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Investigating Groundwater Contamination Using Vertical Electrical Sounding andPhysio-Chemical Analysis aroundAngwanJukpa Municipal Solid Waste, Minna, North-central, Nigeria

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Abstract: *The work investigated groundwater contamination in the study area using Vertical Electrical Sound technique and Physio-chemical analysis of soil and water samples within the vicinity of the Site. ABEM Terrameter SAS 4000 was used to carry out the geophysical survey. The VES data were plotted as pseudo and resistivity-sections so as to reveal the spatial distribution of the contaminant plumes. The interpreted VES data observed in the dump showed contamination plume as low zone with resistivityvalues between 1-20.5Ωmfrom the surface extending to a shallow aquifer of 5.8m, while the VES observed at the area free of waste dump showed a resistivity values of 174-178.5Ωm from the surface to the aquifer which is free from being polluted. The Physio- chemical analysis of soiland groundwater showed elevation in some of the parameters.*
Keywords: *Groundwater, Vertical, Plume, Resistivity, Spatial, Municipal*

I. Introduction

AngwanJukpa 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, Bossocampus.It is fast growing and developing as a result of this the municipal solid wastes (MSW) is also increasing and the only method of disposing this is by landfills. As a result, waste materials are disposing indiscriminately throughout the area and its environs. If this menace is not checked, it will cause a great problem in the years to come. Thisrefuse dump lacks the top and bottom cover which pose a big treat to groundwater which is believe to be of high quality and require little or no treatment before consumption, also soil within the vicinity of the landfills are at risk . According to (Sampat, 2001) and cited by Osazuwa and Abdullahi (2008), bacteria, fungi and other biological pollutants are naturally filtered and diluted as water percolates through the soil. Groundwater is also widely used because the provision of potable water through the water supply is not adequate for the need of inhabitants. But as a result of careless management of hazardous materials, fresh groundwater supplies would be greatly reduced. Urban waste materials, mainly domestic garbage, are usually disposed off inadequately in land surface, shallow excavation, river and stream channels which place the groundwater at high risk of being polluted. Pollution of groundwater under and near waste disposal sites occurs as a result of infiltration of contaminants through the soil under these sites.

Fig.1: Study Area

II. Geology of the Area

The area of survey lies directly within the northwestern part of the Nigerian Basement Complex, which is composed of three fold lithological units and forms a part of the large pan-African mobile belt which lies between the West Africa and Congo cratons. The Nigerian Basement Complex is in places especially at the northcentral part intruded by Mesozoic calc-alkaline ring complex rock referred to as the Younger Granites, to differentiate them from the much foliated, complex and deformed Older Granites. The Basement Complex is in parts overlain by the Createaceous and younger sediments.

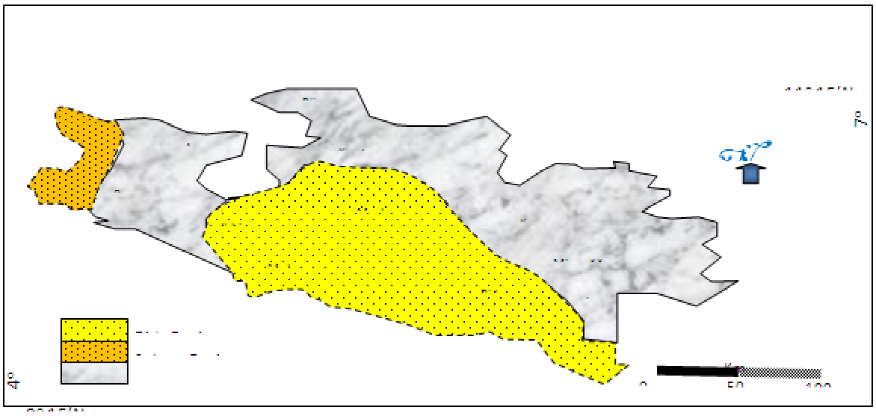

Figure 2. Map showing the geology of Niger State

III. Data Collection

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

3.1 Geophysical Survey

Twenty VES were collected at the site, along three profile, two of the profiles were drawn inside the waste dump comprising of sixteen VES, eight on each of the profile while four VES point were carry out at a distance of about 300 metres away from the waste dump to serve as control.

3.2 Physio-chemical Analysis

Water samples were collected from the existing well withinthe 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

IV. Results and Discussion

4.11D Interpretation

Figures 3a to 5b show 1D interpretation of Vertical Electrical Sounding using IPI2Win v.2.1 version 2008 developed by Department of Geophysics, Moscow State University.

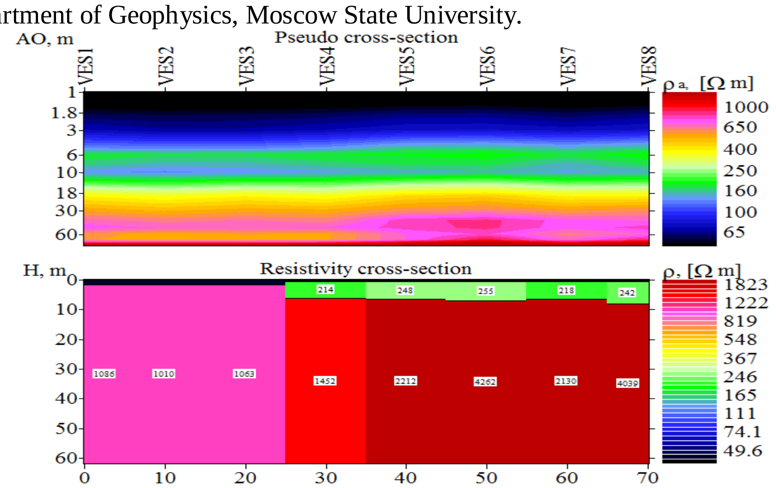

Fig.3 (a) Pseudo cross-section and **3(b)** Resistivity cross-section of VES 1-8 along profile A in AnguwanJukpa.

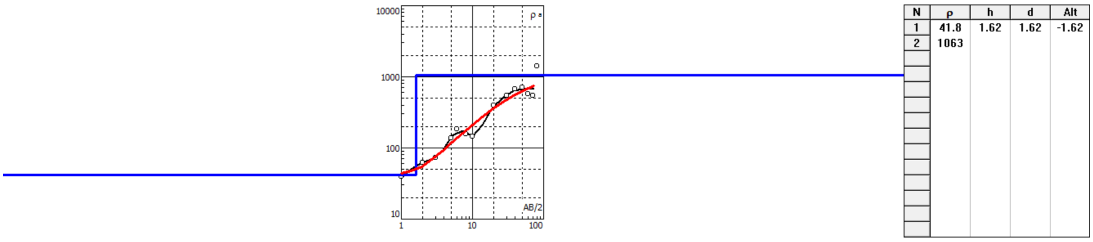

Fig.4: Typical Curve and Table for VES 3 along Profile A

Figures 3a and 3b show the pseudo and resistivity cross sections for VES points 1-8 along Profile AAnguwan-Jukpa refuse dump during the session. Figure 3a shows a low resistivity zone (1-48Ωm) for AB/2 spacing of (1-5.8m). This low apparent resistivity is attributed to contamination of top soil due to accumulation of leachate. The lower limit (black colour observed across the eight VES points indicates that the waste are even dumped there, this could be attributed to the age of the waste dump which span more than two decades. The horizontal horizon made up of green, grey, yellow and pink colours is the water bearing zone. The horizontal horizon made of up of blue colour indicates contamination infiltrate in water bearing at a depth of about 10m. The low apparent resistivity end <80 Ωm could be attributed to contamination of the groundwater due to leachate invasion (Abdullahiet al, 2010). Fig 3b showed two to three geologic sections of AA for the eight VES points. The basement rocks here have a resistivity greater than 1000Ωm. Figure 4 show the curve and table for VES 3 along profile A.

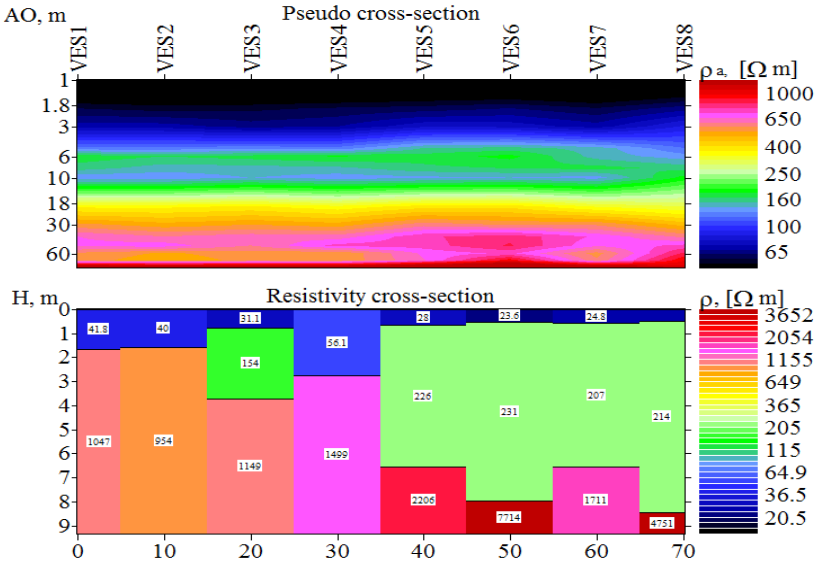

Fig.5(a) Pseudo cross and**4(b)** Resistivity cross-section of VES 1-8 along profile B in AnguwanJukpa.

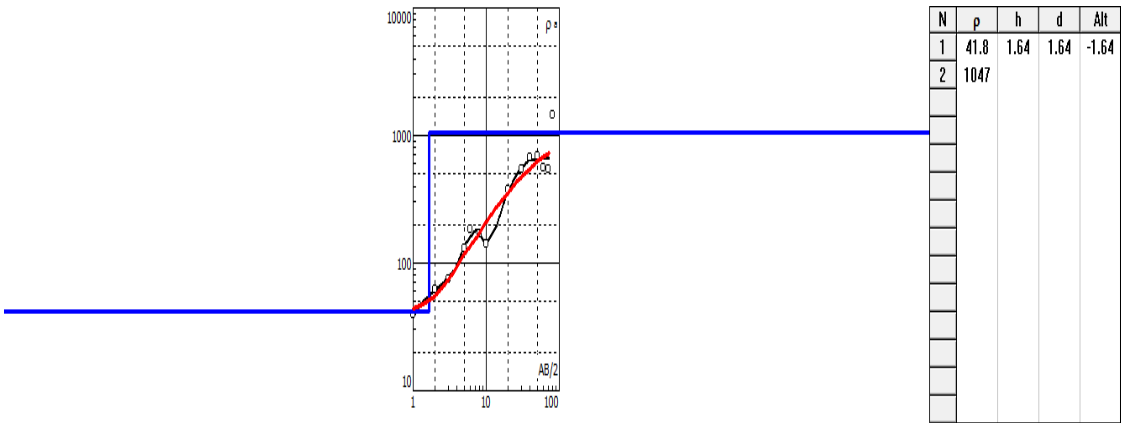

Fig.6: Typical Curve and Table for VES 1 along Profile B

Figures 5a and 5b show the pseudo and resistivity cross sections for VES points 1-8 along Profile B Anguwan-Jukpa refuse dump during the dry session. Figure 5a shows a low resistivity zone (1-20.5Ωm) for AB/2 spacing of (1-2.8m). This low apparent resistivity is attributed to contamination of top soil due to accumulation of leachate. The lower limit (black colour observed across the eight VES points indicates that the waste are even dumped, this could be attributed to the age of the waste dump which span more than two decades. The horizontal horizon made up of green, grey, yellow and pink colours is the water bearing zone. The horizontal horizon made of up blue colour indicates contamination infiltrate in to the water bearing at a depth of about 10m. The low apparent resistivity end <80Ωm could be attributed to contamination of the groundwater due to leachate invasion (Abdullahiet al, 2010). Fig 5b showed two to three geologic sections of A for VES (1, 2 and 4) and AA for VES (3, 5-8). The second layer for VES points (3, 5-8) show resistivity 154Ωm to 231Ωm which show presence of sandy soil (permeable), therefore the accumulation of leachate at first layer can easily percolate in to water bearing zone, thus the groundwater will be contaminated.Figure 6 show the curve and table for VES 6 along profile B

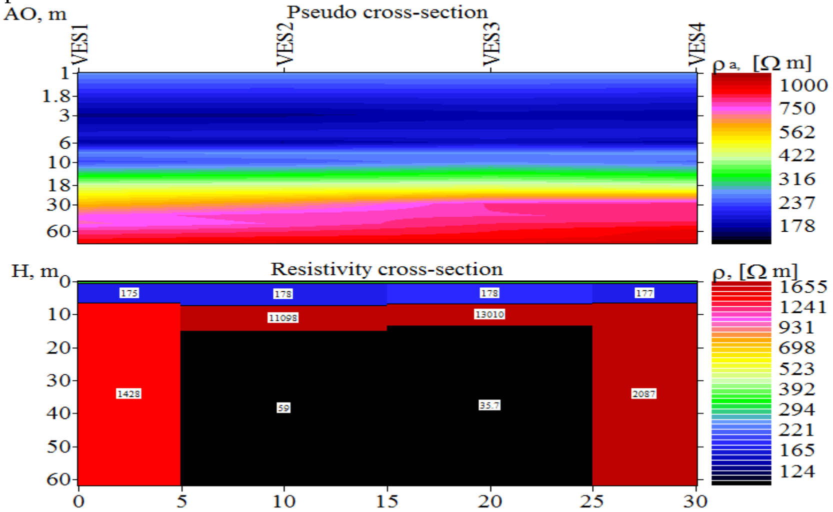

Fig.7 (a) Pseudo cross and **(b)** Resistivity cross-section of VES 1-4 at control site in AnguwanJukpa.

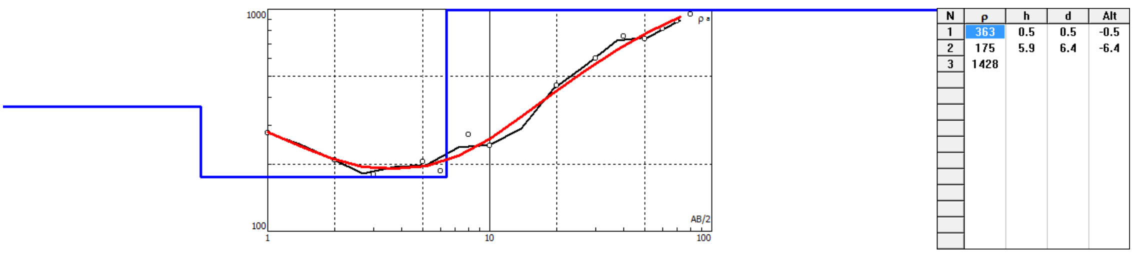

Fig.8: Typical Curve and Table for VES 3 along the control Profile

Figures 7a and 7b show the pseudo and resistivity cross sections for VES points 1-4 outside the refuse dump about 200m away from Anguwan-Jukpa refuse dump during the dry session. Figure 7a shows a low resistivity zone (174-178.5Ωm) for AB/2 spacing of (1-6.4m). This apparent resistivity values show presence of sandy soil on the surface which is free from contamination. The horizontal horizon made up of green, grey, yellow and pink colours is the water bearing zone. Fig 5b showed two to three geologic sections of A for VES (1and 4) and K for VES (2 and 3). The second layer for VES points show resistivity >1000Ωm which reduces to less for VES 2 and VES 3, therefore these two VES points are fractured and saturated. The groundwater here is free from contamination. These two points have high potential for water drilling. Figure 8 is a typical curve and table for control site.

Table1: Physio-Chemical Analysis of Hand Dug Wells in AnguwanJumkpa refuse dump

Parameter	Unit	Well A	Well B	Well C	Control Well	WHO
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	
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	
Cobalt	mg/l	0.0286	0.0286	0.0286	0.0015	
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 et al, 2011.

4.3 Physio-Chemical Analysis of Soil Samples

Table 2: Physio-Chemical Analysis of Soil Samples in AnguwanJumkpa 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	6.7568	50.0000	125.0000	30.0000	8.5714	9.3939
AJ2	6.55	4.8843	26.6154	20.85714	6.3784	42.0000	105.0000	25.0000	5.7143	6.8485
AJ3	6.44	4.5990	23.2308	19.42860	5.7568	37.5000	83.3333	20.0000	4.2857	4.3333
AJ4	6.77	3.9563	19.6154	18.57140	5.0686	28.5000	62.6667	15.0000	3.5254	3.8182
AJ5	6.59	3.5990	18.8462	16.42860	3.3784	18.0000	41.6374	10.0000	2.8571	2.1387
AJ6	6.49	3.0990	16.2358	12.14290	1.6893	12.5000	20.8333	5.0000	1.4286	1.9563
Min	6.44	3.0989	16.2358	12.14290	1.6892	12.5000	20.8333	5.0000	1.4286	1.9563
Max	6.88	6.8124	28.8462	22.4286	6.7568	50.0000	125.0000	30.0000	8.5714	9.3939
Mean	6.62	4.4917	22.2316	18.3095	4.8380	3.1417	7.30785	1.7500	4.3971	4.7482
S.D	0.17	1.3096	4.8625	3.6426	1.9492	14.4271	39.1063	9.3541	2.4946	2.8857
AJC1	6.18	0.0000	1.2467	0.4286	0.0000	0.0000	8.1066	3.0000	0.3030	1.8182
AJC2	6.21	1.5990	0.6154	0.2860	0.0682	7.5000	12.8333	4.0000	1.4286	1.5391
AJC3	6.27	0.0990	0.1544	0.2857	0.0000	5.0000	0.0000	2.5000	0.0000	1.3681
Min	6.18	0.0000	0.1544	0.2857	0.0000	0.0000	0.0000	2.5000	0.0000	1.3681
Max	6.27	1.5997	1.2467	0.4286	0.0682	7.5000	12.8333	4.0000	1.4286	1.8182
Mean	6.22	0.5660	0.6722	0.3335	0.0227	4.1667	6.9800	2.5000	0.5772	0.7527
S.D	0.05	0.8960	0.5484	0.0824	0.3937	3.8188	6.4904	0.7637	1.5751	0.2272

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 Stastical Package for Social Scientists (SPSS) Version 16.0. In all the metals analysed, the concentrations are higer 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 Awokunmiet al 2010 and Shemdoe 2010. The pH value for all points at the seven sites is less than 7. 0 this implies slightly acidic.

V. Conclusion

The Vertical Electrical Sound (VES) technique is applied to map pollution plume in this study. Two to three surface geoelectric layers. They are topsoil, weathered layer and fractured/fresh basement rock. The risk of pollution is more in the second profile (fig. 4) where weathered layer constitute of sandy (porous), which allow easy transport of leachate from topsoil into the aquifer especially VES points 3, 5 and 8 respectively. The VES points interpreted for the third profile (fig, 5) showa low resistivity zone (174-178.5Ωm) for AB/2 spacing of (1-6.4m).The range of value here represent sandy and from leachate. VES points 2 and 3 are the major aquifer.Some of the parameters measured in these wells are elevated especially Lead, Chromium and Cadmium. Also trace elements in soil around the vicinity of the refuse dump decreases as the distance moves away from the refuse dump. This shows that this is cause by the effect of refuse dump at this area.

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