VERTICAL ELECTRICAL RESISTIVITY EVALUATION AT SOLID WASTE DISPOSAL SITE, DUSTENKURA, MINNA, NIGER STATE

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Abstract

Geophysical investigation using the Schlumberger Vertical Electrical Sounding around waste dump in Dusten Kura Gwari area of Minna, Niger State, Northcentral, Nigeria is carried out to map contaminants in the groundwater due to the effect of refuse dump. Soil and water samples within the study area were also analysed for comprehensive study using The Atomic Absorption Spectrophotometer (AAS). The results of interpretation ofVES data show three subsurface layers: the topsoil, weathered layer and the fractured/fresh basement rock. The topsoil resistivity and thickness values range from (22.2-50Ωm) and (1-6m) respectively. VES point 5 in profile A and VES points 5 and 7 in profile B are more prone to contamination, thus groundwater at these points is not fit for consumption. The Physico-chemical parameters of groundwater and soil samples collected within the study area showed higher concentration than those collected at about 200m away from refuse dump, which shows that this higher concentration is as a result of the landfill.
Keywords: Bedrock environment, infiltrate, subsurface, vulnerability

Introduction

Wastes are defined as any material which has no further use to the owner and hence disposed off (Allen, 2001). Solid waste materials are usually disposed without consideration for environmental hazard. This improper disposal consequently constitutes a high risk to groundwater. There are several waste disposal sites within Minna and its environs. All these sites lack both under and top linen to protect migration of leachate in to the groundwater. The decomposed organic matter would generate enough leachate plumes over the years which would infiltrate and pollute the groundwater in the study area (Bayode*et al* 2011). The significance of investigating the vulnerability of the aquifer to the surface pollutants due to the solid waste is eminent to the availability of portable water resources for both present and future uses. Vertical Electrical resistivity sounding is a unique method used in groundwater and landfills investigation (Dahlin and Zhou, 2002; Rosqvist*et al*, 2003. It provides information about vertical changes in subsurface electrical properties and thus useful in determination of hydrogeologic conditions such as the depth to water table, depth to bedrock and thickness of soil(Ehirim and Ofor, 2011).This study involved the use of Vertical Electrical Sounding (VES) and Physio-chemical analysis of groundwater and soil in the vicinity of the site.

Location and Geology of the Area

Dusten Kura Gwari is along Western Bye Pass, Minna. It lies along longitude 6.52^{o}S and latitude 9.63°N. The area extent of the refuse site is about 100 by 75 m^2. The site is bordered at three sides by buildings and the fourth side by access road.

Minna is located between longitude 6.25°E and 6.45°E and latitude 9.24°N and 9.48°N, it occupy the central portion of the Nigerian basement complex. The Minna area comprises of meta - sedimentary and meta-igneous rocks which have undergone polyphase deformation and metamorphism. These rocks have been intruded by granitic rocks of Pan-African age. Five litho-stratigraphic units have been recognized in Minna area (Figure 1). The schist which occur as a flat laying narrow southwest-northeast belt at the central part of Minna with small quartzite ridge parallel to it, the gneiss which occur as a small suites at the northern and southern part of the area forming a contact with the granite. Feld spathicrich pegmatite is bounded to the east, with average width of 65meters and 100 meters long, the pegmatite host tourmaline and the granitic rocks which dominate the rock types in the area and vary in texture andcomposition.

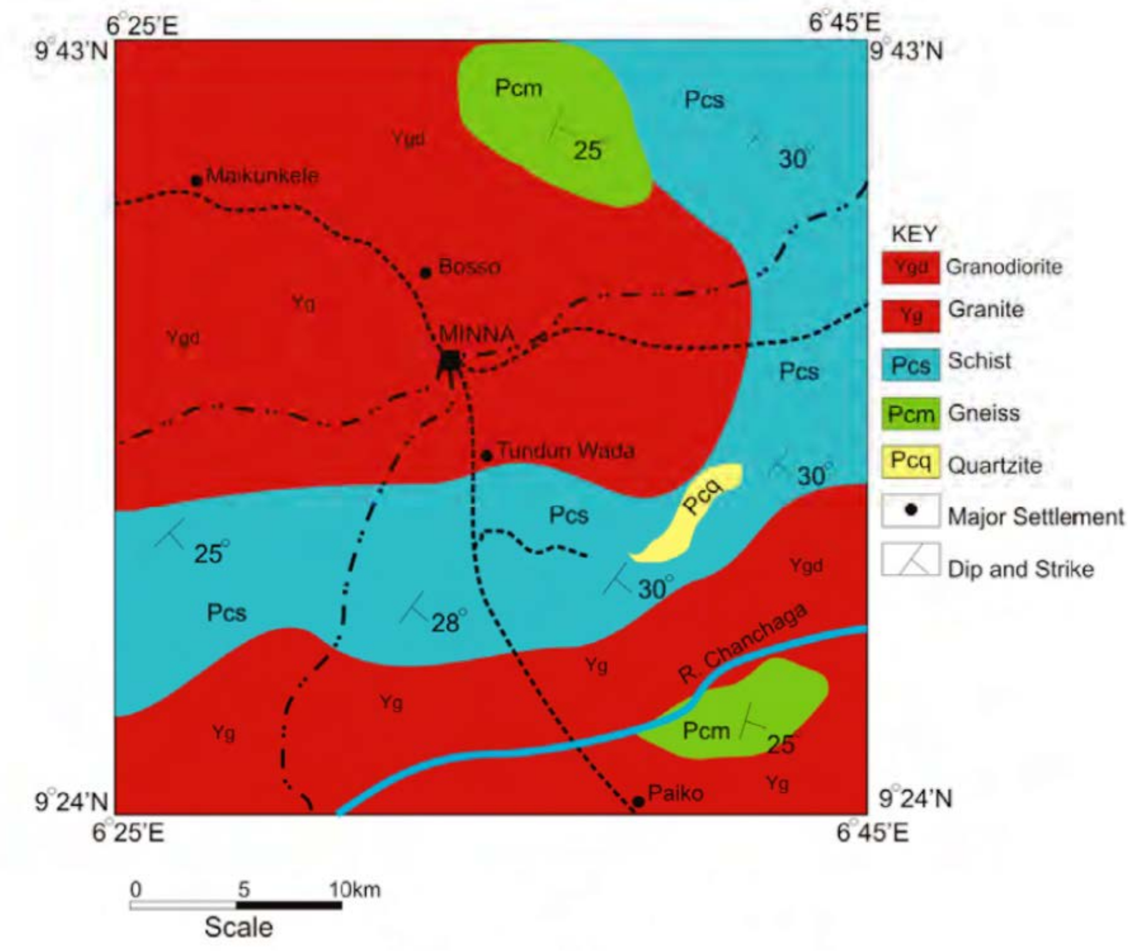


Figure 1. Map showing the geology of Minna (Alabi, 2011)

Methods

An ABEM Terrameter SAS4000 and its accessories were employed to carry out a total of twenty (20) Vertical Electrical Soundings (VES using Schlumberger array with maximum current electrode separation of AB/2 of 80m. Sixteen (16) VES were carried at the edges of refuse disposal site along two profiles and another four (4) at a distance of 200m away from the refuse dump to serve as thecontrol.Three(3) groundwater samples and six (6) soil samples were analysed for physico-chemical analysisThe Atomic Absorption Spectrophotometer (AAS).

Results and Discussion

Figures 2 to 4 show (a) Pseudo cross and (b) Resistivity cross-section of three (3) profiles in the landfill.

Figures 2 to 4 show (a) Pseudo cross and (b) Resistivity cross-section of three (3) profiles in the landfill. Figure 2a shows a low resistivity zone (22.2-50Ωm) for depth of 1-6m. This low apparent resistivity(high conductivity)is attributed to contamination of top soil due to accumulation of leachate (Jegede*et al.*, 2011, Abdullahi*et al*, 2010). The horizontal horizon made up of green, grey, yellow and pink colours is the water bearing zone (Abdullahi*et al*, 2010). The low apparent resistivity at VES 3 is an indication of downward migration of leachate from top layer. The resistivity of third layer of most of the VES point are >1000Ωm and drop to between 6.38-20.8Ωm is an indication of fractured and saturation, which make the leachate from top soil to migrate into groundwater and thereby pollute it. Fig 2b showed three (3) to four (4) geo-electric sections. The curve types for VES points 1, 5 and 7 consist of AK; VES points 2, 6 and 8 are A type and VES points 3 and 4 and consist of K type. The lower resistivity between 24.1 to 40.2 Ωm could be attributed to presence of contamination (Ehirim and Ofor, 2011).The thickness of this layer is between 0.5 to 5.94 m.Lower resistivities below the high resistivity zones could be water saturated gravel or some finer grained, more clay rich material or leachate accumulation (Rana *et.al.* 2009 and Abdullahi*et al*, 2010). The presence of 4.5m thick horizontal impermeable(clay) layer above an aquifer can limit the danger ofcontamination of the aquifer (Fejes and Josa, 1990, Egwebe, 2003).Therefore, the clay of thicknesses,5.54 (VES 2) and 6.25 m (VES 4) above the aquifer in waste site is capable of protecting theaquifer from contamination because of its impervious nature.However, VES 3, 4, 6 and 8 points are likelyto be contaminatedas a result of fractured noticed in VES 3 and 4 which is caused by sharp drop in the resistivity to less 1000Ωm (Olayinka and Olorunfemi, 1992).

Figures 3a and 3b show the pseudo cross sections and resistivity cross sections for VES points 1-8 along Profile B at Dusten Kura refuse dump. Figure 3a shows a low resistivity zone (24.2-50 Ωm) for depth spacing of (1 m to more 6 m). This low apparent resistivity is attributed to contamination of top soil due to accumulation of leachate (Jegede*et al.*, 2011, Matias, 1994). The low apparent resistivity at VES Points 3 and 4 at a depth of above 11 m is an indication of downward migration of leachate from top layer. The resistivity of third layer of most of the VES points are >1000 Ωm and drop to between 6.74-39.2 Ωm is an indication of fractured and saturation, which makes the leachate from top soil to migrate into groundwater and thereby pollute the groundwater (Olayinka and Olorunfemi, 1992). The horizontal horizon made up of green, grey, yellow and pink colours is the water bearing zone (Abdullahi*et al*, 2010). Fig 3b showed three (3) to four (4) geo-electric sections. The curve types for VES points 1, 5 and 7 consist of AK; VES curves 2, 6 and 8 are A type and VES curves 3 and 4 consist of K type. Areas where high resistivity occurs may be interpreted asareas where impermeable fill material was disposed as impermeability gives high resistivity values (Aweto, 2012). The relatively high resistivity values detected at the site can also be ascribed to theweathering of the waste material and the outgoing percolate due to the lack of animpermeable bottom membrane. On the other hand, areas where low resistivity(high conductivity) values exist may be interpreted as areas where metallic materialswere disposed. The clays of the second layer play a vital role of confining beds around VES 1, 2, 5 and 7 and also protect the aquifer under them from being contaminated by surface and nearsurface contaminants. (Aweto, 2012).

Figure 4a shows a low resistivity zone (135-268Ωm) for depth spacing of (1-8.9m). This apparent resistivity values show presence of sandy soil on the surface which is free from contamination (Ehirim and Ofor, 2011). The horizontal horizon made up of blue, green, grey, yellow and pink colours is the water bearing zone (Abdullahi *et al.* 2010). The low apparent resistivity observed at third and fourth layers indicate water bearing zones. Fig 4b showed three to four geo electric sections of H for all VES points. Most of part of this area comprise of good quality water since the area is majorly dominated by H type curve (Selvam and Sivasubramanian, 2012).The groundwater here is free from contamination. The basement rocks are competent (resistivity exceeds1000Ωm (Olayinka and Olorunfemi, 1992).

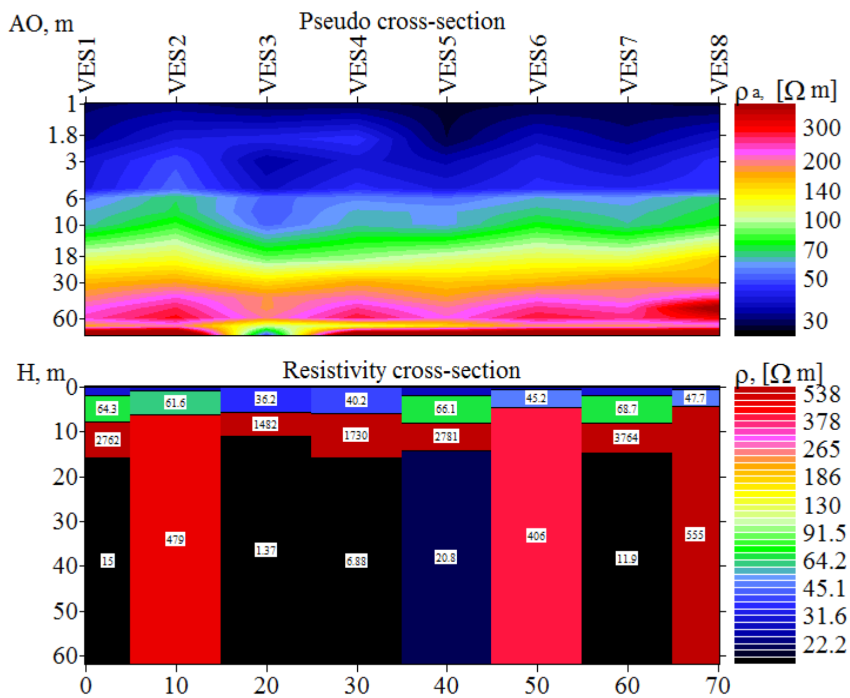


Fig.2 (a) Pseudo cross-section and (b) Resistivity cross-section of VES 1-8 along profile A Dusten Kura Refuse dump.

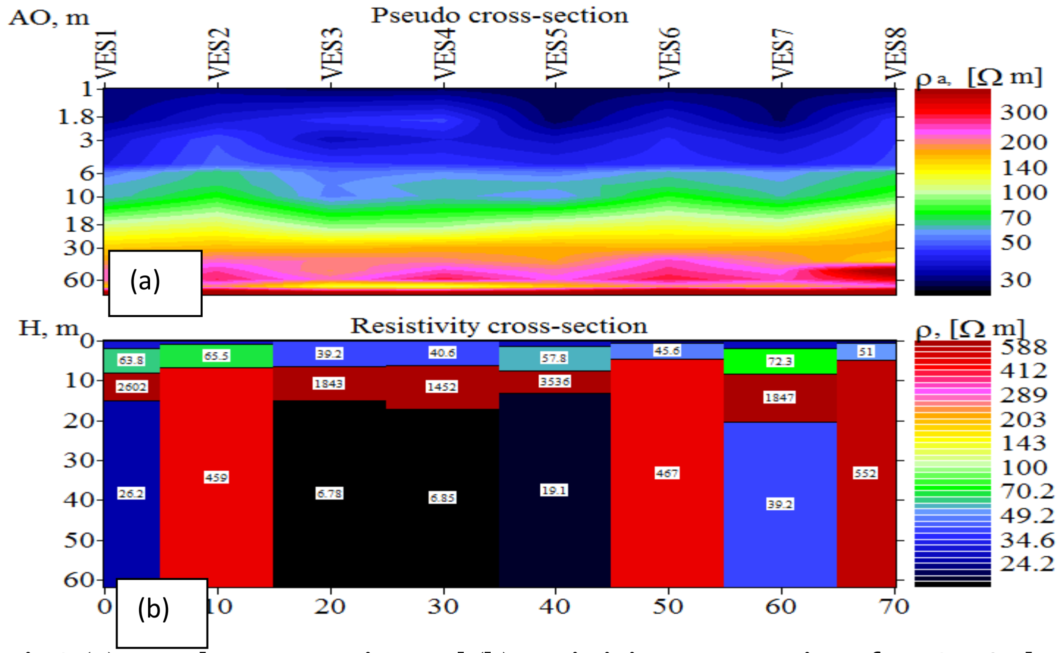
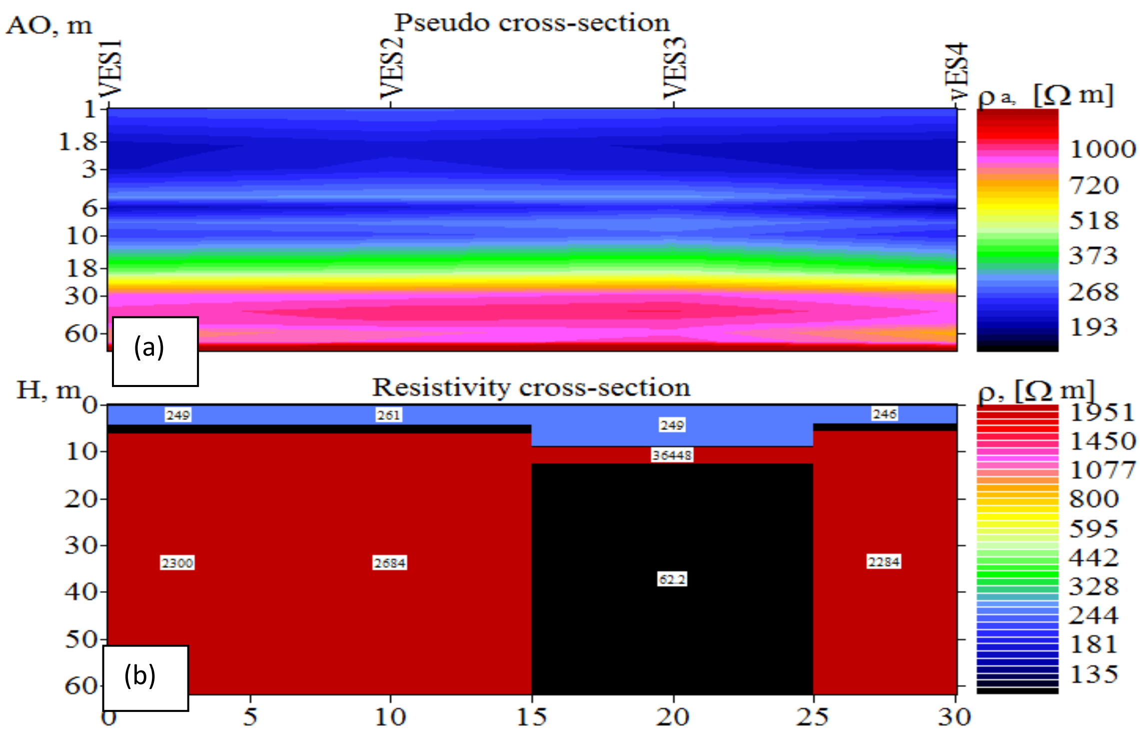


Fig.3 (a) Pseudo cross-section and (b) Resistivity cross-section of VES 1-8 along profile B Dusten Kura Refuse dump.



Figures 4a and 4b show the pseudo cross sections and resistivity cross sections for VES points 1-4 outside the refuse dump about 200m away from Dusten Kura refuse dump .

Table 1: Physio-Chemical Analysis of Hand Dug Wells in Dutsen Kura Gwari refuse dump

Parameter	Unit	Well A	Well B	Well C	Control Well	WHO
Temp	^{O}C	22.8	22.7	22.7	32.7	35-40
pH		7.44	7.83	7.69	7.9	6.5-9.2
Conductivity	µS/cm	726	752	762	78	100
Alkalinity	mg/l	450	750	300	75	200
Acidity	mg/l	41	49	32	50	NA
TDS	mg/l	1200	1900	1710	376	500-550
Total Hardness	mg/l	48	42	47	38	500
Zinc	mg/l	0.0720	0.08483	0.07198	0.0024	3.0
Lead	mg/l	0.7300	0.9361	0.7950	0.0000	0.001
Manganese	mg/l	0.2286	0.15714	0.22857	0.0014	0.5
Iron	mg/l	1.000	0.63878	0.6475	0.7060	0.3
Copper	mg/l	0.5000	0.25000	0.30000	0.0000	2.0
Chromium	mg/l	0.4167	0.7048	0.6567	0.0000	0.05
Nitrogen	mg/l	0.1000	0.2800	0.20000	0.0000	NA
Cobalt	mg/l	0.0286	0.02857	0.00000	0.0000	NA
Cadmium	mg/l	0.0667	0.0606	0.03636	0.0001	0.003

The temperature for the groundwater in the study area ranged between 22.7 ^{O}C and 22.80^{O}C which is below (WHO 2004) limits and the control well has a temperature of 32.3 ^{O}C. The Groundwater pH value for Dusten Kura Gwari well averaged 7.66, while pH value for control well is 7.9. The pH values for both wells as well as control well meet the WHO standard. The value of alkalinity for wells A and B exceed WHO limits allowable, while the value for Well C is within allowable limits. The Total Dissolve Solid and Total Hardness are lower than WHO allowable limit. Water in this area is found to be contaminated by Lead, Chromium and Cadmium with level of contamination exceeds WHO (2004) regulated guidelines; this is similar to work of Jegede e*t al*, 2011.

Table 2: Physio-Chemical Analysis of Soil Samples in Dutsen Kura Gwari refuse dump

Location	pH	Zn (mg/Kg)	Pb (mg/Kg)	Mn (mg/Kg)	Fe (mg/Kg)	Cu (mg/Kg)	Cr (mg/Kg)	Ni (mg/Kg)	Co (mg/Kg)	Cd (mg/Kg)
DG1	6.36									
		6.8124	28.8462	25.71430	3.3784	50.00000	166.6670	25.00000	8.5714	0.8563
DG2	6.81									
		4.8843	19.6154	11.4286	3.3124	37.50000	125.0000	15.00000	4.2857	0.4849
DG3	6.73									
		3.5990	19.2308	7.8571	3.0021	25.00000	62.5000	10.00000	2.8571	0.1782
DG4	6.49									
		3.5990	19.2308	7.5725	1.6892	20.00000	41.6667	5.00000	1.4286	0.1157
DG5	6.57									
		2.9563	9.6154	4.8573	1.4396	15.00000	40.4565	3.00000	1.2769	0.6467
DG6	6.14									
		2.9563	9.6154	4.2876	1.3255	12.50000	20.8333	5.0000	1.4286	0.4232
Min	6.14									
		2.9563	9.6154	4.2876	1.3255	12.50000	20.8333	5.0000	1.4286	0.2835
Max	6.81									
		6.8124	28.8462	25.71430	3.3784	50.00000	166.6670	25.00000	8.5714	0.8563
Mean	6.62	4.4917	22.2316	18.3095	4.8380	3.1417	7.30785	1.7500	4.3971	0.4748
S.D	0.17	1.3096	4.8625	3.6426	1.9492	14.4271	39.1063	9.3541	2.4946	0.2886
DGC1	6.02									
		0.0000	1.2467	0.4286	0.0000	0.0000	8.1066	3.0000	0.3030	0.1412
DGC2	6.17									
		1.5990	0.6154	0.2860	0.0682	7.5000	12.8333	4.0000	1.4286	0.1539
DGC3	6.27									
		0.0990	0.1544	0.2857	0.0000	5.0000	0.0000	2.5000	0.0000	0.1368
Min	6.02	0.0000	0.1544	0.2857	0.0000	0.0000	0.0000	2.5000	0.0000	0.1368
Max	6.27	1.5997	1.2467	0.4286	0.0682	7.5000	12.8333	4.0000	1.4286	0.1539
Mean	6.22	0.5660	0.6722	0.3335	0.0227	4.1667	6.9800	3.1667	0.5772	0.1440
S.D	0.05	0.8960	0.5484	0.0824	0.0394	3.8188	6.4904	0.7638	0.7527	0.0272

DG: Dutsen Kura Gwari, DGC: Dutsen Kura Gwari Control

Table: 2 showsthe results of parameters measured for soil samples inside the dump and area free from refuse dump. The concentrations of the parameters are higher at the centre of the refuse dump and decrease significantly as the distance decrease down the slope. This concentration is not noticed at the area free from the refuse dump. Minimum, maximum, mean and standard deviations of the concentration were calculated using Statistical Package for Social Scientists.

Conclusions

Interpretation of geo-electric soundings of refuse dump to other location free of dump yielded information on groundwater contamination as shown by the measured values of refuse dump resistivity, curve types and physico-chemical parameters of water samples and soil samples. Conclusively, waste disposal has affected the groundwater quality in the study area leading to contaminations. A combination of Vertical Electrical Soundings and Physico-chemical analysis of groundwater samples and soil samples in the vicinity of refuse dump is a vital and useful tool for investigating groundwater contamination at landfill as well as examining shallow complex subsurface structure.

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