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ARTICLE

Electrical Resistivity Survey on Two Waste Dumpsites at Nguru, Potiskum, Yobe State, Nigeria to Determine the Effect of Leachates on Ground Water Aquifer

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ABSTRACT

The research intends to bring out the contribution of leachate on groundwater in two dumpsites in Nguru and Potiskum all in Yobe state, Nigeria. A total of seven (7) and eight (8) VES by Schlumberger electrode with the use of Wenner electrode configuration. The results were interpreted by the use of WinRESIST for VES and IPWIN2INV for ERT. The study pointed out that, the area in question is comprised of four layers of geoelectric such as the topsoil, clay, sand, sandy clay and sand. The range of the first resistivity layer was from 6.16 Ωm to 332 Ωm in the first geo-electric layer and its thickness range from 2.77 m to 37.7 m and a depth range of 2.77 m to 37.7 m. the range of the second resistivity layer was from 16.5 Ωm to 37.9 Ωm which has the range of its thickness from 4.1 m to 10.7 m. The range of the third resistivity layer was from 101.2 Ωm to 288.2 Ωm which has the range of its thickness from 38.9 m to 99.7 m, and the first aquifer in the area. The range of the first resistivity layer was from 100.7 Ωm to 214.3 Ωm which has the range of its thickness from 28.5 m to 94 m. The fifth layer which is the second aquifer and has resistivity from 254 Ωm to 350 Ωm with a very large thickness. The range of the first resistivity aquifer is from 101.2 Ωm to 288.2 Ωm and the range of the second resistivity aquifer is from 253.8 Ωm to 350.1 Ωm. The 2D ERT profiles unveiled areas with low resistant zones and later discussed as zones penetrated by contaminants originated from dumpsites whereas high resistant zones represent areas of low or non-conductive materials in the area. Data obtained from four dumpsites indicated that leachate of the waste dumpsites penetrated into aquifers and polluted the groundwater. The existence of contaminants in the water was noted by a decrease in the formation resistant values. It is seen, from the results of the survey (geophysical) that the water in the area is polluted and it accounts for the prevalence of any disease related to water that are common in the area.

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1. Introduction

Ground water resources have been under rapidly increasing stress in large parts of the world as a result of pollution. Pollution is primarily the result of irrigated agriculture, industrialization, and urbanization, which generates large wastes, with the large impact on the ecosystem and groundwater [1]. Waste is accumulated universally and is a direct consequence of all human activities. They are generally classified into solid, liquid and gaseous.

Most human activities revolve round ground water, and its quality in a long way affects health and the socio-economic development. Anthropogenic factors contribute highly to contamination of both surface and under ground water [2]. Water contaminants have been mainly biological and chemical in origin [2,3]. The quality of under ground water could be compromised if it is not distant from constant source of pollution. Like many towns in Nigeria, Nguru and Potiskum are faced with the problems of improper collection, handling and disposal of domestic wastes. The number of man's activities has results to increase in volume of solid waste worldwide even though the current level of technological advancement and industrialization. Large growth in the population happened to be one of the major causing factors which resulted in the increase in the municipal solid waste (MSW). Filling of Land with the municipal solid waste is the most common waste management practice and one of the cheapest methods for organized waste management in many parts of the world [4-7]. In most of the low to medium income developing countries, almost 100 per cent of municipal solid waste which are accumulated goes to landfills.

Landfill operations are most feasible in these countries as land is vastly available and moderately inexpensive. Even in many developed countries where land is scarce and where policies of reduction, reuse and diversion from landfills are strongly promoted, great percentage of their accumulated municipal solid waste are still land filled. For instance, in 2006, out of the 251 million tons of MSW generated in the United States of America, 138.2 million tons representing 55% was disposed of in landfills [8]. In England, out of the 29.1 million tons of municipal solid waste generated between 2003 and 2004, 72% was land filled [9]. The scenario is similar in Northern Ireland and Scotland where 82.9% and 85.4% of their generated MSW were land filled in 2005 and 2007 respectively [10,11]. Nowadays, however, there is a successive decrease in the volume of municipal solid waste being land filled in these developed countries on a yearly basis as great efforts in solid waste management are nowadays directed towards waste reduction and recycling programmes which happened to be the real giant step in improving the environmental management [12,13]. Disposal of the refuse occurs all over the world and proves to be a major problem. Careless dumping of refuse and poor management can greatly affect one's health. Pollution from solid wastes always begins with precipitates carrying the leachates into land surface and ends with the water reaching surface water or groundwater. Precipitate on the refuse dumpsite will either infiltrate the refuse or run off over as land flow. During the vertical percolation process (with rain water) the water leaches both organic and inorganic constituents from refuse. Leachates is a fluid that results when water passes through dumpsite fraught with organic matter. It consists of water- and water-soluble compounds in the refuse that accumulate in the dumpsite as water moves through the dumpsite and its harmful contaminants pollute the underlying aquifers [14,15]. Once leachates are formed and release to ground water environment, it will migrate downward through the unsaturated zones until it reaches the saturated zone, the leachates becomes part of the ground water flow system immediately they reach the water table. The extent of pollution is greater in high rainfall areas than less humid and arid areas. Permeable soil permits rapid movement of leachates unlike in less permeable zone.

This study will unveil the effect of leachates on ground water aquifer in two waste dumpsites at Nguru, Potiskum, Yobe State, Nigeria.

2. Materials and Method

2.1 Materials

The materials used for this study of Electrical Resistivity Survey on Two Waste Dumpsites at Nguru, Potiskum, Yobe State, Nigeria to Determine the Effect of Leachates on Ground Water Aquifer are:

i. The Abem Terametre (SAS 1000).
ii. Global Positioning System.
iii. Surface 9.0 golden software package.
iv. 3D field pro software.
v. The WinRESIST version 1.0 software.

2.1.1 Geology and Location of the Study Area

The two dumpsites are located within Nguru and Potiskum L.G.A of Yobe state. They both fall within the western fringes of the Chad Basin and has some rocks of the chad formation underlying it. The Chad Basin is the largest area of inland drainage in Africa [16] occupying about 230000 kilometres-square in the central Sahara and the southern Sudan.

About one-tenth of the basin is situated in the northern part of Nigeria. The stratigraphy and composition of the various formations are discussed [17]. Chad formation is a sequence of lacustrine and fluviatile deposits of clays and sands of Pleistocene age. These sedimentary rocks dip gently and thicken eastward towards the centre of the chad basin [18]. The chad formation consists of three water bearing horizon namely: the upper, the middle and the lower zone [18]. The upper zone provides water for numerous dug wells throughout the rural areas.

2.1.2 Nguru Dumpsite

Nguru or N'Gourou is a local government area in Yobe State, Nigeria. Its headquarters are in the town of Nguru near the Hadejia River at 12° 52' 45''N 10° 27' 09''E. It has an area of 916 km^2 and a population of 150,632 at the 2006 census.

The town probably dates around the 15th century. There is a variety of landscape types in their area, including the protected Hadejia-Nguru wetlands of Nguru Lake and the sand dunes a semi-desert area. The primary occupation of the people is farming and fishing. It also has an old wind mill company.

The dumpsite is located in an area called Hausari Sabonfegi a densely populated area in Nguru town. The post office of the town is just some few meters away from the dumpsite with a cinema viewing centre around it too. Figure 1 shows the google earth image of showing the VES line around the Nguru dumpsite.

2.1.3 Potiskum Dumsite

Potiskum or Pataskum is a local government area in Yobestae. Its headquarters is in Potiskum. It falls at 11°72' 55''N and 10°72'45''. It has an area of 106 km^2 and a population of 240,547 at the 2006 census.

The dumpsite is located at the New Jerusalem settlement in Potiskum. An area where much of the churches in the town are located. Figure 2 shows image sight of the Nguru dumpsite.

2.2 Method

2.2.1 VES Data

Electrical resistivity method is an active and surface based geophysical survey method that employs measurements of electrical potential associated with subsurface electrical current flow generated by a direct current (dc) or slowly varying alternating current (ac) source and the resulting resistances are measured at the surface [19,20]. To determine the subsurface resistivity distribution, measurements are made on the surface.

These measurements involved the measuring of electrical potential associated with the subsurface electric current flow. The transmitting and the receiving electrodes are current and potential electrodes respectively.

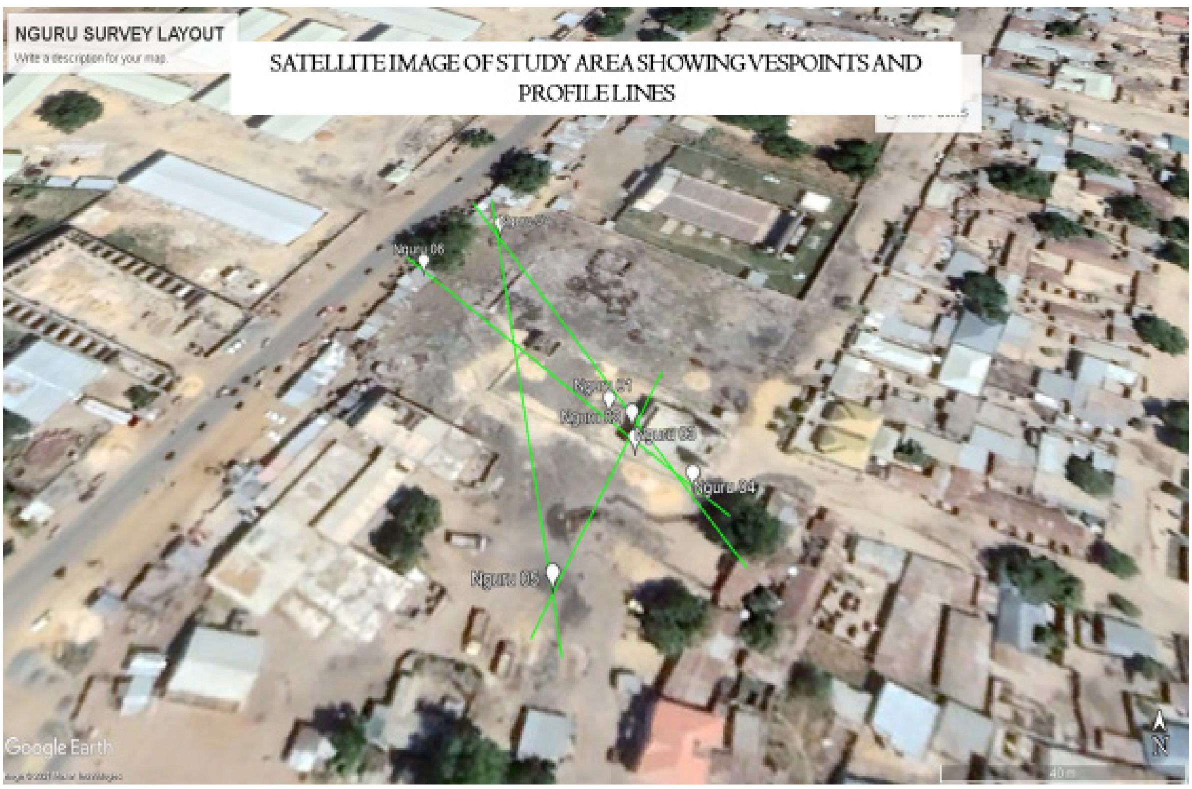

Figure 1. Google Earth Image of Showing the VES Line Around the Nguru Dumpsite.

Figure 2. Image Sight of the Nguru Dumpsite.

2.2.2 Method of Data Collection

A total of twelve (12) electrical resistivity imaging traverse were measured in each of the dumpsites using the Wenner Array configuration with the aid of Abem Terametre. The electrode spacing for each traverse will range from 5 m to 25 m with a station interval of 5 m.

All the traverses run in the N-S direction of each dumpsites with the exception of traverses 11and 12. Traverse 1-10 of the 2D resistivity survey was mapped out within the dumpsite while the control traverses were carried out at 300 m away from each of the dumpsites. In this survey, the parameter was set for four cycle-stacking and a standard error of measurement of 5%. The recorded resistance was then be used to compute apparent resistivity values. The computer modelling was done using the WinResist software, where the calculated apparent resistivity values were processed that would yield a set of geoelectric curves, from the curves, the values of resistivity, thickness and depth of each geoelectric layer were obtained. This was constrained by a borehole lithologic log.

3. Result Presentation and Discussion

3.1 Results Presentation

The data presented in Tables 1 and 2 were used to obtained the interpretations as presented in Figures 1-13.

Table 1. Summarised result from the Nguru geo-electric from the curve profiles.

VES Location	Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Layer Characteristics
Nguru 1	1	6.16	343	3.43	Topsoil/fine grain dry sand
	2	23.4	12.2	15.6	Laterite
	3	106	15	30.6	Shallow aquifer with Saturated coarse grain sand
	4	323			Aquifer with Saturated coarse grain sand
					Consolidated sand
Nguru 2	1	39.81	3.325	3.325	Topsoil/fine grain dry sand
	2	28.9	3.325	12.94	Laterite
	3	37.49	13.02	31	Shallow aquifer with Saturated coarse grain sand
	4	78.64			Aquifer with Saturated coarse grain sand
					Consolidated sand
Nguru 3	1	43.48	3.325	3.325	Topsoil/fine grain dry sand
	2	15.69	9.649	12.97	Laterite
	3	27.21	18.02	31	Shallow aquifer with Saturated coarse grain sand
	4	49.62			Aquifer with Saturated coarse grain sand
					Consolidated sand
Nguru 4	1	23.7	5.31	5.31	Clay sand
	2	19.3	6.93	12.2	Aquifer with saturated grain sand
	3	14.2	20.5	32.7	Consolidated sand
	4	127			
Nguru 5	1	37.3	2.77	2.77	Clay sand
	2	23.9	8.7	11.47	Aquifer with saturated grain sand
	3	41.9	25.4	36.87	Consolidated sand
	4	59			
Nguru 6	1	59.7	3.95	3.95	Clay sand
	2	31.4	11	14.95	Aquifer with saturated grain sand
	3	16	15.1	30.5	Consolidated sand
	4	59			
Nguru 7	1	52.6	4.69	4.69	Clay sand
	2	27.7	10.3	14.4	Aquifer with saturated grain sand
	3	13.6	37.7	37.7	Consolidated sand
	4	53.3			

Table 2. Summarised result from the Potiskum geo-electric from the curve profiles

VES Location	Layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Layer Characteristics
Potiskum 1	1 2 3 4	30.2 77.4 318 111	3.5 1.88 28.7	3.5 5.38 34.08	Clay sand Lateritic sand Clay sand Aquifer with saturated coarse grain sand Consolidated sand
Potiskum 2	1 2 3 4	56 108 395 167	2.57 2.96 34	2.57 5.53 3.96	Clay sand Lateritic sand Aquifer with saturated coarse grain sand Consolidated sand
Potiskum 3	1 2 3 4	26.4 42.2 286 126	3.59 3.74 4.1	3.59 7.33 48.3	Clay sand Lateritic sand Clay sand Aquifer with saturated coarse grain sand Consolidated sand
Potiskum 4	1 2 3 4	107 31 118 417	2.86 5.65 26.5	2.86 8.51 35	Clay sand Lateritic sand Clay sand Aquifer with saturated coarse grain sand Consolidated sand
Potiskum 5	1 2 3 4	65.4 23.2 298 207	1.36 4.55 24.3	1.36 5.91 30.2	Clay sand Lateritic sand Clay sand Aquifer with saturated coarse grain sand Consolidated sand
Potiskum 6	1 2 3 4	34.1 168 116 224.3	3.45 26.3 17.9	3.45 29.75 47.63	Clay sand Lateritic sand Clay sand Aquifer with saturated coarse grain sand Consolidated sand
Potiskum 7	1 2 3 4	20.8 92.2 440 196	2.86 9.71 16	2.86 12.6 28.6	Clay sand Lateritic sand Clay sand Aquifer with saturated coarse grain sand Consolidated sand

3.1.1 Data Interpretation

Leachate from the dumpsite was noted as a big threat to the quality of water in the area. They gradually percolate into the subsurface through the vadose zone and transfer to the aquifers where they contaminate the water. The existence of the contaminants in water was noed by a decrease in the formation resistant values. The range of low resistive zones (deep blue) was from 8 Ωm to 17.5 Ωm and explained as leachate contaminants containing toxic substances.

3.1.2 Result from the Pseudo-Profiles

From the pseudo-profiles produce from the analysis using IPWIN2 software the NW-SE pseudo-profile VES point across points 7, 1, 3 and 4, the resistivity value ranges from 8.86 Ωm to 88.6 Ωm. The dark spot points in the profiles represents regions with very low resistivity value and they are at shallow points of 1 m-4 m.

For the NS-SE pseudo-profile across VES points 6, 1, 3, and 4. Resistivity value ranges 9.41 Ωm to 94.1 Ωm.

For the SW-NE pseudo-profile across VES points 5, 3, and 2, the resistivity value ranges from 16.4 Ωm to 63.1 Ωm.

And lastly for the NNW-SSE pseudo-profile across VES points 7 and 5 with resistivity value range from 17.8 Ωm to 64.9 Ωm. The regions with the low resistivity value are at depths of 37 m-51 m. (very deep).

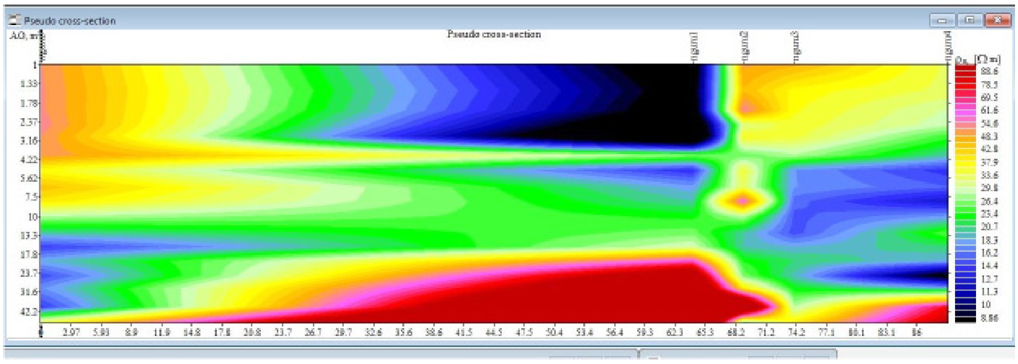

Figure 3. NW-SE Profile across VES Points 1, 3, 4 and 7.

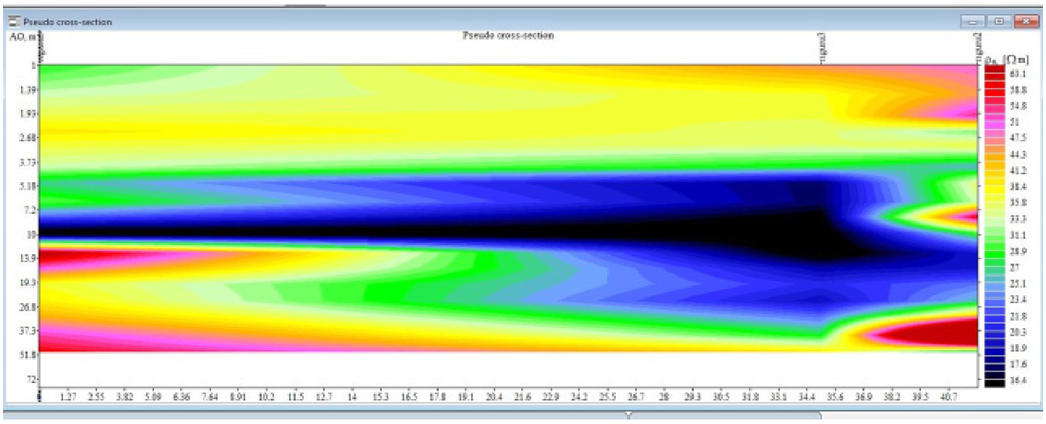

Figure 4. NW-SE Profile across VES Points 2, 3 and 5.

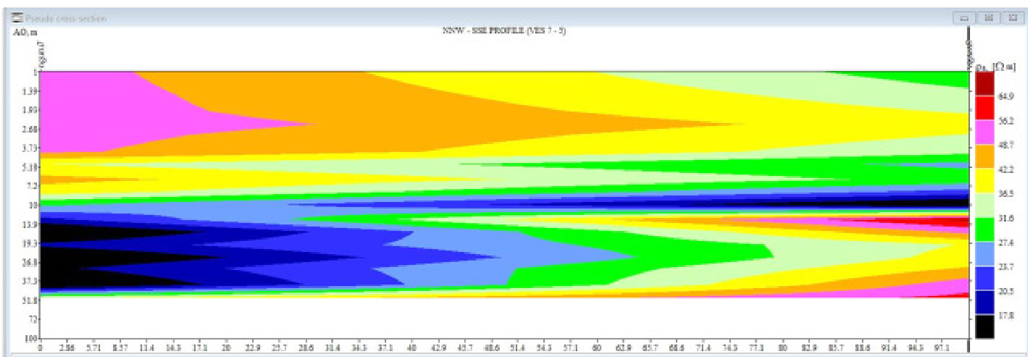

Figure 5. NW-SE Profile across VES Points 5 and 7.

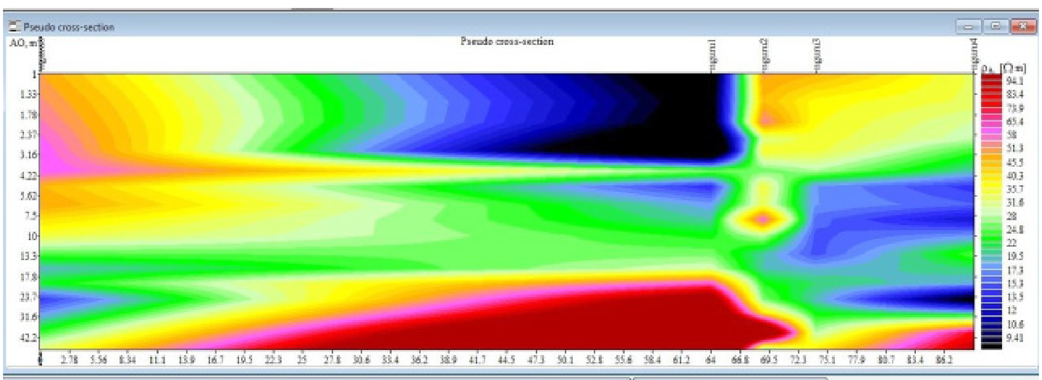

Figure 6. NW-SE Profile across VES Points 1, 3, 4 and 6.

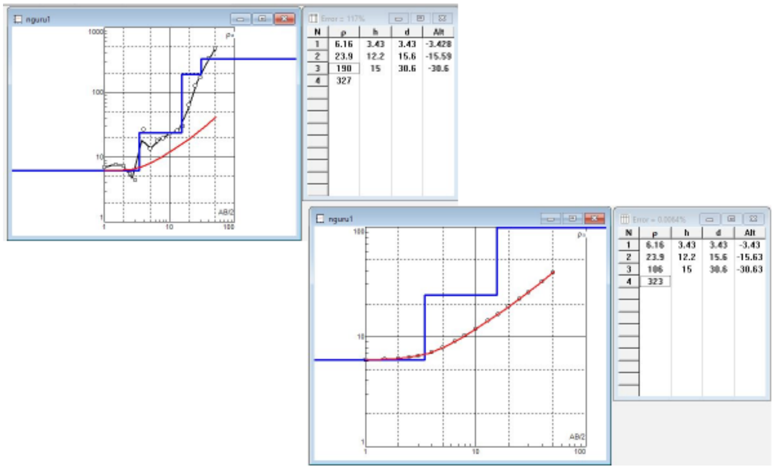

Figure 7. Geo-electric Layer curve Model for Nguru 1.

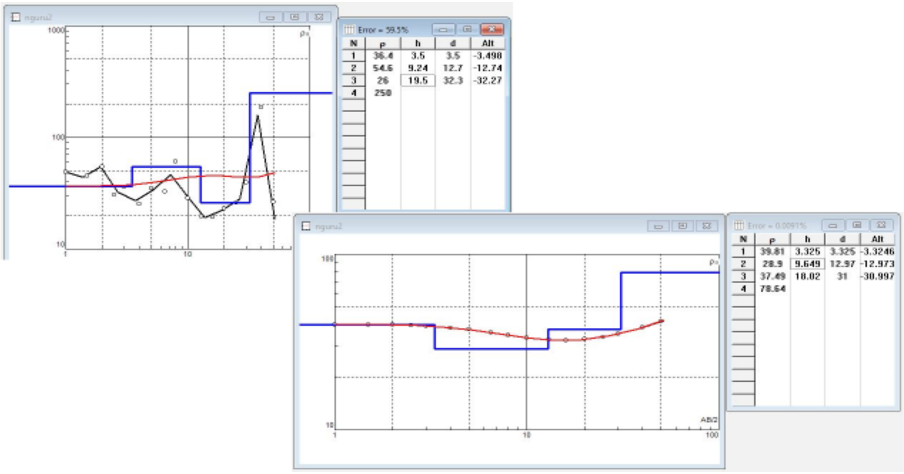

Figure 8. Geo-electric Layer curve Model for Nguru 2.

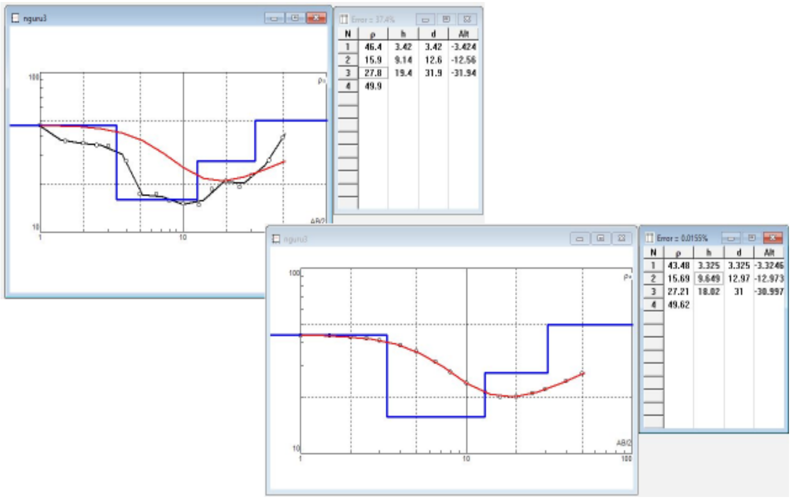

Figure 9. Geo-electric Layer curve Model for Nguru 3.

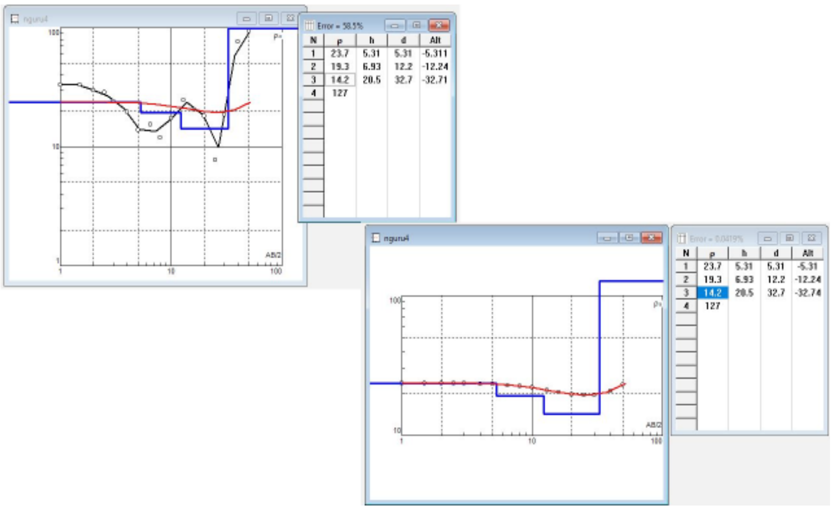

Figure 10. Geo-electric Layer curve Model for Nguru 4.

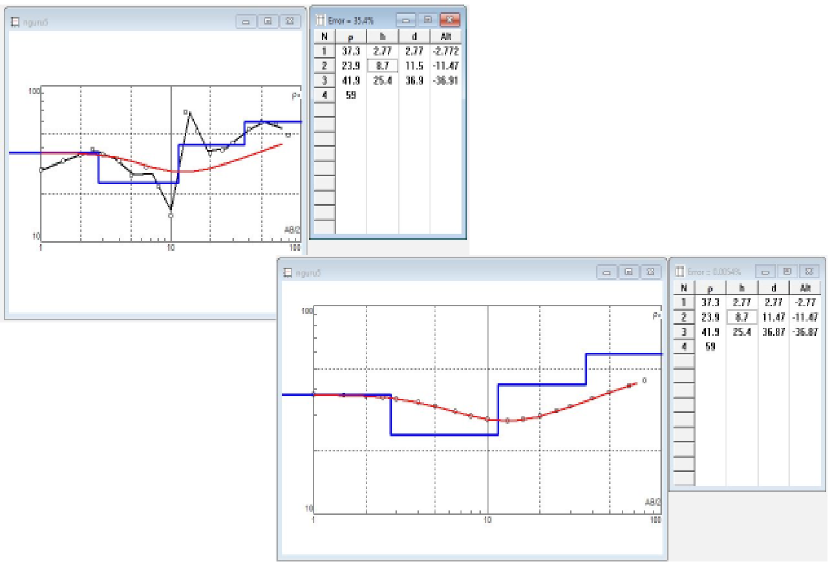

Figure 11. Geo-electric Layer curve Model for Nguru 5.

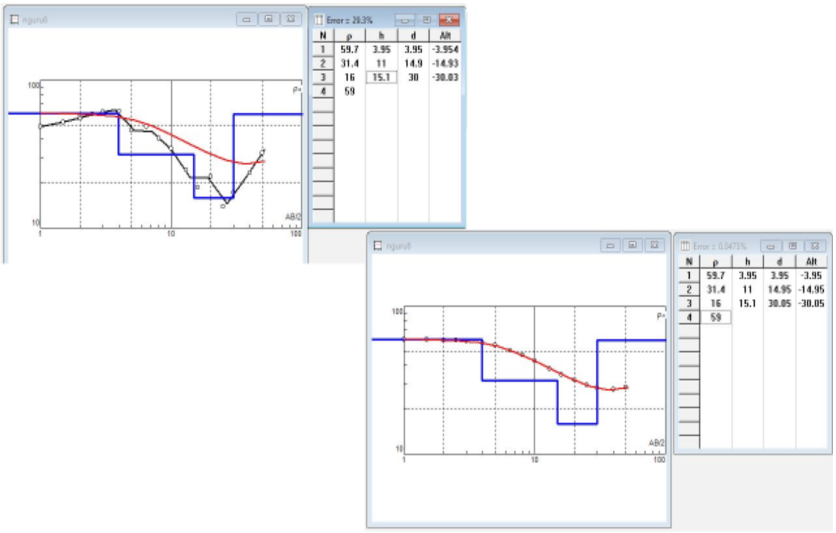

Figure 12. Geo-electric Layer curve Model for Nguru 6.

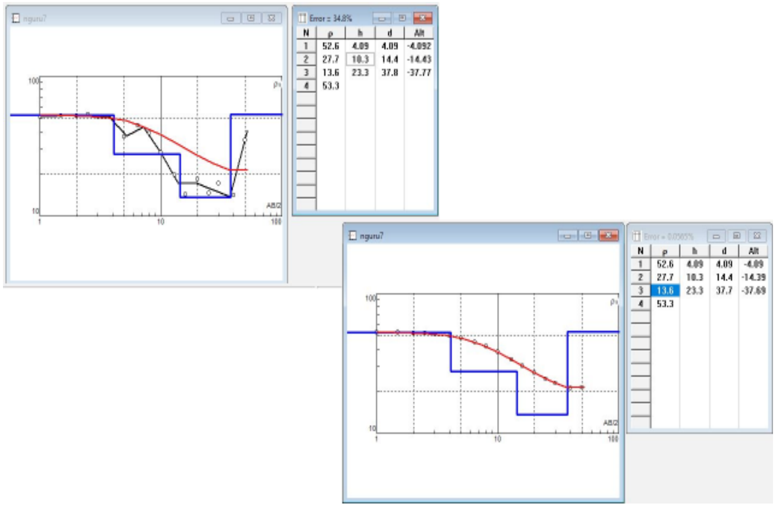

Figure 13. Geo-electric Layer curve Model for Nguru 7.

3.2 Discussion

Figures 7 to 13 show the Geoelectric sections for Nguru VES 1-7 throughout the four dumpsites of the solid waste in the area. To larger extent, the data indicate good correspondence in comparison of layers with the borehole log that exist in the location. The VES data were presented as the resist graph/VES curves (Figures 7-13). Several computations were made to ensure low root mean square (RMS) and accuracy of the data. The data of the VES helped to characterize the subsurface geology of the dumpsites.

The geo-electric layers representation was characterized as (4) four layers (Table 1) for all the (7) VES points, which are; the topsoil, clay, sand, sandy-clay and sand. For Nguru 1 geo-electric layers with four layers, the first layer has a resistivity value of 6.16 Ωm at a depth of 3.43 m, the second layer has a resistivity value 23.4 Ωm at depth of 15.6 m and lastly the third layer has a resistivity of 106 Ωm at a depth of 30.6 m. This geo-electric curve for Nguru 1 clearly shows that the resistivity value increases with depth.

For Nguru 2 geo-electric layers with four layers, the first layer has a resistivity value of 39.81 Ωm at a depth of 3.325 m, the second layer has a resistivity value 28.9 Ωm at depth of 3.325 m and lastly the third layer has a resistivity of 37.4 Ωm at a depth of 31 m. This geo-electric curve for Nguru 2 clearly shows that the resistivity value is low at the second layer which could indicate the presence of good water.

For Nguru 3 geo-electric layers with four layers, the first layer has a resistivity value of 43.48 Ωm at a depth of 3.325 m, the second layer has a resistivity value 15.69 Ωm at depth of 12.97 m and lastly the third layer has a resistivity of 27.21 Ωm at a depth of 31 m. This geo-electric curve for Nguru 3 clearly shows that the resistivity value is low at the second layer which could indicate the presence of good water.

For Nguru 4 geo-electric layers with four layers, the first layer has a resistivity value of 23.7 Ωm at a depth of 5.31 m, the second layer has a resistivity value 19.3 Ωm at depth of 12.2 m and lastly the third layer has a resistivity of 14.2 Ωm at a depth of 32.7 m. This geo-electric curve for Nguru 4 clearly shows that the resistivity value is low at the first layer which could indicate the presence of water at shallow depth.

For Nguru 5 geo-electric layers with four layers, the first layer has a resistivity value of 37.3 Ωm at a depth of 2.77 m, the second layer has a resistivity value 23.9 Ωm at depth of 2.77 m and lastly the third layer has a resistivity of 41.9 Ωm at a depth of 36.8 m. This geo-electric curve for Nguru clearly shows that the resistivity value is low at the third layer which could indicate the presence of water at a very location.

For Nguru 6 geo-electric layers with four layers, the first layer has a resistivity value of 59.7 Ωm at a depth of 3.95 m, the second layer has a resistivity value 31.4 Ωm at depth of 14.5 m and lastly the third layer has a resistivity of 16 Ωm at a depth of 30.5 m. This geo-electric curve for Nguru 6 clearly shows that the resistivity value is very at the first layer which could indicate the presence of water at shallow depth.

And lastly, for Nguru 7 geo-electric layers with four layers, the first layer has a resistivity value of 52.6 Ωm at a depth of 4.69 m, the second layer has a resistivity value 27.7 Ωm at depth of 14.4 m and lastly the third layer has a resistivity of 13.6 Ωm at a depth of 37.7 m. This geo-electric curve for Nguru 7 clearly shows that the resistivity value is very at the first layer which could indicate the presence of water at shallow depth similar to Nguru 6 geo-electric layer.

4. Conclusions

The geophysical data obtained from the area under investigation were analyzed and the results indicated that the leachate from the dumpsites of both in Nguru and Potiskum has penetrated the sandy aquifers thereby pollutes the water in the area. Hand dug well water and drilled boreholes within contamination areas may be the cause of high danger in the water of the area under study. The depth of wells in the area under study is 20 m. Many boreholes were seen in the first aquifer which are unconfined, and this makes them sensible to pollution by leachate from the dumpsites. The 1D VES and 2D ERT data revealed that the aquifers in the area under study are contaminated by leachate from dumpsites solid waste. From the findings presented, it is recommended that deeper drilling and constant monitoring of borehole water should be encouraged, government should enforce environmental protection laws that will prohibit indiscriminate disposal of solid waste material from domestic and industries. Nonetheless, this work is to be continued for more and better understanding of the area.

Conflict of Interest

There is no conflict of interest.

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