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# The Impact of a Waste Disposal Site on Soil and Groundwater in Dusten-Kura Gwari, Minna, Niger State, Nigeria

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***Abstract:*** *This work studies the impact of waste disposal site on soil and groundwater from a refuse dump site in Dusten Kura Gwari, Minna, Niger state, northcentral Nigeria using vertical electrical sounding and results of soil and water analysis in the vicinity of the dump. Twenty Vertical Electrical Sounding were carried out along two profile inside the dump comprise of sixteen VESand another fouroutside the dump to serve as control.The resistivity values for all VES in the dump have low resistivity (25.6Ωm - 85.1Ωm), while that of control sit range between (190.9Ωm – 233.6Ωm).The result of well water and soil within the study area showed elevation in some of the parameters analysed which make the water unsafe for drinking.*
***Keyword:*** *Groundwater, Refuse, Disposal, Resistivity and contamination*

## I. Introduction

Municipal wastes are improperly disposed without regards for environmental risk. This improper dumping of refuse imposes high risk to the groundwater resources. There are several of these refuse dumps all overMinna and its environs. The area under study is characterised by the proximity of the aquifer to the surface, thus short travelling time in the unsaturated zone do not allow enough time for landfill emissions to be consumed before getting to the aquifer (Ehirim*et al* 2009. Generation of leachate in a landfill results from the flow of percolating water through waste materials (Olowofela and Akinyemi 2001). Leachate composition is determined by the nature of the waste, the amount of rate of flow through the waste (Olowofela*et al* 2012). The evolution of leachate composition in alandfill follows a four-stage decomposition process from aerobic, anaerobic, methanogenic and returning to aerobic condition as degradation near completion (Radulescu*et al,* 2007) and cited byOlowofela*et al* 2012.

Communities which depend solely on shallow hand dug wells as in the case of the study area are at a high risk. In the basement complex, groundwater is located in the weathered layer, joints, fractures and faults of the host rock. It is therefore important to map and monitor the migration path of the leachates through the weathered and the fractured bedrock which constitute the major aquifer units in the area under study.

Some many geophysical techniques are commonly used in investigating groundwater pollution, but electrical resistivity method is the most unique one because it is capable of detecting increases in pore water conductivity (AdulNasir*et al*, 2000) and reported by (Popoola and Fakunle 2011).

## 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.

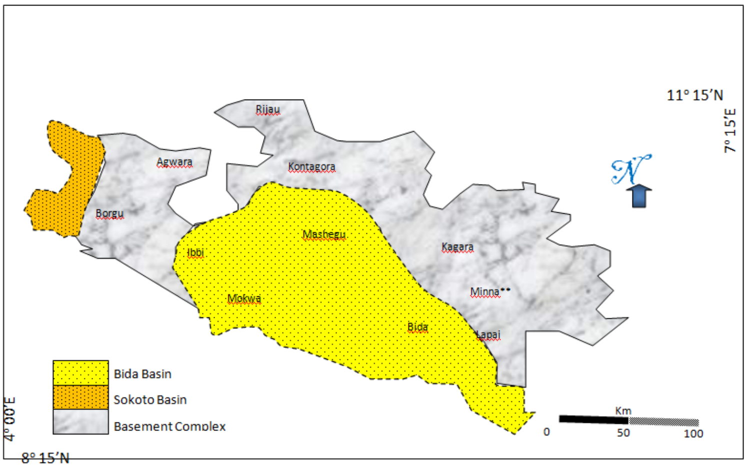


Figure 1. Map showing the geology of Niger State

**SiteDesription**

Dusten Kura Gwari is along Western Bye Pass, Minna. It lies along longitude $6.52^0$S and latitude $9.63^0$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.

## III. Material and Methods

**Geophysical Survey**

Twenty VES points were measured using Schlumberger array with the aid of ABEM Terrameter SAS4000 and its accessories. Two profiles inside the dump comprise of sixteen VES and another four outside the dump to serve as control.A maximum current electrode separation of AB/2 of 80m was used in this study. The apparent resistivity from the survey was processed by a computer software program called Winresist.

**Physio-Chemical**

For comprehensive study, three groundwater samples around the site and six soil samples inside dump and another three soil sample from area from refuse were taken for physio-chemical analysis.

## IV. Results and Discussion

Table 1 to 3 show the VES results from profile A, profile B and the control site during the dry and wet seasons at the DustenKuraGwari refuse dump.

Table 1: General VES results from Profile A at the DustenKuraGwari Refuse dump.

| VES NO | Number of ressitivities of layers(Ωm) | | | | Thickness of layers(m) | | | | Depth to bottom layers(m) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ρ1 | ρ2 | ρ3 | ρ4 | t1 | t2 | t3 | t4 | d1 | d2 | d3 | d4 |
| 1 | 30.0 | 52.3 | 781.2 | | 1.1 | 6.1 | -- | | 1.1 | 7.2 | -- | |
| 2 | 29.7 | 74.8 | 1291.4 | | 0.9 | 8.7 | -- | | 0.9 | 9.6 | – | |
| 3 | 30.1 | 46.2 | 883.51.0 | 7.5 -- | 1.0 | 8.5 | -- | | | | | |
| 4 | 30.3 | 66.5 | 1725.41.4 | 8.4 -- | 1.4 | 9.8 | -- | | | | | |
| 5 | 28.1 | 68.1 | 783.3 | | 1.6 | 7.8 | -- | | 1.6 | 9.5 | -- | |
| 6 | 27.9 | 63.6 | 933.7 | | 0.9 | 7.1 | -- | | 0.9 | 8.0 | -- | |
| 7 | 28.6 | 58.4 | 927.3 | | 1.2 | 6.3 | | | 1.2 | 7.4 | -- | |
| 8 | 28.0 | 71.5 | 1139.2 | | 1.0 | 6.3 | -- | | 1.0 | 7.3 | -- | |

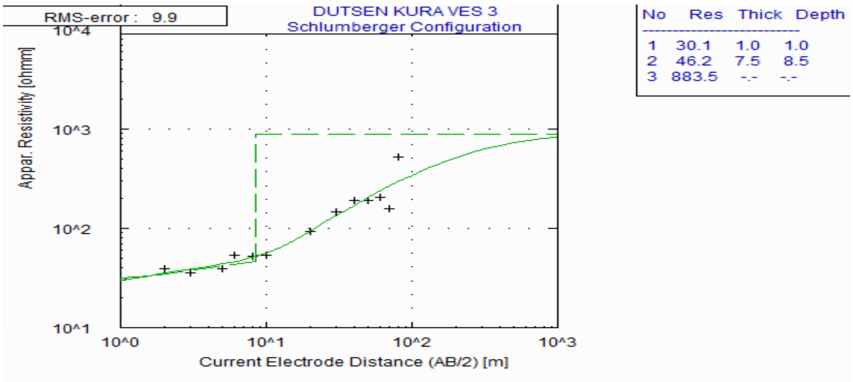


Figure 3: Interpretation ofVES 3 along Profile A at Dusten Kura Refuse dump.

The VES curves in this profile are characterised to be a three layer model. All VES curves for this profile are A type curves with configuration ρ1< $\rho_2 < \rho_3$. The resistivity values for the first layer range between 27.9Ωm and 30.1Ωm, while the corresponding thickness range between 0.9m to 1.6m and the corresponding depth also range between 0.9m to 1.6m. The lowest resistivity is at VES6 and the highest at VES3. The resistivity values for the second layer range between 46.2Ωm and 94.8Ωm, while the corresponding thickness range between 6.1m to 8.7m and the corresponding depth also range between 7.2m to 9.8m. The lowest resistivity is at VES3 and the highest is at VES2. The third layer resistivity range between 781.2Ωmand1725.4Ωm. All the VES have cumulative depth that range between 730m and 9.8m. The first layer apparent resistivity values are low which may be leachate deposited as a result of refuse dump. Low apparent resistivity noticed at second layer indicate clay sand of thickness of between 6.1m and 8.7m which service as a cap to prevent plume from entering the groundwater, thus the ground water around this refuse dump may be free from contamination.

Table 2: General VES results from Profile B during dry season at the DustenKuraGwari Refuse dump.

| VES NO | Number of ressitivities of layers(Ωm) | | | | Thickness of layers(m) | | | | Depth to bottom layers(m) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ρ1 | ρ2 | ρ3 | ρ4 | t1 | t2 | t3 | t4 | d1 | d2 | d3 | d4 |
| 1 | 29.7 | 37.2 | 63.4 | 1061.3 | 0.9 | 0.9 | 11.5 | -- | 0.9 | 1.8 | 13.3 | -- |
| 2 | 29.7 | 85.1 | 38.7 | 1141.7 | 1.0 | 3.2 | 3.1 | -- | 1.0 | 3.1 | 5.2 | – |
| 3 | 31.0 | 73.3 | 19.7 | 654.9 | 1.1 | 1.9 | 2.1 | -- | 1.1 | 5.8 | 10.6 | -- |
| 4 | 31.0 | 76.2 | 22.0 | 664.8 | 1.0 | 1.9 | 2.1 | -- | 1.0 | 2.9 | 5.0 | -- |
| 5 | 30.2 | 29.3 | 245.6 | 1358.2 | 1.7 | 1.4 | 25.8 | -- | 1.7 | 3.1 | 29.0 | -- |
| 6 | 28.3 | 59.2 | 595.1 | 2351.0 | 0.9 | 5.7 | 24.0 | -- | 0.9 | 6.6 | 30.6 | -- |
| 7 | 31.0 | 29.8 | 255.2 | 1688.6 | 1.7 | 1.5 | 23.3 | -- | 1.7 | 3.1 | 26.4 | -- |
| 8 | 25.6 | 73.7 | 48.4 | 1288.1 | 0.7 | 1.1 | 3.7 | -- | 0.7 | 1.8 | 5.5 | -- |

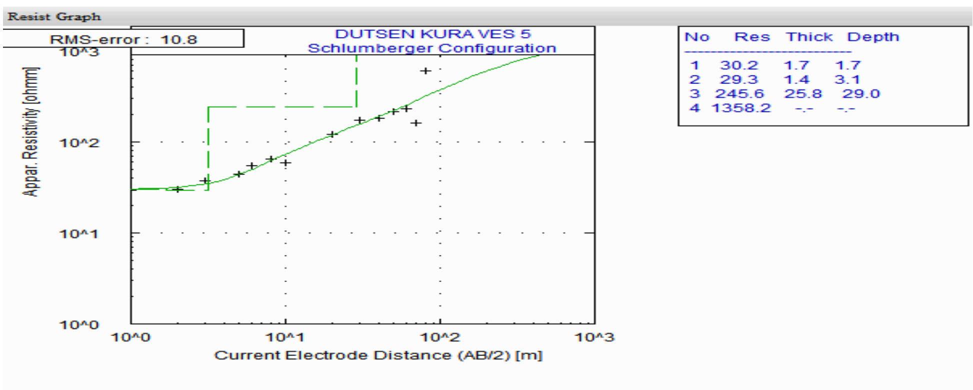


Figure 4: Interpretation ofVES 5 along Profile B at Dusten Kura Refuse dump.

The VES curves in this profile also have been delineated to be a four layer model. VES curves 1and 6 are AA type curves with configuration $\rho_1 < \rho_2 < \rho_3$ = A and $\rho_1 < \rho_2 < \rho_3$ = A which equal $\rho_1 < \rho_2 < \rho_3 < \rho_4$ = AA curve, VES curves 2,3,4 and 8 are KH curves type that is $\rho_1 < \rho_2 > \rho_3$ = K and $\rho_1 > \rho_2 < \rho_3$ = H which gives $\rho_1 < \rho_2 > \rho_3 < \rho_4$ = KH and VES curves 5 and 7 are HA that is $\rho_1 > \rho_2 < \rho_3$ = H and $\rho_1 < \rho_2 < \rho_3$ = A which equal $\rho_1 < \rho_2 < \rho_3 < \rho_4$ = HA. The resistivity values for the first layer range between 25.6Ωm and 31Ωm, while the corresponding thickness range between 0.7m to 1.7m and the corresponding depth also range between 0.7m to

1.7m. The lowest resistivity is at VES8 and the highest at VES3 and VES7. The resistivity values for the second layer range between 29.3Ωm and 85.1Ωm, while the corresponding thickness range between 0.9m to 5.7m and the corresponding depth also range between 1.8m to 5.7m. The lowest resistivity is at VES5 and the highest at VES3. The third layer resistivity values range between 19.7Ωmand595.1Ωm. The corresponding thickness and depths for the third layer range between 2.1m and 25.8m and5m and 30.6m respectively. The lowest resistivity is at VES3 and the highest at VES6. The resistivity values for the fourth layer range between 664.8Ωm and 2351Ωm. The lowest resistivity is at VES4 and the highest at VES6. All the VES have cumulative depth that range between 5.m and 30.6m. The first layer apparent resistivity values are low which may be leachate deposited as a result of refuse dump. Low apparent resistivity value noticed at second layer indicates clay sand of thickness of between 0.9m and 5.7m. Here VES6 with thickness of 5.7m may prevent the groundwater from being contaminated as reported by (Fejes and Josa, 1990, Egwebe, 2003) and cited by Otobo*etal* 2007. However other VES point may be at risk because the thickness of the second layer thin and leachate will migrate into the groundwater easily, thereby contaminating the groundwater.

Table 3: General VES results from Control site during dry season at the DustenKuraGwari Refuse dump.

| VES NO | Number of ressitivities of layers(Ωm) | | | | Thickness of layers(m) | | | | Depth to bottom layers(m) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ρ1 | ρ2 | ρ3 | ρ4 | t1 | t2 | t3 | t4 | d1 | d2 | d3 | d4 |
| 1 | 227.4 | 208.6 | 290.1 | | 0.8 | 6.1 | -- | | 0.8 | 6.9 | -- | |
| 2 | 266.8 | 233.6 | 223.7 | 2132.1 | 0.9 | 4.7 | 1.0 | -- | 0.9 | 5.7 | 6.7 | -- |
| 3 | 268.9 | 190.9 | 581.5 | 2853.0 | 1.1 | 2.7 | 8.8 | -- | 1.1 | 3.7 | 12.5 | -- |
| 4 | 285.6 | 193.4 | 228.9 | 1992.7 | 0.7 | 1.8 | 5.0 | -- | 0.7 | 2.5 | 7.6 | -- |

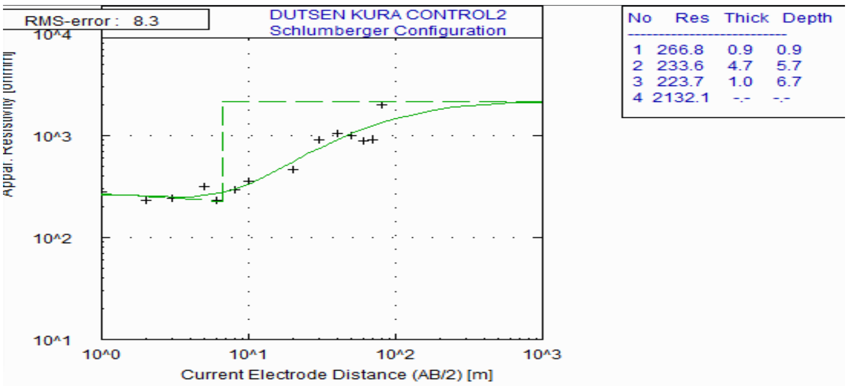


Figure 5: Interpretation ofVES 2 at control site at Dusten Kura Refuse dump.

The VES curves in this profile also have been delineated to be a three to four layer model. VES1 is H type curve, VES2 is QH type curve, and VES3 and VES4 are HA type curves. The resistivity values for the first layer range between 227.4Ωm and 285.6Ωm, while the corresponding thickness range between 0.7m to 1.1m and the corresponding depth also range between 0.7m to 1.1m. The lowest resistivity is at VES1 and the highest at VES4. The resistivity values for the second layer range between 190.9Ωm and 233.6Ωm, while the corresponding thickness range between 1.8m to 6.1m and the corresponding depth also range between 2.5m to 6.9m. The third layer resistivity range between 223.7Ωmand581.5Ωm. The corresponding thickness and depths for the third layer range between 1.0m and 8.8m and 6.7m and 12.5m. The lowest resistivity is at VES2 and the highest at VES3. The resistivity values for the fourth layer range between 1992.7Ωm and 2853.0Ωm. All the VES have cumulative depth that range between 6.7m and 12.5m. The not too high apparent resistivity values at the first layer and second layer correspond to sandy soil which is free from pollution.

Table 4: 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 | |
| TDS | mg/l | 120 | 190 | 170 | 76 | 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 | 0.0000 | 0.19231 | 0.00000 | 0.0000 | 0.001 |
| Manganese | mg/l | 0.2286 | 0.15714 | 0.22857 | 0.0014 | 0.5 |
| Iron | mg/l | 0.0000 | 0.03378 | 0.06757 | 0.0000 | 0.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Copper | mg/l | 0.5000 | 0.25000 | 0.00000 | 0.0000 | 2.0 |
| Chromium | mg/l | 0.4167 | 0.00000 | 0.41667 | 0.0000 | 0.05 |
| Nitrogen | mg/l | 0.1000 | 0.00000 | 0.20000 | 0.0000 | |
| Cobalt | mg/l | 0.0286 | 0.02857 | 0.00000 | 0.0000 | |
| Cadmium | mg/l | 0.0667 | 0.00606 | 0.03636 | 0.0001 | 0.003 |

The temperature for the groundwater in the study area ranged between 22.7 $^{O}$C and 22.8 $^{O}$C which is below WHO 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 regulated guidelines, this is similar to work of Jegede e*t al,* 2011.

Table5: 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 | 9.3939 |
| DG2 | 6.81 | 4.8843 | 19.6154 | 11.4286 | 3.3124 | 37.50000 | 125.0000 | 15.00000 | 4.2857 | 4.8485 |
| DG3 | 6.73 | 3.5990 | 19.2308 | 7.8571 | 3.0021 | 25.00000 | 62.5000 | 10.00000 | 2.8571 | 1.8182 |
| DG4 | 6.49 | 3.5990 | 19.2308 | 7.5725 | 1.6892 | 20.00000 | 41.6667 | 5.00000 | 1.4286 | 1.1568 |
| 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 | 0.3030 |
| Min | 6.14 | 2.9563 | 9.6154 | 4.2876 | 1.3255 | 12.50000 | 20.8333 | 5.0000 | 1.4286 | 0.3030 |
| Max | 6.81 | 6.8124 | 28.8462 | 25.71430 | 3.3784 | 50.00000 | 166.6670 | 25.00000 | 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 |
| DGC1 | 6.02 | 0.0000 | 1.2467 | 0.4286 | 0.0000 | 0.0000 | 8.1066 | 3.0000 | 0.3030 | 1.8182 |
| DGC2 | 6.17 | 1.5990 | 0.6154 | 0.2860 | 0.0682 | 7.5000 | 12.8333 | 4.0000 | 1.4286 | 1.5391 |
| DGC3 | 6.27 | 0.0990 | 0.1544 | 0.2857 | 0.0000 | 5.0000 | 0.0000 | 2.5000 | 0.0000 | 1.3681 |
| Min | 6.02 | 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 | 3.1667 | 0.5772 | 1.5751 |
| S.D | 0.05 | 0.8960 | 0.5484 | 0.0824 | 0.0394 | 3.8188 | 6.4904 | 0.7638 | 0.7527 | 0.2272 |

From table 5, it is observed that there is decease in the values of trace element from the centre of the dump to a distance of 60m and the values were minimal or zero at the control site which means that the trace element observed are caused as a result of the refuse dump.There is a significant different of trace elements from the centre of the dump to the bottom of the dump (DG1-DG6).There is no presence of trace element at thecontrol site.

## V. Conclusion

Vertical Electrical Sounding integrated with physiochemical analysis of groundwater and soilis used to monitor the effect of landfill on groundwater and soil aiDusten Kura Gwari, Minna. The VES delineated three to five geologic layers which infer geologic units. The fractured/fault zones constitute the major aquifer units. Which host groundwater and leachate. The migration of the leachathe is being controlled by the fractured/fault zones, thus polluting the groundwater around the refuse dump.The concentrations of heavy metals were found to be higheratthe centre of the dump and decease slightly at a distance of 10m to 60m down slope. The result of physiochemical analysis of groundwater in the vicinity of landfills show elevation in some of parameters analysed while some are within tolerable range.

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