INVESTIGATION OF SOLID WASTE DISPOSAL SITE AND ITS RELATIONSHIPS WITH GROUNDWATER IN ANGWAN JUKPA, MINNA, NIGER STATE, NIGERIA

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Abstract
The possibility of groundwater pollution in and around municipal waste in Angwan Jukpa, Bosso, Minna, Niger state, North central Nigeria was carried using Schlumberger array of Vertical Electrical Sound integrated with Physico-chemical analysis of well water and soil within the vicinity of the site. The VES data were interpreted with the aid of computer programme called WINRESIST. The result of the interpreted curves delineated three to five layers. The area with low resistivity values were delineated as contaminated zone. The result of the physico-chemical analysis of well water and soil shows elevation in some of the parameters analysed.

Keyword: Schlumberger, Winresist, Landfills, Intrusion, Contaminant,

Introduction

Landfills are a common way of disposing waste. In recent years there has been a growing concern, and some passionate discussions, about the effect of landfills on public health(Matias *et al*., 1993).In fact, they can cause atmospheric pollution, fire, and contamination of local aquifers(Meju,2006). Landfills can seriously affect local wells and drilled holes used for public water supply and, therefore, landfill locations must be planned and monitored carefully and conveniently.
Geophysics has been applied for some time to study saline water intrusions in coastal aquifers (Kaya *et al.,* 2007)and, more recently; it has also been adapted to other water pollution studies (Benson *et al*., 1983). In fact, geophysics provides fast, economic and non-invasive methods to study water contamination, as well as other environmental issues, and it has proved to be as promising and successful as predicted (Ward, 1985)

Although the use of geophysics in the direct detection of contaminants is not clear, geophysics can be used in the investigation of geological environments through which the contaminants move, and in the determination of the distribution of pollutants in space and time through monitoring (Greenhouse *et al*., 1993).
The efficacy of the use of geophysics in environmental problems depend on several parameters, such as the degree of contaminations, depth of burial, geological characteristics of the site, and, thus, inhomogeneity's and lateral variations of earth materials, and, thus, geophysical techniques need to be carefully adapted and developed for this purpose (Osazuwa and Abdullahi 2008).

The Study Area

Angwan Jukpa is one of the communities in Bosso Local area of Minna, the capital of Niger State. It is located at the back of Federal University of Technology, Bosso campus.

Fig. 1: Pictorial of the study area

Geology of the Area

Angwan Jukpa is within the North-Central portion of the Nigerian Basement Complex and the area consists predominantly of coarse-grained biotite granite and granodiorite (Kogbe, 1976). It is surrounded on its Northwest by medium-grained biotite and biotite-hornblende granite, on the North by coarse-grained biotite-muscovite granite and weakly foliated granodiorite, and on the South and Southwest by migmatite-gneiss complex. The granite types and the granodiorite together form part of the older granite (Rahaman, 1988). This portion of the older granite combined with the migmatite-gneiss complex, separates the Kushaka schist belt on the East from the Zungeru-BirninGwari schist belt on the far West. Particular to the area is the granite-gneiss and granitic rocks of different grain sizes, outcropping at different locations within the area, with noticeable fractures and joints. The joints are of two generations depending on their orientations, some trending NNE-SSW and the other NE-SW. In most cases the joints are filled with Quartzo-feldspardic veins, while others are fairly well exposed along the river channel. The values of the joints directions range between 120° and 160°. Foliation was also noticed on some of the outcrops in the area. The outcrops in the area are randomly located at the south eastern parts.

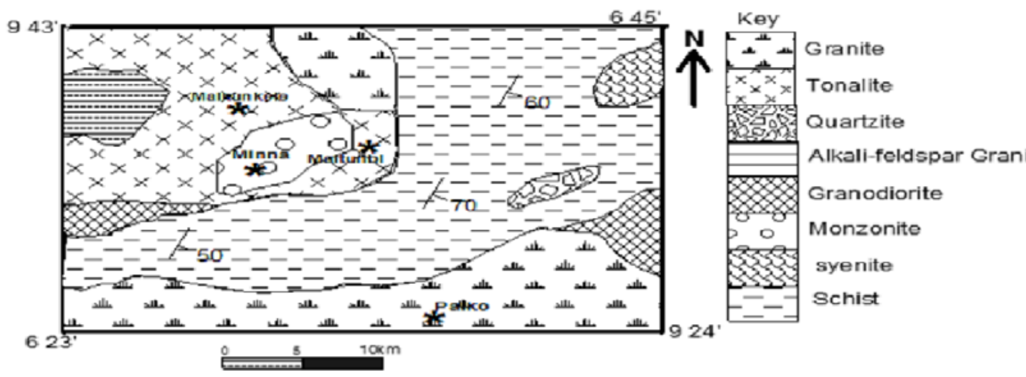

Figure 2: Geological map of Minna Area (Alabi 2011)

Data Collection

This study involves Geophysical survey and collection of water and soil samples within the study area.

Geophysical Survey

Thirty VES were collected at the site, twenty were collected during the dry season along three profile, two of the profiles were drawn inside the waste dump comprising of sixteen (16)VES, eight (8)on each of the profile while four (4) VES points were carriedout at a distance of about 300 metres away from the waste dump to serve as control. Ten(10) VES points were also collected during the wet season, eight(8) on the waste dump and another two at a distance not less than 300 metres away from the waste dump.

Physico-chemical Analysis

Water samples were collected from the existing well within the vicinity of the waste dump and analysed at the department of Water Resources, Aquaculture and Fisheries Technology of Federal University of Technology, Minna, Nigeria,while soil samples collected at six different points from the centre of waste dump at interval of 10 metres were also analysed at the Soil Science Department of Federal University of Technology, Minna, Nigeria

Vertical Electrical Sounding Interpretation

The acquired apparent resistivity data were interpreted using geophysical software known as WINRESIST version 1.0 (1988, 2004). The result from the graph drawn by the software shows the thickness, depth and resistivity. In the graph, the apparent resistivity values (Ohms) were plotted against current electrode spacing (AB/2) (m) by the software. An iteration process was then commenced until a good fit was obtained; there is always a root mean square error value which gives the percentage of error associated with the readings from the field data.

Tables1 to 3 show the VES results from profile A, profile B and the control site during the at the Anguwan Jikpan refuse dump.

Table 1: General VES results from Profile A at Anguwan Jikpan

VES NO	Number of resistivities of layers(Ωm)					Thickness of layers(m)				Depth to bottom layers(m)			
	ρ1	ρ2	ρ3	ρ4	ρ5	t1	t2	t3	t4	d1	d2	d3	d4
1	31.1	259.6	1751.1			0.8	5.5			0.8	6.3		
2	31.2	241.6	1615.4			0.8	5.7			0.8	6.5		
3	31.7	249.6	1574.8			0.8	5.0			0.8	5.9		
4	30.5	266.1	1726.8			0.8	6.2			0.8	7.0		
5	29.3	282.5	2334.4			0.7	5.7			0.7	6.4		
6	27.4	296.3	4411.3			0.6	6.7			0.6	7.3		
7	30.0	247.3	2302.4			0.7	6.1			0.7	6.8		
8	28.9	284.3	3060.4			0.7	7.2			0.7	7.8		

The VES curves in this profile have been delineated to be a three layer model. VES curves 1 to 8 for this profile are A type curves with configuration $\rho_1 < \rho_2 < \rho_3$ = A curve. The resistivity values for the first layer range between 27.4Ωm and 31.7Ωm, while the corresponding thickness range between 0.6m to 0.8m and the corresponding depth also range between 0.6m to 0.8m. The lowest resistivity is at VES6 and the highest at VES3. The resistivity values for the second layer range between 241.6Ωm and 296.3Ωm and correspond to sand which are porous, thus allowing the leachate from the topsoil to percolate the aquifer and may eventually contaminate the underground water. The third layer resistivity values range between 1574.8Ωmand4411.3Ωm. All the VES have cumulative depth that range between 5.9m and7.8m. All the VES points in this profile are shallow as seen in the hand dug wells within the vicinity of the refuse dump. Therefore the underground could be easily polluted (Oladunjoye*et al.*, 2011).

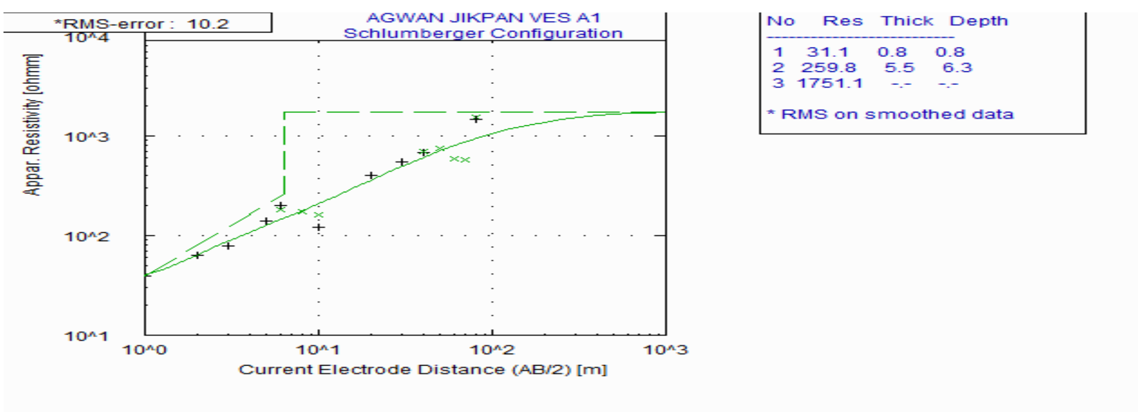

Figure 3Interpretation ofVES1along Profile A at AnguwanJikpan refuse dump at back of FUT Bosso Campus.

Table 2: General VES results from Profile B at AnguwanJikpan

VES NO	Number of resistivities of layers(Ωm)					Thickness of layers(m)				Depth to bottom layers(m)			
	ρ1	ρ2	ρ3	ρ4	ρ5	t1	t2	t3	t4	d1	d2	d3	d4
1	31.7	253.1	1037.1			0.8	5.5			0.8	6.3		
2	30.8	230.3	1638.9			0.8	5.8			0.8	6.6		
3	31.6	255.5	1379.6			0.9	5.5			0.9	5.5		
4	30.5	231.2	1640.2			0.8	5.6			0.8	6.4		
5	30.4	251.1	2376.4			0.7	5.9			0.7	6.6		
6	29.1	264.7	4407.3			0.7	6.8			0.7	7.5		
7	28.9	235.9	1823.8			0.7	6.0			0.7	6.7		
8	28.1	246.9	3517.7			0.6	7.8			0.6	8.5		

The VES curves in this profile also have been delineated to be a three layer model. VES curves 1 to 8 for this profile are A type curves with configuration $\rho_1 < \rho_2 < \rho_3$ = A curve. The resistivity values for the first layer range between 28.1Ωm and 31.7Ωm, while the corresponding thickness range between 0.6m to 0.9m and the corresponding depth also range between 0.7m to 0.9m. The lowest resistivity is at VES8 and the highest at VES1. The resistivity values for the second layer range between 230.3Ωm and 264.7Ωm, these resistivity values are corresponding to sand which is porous and the leachate from the topsoil can percolate the aquifer and may eventually contaminate the underground water. The third layer resistivity values range between 10374.8Ωm and4407.3Ωm. The corresponding thickness and depths of the third layer are at infinite. All the VES have cumulative depth that range between 5.5m and 8.5m respectively. All the VES points in this profile are shallow as seen in the hand dug wells within the vicinity of the refuse dump. This shallowness of the area may likely makes it possible to for the groundwater to be contaminated by the leachate as it take short time for it to percolate into the groundwater

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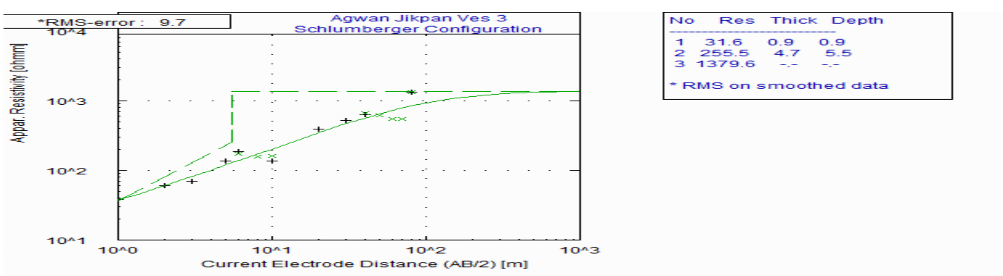

Figure 4: Interpretation ofVES3 along Profile B at Anguwan Jikpan Refuse dump at back of FUT Bosso Campus.

Table 3: General VES results from Control site Anguwan Jikpan

VES NO	Number of resistivities of layers(Ωm)					Thickness of layers(m)				Depth to bottom layers(m)			
	ρ1	ρ2	ρ3	ρ4	ρ5	t1	t2	t3	t4	d1	d2	d3	d4
1	311.5	127.1	298.9	1305.6		0.8	1.9	4.5		0.8	2.8		
2	313.9	126.3	308.8	1389.8		0.8	1.9	4.3		0.8	2.7		
3	305.9	121.5	352.8	1419.5		0.9	2.0	3.5		0.9	2.8		
4	307.3	123.2	314.7	1693.6		0.9	2.0	3.6		0.9	2.8		

The VES curves in this profile also have been delineated to be a four layer model. VES curves 1 to 4 for this profile are HA type curves with configuration $\rho 1 > \rho_2 < \rho_3$ = H and $\rho_1 < \rho_2 < \rho_3$ = A which equal $\rho_1 > \rho_2 < \rho_3 < \rho_4$ = HA curve. The resistivity values for the first layer range between 305.9Ωm and 313.9Ωm, while the corresponding thickness range between 0.8m to 0.9m and the corresponding depth also range between 1.9m to 2.0m. The lowest resistivity is at VES3 and the highest at VES2. The resistivity values for the second layer range between 121.5Ωm and 127.1Ωm. The third layer resistivity values range between 298.9Ωmand325.8Ωm. The corresponding thickness and depths for the third layer range between 3.5m and 4.5m. The lowest resistivity is at VES2 and the highest at VES3. The resistivity values for the fourth layer range between 298.9Ωm and 325.8Ωm. All the VES have cumulative depth that range between 6.3m and 7.3m. Since the resistivity values of the first layer in the profile are high, they are free from pollutant and thereby the groundwater is not contaminated. All the VES points in this profile are shallow as seen in the hand dug wells within the vicinity of the refuse dump.

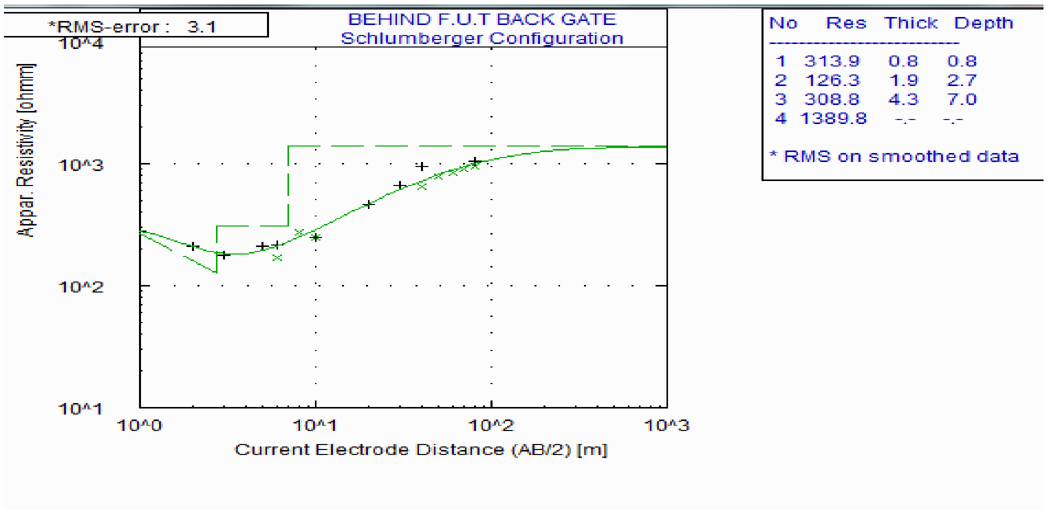

Figure 5. Interpretation ofVES2 of the Control Site at AnguwanJikpan Refuse dump at back of FUT Bosso Campus

Table 4: Physio-Chemical Analysis of Hand Dug Wells in Anguwan Jumkpa refuse dump

Parameter	Unit	Well A	Well B	Well C	Control Well	WHO(2004
Temp	^{O}C	22.6	22.0	22.0	28.7	35-40
Ph		7.52	7.15	7.34	7.9	6.5-9.2
Conductivity	µS/cm	626	706	720	89	100
Alkalinity	mg/l	220	503	140	105	200
Acidity	mg/l	23	22	24	34	NA
TDS	mg/l	150	100	120	60	500-550
Total Hardness	mg/l	66	62	64	55	500
Zinc	mg/l	0.0848	0.0591	0.0720	0.0001	3.0
Lead	mg/l	0.1923	0.7692	0.0000	0.0000	0.001
Manganese	mg/l	0.0857	0.2286	0.2286	0.0025	0.5
Iron	mg/l	0.0676	0.0378	0.0338	0.0139	0.3
Copper	mg/l	0.2500	0.00000	0.0000	0.0000	2.0
Chromium	mg/l	0.8333	0.4167	2.0833	0.0053	0.05
Nitrogen	mg/l	0.2000	0.0000	0.3000	0.0000	NA
Cobalt	mg/l	0.0286	0.0286	0.0286	0.0015	NA
Cadmium	mg/l	0.00606	0.0364	0.0667	0.0002	0.003

The temperature for the groundwater in the study area ranged between 22.0 ^{O}C and 22.6 ^{O}C which is below WHO limits and the control well has a temperature of 28.7 ^{O}C. The Groundwater pH value for AnguwanJukpa well averaged 7.33, 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 are above WHO limits, while the value for Well C is within allowable limits. Some of the parameters measured in these wells are elevated especially Lead, Chromium and Cadmium as showed by Jegede e*t al*, 2011.

Physico-Chemical Analysis of Soil Samples

Table 2 shows the results of Physio-chemical analysis from different six locations in the refuse dump site. Data generated from the laboratory analysis were analysed for Descriptive Statistics using Statistical Package for Social Scientists (SPSS) Version 16.0. In all the metals analysed, the concentrations are higher at distance 10m from the centre of each dumpsite and decreases as distance increases to 60m. The concentrations further decrease at control points of about 200m away from three sides of the refuse dump. This trend is observed in Awokunmi*et al* 2010 and Riziki 2010. The pH values for study areaare less than 7.0 this implies slightly acidic.

Table 5: Physio-Chemical Analysis of Soil Samples in Anguwan Jumkpa 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)
AJ1	6.88									
		6.8124	28.8462	22.42860	67.568	50.0000	12.50000	30.0000	8.5714	0.93939
AJ2	6.55									
		4.8843	26.6154	20.85714	63.784	42.0000	10.0000	25.0000	5.7143	0.68485
AJ3	6.44									
		4.5990	23.2308	19.42860	57.568	37.5000	8.33333	20.0000	4.2857	0.43333
AJ4	6.77									
		3.9563	19.6154	18.57140	50.686	28.5000	6.26667	15.0000	3.5254	0.38182
AJ5	6.59									
		3.5990	18.8462	16.42860	33.784	18.0000	4.16374	10.0000	2.8571	0.21387
AJ6	6.49									
		3.0990	16.2358	12.14290	16.893	12.5000	2.08333	5.0000	1.4286	0.19563
Min	6.44	3.0989	16.2358	12.14290	16.892	12.5000	2.08333	5.0000	1.4286	0.19563
Max	6.88	6.8124	28.8462	22.4286	67.568	50.0000	12.50000	30.0000	8.5714	0.93939
Mean	6.62	4.4917	22.2316	18.3095	48.380	3.1417	7.30785	1.7500	4.3971	0.47482
S.D	0.17	1.3096	4.8625	3.6426	1.9492	14.4271	39.1063	9.3541	2.4946	0.28857
AJC1	6.18									
		0.0000	1.2467	0.4286	0.0000	0.0000	8.1066	3.0000	0.3030	0.0018
AJC2	6.21									
		1.5990	0.6154	0.2860	0.0682	7.5000	12.8333	4.0000	1.4286	0.0015
AJC3	6.27									
		0.0990	0.1544	0.2857	0.0000	5.0000	0.0000	2.5000	0.0000	0.0013
Min	6.18	0.0000	0.1544	0.2857	0.0000	0.0000	0.0000	2.5000	0.0000	0.0013

Max	6.27	1.5997	1.2467	0.4286	0.0682	7.5000	12.8333	4.0000	1.4286	0.0018
Mean	6.22	0.5660	0.6722	0.3335	0.0227	4.1667	6.9800	2.5000	0.5772	0.0015
S.D	0.05	0.8960	0.5484	0.0824	0.3937	3.8188	6.4904	0.7637	1.5751	0.0002

AJ: Anguwan Jumkpa, AJC: Anguwan Jumkpa Control

Conclusion

Interpretation of geo-electric soundings of refuse dump yielded information on groundwater pollution as shown by the curve types, measured resistivity values and physico-chemical parameters of bothsoil and well water around the study area. The results reveal that the quality of groundwater at this site was affected as a result of domestic dumping. Therefore, combination of vertical electrical soundings and physico-chemical analysis is a vital tool for investigating groundwater pollution

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