

Electrical Resistivity and Physio-chemical Survey Applied to the Study of Ground Water Contamination Around an Old Cemetery in Gashua, Bade Local Government Area Yobe, State, Nigeria

OO Galdima¹, GA Bala¹, IG Buba¹ and U Rilwan^{2*}

¹Federal University, Gashuwa, Yobe State, Nigeria

²Nigerian Army University, Biu, Borno State, Nigeria

*Corresponding Author: U Rilwan, Nigerian Army University, Biu, Borno State, Nigeria.

Received: May 09, 2022

Published: June 23, 2022

© All rights are reserved by U Rilwan, *et al.*

Abstract

In this study, 1D and 2D electrical resistivity and physio-chemical survey applied to the study of ground water contamination around an old cemetery in Gashua, Bade Local Government area Yobe, State, Nigeria was investigated. It was revealed that, all the seven (7) VES points have four layers. The types of curve in Bade 1-7 Community are majorly Q, KH, K, KHK and QHK respectively. These curves indicate a good type of curve for the viable existence of groundwater aquifer. The pseudo-sections along profile line N-S across VES 5&3 has a resistivity value range between 23-237 Ω m, profile line N-S across VES 6-2 have resistivity value range of 35-278 and pseudo-sections along profile line N-S across VES (7-1) have resistivity value of 19.3-268 Ω m. The regions in the pseudo-profile showing low resistivity value signifies the presence of a fluid which indicates presence of good water table. As it goes deeper, the resistivity (apparent) reduces and later rise again as it goes deeper, which may be due to reduction in the size of the grain, since a low resistivity layer exists, or a low resistivity surface water (water log) value exists in the upper layers of the area (in depth), then, grain sizes reduces which may lead to high resistivity value. The result also showed that the range of the Alpha activity was obtained to be 0.02078 for maximum value and 0.0016 for minimum value of Alpha activity concentration, and 0.22324 for maximum value and 0.00443 for minimum value of Beta activity concentration. The mean of the activity values was calculated to be 0.0112 for Alpha and 0.0452 for Beta activity. The overall result showed that both Alpha and Beta in the thirteen (13) samples are far below the recommended level by WHO. The results of AAS showed the presence of Magnesium (MG), Manganese (Mn), Copper (cu), Cadmium (cd), Chromium (Cr), Cobalt (Co)₂ Nickel (Ni) Lead (pb), Zink (Zn), and selenium (Se) in the Gashua cemetery soil.

Keywords: Cemetery; Groundwater; Contamination; 2D Resistivity; Physiochemical; Bade

Introduction

A holistic approach is needed to manage and protect the groundwater resources [1]. Cremated remains are rich in phosphate and metals and can contribute to excessive levels of these elements in the groundwater and greater environment. There are increasing methods to protect the groundwater resources which are incorporated into land use planning, and are considered in the approval of new developments [2]. The introduction and acceptance of Environment Impact Assessment legislation has led to the impact developments on groundwater resources to the attention of many policy makers. Where pollution of groundwater happens, it usually led to change and poor natural quality of groundwater. Many pollutants which happens in groundwater

have been recognized [3]. These includes bacteria and other micro-organism, major inorganic ions (etc.) ions like metals, and many organic chemicals [4-6].

Materials and Methods

Materials

The materials used for this study are:

- The Abem Terametre (SAS 1000)
- Global Positioning System.
- Surface 9.0 golden software package.
- 3D field pro software.
- The WinRESIST version 1.0 software.

Method

Study area

The study area is located towards the western of the chad basin fringes and underlying it, is some rocks of the chad formation. Almost one out of ten of the basins is located in some parts of northern Nigeria. The stratigraphy and composition of the most formations were pointed out by [8-13]. The chad formation includes the water bearing horizon like upper, middle and lower zone [12,13]. The upper zone gives water for several dug wells all through the rural localities.

The survey was conducted in Bade local government area of Yobe State, Nigeria. The headquarters of Bade are in Gashua with an area of approximately 772 km² and Coordinates: 12°52'5"N 11°2'47"E with population of about 139,782 according to 2006 census. Gashua has postal code of 631 [14].

The old-dumped cemetery is now situated in the heart of Gashua town, and is usually called Makabartan cikingari or Makabartan Low-cost in hausa language. It is approximately 500 square kilometres in size. Though it used to be far from the town when it was initially situated, the growth in population has made it where it is now. The cemetery was active since 1960s up till 2000. It is now densely populated with residential houses surrounding it. There are approximately 200 residential houses that are within 10-20m away from the cemetery, with approximately 15 boreholes and 25 dug wells in these houses. And these wells and boreholes are the major source of groundwater to these residential houses and beyond [14]. Figures 1 (a), (b) and (c), shows the cemetery and its surroundings.

(a)

(b)

(c)

Figure 1

Figure 2: Layout of the survey location in Bade.

Hydrogeology of the study area

Since the survey has to do with the contamination of water, it is important to look at the hydrogeology of the survey locations. The major hydrological feature in area are due to those delineating the geological units in the area. Level of Water evaluated from hand dug well was about, 20m. This shallow level was expected because the pool of the water forms "wet-land" in the area [15].

The geophysical methods are characterized by being non-invasive. In this work the geo-electrical method was used in the technique of vertical electrical sounding (VES). The geo-electrical

method depends upon measuring the electric impedance of the ground terrain through its coupling electrodes. Through two electrodes an alternating electric current of low frequency, is inserted to the ground; through two other electrodes the potential difference caused by this current is 199 V [16]. In the resistivity method applied the technique of vertical electrical sounding using the Schlumberger electrode array. The VES technique is performed to obtain measurements of resistivity at different depths from surface measurements made at different electrode spacing. The depth of investigation is increased as the spacing of the electrodes increases [17].

Method of data analysis

A maximum electrode extension of 180 m and of 5 m were used in the survey by the Schlumberger electrode array for the VES. The measured resistance was converted into apparent resistive by multiplying with a geometric factor according to [18] such that.

$$\rho_a = \frac{[(AB/2)^2 - (MN/2)^2] R}{MN} = \dots\dots\dots 1$$

$$\rho_a = KR = \dots\dots\dots 2$$

On the Schlumberger array, A and B are responsible for inserting current to the ground, while M and N, are used to estimate the potential difference. For heterogeneous and anisotropic media eq. (1) may be yet applied to compute a mathematical function, called apparent resistivity function from which the geophysicist can infer the resistivity distribution in the sub-soil geology.

The 2D resistivity imaging was accomplished using a four-electrode system with same electrode spacing “a” which range from 10-60 m for successive measurements covering a distance of 160-180 m. The apparent resistivity values were calculated from

the field resistance values by the use of equation (3) according to [19].

$$\rho_a = 2\pi aR \dots\dots\dots 3$$

Where a= electrode spacing; R= field resistance value.

A total of twelve (12) vertical electrical soundings and eight (8) 2D electrical imaging (Wenner) was carried out for the study. Out of these, nine (9) vertical electrical soundings and six (6) 2D electrical imaging was carried out on the cemetery while three (3) VES and two (2) electrical imaging was carried out around the four sides of the cemetery.

Water samples collection

Water samples was collected aseptically using sterile sampling bottles from the wells and boreholes close to the cemetery. The distance between the well and the feet of the cemetery, and the depth of the well and borehole will be measured to the nearest meter.

Soil samples collection

In this survey we collected soil samples at different depth to determine the physiochemical and microbiological contamination in the old cemetery in Gashua, Bade L.G.A, Nigeria. A total of 11 soil sample at different depths were collected and were analysed using an atomic absorption spectrometer. Heavy elements which may be useful to the soil were but have hazardous health effect to the human body when lost to water through leaching were detected. The elements found at different depths are shown in Table. 2 below

Result and Discussion

Results

| VES Location | Layer | Resistivity | Thickness | Depth | Layer Characteristics |
|--------------|-------|-------------|-----------|-------|--|
| BADE 1 | 1 | 30.2 | 3.5 | 3.5 | Topsoil/fine grain dry sand |
| | 2 | 77.4 | 1.88 | 5.38 | Laterite |
| | 3 | 318 | 28.7 | 34.08 | Shallow aquifer with Saturated coarse grain sand |
| | 4 | 111 | | | Aquifer with Saturated coarse grain sand Consolidated sand |
| BADE 2 | 1 | 56 | 2.57 | 2.57 | Clay sand |
| | 2 | 108 | 2.96 | 5.53 | Lateritic sand |
| | 3 | 395 | 34 | 3.96 | Aquifer with saturated coarse grain sand |
| | 4 | 167 | | | Consolidated sand |

| | | | | | |
|--------|---|-------|------|-------|--|
| BADE 3 | 1 | 26.4 | 3.59 | 3.59 | Clay sand Lateritic sand Aquifer with saturated coarse grain sand Consolidated sand |
| | 2 | 42.2 | 3.74 | 7.33 | |
| | 3 | 286 | 4.1 | 48.3 | |
| | 4 | 126 | | | |
| BADE 4 | 1 | 107 | 2.86 | 2.86 | Clay sand Lateritic sand Aquifer with saturated coarse grain sand Consolidated sand |
| | 2 | 31 | 5.65 | 8.51 | |
| | 3 | 118 | 26.5 | 35 | |
| | 4 | 417 | | | |
| BADE 5 | 1 | 65.4 | 1.36 | 1.36 | Clay sand Lateritic sand Aquifer with saturated coarse grain sand Consolidated sand |
| | 2 | 23.2 | 4.55 | 5.91 | |
| | 3 | 298 | 24.3 | 30.2 | |
| | 4 | 207 | | | |
| BADE 6 | 1 | 34.1 | 3.45 | 3.45 | Clay sand Lateritic sand Aquifer with saturated coarse grain sand Consolidated sand |
| | 2 | 168 | 26.3 | 29.75 | |
| | 3 | 116 | 17.9 | 47.63 | |
| | 4 | 224.3 | | | |
| BADE 7 | 1 | 20.8 | 2.86 | 2.86 | Clay sand Lower aquifer Shallow aquifer Consolidated sand as a protective layer Consolidated sand |
| | 2 | 92.2 | 9.71 | 12.6 | |
| | 3 | 440 | 16 | 28.6 | |
| | 4 | 196 | | | |
| BADE 8 | 1 | 16.6 | 4.2 | 4.2 | Clay sand Lower aquifer Shallow aquifer Consolidated sand as a protective layer Consolidated sand. |
| | 2 | 133 | 8.29 | 12.6 | |
| | 3 | 323 | 26.2 | 38.7 | |
| | 4 | 133 | | | |

Table 1: Summarized Results of the Data Interpretation.

The 8 VES location (BADE1-8) all have a four (4) curve. For BADE 1 the first geo-electric layer has a resistivity of 30.2 Ωm and a depth of 3.5 m while the second and third geo-electric layer has

resistivity and depth value of 77.4 Ωm, 318 Ωm and 5.38m and 34.08m respectively.

The formation is composed of sand and laterite.

| Sample I.D | Vol Evaporated (ml) | WT of Dish (g) | WT of Dish+ Sample (g) | WT of Residue (g) | Actual Vol (l) | REQ Weight (g) | Alpha conc. (Bq/l) | Beta conc. (Bq/l) |
|------------|---------------------|----------------|------------------------|-------------------|----------------|----------------|--------------------|-------------------|
| SALG | 2400 | 75.79 | 76.31 | 0.52 | 0.356 | 0.0772 | 0.00160 | 0.03784 |
| BULT | 2900 | 95.02 | 96.20 | 1.18 | 0.189 | 0.0771 | BDL | 0.04193 |
| LOK | 2000 | 75.81 | 76.34 | 0.53 | 0.290 | 0.0771 | 0.00980 | 0.01366 |
| DOB.T | 2950 | 75.86 | 76.54 | 0.68 | 0.335 | 0.0772 | 0.02659 | 0.02366 |
| NAS | 3000 | 44.54 | 45.55 | 1.01 | 0.229 | 0.0772 | BDL | 0.05191 |
| BIG. J | 3000 | 44.72 | 45.06 | 0.34 | 0.682 | 0.0773 | BDL | 0.01685 |
| NAG | 3000 | 95.08 | 96.12 | 1.04 | 0.222 | 0.0772 | BDL | 0.02677 |
| M.M | 1500 | 44.55 | 45.03 | 0.48 | 2.413 | 0.0772 | BDL | 0.00443 |
| ALB | 2900 | 95.10 | 95.59 | 0.49 | 0.456 | 0.0772 | BDL | 0.03824 |
| FG | 3000 | 95.11 | 96.74 | 1.63 | 0.142 | 0.0773 | 0.00267 | 0.22324 |
| HUR | 900 | 75.85 | 76.08 | 0.23 | 0.301 | 0.0770 | 0.02078 | 0.01316 |
| UYU | 1400 | 75.85 | 76.28 | 0.43 | 0.251 | 0.0772 | 0.00528 | 0.05841 |
| HAMD | 1400 | 44.57 | 44.96 | 0.39 | 0.276 | 0.0770 | 0.01236 | 0.03876 |

Table 2: Result of Alpha Beta Radioactivity in Some Water Samples.

Result analysis

| Samples | Concentrations (PPM) | | | | | | | | | |
|---------|----------------------|------|------|----|------|----|------|----|------|------|
| | M2 | 4n | Cu | Cd | Cr | Co | Ni | Pb | Zn | 8c |
| 2 cm | 4.14 | 5.00 | 0.36 | ND | 0.03 | ND | 0.08 | ND | 0.23 | 0.04 |
| 3 cm | 1.53 | 0.85 | 1.2 | ND | ND | ND | 0.17 | ND | 0.19 | ND |
| 5 cm | 5.59 | 5.98 | 1.87 | ND | ND | ND | ND | ND | 2.7 | ND |
| 10 cm | 4.55 | 2.56 | 2.48 | ND | 0.12 | ND | ND | ND | 1.83 | ND |
| 12 cm | 4.53 | 2.07 | 1.79 | ND | ND | ND | ND | ND | 2.4 | ND |
| HD | 4.00 | 1.10 | ND | ND | ND | ND | 0.05 | ND | 0.31 | ND |
| TL 2 | 3.76 | 0.85 | ND | ND | ND | ND | 0.07 | ND | 0.22 | ND |
| MJP | 4.65 | 0.85 | ND | ND | ND | ND | ND | ND | 0.27 | ND |
| TLCC | 6.62 | 0.12 | ND | ND | 0.08 | ND | 0.09 | ND | 0.22 | ND |
| A | 4.55 | 0.61 | ND | ND | ND | ND | ND | ND | 0.17 | ND |
| B | 4.33 | 0.32 | ND | ND | ND | ND | ND | ND | 0.18 | ND |

Table 3: Result of the Atomic Spectrometer Analysis of Some Soil Samples.

N.D - Not Detected; HD - Highly Densed; TL - Top Layer; TLCC - Top Layer Center of the Cemetery; R1 - Random Sample 1; R2 - Random Sample 2; R3 - Random Sample 3.

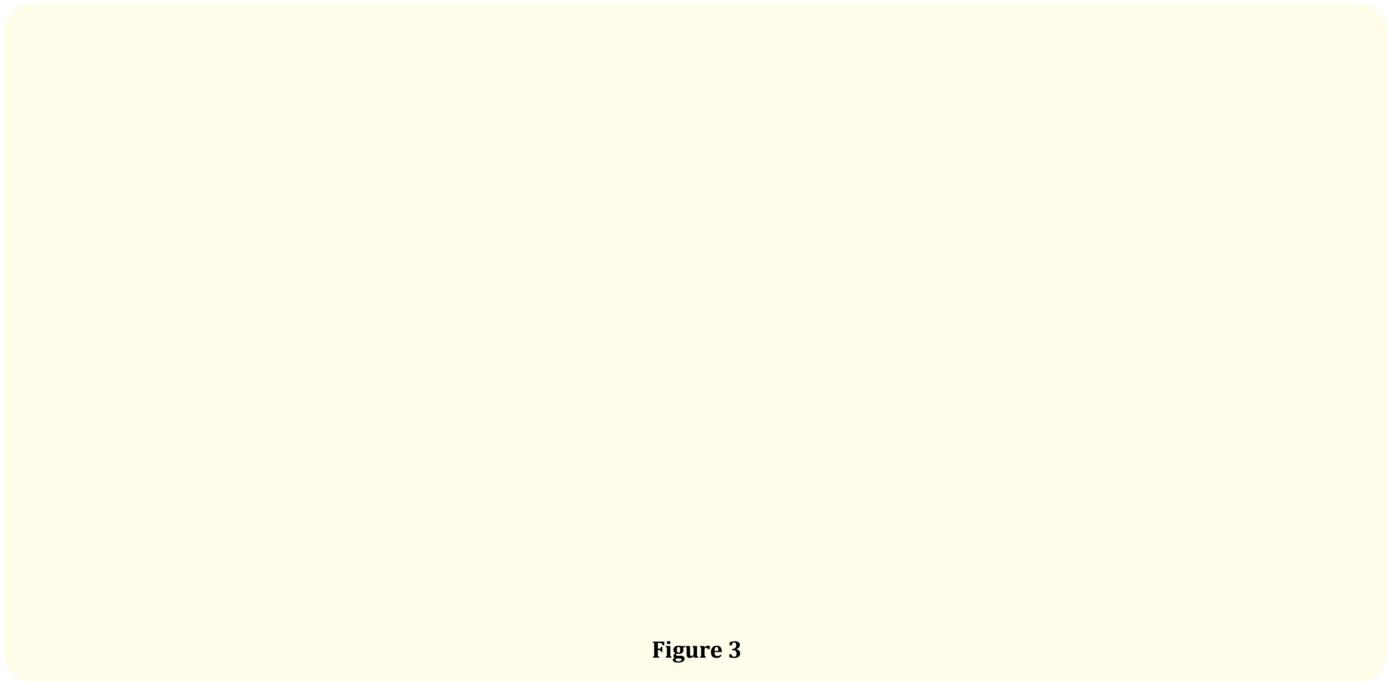


Figure 3

N-S PROFILE ACROSS VES POINTS 6 and 2

Figure 4

N-S PROFILE ACROSS VES POINTS 7 and 1

Figure 5

N-PROFILE ACROSS VES POINTS 4 and 8

Figure 6

Figure 7: Model Layer Curve for Bade 1.

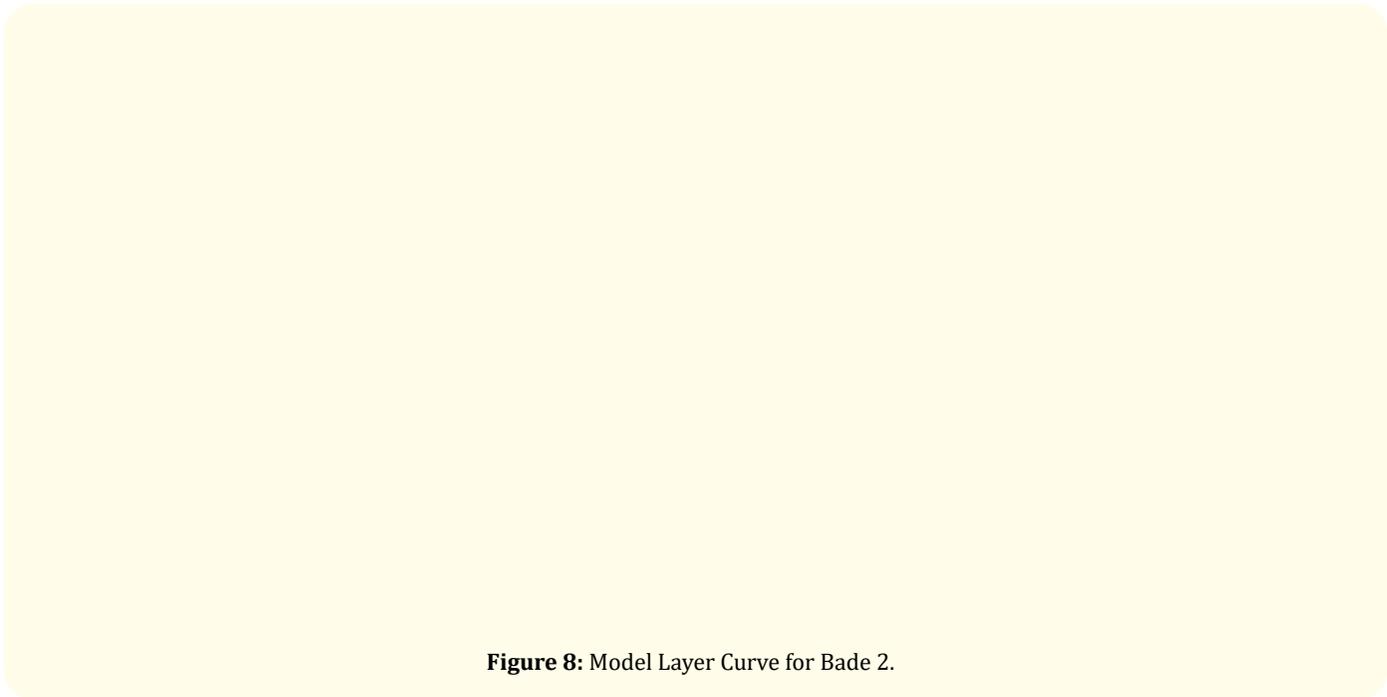


Figure 8: Model Layer Curve for Bade 2.

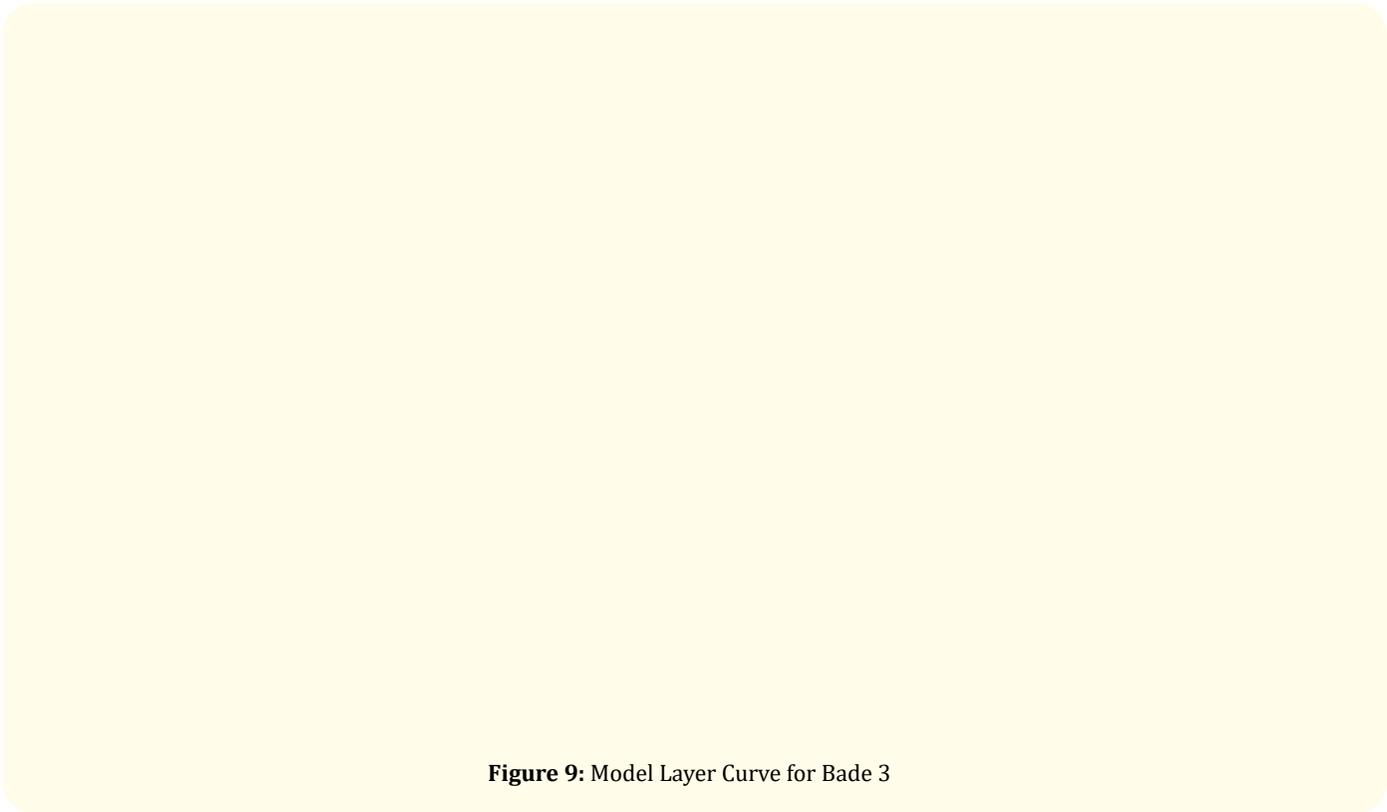


Figure 9: Model Layer Curve for Bade 3

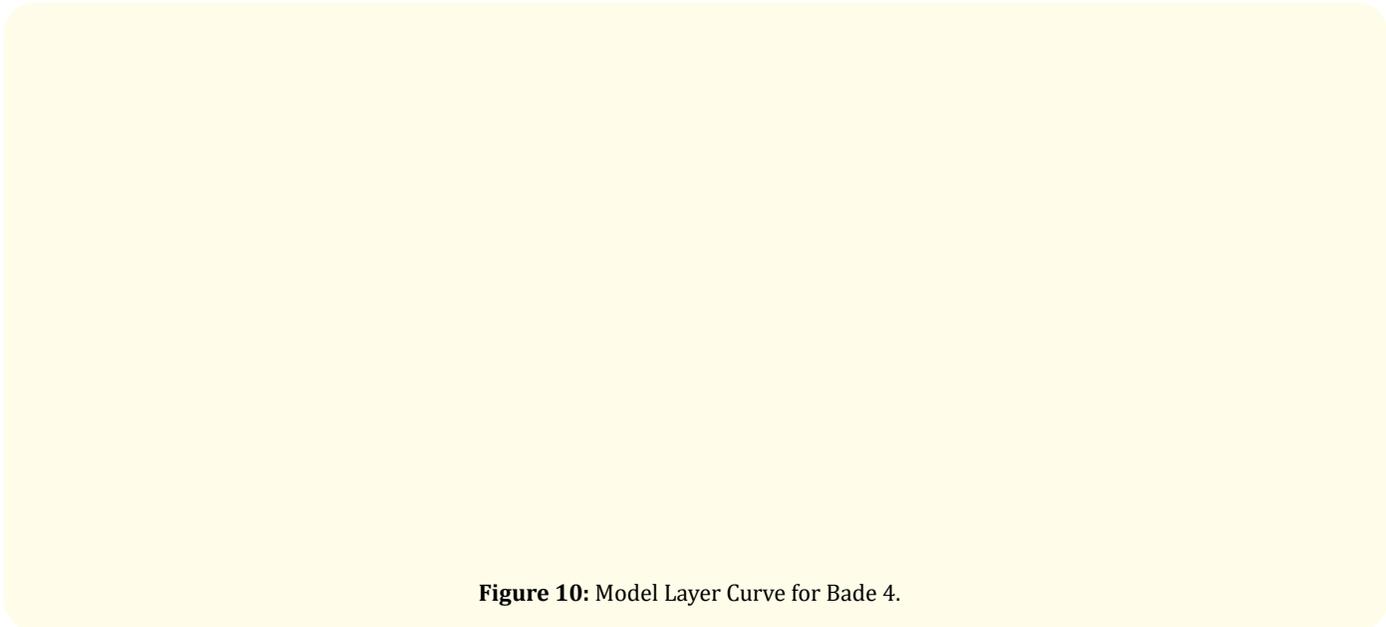


Figure 10: Model Layer Curve for Bade 4.

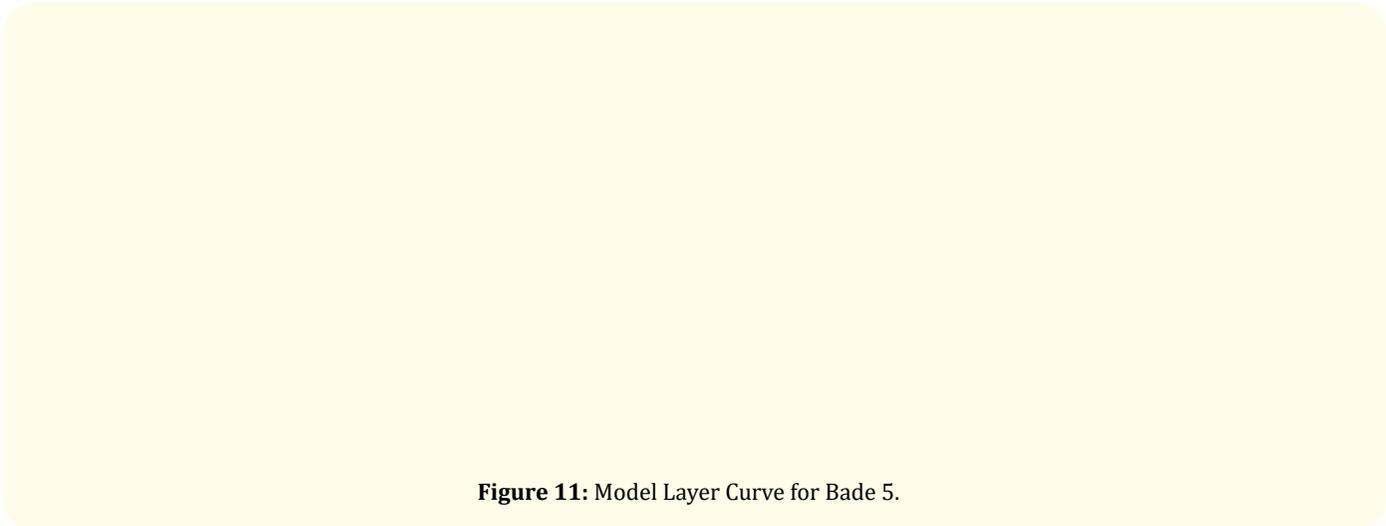


Figure 11: Model Layer Curve for Bade 5.

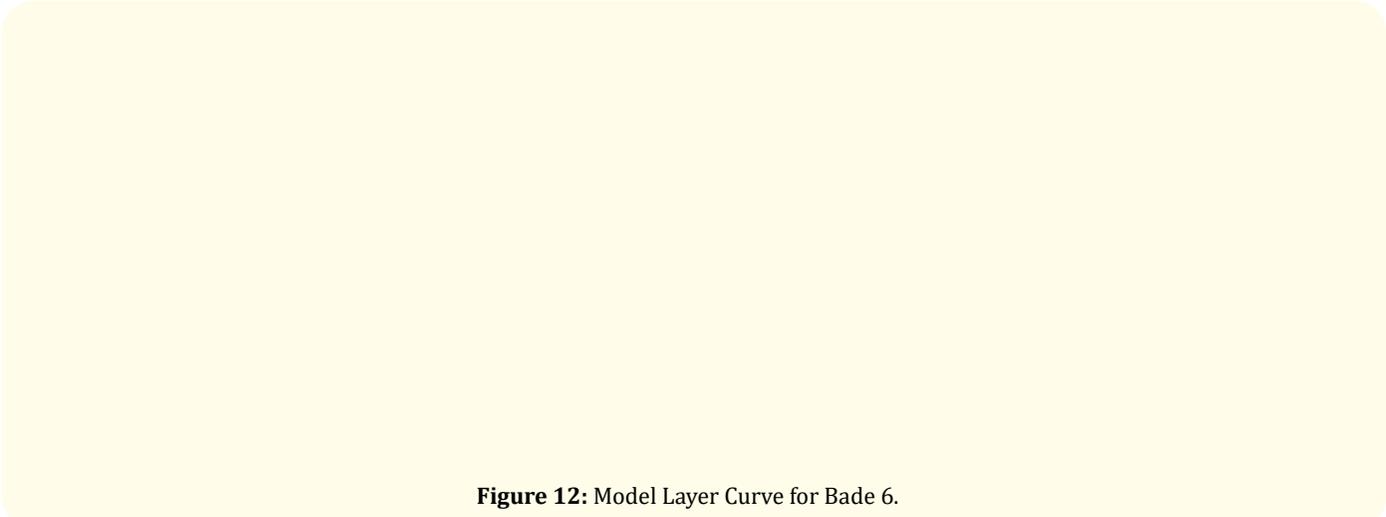


Figure 12: Model Layer Curve for Bade 6.

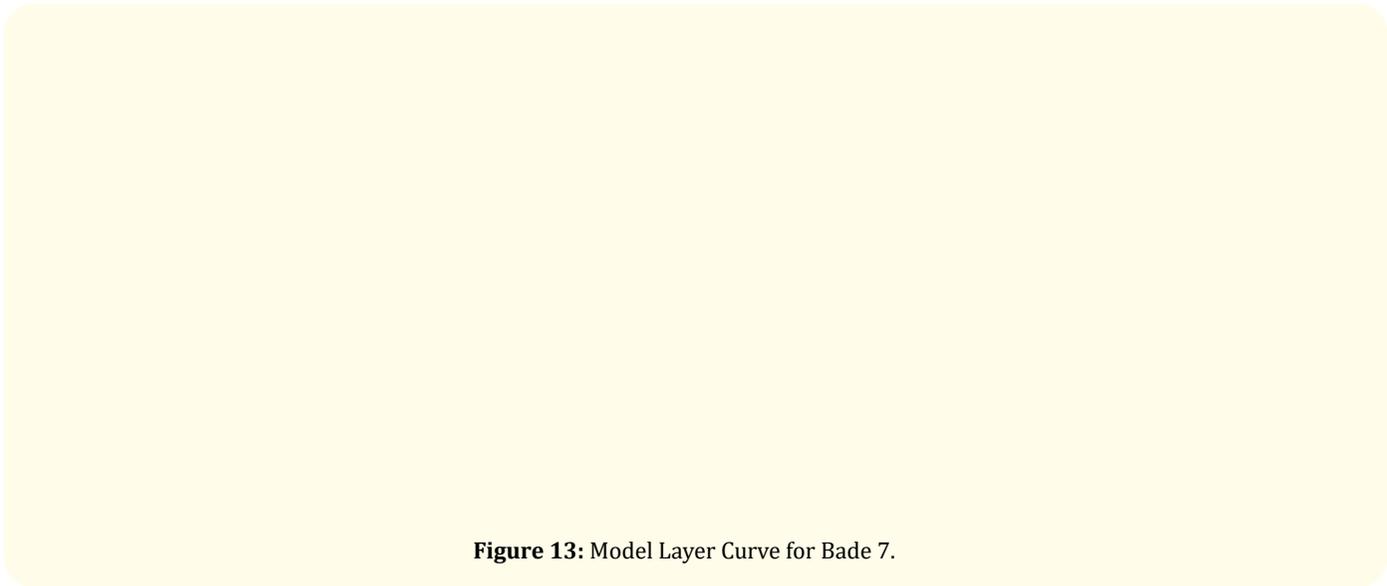


Figure 13: Model Layer Curve for Bade 7.

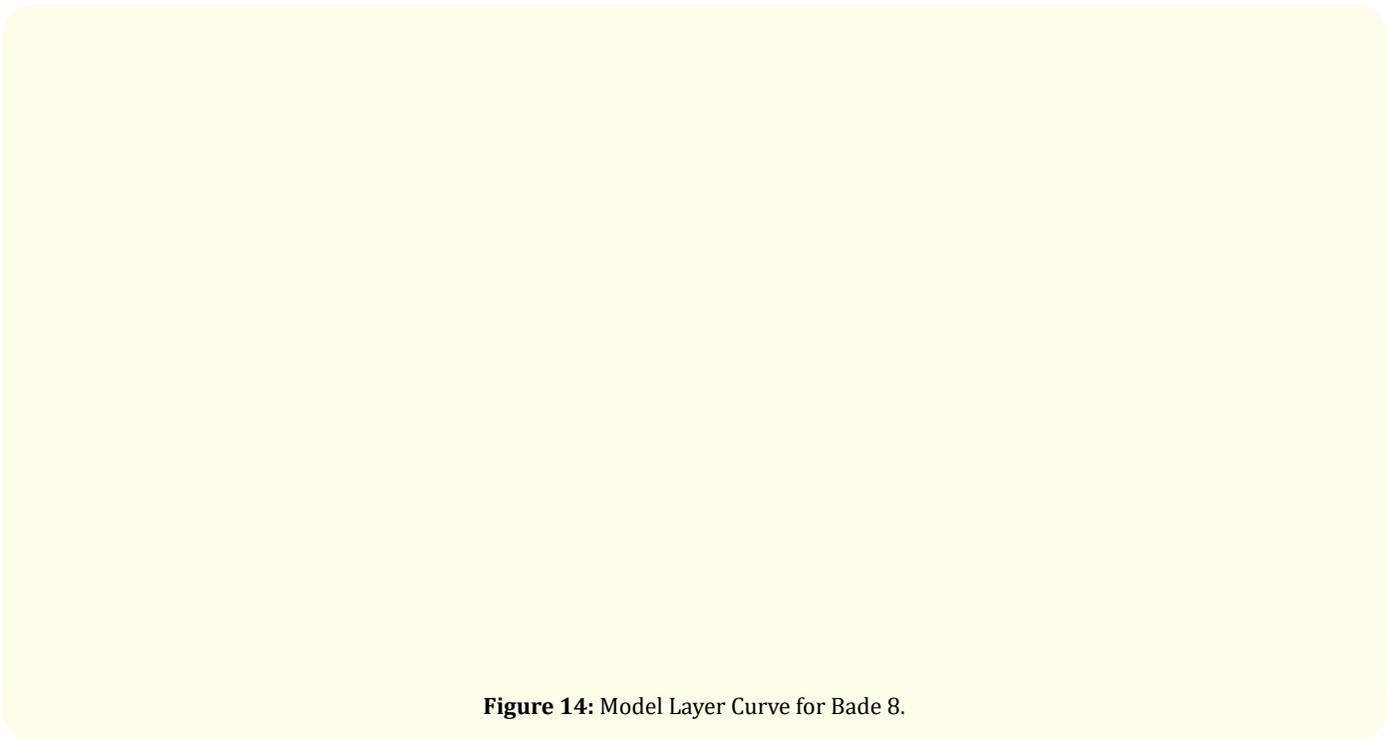


Figure 14: Model Layer Curve for Bade 8.

Discussion

The electrical resistivity survey involves electrical sounding using Schlumberger configuration with ABEM WADI (SAS 300B) Terametre. The potential electrodes remain fixed and the current electrodes are expanded simultaneously about the centre of the

spread. The Schumberger array used, with maximum current electrode separation of 100m-300m electrodes are normally arranged along a straight line, with the potential electrode placed in between the current electrodes. This configuration ranged between $1/3$ and $1/4$ of the total current electrode separation. These

resistivity values were further subjected to computer modelling using the inversion technique.

Because of the geological nature of the study area (sedimentary area), there are resistivity values that shows the structure of the study area which are in layers. The layer parameters: resistivity, depth and thickness for each (VES) point were obtained after a series of iteration to match the field curve with theoretical curves. From the modelled VES data, it was observed that all the seven (7) VES points have four layers. (Figures 2-8). The figures depict the fact that the curve types for the Bade 1-7 Community are mainly Q, KH, K, KHK and QHK respectively. These curves represent a good curve types for the existence of a viable groundwater aquifer.

In apparent resistivity pseudo-section, each observed apparent resistivity value is related to the center point of the spread along the profile and the particular n-value along the vertical. Pseudo-sections were generated by contouring data recalculated along regular grids by triangulation or linear interpolation. The pseudo-sections along profile line N-S across VES 5&3 has a resistivity value range between 23-237 Ω m, profile line N-S across VES 6-2 have resistivity value range of 35-278 and pseudo-sections along profile line N-S across VES (7-1) have resistivity value of 19.3-268 Ω m. The regions in the pseudo-profile showing low resistivity value (mostly the blue and dark color point) signifies the presence of a fluid (mostly water). And it means presence of good water table.

As it goes deeper, the resistivity (apparent) reduces and later rise again as it goes deeper, which may be due to reduction in the size of the grain, since a low resistivity layer exists, or a low resistivity surface water (water log) value exists in the upper layers of the area (in depth), then, grain sizes reduces which may lead to high resistivity value.

Conclusion

The study is the Electrical Resistivity and Physio-chemical Survey Applied to The Study of Ground Water Contamination Around an Old Cemetery in Gashua, Bade Local Government Area Yobe, State, Nigeria. 2D resistivity imaging, vertical electrical sounding (VES) surveys and a detailed physiochemical analysis of water sample from the wells and boreholes surrounding the cemetery was integrated in this study of the level of the groundwater contamination. The results help mapped and delineate the contaminant beneath the surroundings of the cemetery and also

indicate the polluted depth of the contaminants. In the same vein, statistical analyses of the geochemical and physical parameters of some ground water from the well and boreholes located in the precinct of this site has agreed to the contamination status of the site, having elevated concentrations of some macro-elements and heavy metals due to the decomposition of the corpse. The concentration and the flow of all the geochemical elements measured was known from the Atomic Spectrometer. This agreed with flow pattern deduced from the resistivity survey result. The findings in this work are envisaged to provide reliable background information for an elaborate ground water supply in the area. Future studies in this respect may adopt integrated geophysical methods in order to enhance accurate delineation of ground water potential zones in the study area. Nonetheless, this work is to be continued for more and better understanding of the area.

Bibliography

1. Usman R., *et al.* "Assessment and Analysis of the Presence of Heavy Metals in Water in Ara and Laminga of Nasarawa State, Nigeria: Health Implication on the Populace". *The Pacific Journal of Science and Technology* 21.1 (2020): 240-246.
2. Rilwan Usman A M., *et al.* "Health Implication of the Accumulation of Heavy Metals Concentration in Ara and Laminga Water Sources of Nasararawa Local Government Area in Nasarawa State, Nigeria". *NAUB Journal of Science and Technology (NAUBJOST)* 1.1 (2021): 101-106.
3. Usman Rilwan., *et al.* "Heavy Metal Contamination in Swampy Agricultural Soils of Kokona, Nasarawa, Nigeria". *Asian Journal of Applied Chemistry Research* 5.1 (2020): 28-33.
4. U Rilwan., *et al.* "Heavy Metal Contamination and Its Risk for Swampy Agricultural Soils of Keffi, Nasarawa West, Nigeria". *Asian Journal of Applied Chemistry Research* 5.1 (2020): 1-11.
5. Akinbiyi R. "Improving the urban environment". *Africa Health* 15.1 (1992): 112-124.
6. Akpan AY. "Physico-chemical studies on the pollution potential of Itu River, Akwa Ibom State, Nigeria". *World Journal of Agriculture and Soil Science* 5.1 (2004): 1-4.
7. Ali MH and Abdel-Satar AM. "Studies of some heavy metals in water, sediment, fish and fish diets in some fish farms in El-Fayoum province". *Egyptian Journal of Aquatic Research* 31.1 (2005): 261-273.

8. Barber W and Jones DG. "The Geology and Hydrology of Maiduguri, Bornu Province". *Rec. Geol. Surv. Nigeria* 1.1 (1958): 5-20.
9. Barber W. "Pressure Water in the Chad Formation of Bornu and Dikwa Emirates, north-Eastern Nigeria". *Geological Survey of Nigeria* 35 (1965).
10. Breusse JT. "Modern Geophysical Methods for Subsurface Water Exploration". *Geophysics* 28.1 (1963): 633-657.
11. Carter JD, *et al.* "The Geology of parts of Adamawa, Bauchi and Bornu Provinces in North-Eastern Nigeria". *Geological Survey of Nigeria* 30 (1963): 109.
12. Cratchley CR. "Geological Survey of the South Western Part of the Chad Basin". *C.C.T.A. Publ.*, No 31.1 (1960): 1-9.
13. Corry JEL. "Post-mortem ethanol production". *Journal of Applied Bacteriology* 44.1 (1978): 1-48.
14. Dent BB and Knight MJ. "Cemeteries: a special kind of landfill". In: Proceedings of IAH Sustainable Solutions Conference, Melbourne, February 1998. Kenilworth, International Association of Hydrologists (1998).
15. Dent BB. "Hydrogeological studies at Botany Cemetery". Sydney, University of Technology, M.Sc. project report (1995).
16. Duboise SM. "Poliovirus survival and movement in a sandy forest soil". *Applied and Environmental Microbiology* 31.1 (1976): 536-543.
17. Pedley S and Guy H. "The public health implications of microbiological contamination of groundwater". *Quarterly Journal of Engineering Geology* 30.1 (1996): 179-188.
18. O'Brien RT and Newman JS. "Inactivation of polioviruses and coxsackie viruses in surface water". *Applied and Environmental Microbiology* 33.1 (1977): 334-341.
19. Lance JC and Gerba CP. "Poliovirus movement during high rate land filtration of sewage water". *Journal of Environmental Quality* 1.1 (1980): 31-34.