

1.1. Description of the Study Area

Ibadan falls within the Precambrian basement complex of South-western part of Nigeria which is dominated by rock types such as granite and granitic schist of the metasedimentary series, banded gneiss and granite gneiss, augen gneiss and migmatite complex (Obaje *et. al.* 2009; Okunlola *et al*., 2009) (Figure 3). The study area of investigation is monolithic as preliminary geological investigation revealed that the study area is underlain mainly by granite gneiss. It lies between longitude 3° 52' 12" E to 3° 53' 54" E and latitude 7^{o} 24' 8.5" N and 7° 24' 31.2" N.

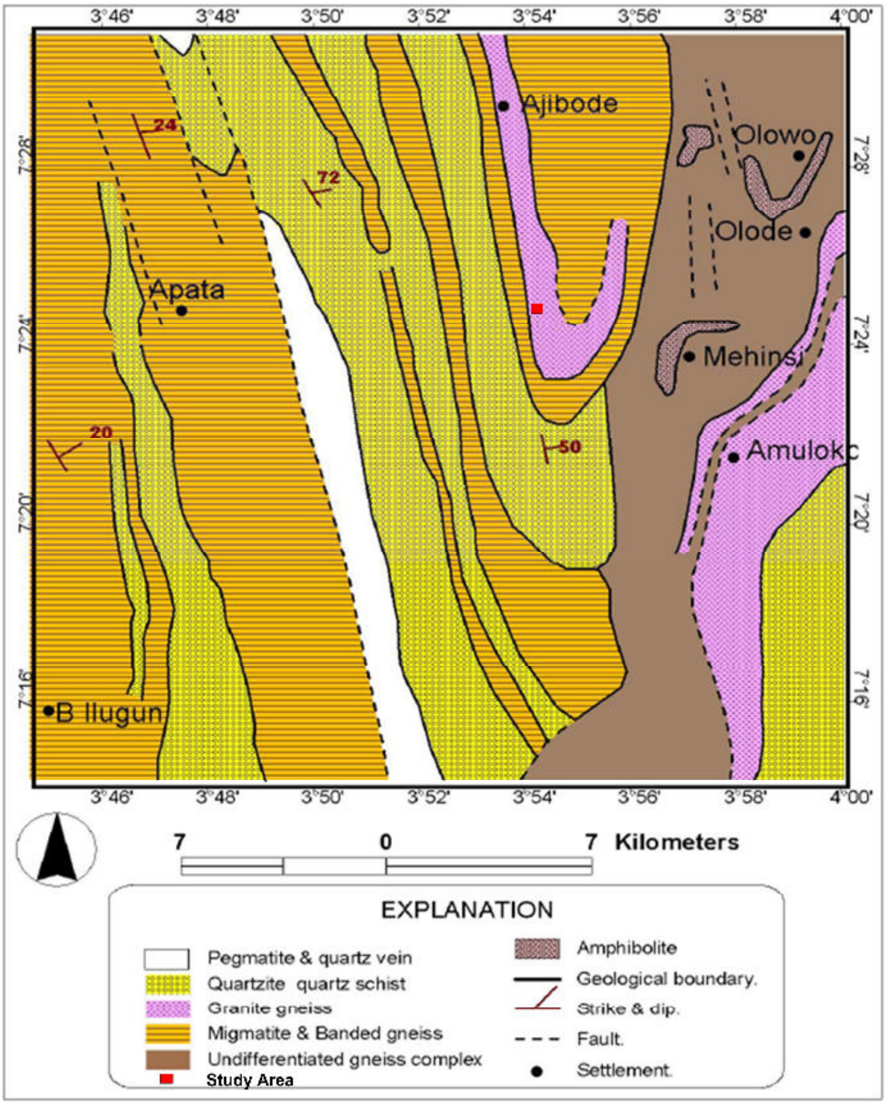

Figure 3: Geological Map of Ibadan Showing the Study Area (after Okunlola *et al*., 2009).

The area occupies an area of about 0.21 km^2 and drained by River Ogunpa, which traverses the area in approximately north-south direction (Figure 2). The river constitutes major transport mechanism for the wastes downstream. The study area is characterized by a gently undulating relief with elevation ranging between 185 m and 202 m.

2. Methodology

The geophysical surveys were carried out using dipole-dipole profiling and Vertical Electrical Sounding (VES). The layout of the data points and traverses are as shown in Figure 2. The dipole-dipole survey was carried out along five traverses using electrode separation of 5 m, with sampling level or expansion factor n ranging from 1 to 5. The data were processed by the use of DIPPROwin software and presented as 2D goelectric structures (pseudo-sections).

A total of 29 VES points were occupied and the selection of VES points was based on the results obtained from Dipole-Dipole. Schlumberger configuration was employed for the electrical sounding, utilizing current electrode separation varied between 1 m and 130 m. The VES data were manually curve matched and inverted geoelectric parameters obtained subjected to computer iteration using Winresist software.

Iterated geoelectric parameters obtained were also used to generate geoelectric sections along the traverses. The results of the VES and dipole-dipole enabled the mapping of leachate plumes from the dumpsite that has infiltrated the subsurface across the traverses.

A total of nine (9) hand-dug wells were selected for the hydrochemical analysis. Water samples from the nine wells and Ogunpa River within the study area were collected and chemical analysis were conducted on the samples.. The quality of the ambient groundwater was evaluated by comparing the concentration levels of the measured parameters obtained with the recommended standards of the World Health Organisation (WHO, 2004) and Standard Organisation of Nigeria (SON, 2007). A control well (well 12) sited on a topographic high and remote from the dumpsite served as a control well in the area.

3. Results and Discussion

Figures 4 shows the 2-D dipole-dipole resistivity structures along the five traverses in the study area. The models depict the apparent image of both the lateral and vertical variation of the resistivity beneath the traverses as a means of establishing the subsurface geology and delineating the media contamination from leachates from the dumpsite. Generally, the 2-D Dipole-Dipole resistivity models beneath traverse 1-5 depict that the subsurface is characterized by four main regions; zones with anomalous low resistivity coloured in blue (2 – 15 Ohm-m), zones with distribution of relatively low resistivity values coloured in green (15-80 Ohm-m), areas with relatively high resistivity values coloured in yellow (100-238 Ohm-m) and areas with high resistivity values coloured in red to purple (800-8128 Ohm-m). The anomalously low resistivity zones in blue are suspected to be due to the leachates from the old dumpsite that has infiltrated the subsurface along bedrock depressions or paths characterized by loose materials at different depths across the traverses.

It was observed that there are two possible other sources of leachate infiltration along the rivers, especially at the upper end of the dumpsite where materials are being deposited into the Ogunpa River and possible degraded hydrocarbon products from the mechanic workshop, as depicted by low resistivity to the east of Traverse 1 at the upper section of the active dumpsite in Figure 4a. Other possible source is to the east of traverse 4 along a tributary of Ogunpa River, where low resistivity values are observed at shallow and intermediate levels within the reclaimed area (Figure 4d). Along traverse 5 (Figure 4e), situated NW of the active dumpsite, absence of low resistivity zones shows that migration of leachates is topographically controlled and confined down the slope in the area. There is also evidence that the leachate flow is structurally controlled by bedrock highs and depressions, which can influence the concentration of plumes in the aquifer system in the whole area.

From quantitative interpretation of the geo-electric parameters obtained from the vertical electrical soundings, five curve types including A-, H-, KH-, HA-, HK-, KHA-, and HKH-type were identified in the area. The H-type curve type dominates, while the HK-type is the list occurring around the locality of the dumpsite (Table 1). The underlying geo-electrical layers or units were interpreted to form three to five subsurface geologic sequence (topsoil, plume infected layer, clayey/highly weathered layer, weathered/aquiferous layer, and partly weathered/fracture/ fresh bedrock).

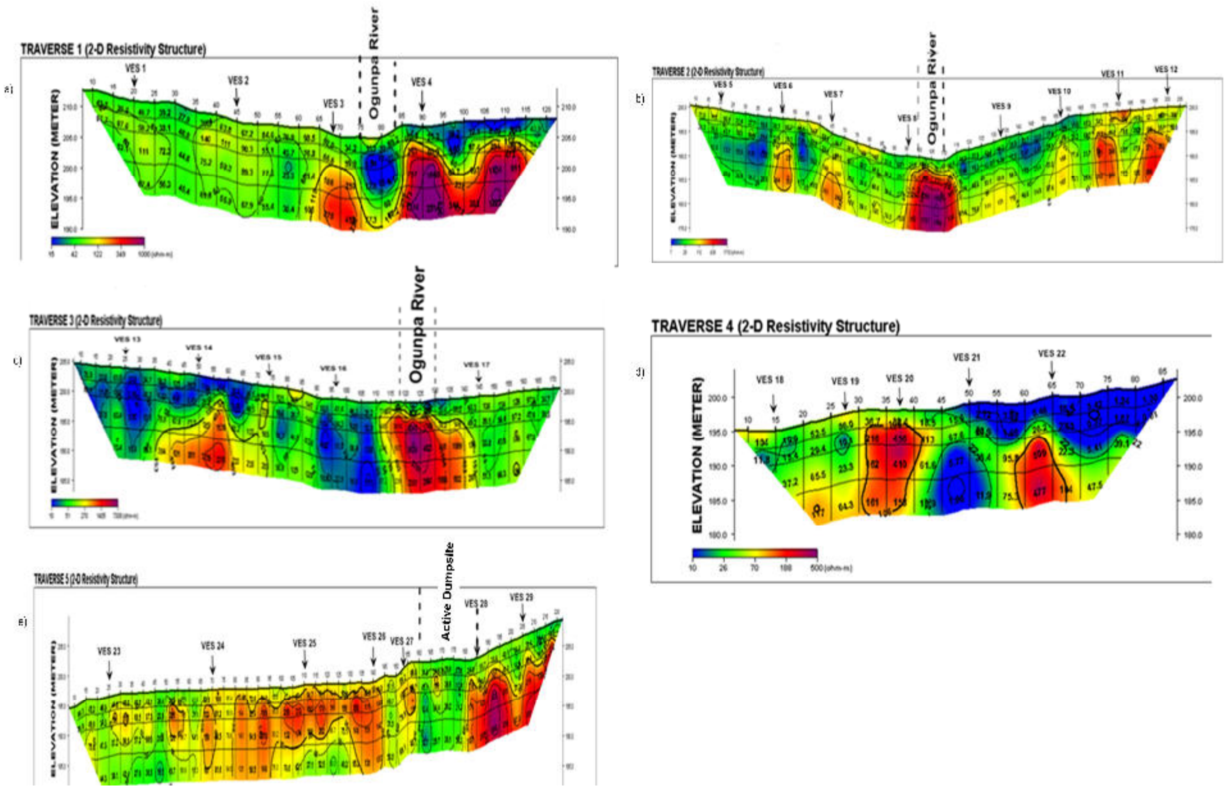

Figure 4: 2D Electrical imaging of the subsurface along Traverses 1 to 5.

Table 1: Geo-electrical characteristic of the study area.

Field Curve	Layer resistivity (ohm-m)					Layer Thickness (m)			
	Topsoil	1st substratum	2nd substratum	Weathered /Aquiferous layer	Bedrock	Topsoil	1st substratum	2nd substratum	Weathered /Aquiferous layer
Group I A-type [VES- 11, 12, 20]	52, 41, 31			78, 63, 57,	∞, 316, ∞,	1.9, 1.1, 1.5			12.4, 5.8, 7.6
Group II H-type [VES-2, 4, 6, 8, 9, 14, 15, 16, 17, 22, 23]	100, 153, 154, 133, 190, 144, 225, 239, 146, 229, 83			65, 15, 47, 24, 29, 13, 51, 24, 64, 15, 59	2800, 245, 150, 526, ∞, 963, 410, 442, 334, 630, 86	1.4, 1.0, 0.9, 2.0, 1.0, 1.5, 1.9, 2.2, 0.7, 0.9, 0.7			19, 3.5, 3.9, 4.4, 10.3, 6.6, 11.3, 11.6, 11.8, 13.5, 5.1
Group III HA-type [VES-1, 21, 4]	60, 47, 54	*16, 3, 14		55, 53, 60	146, ∞, 98	0.7, 0.5, 0.4	0.4, 0.7, 1.4		4.3, 16.8, 1.3
Group IV HA-type [VES-1,5, 21, 24, 4]	77, 194		50, 64	560, 109	∞, 4401	1.3, 0.5		8.4, 0.7	7.8, 46.3
Lithological Characteristic	Clayey	*Plume infected/ †Clayey soil	Clayey /highly weathered layer	Weathered/Aquifer	Partly weathered / fractured /fresh bedrock,				

Table 1 Cont'.

Field Curve	Layer resistivity (ohm-m)					Layer Thickness (m)			
	Topsoil	1st substratum	2nd substratum	Weathered /Aquiferous layer	Bedrock	Topsoil	1st substratum	2nd substratum	Weathered /Aquiferous layer
Group V HK-type [VES- 10]	66	*15		643	97	1.0	2.3		4.5
Group VI KH-type [VES- 29]	100	*12		1014	130	0.5	1.0		1.7
Group VII KH-type [VES- 3, 7, 13, 19,]	30, 53, 57, 6		54, 387, 486, 284	38, 13, 14, 33	231, 244, ∞, ∞	0.7, 0.7, 0.4, 0.5		1.3, 0.2, 0.9, 0.4	15.6, 2.4, 5.5, 14.4
Group VIII HKH-type [VES- 18]	55,	*14,	79,	15,	∞,	0.7	0.2	3.6	17.6
Group IX HKH-type [VES- 25, 26, 27]	119, 127, 68,	†39, 89, 54	242, 133, 115,	69, 65, 61	1560, 1142, 272	0.5, 0.8, 0.7	1.7, 1.3, 1.5	4.6, 3.5, 2.0	26.6, 21.0, 21.9
Lithological Characteristic	Clayey	*Plume infected/ †Clayey soil	Clayey /highly weathered layer	Weathered/Aquifer	Partly weathered/ fractured /fresh bedrock,				

Figure 5 shows the geo-electric sections along the traverses; four in the W-E direction and one in the SW-NE direction. It was observed from the resistivity sections, that there is possible downward movement of effluent from the dumpsite into the weathered layer resulting into lowering of resistivity (3-16 Ohm-m) in the first substratum (second layer) of the overburden across the traverses. This imparted zones fall within topographic depressions, especially along traverses 2 and 4 within the reclaimed section of the study area, thereby suggesting a possible topographically controlled migration of the leachates. Along these sections, it was discovered that presence of thick clayey overburden could serve as natural barriers, which might prevents further leachate migration to the unaffected zones within some parts of the study area. Downward migration of leachate can negatively impact on the fractured basement aquifer when unconfined, except in a situation where the overburden is thick enough and protective.

In Figure 5e, along Traverse 5 designed as a control traverse to the western flank of the active dumpsite on the topographic high in approximately (SW-NE) direction, the geo-electric section indicates that the basement is generally shallow, but deepens relatively towards the southern part of the study area. The weathered layer beneath VES 28 and 29 shows evidence of leachate impartation with resistivity values ranging between 12 and 14 Ohm-m, which is a reflection of the proximity of the VES positions to the active dumpsite.

Figure 6 shows the distribution of the topsoil resistivity over the entire study area, showing values ranging from 30 to 285 Ohm-m. It was observed that local areas of moderate resistivity between 100 ohm-m and 150 Ohm-m were observed to the western, eastern and southern parts of the active dumpsite and right within the reclaimed sections, diagnostic of top soil comprising of sandy clay to clayey sand. However, the map shows that there are isolated areas of low resistivity close to Ogunpa river in the northern part and outside the reclaimed land to the east and south-eastern end of the study area, which could be attributed to either silty topsoil. Figure 7 also, shows that the weathered layer resistivity around the dumpsite are generally low, ranging from 13 to 80 Ohm-m (Table 1), indicating possible long time and recent of impacts of leachate infiltration into the weathered layer or high clayey content in the aquiferous layers within the reclaimed area and around the active dumpsite.

From the laboratory analyses carried out on the nine groundwater samples drawn from wells around the dumpsite for both physical and chemical parameters, a total of twenty four (24) parameters were analysed and their results presented in Table 2. The results show that there is no evidence of pathogens within the samples and the traces of heavy minerals such as lead, copper, cadmium and zinc were completely absent except in the river sample. However, the detected heavy metals in the river sample falls within permissible standard. The table shows that all the analyzed parameter values fall within the WHO (2004) and SON (2007) reference standards for portable drinking water with the exception of the pH parameter values in the samples.

Besides sample 4 from well 5 located up slope of the active dumpsite and the river sample, all other water samples have pH values less than the WHO (2004) and SON (2007) minimum permissible standards, which indicates that these samples are slightly acidic . This is probably due to the waste materials from mechanic workshops and households disposed in the waste dump.

The concentration of the electrical conductivity of the groundwater in the study area is noted to be anomalously high in areas around the dumpsite relative to other areas away from the dumpsite. This scenario is also reflected from the concentration of the total dissolved solids (TDS). The concentrations of the anions (Cl^-, $S0_4^{2-}$, $N0_3^-$) have been observed to build up within the vicinity of the dumpsite and increase down slope towards the eastern part of the dumpsite. Meanwhile other areas outside the dumpsite reflect low concentration of the anions with increasing distance away from it. This indicates that there is possible impact of dumpsite on the groundwater and such impact are aided by gravity to infiltrate areas down slope of the dumpsite within the study area. The mere presence of phosphates and nitrates within the groundwater are probably due to the biological wastes from the dumpsite (Ehirim *et al.*, 2009).

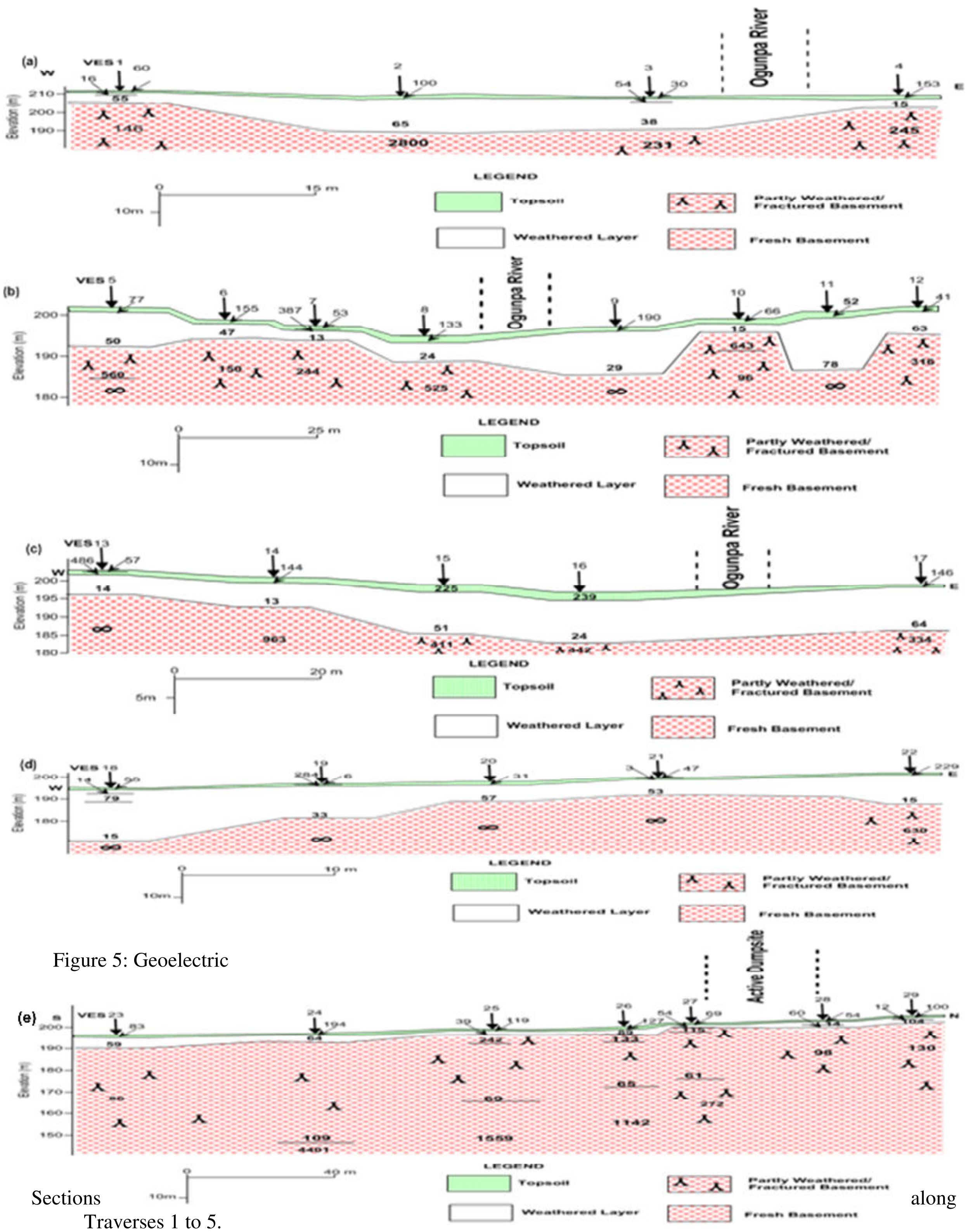

Figure 5: Geoelectric Sections along Traverses 1 to 5.

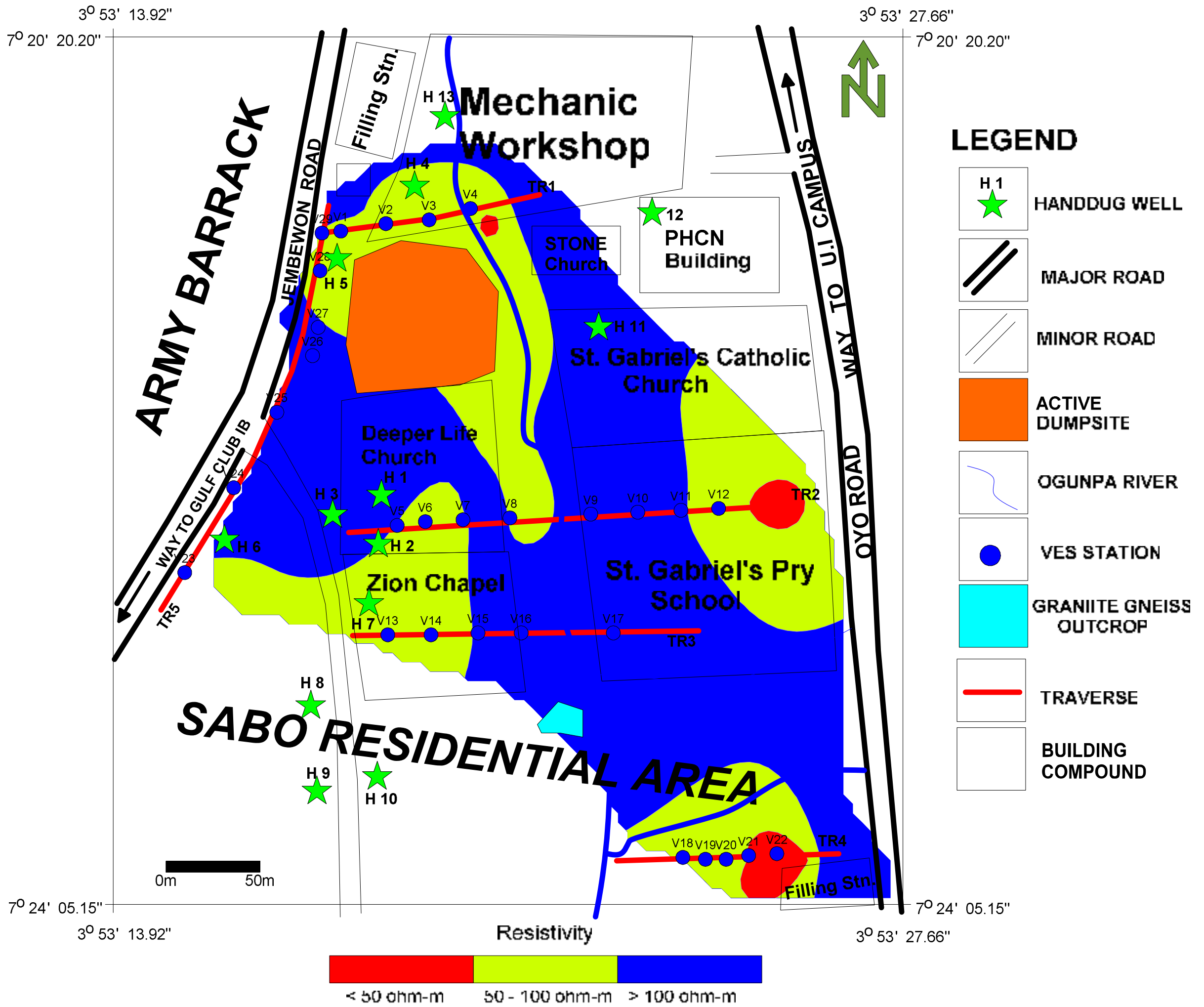

Figure 6: Resistivity distribution map of the topsoil within the study area.

Samples from wells close and down slope of the dumpsite show the highest concentration in contrast to samples away from it. The concentration of iron is high from samples close to the active dumpsite with highest value of 0.2 mg/L in sample 7 from well 11 located down slope of the active dumpsite. Samples at distance from dumpsite show a uniform value of 0.01 mg/L, whereas sample 8 from well 12 (control well), located away out of both the active dumpsite and reclaimed area, show no evidence of iron content. Notably, water samples from hand-dug wells 5 and 11 located close and down slope to the active dumpsite respectively show anomalous concentrations of these analysed parameters and there is possible indication that they are reflections of the direct impact of the dumpsite within areas where they are situated. Generally, there is an increase in concentration of the analysed parameters of the water samples with decreasing distance away from the dumpsite, but major evidence of pollution is not revealed as the analysed parameters fall within the WHO (2004) reference standard.

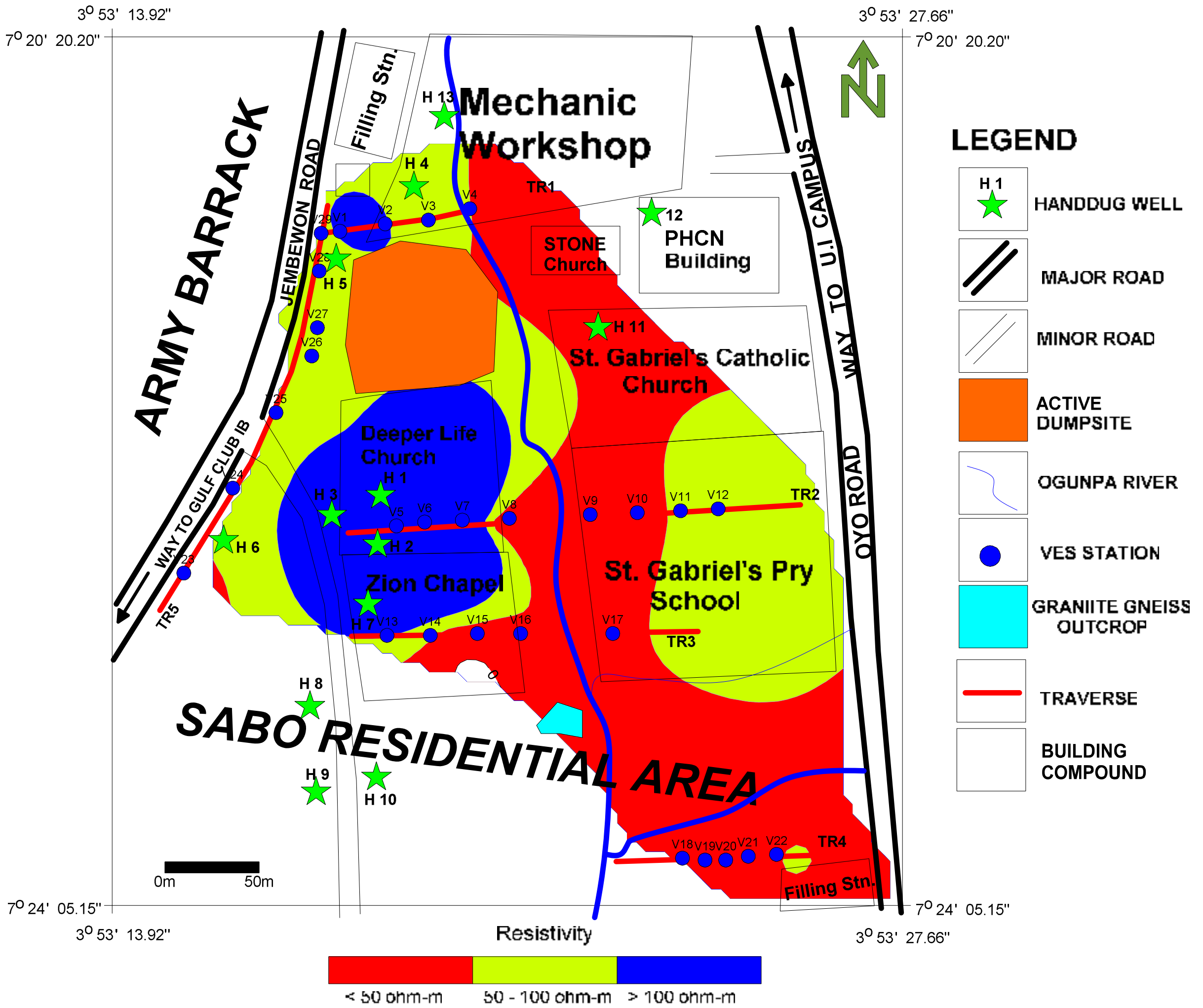

Figure 7: Resistivity distribution map of the weathered layer within the study area.

Figures 8 shows the integration of the results of the dipole-dipole profiling and vertical electrical soundings showing good correlation in the delineation of the suspected saturation of the contamination plumes from the active dumpsite and the reclaimed land. The interpretation of the geo-electric sections along the five traverses shows that the subsurface media underlying the dumpsites are characterized by relatively low resistivity values which range between 3 and 153 Ohm-m for the topsoil and 13 and 242 for the weathered layer. It was suspected that the topsoil and weathered layer in the study area have been infiltrated by leachates from both the active dumpsite and reclaimed area characterized by the relatively low resistivity values (< 30 Ohm-m). This is in agreement with the results of the dipole-dipole profiling where zones defined by blue colour band (< 15 Ohm-m) have been inferred to image the leachate saturation across the traverses (Figure 9).

Table 2: Comparison of the Concentration of the Analysed Parameters with the WHO (2004) /SON (2007) Standards.

Parameters	Range	Mean	WHO (2004) / Son (2007) Standard Maximum Permissible Levels
PH	6.1 - 6.6	6.3	6.5 - 8.5
Temperature(^{0}c)	25.20 - 26.20	26.2	-
Conductivity(μ ohms/cm)	150 - 350	189	1000
Turbidity(NTU)	0.01 - 0.05	0.02	0.5/5
Total Solid (mg/L)	30.25 - 45.67	30.84	-
Total Dissolved solid (mg/L)	12.76 - 19.55	16.44	500
Total Suspended Solid(mg/L)	17.41 - 26.12	22	-
Total Alkalinity(mg/L)	22 - 34	29.8	-
Nitrate(mg/L)	4.10 - 6.80	5.3	10/50
Sulphate (mg/L)	5.30 - 9.56	7.1	200/100
Chloride(mg/L)	19.53 - 24.30	21.77	250
Total Hardness(mg/L)	20.00 - 38.00	32.1	500
Phosphate(mg/L)	12.50 - 17.00	15.6	10
Total plate count(cfu/ml)	23 - 46	28.7	-
Sodium	11.43 - 13.63	12.4	200
Potassium	12.22 - 17.41	13.4	-
Calcium	8.33 - 14.01	13.3	75
Iron	0.01 - 0.12	0.1	0.3
Magnesium	6.12 - 8.01	6.55	150
Lead	0.001	0.001	1.05
Zinc	1.50	1.50	4.00
Cadmium	0.01	0.01	1.0

Stacked 2D resistivity structures (Figure 9) across traverses 1-4 reveal the lateral disposition of the leachate flow in the north-south direction similar to the pattern of low resistivity values for the aquuferous layer in Figure 7. The leachate flow in the western part of the area along traverse 1 could be traced to that observed on traverse 2. Similarly, the flow pattern of plumes from the western part of traverse 2 could also be traced to the leachates that infiltrated western part of the traverse 3, while the leachate flow on traverse 4 could be traced as well to traverse 3. This suggests a possible eastward migration of the leachate from traverse 1 to 4. However, the geological barriers are suspected to have held the leachate in place and influence the lateral movements of the leachates.

4. Conclusion

Geophysical and hydro chemical investigations have been undertaken within the vicinity of the Jembewon dumpsite located in the Basement Complex area of Ibadan, southwestern Nigeria. The geoelectric sections identified maximum of four subsurface layers; the topsoil, the weathered layer, the partly weathered/fractured basement and the fresh basement. The partly weathered/fractured basement constitutes the major aquifer unit in the area.

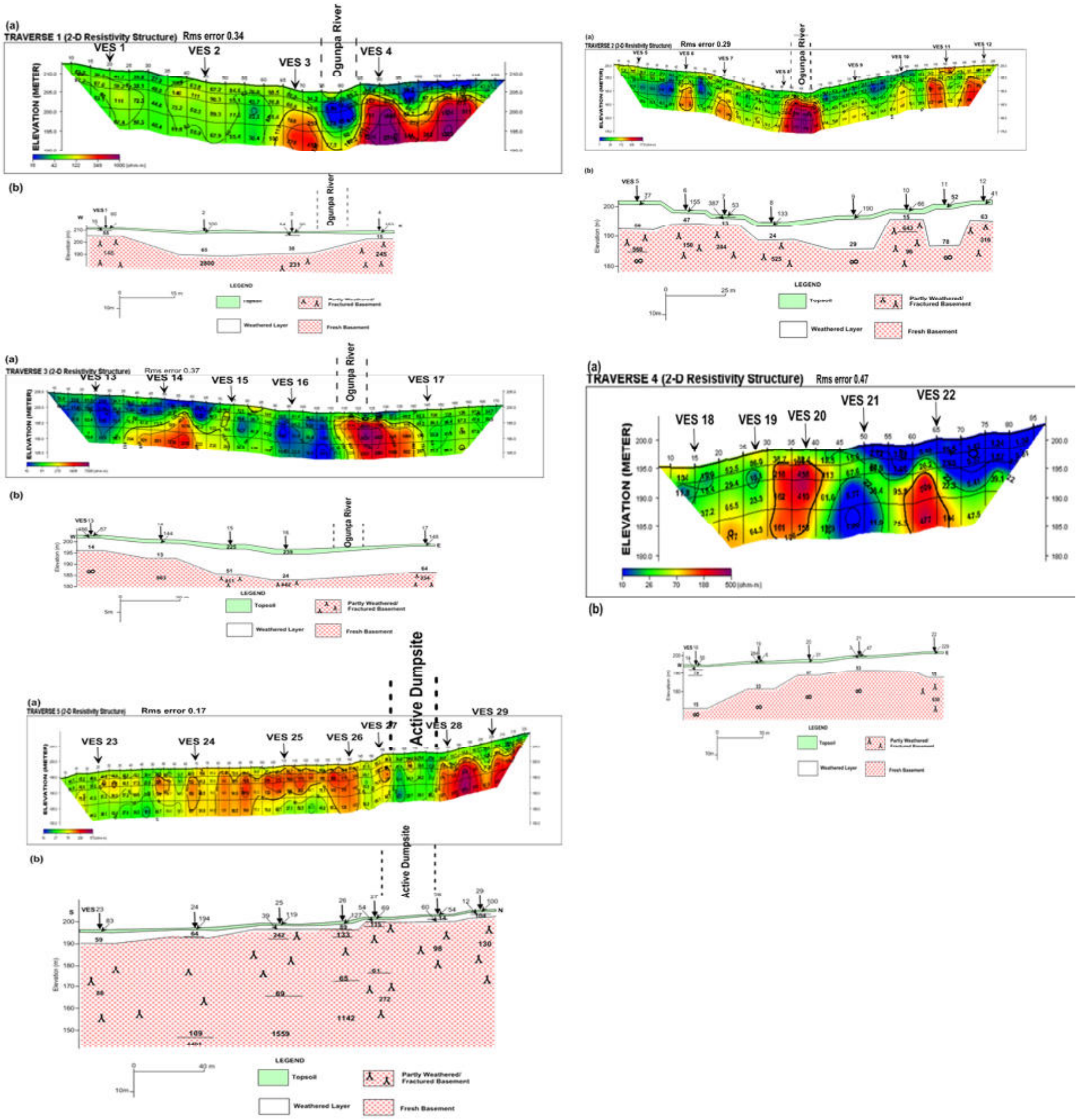

Figure 8: Stacked results of 2-D resistivity structures and geo-electric sections along the traverses.

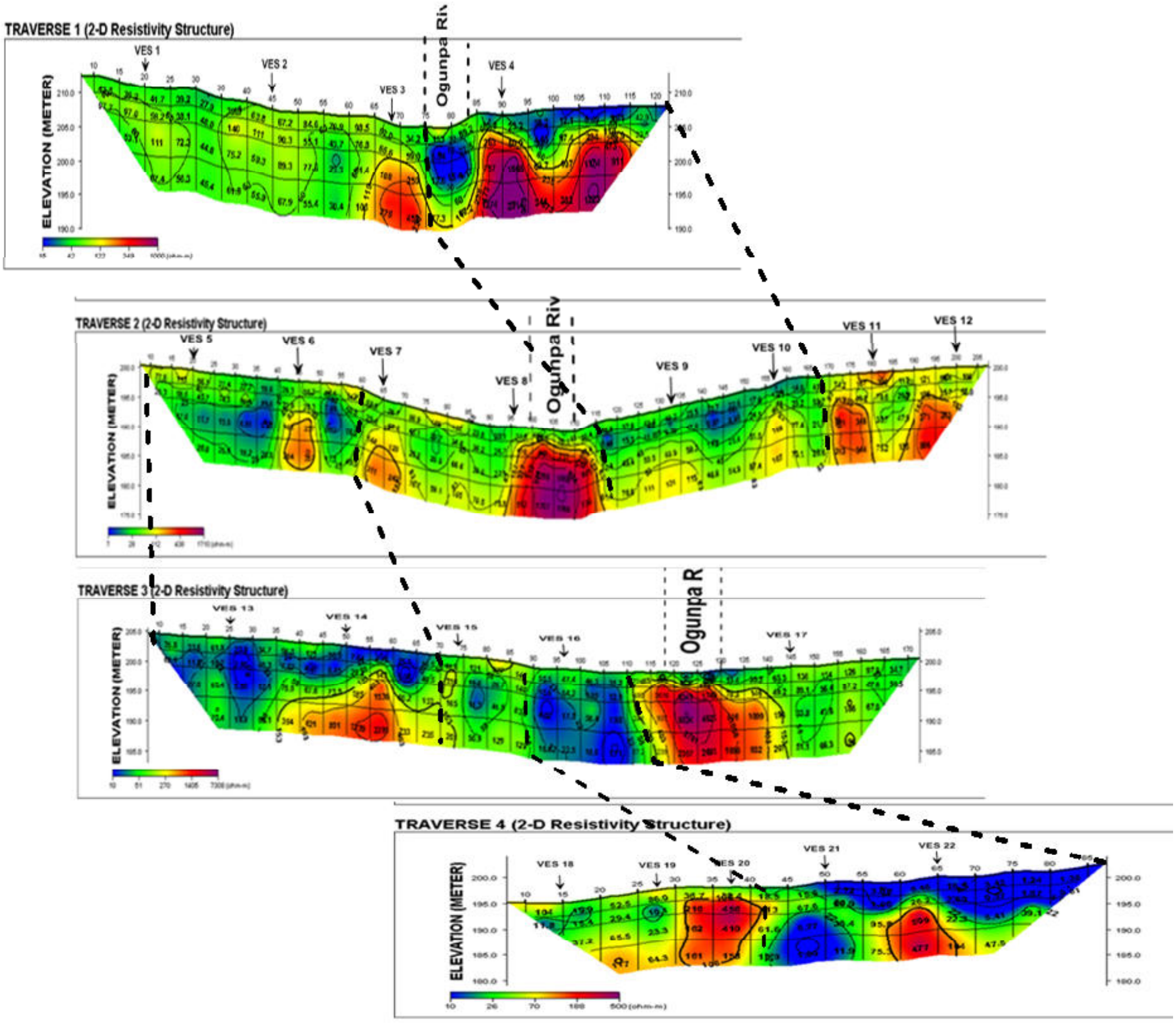

Figure 9: Stacked 2D Dipole Dipole Resistivity Model across Traverses 1-4.

It is suspected that the weathered layer as well as the overlying layers have been imparted by effluent from both the active and reclaimed dumpsites, especially in areas characterised by low resistivity value (< 30 Ohm-m). Similarly, the 2D resistivity structure revealed that the subsurface layers have been contaminated by the leachate from the dumpsite especially in places characterised by typically low resistivity values (<15 Ohm-m). However, the physico-chemical analyses of the water samples generally show that the analysed parameters are within the WHO (2004) and SON (2007) permissible standards despite the fact that the subsurface had been imparted. This scenario could be explained by virtue of the fact that the major aquifer in the study is the partly weathered/ fractured bedrock, while the suspected leachate are held within the weathered layer by the presence of suspected geological barriers as imaged by the resistivity structure. This suspected geological barrier is considered to be responsible for the safety of the aquifer preventing further migration of the suspected leachate plume in both lateral and vertical directions. It is therefore concluded that the scenerios presented by the geophysical interpretations and the hydrochemical analysis can be attributed to the long time impacts on the geology of the area from effluents from the reclaimed and active dumsites, which informs the safety of the available wells of the area from the direct impacts of leachates into groundwater system in the area. However, it might not be a matter of long time before the aquifer sytsem in the study area will be subjected to serious effects of migrating effluents into the aquifer through loose overburden materials and flow paths along the topographic depressions. There is a need to relocate the active dumpsite from residential area and prevent dumping of houshold wastes along the river channles in the area in order to prevent future occurnce of health hazards that might be related to the contimantion of groundwater.

References

Alile, O.M., Ojuh, D.O., Iyoha, A., and Egereonu, J.C. (2011). Geoelectrical investigation and hydrochemical analysis of groundwater in a waste dump environment, Isolo, Lagos. *African Journal of Environmental*

Science and Technology Vol. 5, No. 10, pp. 795-806.

Awoniyi O. O., (2013). Application of geophysical investigation to evaluate the impact of a dumpsite on groundwater: Case Study of Awotan-Apete, Ibadan. Un-published MTech Thesis, Federal University of Technology, Akure.

Badmus B. S., Odewande, A. A., Ayolabi, E. A. and Ayodele T. (2009). Experimental investigation of leachate contamination of groundwater exploration in Basement Complex Area. *Journal of Natural Sciences and Engineering Technology*, 8(1):11-15.

Bayode S., Olorunfemi, M. O., and Ojo, J. S. (2011). Geoelectric mapping of some ancient dumpsites and the associated pollution plume in Akure metropolis, southwestern Nigeria. *Pacific Journal of Science and Technology*. Vol. 13, No. 1, pp 700 -713.

Dada, S.S. (2006): Proterozoic evolution of Nigeria. In: Oshi O (ed), The basement complex of Nigeria and its mineral resources. Akin Jinad & Co., Ibadan. pp 29-44.

Dauda, M., and Osita, O.O., (2003). Solid waste management and reuse in Maiduguri, Nigeria.29th WEDC International Conference towards the Millennium Development Goal, Abuja. pp 20 - 23.

Ehirim, C.N., J.O. Ebeniro, and O.P. Olanegan. (2009). "A Geophysical Investigation of Solid Waste Landfill Using 2-D Resistivity Imaging and Vertical Electrical Sounding Methods in Port Harcourt Municipality, Rivers State, Nigeria". Pacific Journal of Science and Technology. 10(2):604-613.

Ekeocha, N.E., Ikoro, D.O., and Okonkwo, S.E. (2012). Electrical resistivity investigation of Solid Waste dumpsite at Rumuekpolu in Obio Akpor LGA, Rivers State, Nigeria. *International Journal of Science and Technology*. Vol. 1 No. 11, pp 631-637.

Fasunwon, O.O., Jaiyeola, G.B., and Adesugba, F.F. (2010). Impacts of a dumpsite on the neighborhood of a part of Southwestern, Nigeria. *Research Journal of Agriculture and Biological Sciences*, Vol. 6, No. 3, pp 204-214.

Fourchard l., (2003). Urban Slum Reports: A Case of Ibadan, Nigeria. Case Studies for the Global Report on Human Settlements, Institut Francais de Recherche en Afrique (IFRA), University of Ibadan, Ibadan. pp 1 – 27. Accessed from http://www.ucl.ac.uk/ dpuprojects/Global_Report/pdfs/Ibadan.pdf in May, 2015.

Ikem, A., Osibanjo, O., Sridhar, M.K.C., and Sobande, A. (2002), "Evaluation of Groundwater Quality Characteristic near Two Waste Sites in Ibadan and Lagos, Nigeria", Water, Air and Soil Pollution, Vol. 140, pp. 307- 333.

Lawal, O. A., Adegbite, A. A., Oduyiga, O., and Adeyanju A. (2013). Determination and Delineation of Groundwater Pollution from Leachate Generated from dumpsite, Ijagun Community Odogbolu Southwestern Nigeria. *American Academic & Scholarly Research Journal.* Vol. 5, No. 1,

Mathias, M.S., Marques Da silver, M., Ferreira, P., and Ramalho, E. (1994). A Geophysical and hydrological study of aquifer contamination by a landfill. *Journal of Applied Geophysics*. Vol. 32, pp 155 – 162.

Obase, K.O., Olorunfemi, M.O., and Akintorinwa, O.J. (2009). Geophysical and hydro-chemical investigation of the area around a waste dump site in Ile-Ife, Southwestern Nigeria. *Global Journal of Geological Sciences*, Vol. 7, No. 1, pp 47-54.

Ojo, J.S., Olorunfemi, M.O., Aduwo, I.A., Bayode, S., Akintorinwa, O.J., Omosuyi, G.O. and Akinluyi, F.O. (2014). Assessment of surface and groundwater quality of the Akure Metropolis, Southwestern Nigeria. *Journal of Environment and Earth Science*. Vol. 4, No. 23, pp 150-168.

Okunlola A.O., Adeigbe O.C., and Oluwatoke O.O. (2009). Compositional and petrogenetic features of schistose rocks of Ibadan area, southwestern Nigeria. *Earth Science Research Journal*. Vol. 13, No. 2, pp 29-43.

Oluwafemi, O. (2012). The role of geophysics in the investigation of waste disposal site in Ikare-Akoko area, southwestern Nigeria. International Journal of Science and Emerging Technology. Vol. 4, No. 5.

Slomczynska, B., and Slomczynski, T. (2004). Physicochemical and toxicological characteristics of leachates from MSW landfills. *Polish Journal of Environmental Studies*, Vol. 13, No. 6, pp 627- 637.

Standards Organization of Nigeria (SON, 2007). Guideline for drinking water quality, "Nigeria Standards for Drinking Water Quality".

World Health Organization (WHO, 1971). United Nation Standard for Solid Waste Disposal, World Health Organization Report on the Environmental and Health.

World Health Organization (WHO, 2004). Guideline for drinking water quality. "Lenntech water treatment and air purification". Holding: Rotterdamseweg.

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar