Nigerian Journal of Physics (NJP)
ISSN: 1595-0611
Volume 32(3), September 2023

Investigation of the Effect of the Solid Waste on Soil and Ground Water using Electrical Resistivity Method at Kumshe area Maiduguri, Borno State

***[1]Kolo, M., [2]Hassan, M., [2]Atom, Y. T.**

[1]Department of Physics, Borno State University, Maiduguri, Nigeria
[2]Department of Physics, University of Maiduguri, Nigeria

*Corresponding author's email: mkolo@bosu.edu.ng Phone: +2348022662255

ABSTRACT

The dumpsite under investigation was in Maiduguri's Kumshe neighborhood. At the dumpsites, an electrical resistivity survey was conducted to find out how precisely an electrical measurement could identify the leachate flux into the soil and groundwater. To complete the task, a Syscal Junior Resistivity Meter was utilized. This makes use of multi-core cables that are disconnected at different times, with a total of 27 electrodes spread across 200 meters. The dumpsite was the subject of four vertical electrical soundings (VES), which were analyzed using the computer program IPI2WIN. According to the results, contamination plumes were identified as low resistivity zones with resistivity values ranging from 0 to 30 m, from the ground surface to varying depths of 0-3.6 m in VEs1, VEs2, and VEs4. These zones were thought to be formed by leachate from decomposed waste with greater concentrations, whereas ves3 defines contamination plumes with low resistivity zones that stretch from the surface of the ground to different depths thought to be leachate from broken down waste with lower concentrations. The findings showed that leachate had moved from the dump into the nearby soil at the dumpsites, but it had not yet reached the area's shallow aquifer.

Keywords:
Leacheate,
Delineate,
Aquifer,
Plume,
Apparent,
Resistivity.

INTRODUCTION

In urban centers like Maiduguri, Nigeria there is much environmental problem facing the city. Some of these problems are overpopulation, rapid loss of biodiversity; global warming waste management Etc. Due to improper management of waste in both residential and industrial areas soil and the groundwater may be contaminated. The most valuable natural resource in any area is groundwater, which works in tandem with surface sources to provide potable water for use in homes and businesses. To support agriculture, housing, and other commercial and industrial endeavors, the people also depend on groundwater for the quantity, fertility, and integrity of the soils (Jatau and Ajodo, 2006).

Groundwater has excellent microbiological quality and chemical quality that is generally adequate for most uses. Ninety-nine percent of natural groundwater is composed of eight major chemical constituents: Na, Ca, Mg, KHCO3, Cl, SO4, NO3, and Si. The proportion of these elements indicates the history and geology of the groundwater. The remaining 1% is composed of trace and minor ingredients, the presence of which (or absence) can occasionally cause health problems or make the product unfit for use by people or animals. (Sunday, 2012)

Wastes are produced every day in Maiduguri, and the majority of them are dumped in poorly designed and positioned dumping sites. The disposal sites are situated near roadsides, farms, markets, and residential areas. The soil, groundwater, railroad, and road infrastructure are all at risk, and the aesthetics of the impacted areas are not spared.

Leachate (water that has percolated through waste and contains various ions in solution) is formed in part because dumpsites are covered in flood water during the height of the rainy season. Floodwater that covers dumpsites helps to create leachate, which is water that has seeped through waste and is dissolved in different ions. This polluted liquid, known as leachate, creates a "plume" that spreads outward and descends into nearby and subsurface aquifers (Carpenter et al., 2012).

These Leachates (plumes) are electrically conductive when there is a high concentration of chlorine ions in the solution. Hydrogen ions are released into solution by acids dissolved in water (shown by pH values less than 7), which also improves electrical conductivity.

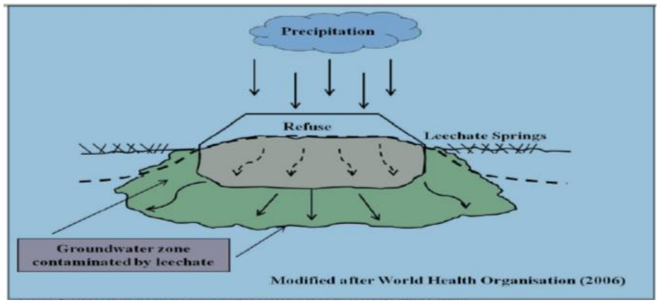

Figure 1: Showing Leachate Migration to Ground Water

The research aims to ascertain whether the Kumshe solid waste dumpsite in the Maiduguri Metropolitan Council has contaminated or polluted the soil and groundwater. The main aim of this research is to examine leachate generation and migration pathways, as well as any potential effects on the environment and human health, using electrical resistivity techniques.

Location of the Study Area

Kumshe is the study area. It is situated behind flour mills along the Maiduguri rail station and has a total area of roughly 1 km^2. Approximately, latitude 11^0, 50', 42" north and longitude 130, 9', and 36" east define the boundaries of the area. It is reachable by road and has a comparatively flat terrain. The surface composition of the dumpsite is made up of solid waste from nearby residents and industries. The Baga road leads along the same rail route to the study area.

General Geology of the Study Area

The Borno basin, which makes up one-tenth of the Chad basin's total area, is the Nigerian portion of the basin. The Chad basin, which spans about 230,000 km2, is located in a large region of Central and West Africa at an elevation of 200–500 m above sea level (Nwankwo and Emujakporue., 2012). In line with the land's slope, the Chad Formation gently dips east and northeast toward Lake Chad. The formations are of lacustrine origin and are composed of a thick bed of clay intercalated with irregular beds of sand, silt, and sandy clay, except the belt of alluvial deposition around the basin's edge. Miller and others (1968).

Sediments from the Chad Formation underlie the region. The Tertiary Kerri Kerri Formation is covered by the Chad Formation, which is itself covered in recent alluvial deposits. These sediments were deposited at the start of the Tertiary period and the end of the Cretaceous period. About 23,000 km2 are covered by the formation in portions of the Nigerian states of Bauchi, Borno, Jigawa, Kano, and Yobe. The sediments that turbulent currents deposited are not well sorted. Finer grains show fluviatile depositional patterns and are deposited at low velocities. Their size and color vary. (Alkali & Uba, 2014).

Three zones of sandy sediments (aquifers) divided by clay deposits are identified within the Chad Formation, which hydrogeologically varies quickly both vertically and horizontally. The middle and lower aquifers are located between 200 and 300 meters below the surface. There is evidence from geophysical and borehole data that the lower aquifer extends past Maiduguri. In the vicinity of Maiduguri, the upper aquifer is made up of three aquifer systems, known as A, B, and C, and they occur at depths of 10–40 m, 40–70 m, and 78–99 m, respectively, according to Bumba et al. (1991). The upper aquifer in the Maiduguri area is made up of three aquifer systems, known as A, B, and C, that occur in the following order: 10–40 m, 40–70 m, and 78–99 m.

MATERIALS AND METHOD

The electrical resistivity method's basic idea is to measure an earth resistance by inserting two metal stakes or electrodes into the ground at low frequency, then measuring the potential difference across the additional two electrodes. A "resistivity" value for the earth can be determined if the four electrode distances are known, along with the results of the electrical potential and current measurements. Through point electrodes or long-line contacts, an artificial source of current is introduced into the ground in all resistivity methods. These days, it is uncommon to employ the latter arrangement (Telford et al., 1990).

The resistivity of rocks is typically influenced by the concentration of dissolved salt and the amount of groundwater present. High temperatures and the presence of numerous ore minerals cause it to decrease (Alan et al., 2000).

Conduction of electricity through rocks is of three types; electronic conduction which occurs when the mineral grains are electrically conductive as with minerals such as pyrite, and magnetite. Most common mineral grains such as quartz, feldspar, and calcite, however, are non-conductive, and in rocks composed only of these, conduction is ionic or through ions in the interstitial fluid. The third type of current conduction is dielectric conduction which occurs in poor conductors or insulators having very few charge carriers or even none. Resistivity surveying is primarily used for mineral prospecting and mapping the presence of rocks with varying porosities, especially with hydrogeology to identify aquifers and contamination. However, other applications include surveying archaeological sites and looking into saline and other forms of pollution.

Instrumentation
Syscal Junior.
In this work, the Schlumberger electrode layout was used.

Figure 2: showing syscal resistivity junior

Field-Work
During the rainy season in 2017, from August 3rd to August 10th, fieldwork was completed. To estimate the least depth to the shallow aquifer, this period was selected for the fieldwork to have good electrode contact and maximum aquifer recharge. All four (4) vertical electrical sounding (VES) were subjected to the Schlumberger array electrical resistivity method
Schlumberger array was used for the vertical electrical sounding (VES) for the survey of the study area site. This array involves the measurement of potential differences (MN) between the other two currents (AB). The measurement of resistance is taken directly from the resistivity meter, which is then multiplied by a geometric factor to calculate the apparent resistivity.

The apparent resistivity data collected in the field from four vertical electrical soundings (VESs) were recorded on the log _ Log graph and presented by plotting the apparent resistivity (ρ_a) against the current electrodes (AB/2) for partial curve matching.
The measured data will be processed using the IPI 2 WIN software. The subsurface is automatically divided into several blocks by this program, and the appropriate resistivity values for each block are then determined using a least-squares inversion scheme so that the calculated apparent resistivity values agree with the measured apparent resistivity values from the field survey.

Table 1: Resistivity Values Adopted for this Work

S/N	SOIL TYPES	RESISTIVITY RANGE (Ωm)
1	Shale	5 – 15
2	Clay	10 – 150
3	Freshwater	5 – 100
4	Sand and gravel	30 -225
5	Clayey sand soil	30 -60
6	Sandy soil with clay	60 -100
7	Lateritic soil	120 – 750
8	Saturated landfill	5 – 30
9	Unsaturated landfill	30 – 100
10	Laterite	800-1500

RESULTS AND DISCUSSION

Software for automatic analysis from Schlumberger was used to process the VES field data. This computer program computes the three-layer parameters of the geoelectric section and automatically generates model curves using initial layer parameters (thickness and resistivity) obtained from partial curve matching of the field curve with standard curves. For each of the four VES positions, the resistivity and depth of the

geoelectric section are displayed as a result of the findings.
To interpret the resistivity data, the IPI2WIN inversion program was used to process the data. The subsurface will be automatically divided into several blocks by the computer program, which then determines the proper resistivity value for each block using a least-square smoothness-constrained inversion scheme. The apparent resistivity values and the electrode locations must be entered.

Table 2: Resistivity Field Record (VES 1-4) – Kumshe Dumping Site

LATITUDE			N11^{0}51'34.75''	N11^0 9'36.16''	N 11^0 51' 36.8''	N11^0 55' 35''
LONGITUDE			E13^0 9'3.03''	E 13^0 9' 2.7''	E 13^0 8' 40''	E 13^0 8' 30''
SNO	**AB/2**	**MN**	**VES 1 (Ωm)**	**VES 2 (Ωm)**	**VES 3 (Ωm)**	**VES 4 (Ωm)**
1.	1.0	0.2	22.5	52	92	20.1
2.	1.5	0.2	25.6	61.2	105	25
3.	2.0	0.2	31.5	71.2	113	32.6
4.	2.5	0.2	37.6	92.3	126	38.1
5.	3.0	0.2	63.6	93	140	38.3
6.	4.0	0.2	41.3	98	185	42
7.	5.0	0.2	44.6	104	210	49
8.	6.5	0.2	43.6	75	246	50
9.	8.0	0.2	41.0	76	296	52
10.	8.0	1.5	50.4	63	404	53
11.	10.0	0.2	54.6	66	322	50.1
12.	10.0	1.5	23.0	55	406	53
13	13.0	1.5	23.0	41	310	49
14	16.0	1.5	18.1	33	312	45
15	20.0	1.5	16.4	27	309	44
16	25.0	1.5	12	25	248	38
17	30.0	1.5	9.1	26	336	29
18	40.0	1.5	8.0	27	351	28
19	50.0	1.5	9.7	25	423	27
20	65.0	1.5	8.2	-	-	25.1
21	80.0	1.5	8.9	-	-	24
22	80.0	16	6.5	-	-	23
23	100	1.5	9.1	-	-	27
24	100	16	7.5	-	-	28
25	130	16	6.5	-	-	23
26	160	16	7.0	-	-	21
27	200	16	7.5	-	-	18

The result of the resistivity values obtained from the field survey is presented in Table 2. The resistivity values obtained range from 7.0Ωm to 423Ωm, with VES 3 having the highest resistivity values followed by VES 4, VES 2, and then VES 1

The figure below is the result of VES1, 2, 3, and 4 showing the lithology, the layer resistivity, and their corresponding depth

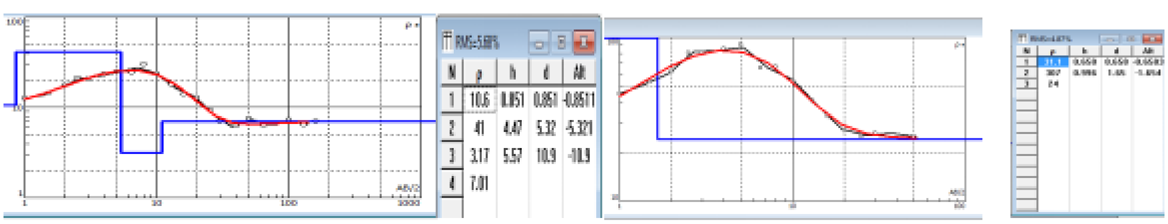

Figure 3: VES1&VES

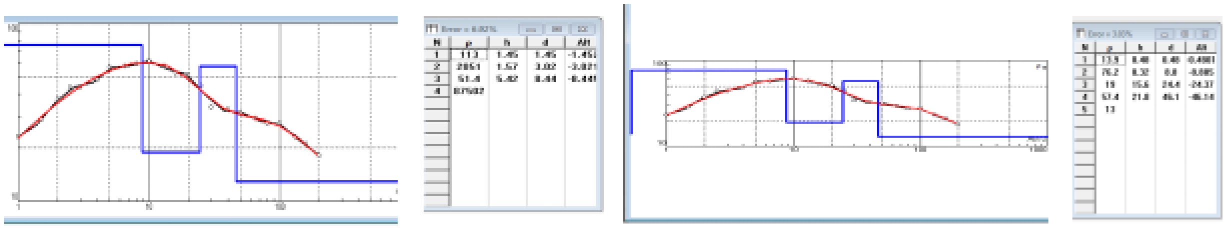

Figure 4: VES3&VES4

Interpretation

VES 1

The topsoil is the first layer with a resistivity of 10.6 Ωm, thickness of 0.851 m, and depth of 0.851 m. The shale is indicated by the layer with a resistivity of 41.50 m, whose thickness and depth are 4.47 m and 5.23 m, respectively, and by the layer with a resistivity of 3.17 m, whose depth and thickness are unknown, which suggests potential contamination and clayey conditions. The first layer, which was identified by the interpreted VES data as a contamination plume, had low resistivity zones with a resistivity value of 10.6 m from the ground surface to a depth of 0.85 m, suggesting that the topsoil is contaminated.

VES 2

The topsoil is the first layer of resistivity, measuring 31.4 Ωm in thickness and 0.65 m in depth. The clay is indicated by a layer with a resistivity of 307 m, thickness, and depth of 0.996 m and 1.65 m, respectively, and a potential contamination zone is indicated by a third layer with a resistivity of 24 m, whose depth and thickness are unknown.

VES 3

There are four layers: the topsoil is the first layer, with a resistivity of 10.6 Ωm, thickness of 0.851 m, and depth of 0.851 m. The second and fourth have unusual resistivity values of 2051 Ωm and 87502 Ωm, respectively, indicating clay soil. The resistivity of the third layer, which is 51.4 Ωm, indicates clayey sand soil. Not every layer had contamination.

VES 4

Five layers with a range of resistivity values are visible in Ves 4. The topsoil is the first layer of resistivity, measuring 13.9 Ωm with a thickness and depth of 0.48 m. The second layer has a resistivity of 76.2 m, which indicates clay soil. Its thickness and depth are 8.32 m and 8.80 m, respectively. The resistivity value of the third layer drops to 19 m at a depth of 24.4 m, indicating sand and gravel. The resistivity value of the fourth layer increases to 57.4 m, which may also indicate clay soil. The sand and gravel can be found in the layer with a resistivity of 13 Ωm, whose thickness and depth are unknown. The first layer, which was the contamination plume, was depicted in the interpreted VES data as low resistivity zones with resistivity value. The topsoil has a resistivity of 13.9 m, a thickness of 0.48 m, and a depth of 0.48 m. The resistivity of the second layer is 76.2 Ωm, and its thickness and depth are 8.32 m and 8.80 m, respectively. These values indicate that the topsoil, third layer, and fifth layer are contaminated, with depths of 13.9 Ωm, 19 Ωm, and 13 Ωm from the ground surface to 0.48 m and 46.1 m, respectively.

CONCLUSION

Mapping resistivity variations at the Kumshe refuse dumpsite has been made easier with the help of geoelectric vertical electric sounding. The VES data could be used to infer leachate because the results point to both its infiltration into nearby soils and its migration into the subsurface. The topsoil, sandy soil, clay soil, and clay are among the three (3) to five (5) layered geologic sections that primarily define the study area. Ves1, Ves2, and Ves4—which are thought to be leachate from decomposed waste of higher concentrations—delineated contamination plumes as low resistivity zones with resistivity values ranging between 1Ωm and 30Ωm, from the ground surface to varying depths of 0-3.6m. Ves3 delineated contamination plumes as low resistivity zones ranging between 100Ωm and 200Ωm, from the ground surface are thought to be leachate from lower concentrations of decomposed waste to varied depths. Because the region has a shallow aquifer (40–50 m), the movement of leachate poses a threat to the groundwater system, particularly to surface water. As a result, drilling boreholes near the dumpsite is risky. It is unknown what chemicals and biological components make up these pollutants. However, this necessitates more thorough integrated studies involving geochemistry and monitory borehole drilling.

REFERENCES

Alan, E., Mussett, M. & Aftab, K. (2000): Looking into the earth. Cambridge University Press, United Kingdom.

Alkali S. C. & Uba M. M. (2014): Surface resistivity for sitting shadow boreholes within the 1000 housing estate, Maiduguri Northeast Nigeria. *Journal of applied geology and geophysics* 2(2): 44-54

Bumba, J., Kida, H. & Bunu, I. (1991): Exploitation of groundwater in Chad formation–Maiduguri as a case study in arid zone hydrology and water resource by Gadzarma NM, Adetunji FA, Richards WS, by aliphillay GGR university of Maiduguri press, Maiduguri 89-98.

Carpenter, P. J., Ding, A. & Cheng, L. (2012): Identifying Groundwater Contamination Using Resistivity Surveys at a Landfill near Maoming, China. Nature Education Knowledge, 3(7), 20.

Fasunwon, O. O., Jaiyeola, G. B., & Adesugba, F. F. (2010). Impacts of a dumpsite on the neighborhood of a part of South-Western Nigeria. *Research Journal of Agriculture and Biological Sciences*, *6*(3), 204-214.

Jatau, B. S. & Ajodo, R. O. (2006): Preliminary Geo-environment evaluation of part of Kaduna North Metropolis, Kaduna, Nigeria. A Paper presented at *Nigeria Association of Hydrogeologists (NAH) 18th Annual National Conference Asaba*, 1-2.

Miller, R. E., Johnston, R. H. Olowu, J. A. I. & Uzoma, J. U. (1965): Groundwater hydrology of the Chad basin in Bornu and Dikwa emirate, northeastern Nigeria with special emphasis on the flow life of the artesian system. *Geological survey water-supply paper*1757-I, 1-54

Nwankwo, C. N & Emujakporue, G. O. (2012): Evaluation of petroleum potentials and prospect of the Chad basin Nigeria from heat flow and gravity data. *Journal of petroleum exploration and production technology, 2*(1): 1-6.

Sunday, J. E. (2012). Application of Geoelectrical resistivity imaging to investigate groundwater potential in Atan Ogun Unpublished m.sc Thesis, college of Physics, college of Science and Technology Covenant University, Ota Ogun State Nigeria.

Telford, W. M., Geldart, L. P. & Sheriff, R. E. (1990): *Applied Geophysics*. Cambridge University Press, London.

World Health Organization (2006). Protecting Groundwater for Health: Managing the Quality of Drinking-water Sources. Edited by O. Schmoll, G. Howard, J. Chilton, and I. Chorus. ISBN: 1843390795. Published by IWA Publishing, London, UK. WWW. en.wikipedia.org/wiki/Sagamu (Sagamu) (As of Aril 28, 2013, 10.50 GMT)