Environmental Impact Assessment Of Solid Waste Dumpsite In Emirin, Ado-Ekiti Using Integrated Geophysical And Physiochemical Methods

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***Abstract*—Surface DC resistivity and Physio-chemical techniques have been used to investigate the subsurface and water characteristics around a dumpsite in Emirin, Ado-Ekiti, Ekiti state, Southwestern Nigeria. Schlumberger Vertical Electrical Sounding (VES) and Dipole-dipole resistivity profiling data were acquired around the dumpsite. The VES data were interpreted quantitatively by partial curve matching and computer iteration using WINRESIST. Geoelectric parameters obtained for the sounding curves were used to generate a geoelectric section beneath the study area. The Dipole-dipole data were processed using the DIPRO windows software to generate 2-D resistivity imaging of the subsurface beneath the dumpsite. The geoelectric sections revealed four probable subsurface layers which were considered to be topsoil, weathered bedrock, partly weathered bedrock and fractured/fresh bedrock. The anomalously low resistivity of 14Ωm to 101Ωm in VES 1, VES 2, VES 3, and VES 4 within the weathered layer was interpreted as an evidence of pollution from conductive contaminant plume. The pseudo sections showed several distinct low resistivity zones which extends into the weathered/fractured bedrock. These were interpreted as probable contamination plumes beneath the dumpsite. The Physiochemical analysis of water compared to World Health Organization standard showed elevation in some of the parameters, which might be as a result of the leachate from the dumpsite.**

Keywords—Geoelectric section, Schlumberger, Subsurface, Conductive, Leachate

1. Introduction

The total amount of water in the earth is virtually constant but its distribution over time and space varies to a great extent. Wherever people live, they must have a clean and continuous supply of water as a primary requirement of human beings. The assessment of quality, supply and renewal of water is a well-known problem, but it is becoming critical with the growth of population and rapid industrialization in Nigeria. The rising population in Nigeria of about 140 million requires knowledge of proper waste disposal. Wastes are dumped recklessly with little environmental regards in major cities of many states in Nigeria including Ado-Ekiti which tends to affect ground water quality. Increase in population, changes or improvement in wages, massive expansion of the urban areas and the changing lifestyle or better standard of living, as well as improvement in technology in Nigeria has encouraged waste generation (UNICEF, 2001). Solid wastes commonly known as trashes or garbages are wastes consisting of everyday items we consume and discard. It predominantly includes food wastes, yard wastes, containers, product packaging, and other miscellaneous inorganic wastes from residential, commercial, institutional and industrial resources (Olusunle, 2016). Underground water is the water found beneath the soil. Underground water occurs as a result of rain fall entering into the soil surface. It may also occur as a result of percolation from surface water into the soil. When rain falls to the ground, the water does not stop, some flow along the surface to the streams or lakes, while some are used by plants, some evaporate and return to the atmosphere while some sink into the ground. (USGS, 2014). Obviously, the quest to satisfy human needs and wants and the development have led to the consumption of various commodities and generation of wastes. Moreover, as settlements grow, they become sophisticated due to high rate of urbanization giving rise to increase in waste generation. The disposal of such wastes, if not properly done can result in the contamination of both surface and groundwater. For instance, open dumpsite has been recognized as the major source of groundwater contamination under a wide range of conditions all over the world. The environmental degradation caused by inadequate disposal of waste can be expressed in the contamination of groundwater through infiltration of leachate. In addition, it is argued that landfills are threat to water quality when rainfall percolates through wastes, leaching out a variety of substances which infiltrate into the groundwater thereby contaminating it. The location of dumpsite within an urban environment should be a primary concern particularly where a greater percentage of the population depends on groundwater for their domestic activities (Visvanathan and Ulrich, 2006). The theory of groundwater movement is based on Darcy's law. Where dumpsites are located at levels of higher energy, there is the tendency for leachates to infiltrate the groundwater and flow towards levels of lower energy. This would contaminate the groundwater along its flow path. Making use of such water for domestic purposes without treatment can have deleterious effect on human health. Hence, it is important to carry out groundwater flow analysis before locating a waste disposal site. Groundwater is the major source of freshwater in many urban centers in developing countries like Nigeria. (Obianuju and Efiong, 2015). In Ekiti state, hundreds of boreholes have been drilled in the capital city of Ado-Ekiti, in order to provide the teaming population with potable water. Yet, there are no records to show that this kind of analysis was conducted for Ado-Ekiti metropolis before the open dumpsite was located at Emirin.

2. Methodology

Geophysical and physiochemical techniques were used to study the subsurface area surrounding the dumpsite.

2.1 Geophysical Investigation

Geophysics is simply the branch of science that applies the principle of physics to study the earth. Geophysical investigation involves taking measurements at or near the earth surface that are influenced by the internal distribution of these physical properties. Analysis of these measurements can reveal how the physical properties of the earth varies laterally or vertically, depending on the scale of work, geophysical method can be applied to a wide range of investigation. Electrical Resistivity method of geophysics has been employed for the research. This method involves the use of artificially generated electric current (direct or alternating) introduced into the ground to investigate the variations in the electrical property of the subsurface materials (rocks). The expected variations result in the build-up of varying potentials distributed according to the presence or absence of conducting materials in the earth. The potential distributions generated are those measured from the ground surface which provides information on the form of, and electrical properties of such subsurface in homogeneities. The electrical resistivity method is used to map the subsurface electrical resistivity structure, which is interpreted by the geophysicist to determine geologic structure and/or physical properties of the geologic materials. The electrical resistivity of a geologic unit or target is measured in ohmmeters, and is a function of porosity, permeability, water saturation and the concentration of dissolved solids in pore fluids within the subsurface. Electrical resistivity methods measure the bulk resistivity of the subsurface. Two different electrode configurations of Electrical resistivity investigation were used for this study, and these are Schlumberger Vertical Electrical Sounding and Dipole-dipole for 2-D electrical imaging.

2.1.1 Schlumberger Configuration

The Schlumberger electrode configuration (figure 1) consists of four electrodes (a pair of potential electrodes and another pair of current electrodes) arranged linearly. The potential electrodes remain fixed while the current-electrode spacing is expanded symmetrically about the center of the spread. For large values of AB/2, it may be necessary to increase MN/2.

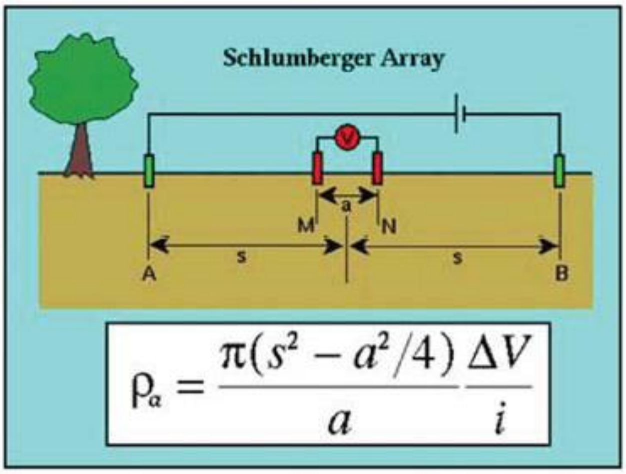

Figure 1: Typical Schlumberger Electrode Configuration

Using half schlumberger configuration, five (5) Vertical Electrical Sounding (VES) were acquired close to the dumpsite so as to delineate the degree of contamination if any. The figure 2 below shows the Vertical Electrical Sounding points on the study location.

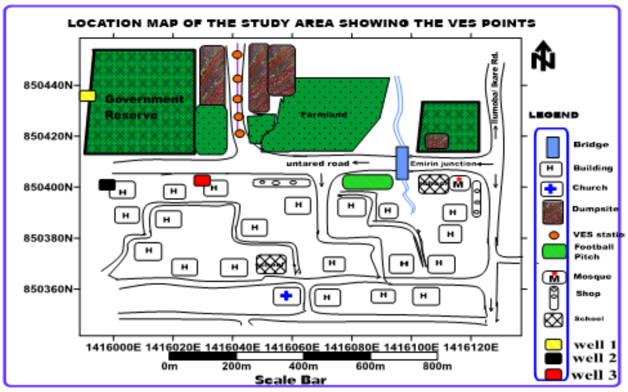

Figure 2: Location Map of the Study Area Showing the VES Points

2.1.2 Dipole-dipole Configuration

The Dipole-dipole configuration (figure 3) is a 2-D Imaging technique that involves the measurement of lateral and vertical variations in apparent resistivity of the subsurface. This array consists of two sets of electrodes, the current (source) and potential (receiver) electrodes. A dipole is a paired electrode set with the electrodes located relatively close to one another; if the electrode pair is widely spaced it is referred to as a bipolar. In this array, the current electrodes are arranged on one side while the potential electrodes are arranged on the other side. The spacing between each set of electrodes is equal. This is not frequently used as it requires more electric currents for its operation than wenner or schlumberger. Figure 4 below shows both the dipole-dipole traverse direction and VES points in the study area. The electrode spacing of 3m was adopted while inter dipole expansion factor (n) was varied from one to five.

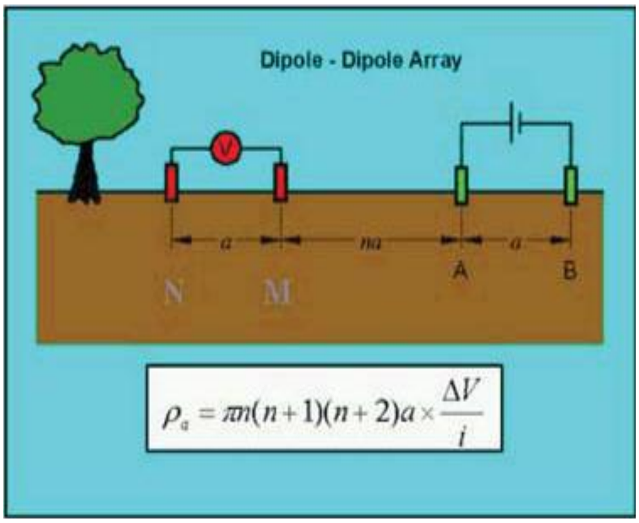

Figure 3: Typical Dipole-Dipole Electrode Configuration

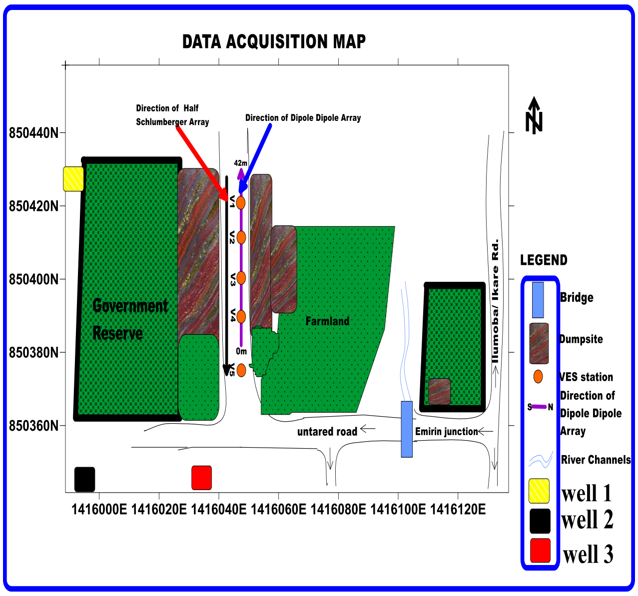

Figure 4: Data Acquisition Map Showing Dipole-Dipole and VES Surveys

2.2 Physiochemical Analysis

The quality of ground water depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. The physical and chemical properties of a freshwater body are characteristic of the climatic, geochemical, geomorphological and pollution conditions (largely) prevailing in the drainage basin and the underlying aquifer. The biota in the surface water is governed entirely by various environmental conditions that determine the selection of species as the physiological performance of the individual organisms.

Water samples were collected at three (3) different wells close to the dumpsite for laboratory analysis. Physical properties of the water such as PH, Electrical conductivity, Hardness, and Temperature were carried out in situ. The water samples were also analyzed for some chemical properties and the results would be compared to WHO water standard. The figure 4 above also shows the positions of the wells relative to the dumpsite.

3. Results and Discussions

3.1 Geophysical Results

Schlumberger

The geophysical data obtained were subjected to qualitative and quantitative analyses. Field data for VES were presented as sounding curves by plotting apparent resistivity ρ_a, against AB/2 (i.e. half the electrode spread length) on a bi-log paper. Curves were generated by partial curve matching and computer iteration using WinResist2 software. The figure 5 below shows the representative VES curves. Also, the table 1 below shows the geoelectric parameters for the VES curves.

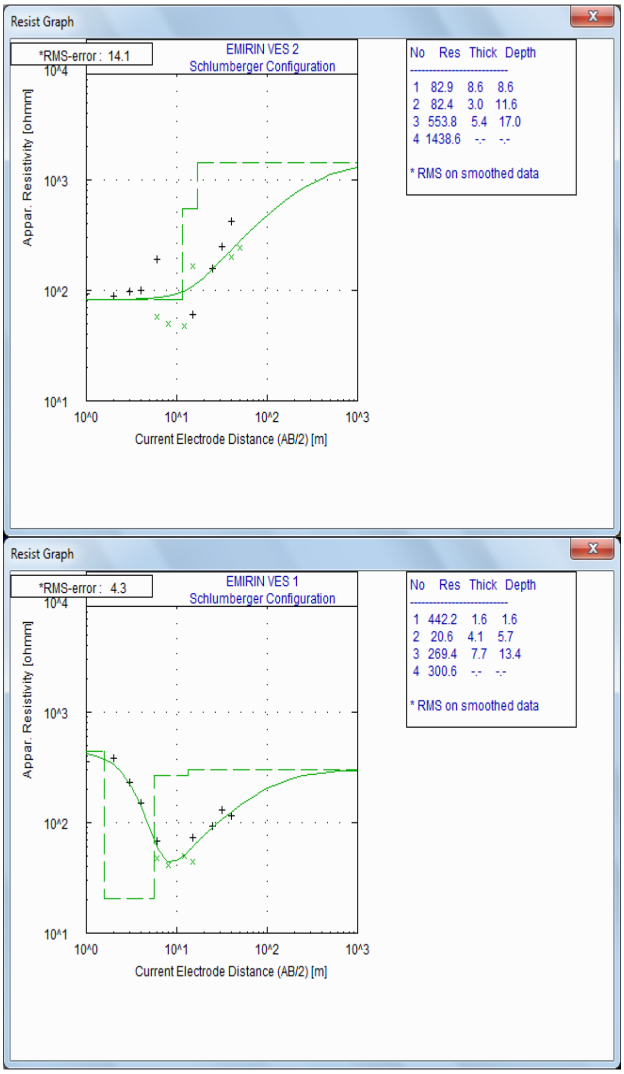

Figure 5: Representative VES curves

Table 1: **Summary of Interpreted VES Curves**

VES NO.	LAYER NO.	RESISTIVITY (Ohm-m)	THICKNESS(m)	DEPTH(m)	LITHOLOGY	CURVE TYPES
1	1 2 3 4	442 21 269 301	1.6 4.1 7.7	1.6 5.7 13.4	Top Soil Weathered Layer Partly Weathered Layer Fractured basement	HA
2	1 2 3 4	83 82 554 1439	8.6 3.0 5.4	8.6 11.6 17.0	Top soil Weathered Layer Partly Weathered Layer Fresh Basement	HA
3	1 2 3 4	161 101 285 2231	7.5 6.0 5.5	7.5 13.5 19.0	Top soil Weathered Layer Partly weathered Fresh Basement	QQ
4	1 2 3 4	234 651 14 824	1.0 1.4 7.4	1.0 2.4 9.8	Top soil Partly weathered Layer Weathered Layer Fresh Basement	KH
5	1 2 3	176 232 859 39	7.0 3.1 9.0	7.0 10.1 19.1	Top Soil Partly Weathered Layer Fresh Basement Fractured basement	AK

Geoelectric section that reveals the vertical and lateral variations in resistivity was produced along the Vertical Electrical Sounding traverse. Figure 6 below shows the geoelectric section along the trave

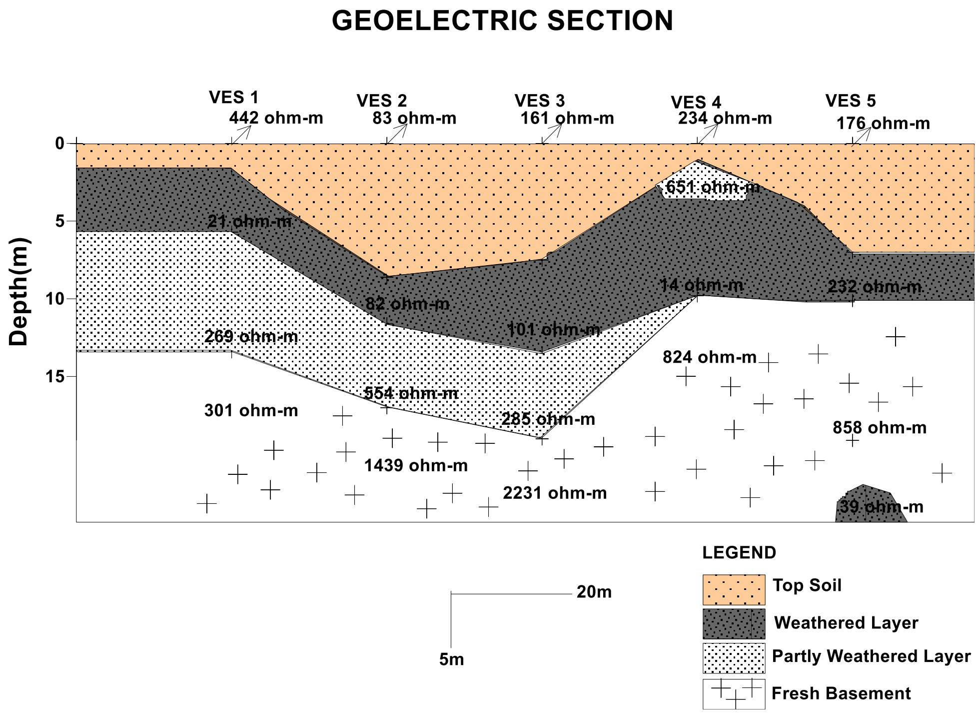

Figure 6: Geoelectric Section along VES Traverse

The VES geoelectric section (Figure 6) is 120 m long and relates VES 1, 2, 3, 4,and 5 in the NW-SE direction. Four distinct geoelectric layers are identified on the section. The first layer with resistivity values varying between 83 and 442Ωm and the layer thickness values range between 0 and 8m was associated with the topsoil. The second layer with resistivity values ranging between 14 and 232Ωm and depth to base of the layer ranges between 2m and 12 m was referred as the weathered zone. This is usually the groundwater interval. The third layer was taken as the partly weathered bedrock with layer resistivity values range between 269 and 651 Ωm within the depth of 6m-16m. The forth layer was taken as the fresh with layer resistivity values range between 301Ωm and 2231 Ωm with the depth of 14 and 20m below the surface.The low resistivity characteristics of the weathered layer beneath VES 1,2,3,4 (14Ωm to 1439Ωm) points have been attributed to the presence of conductive contaminant plume. VES 5 possess a higher resistivity which varies from 176Ωm to 858Ωm.

Dipole-Dipole

The dipole-dipole values were plotted and presented as pseudo sections, a 2-D resistivity structure were generated using the DIPRO windows (2001) software. Figure 7 below shows the pseudo section.

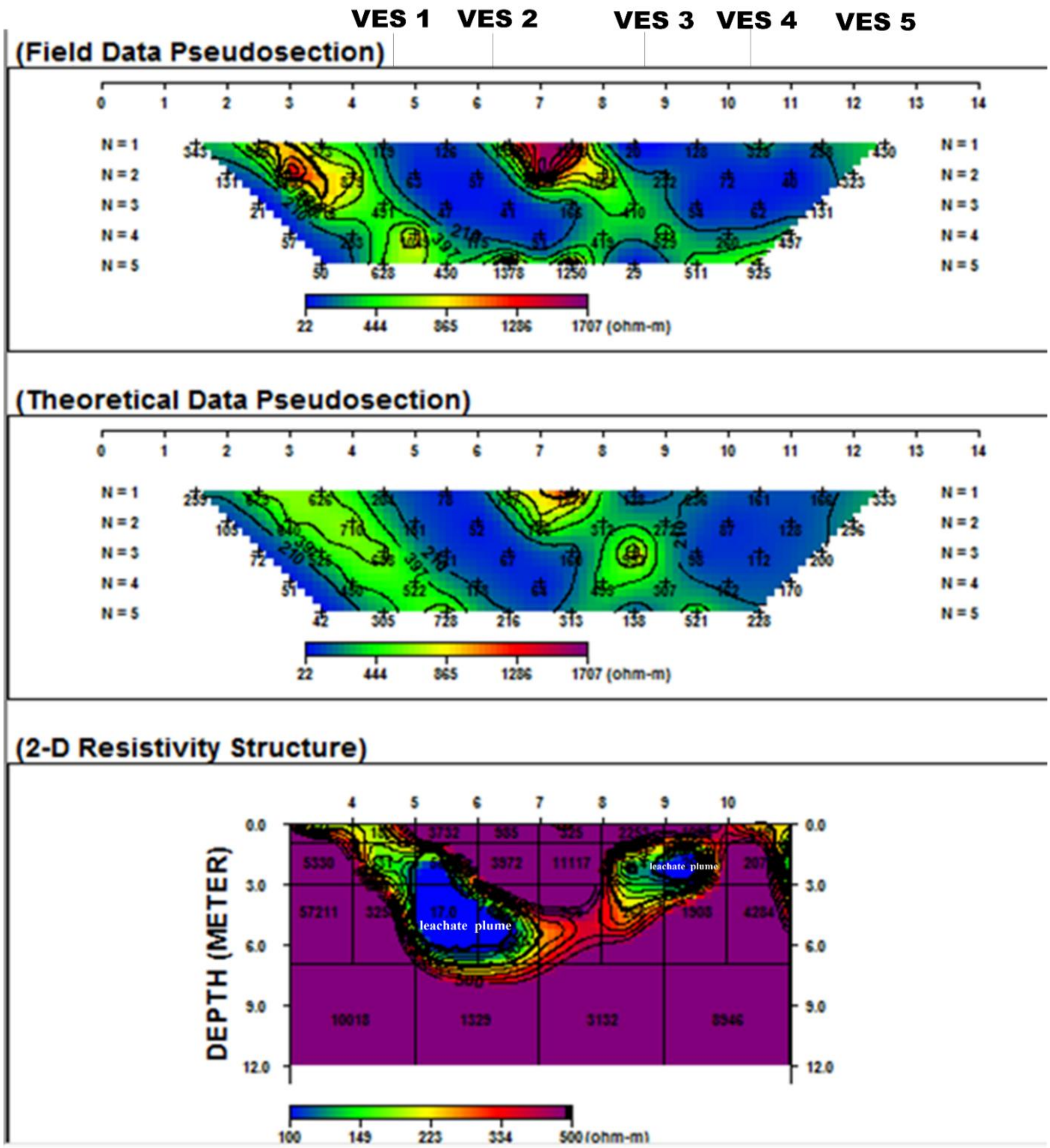

Figure 7: Pseudo section and 2 -D resistivity results from Dipole-Dipole

The 2-D resistivity structure reveals relatively low resistivity (bluish zones) values in the range of 5 and 17Ωm typical of contamination zones (Adepelumi *et al*., 2005; Bayowa *et al*., 2012) between stations 5 and 7 at a depth range between 2m-6m and stations 9 and 10 at about 3m depth. At the depth of detection of the plumes, it is apparent that groundwater is contaminated.

3.2 Physiochemical results

The results of physiochemical analysis of water samples of three major active wells around dumpsite in Iyana Emirin are presented in the table 2 below.

Table 2: Physiochemical Parameters compared to WHO Standards

S/N	PARAMETERS	WELL 1	WELL 2	WELL 3	WHO STANDARDS
1	Ph	6.8	6.7	6.7	6.0 – 8.5
2	Conductivity (µs/cm)	110	90	130	1000
3	Temperature (ºC)	35.3	29.2	28.8	Not Given
4	Dissolved solid	150	30	185	Not Given
5	Suspended solid (mg/L)	90	10	110	Not Given
6	Total solid (mg/L)	240	40	295	500
7	Total alkalnity (mg/L)	70	30	100	Not Given
8	Ca hardness (mg/l)	50	20	20	200
9	Mg hardness (mg/l)	20	60	90	50 - 150
10	Total Hardness	70	80	110	500
11	Cl^- (mg/l)	35	75	50	250
12	SO_4^{2-} (mg/L)	25	26	75	250

Magnesium Hardness

Magnesium concentration in sample 2 and 3 is a little high indicating that the traces of magnesium in the wells are high with a range value of 60 - 90 mg/l. This value is above the WHO's standard of 50 mg/l but the value of sample one is very low with a value of 20 mg/l. Therefore the water in well two and three requires treatment before consumption.

Calcium Hardness

The concentration of calcium in the three wells is below the requirement of WHO standard of 75 mg/l.. The water therefore has to be treated properly before consumption (Table 2). This is to meet the permissible range of WHO and due to the importance of calcium to the body of both plant and animal.

Total Hardness

The average hardness from Table 2 is 86.7mg/l. the highest value is from sample 3 which is 110 mg/l, while sample 1 has the least value which is 70.00mg/l. The presence of concentrated magnesium and calcium is consistent with the level of the hardness observed based on the values from the analysis. Comparing this with the (WHO) standard, that is 500.00mg/l, it still falls within the range of the standard. Effect of hardness would be excessive usage of soap, precipitate form on hardware and in pipeline which increased temperature and PH.

Ph Value

Little variation occurs in PH of different sample and this might be as a result of acidic effluent which permeates into the well. The PH of the samples is within the range of 6.5-6.8 mg/l, and as shown in Table2 this specifies that the water is alkaline and the value is still within the range of the (WHO) standard for drinking water which is between 6.5 – 8.5,and the water is good for human and plant usage. Low PH in ground water is caused by the presence of CO_2 generated by microbial process. The effect of this value supports the growth of algae, the value is also optimum (best) range for fish eggs.

Electrical Conductivity

Conductivity is affected by the presence of dissolved ions in water. From Table 2, all three samples are of less conductivity from the analysis, with a value range of 90-130 µs/cm which is less than that of the WHO standard.

This property is related to the hardness of water because the more dissolved ions (such as Ca2+, Mg2+, etc.) that are present in a water sample, the more would be its conductance and hence its hardness. Conductivity is an invaluable indicator of the range into which hardness and alkalinity values are likely to fall, and also of the order of the dissolved solid contents of the water. Total dissolved solids and conductivity can be used to delineate each other. Conductivity is proportional to the dissolved solids. Both showed analogous trend in all the sites.

Chloride

Chloride's concentration is within the WHO's standard of (200 mg/l). The average concentrate is found to be 138.10 mg/l. It is highest in sample2 with (75 mg/l) and least in sample 1 with (35 mg/l). This means that the water has a low salinity.

Alkalinity

Alkalinity in water should be sufficient to enable a balanced and stable formation with chemical coagulation but this should not be too high as to cause psychological stress to consumer.

The observed alkalinity was in conformity with the standard level of the World Health Organization (WHO) for domestic water supply and agricultural use.

Sulphate

Sulphate concentration also affects the taste of water. From Table 2, the Sulphate ion has an average value of 14.67mg/l of the total sample. Sample 3 has the highest value with 75mg/l and sample 1 has the least value of 25. Mg/l from Table 2, the (WHO) standard for Sulphate ions is 200mg/l, this shows that the Sulphate ion are still within the standard.

Temperature

The temperatureof thesamples ranges from 27^{0C} to 36^{o}c. there is no guideline value for temperature as it mainly depends on the ambient conditions. Hot water is not generally palatable. Temperature affects the state and level of other parameter including conductivity.

Bacteriological activity is also affected by temperatures. Warm temperature, gives rise to accelerated bacterial activity that can cause odour resulting from depletion of oxygen as a result of bacterial oxidation of organic and nitrogenous compounds that may be present in water.

Total Solids (Both Dissolve And Suspended Solids)

TS can be taken as an indicator for the general water quality because it directly affects the aesthetic value of the water by increasing turbidity. The acceptable range of TS is 500 mg/L. Regarding the values of TS, all the water samples showed less presence of contaminants, as the value range of TS of analyzed water samples varied between 40 to 300mg/L as shown in Table 2. The highest TS value was observed at well 3 and this might be due to its closer distance, as the sample 3 is closer to the dumpsite. However; all the values falls within the standard limit of WHO (500 mg/L). The results of both TSS and TS showed that the drinking water would not cause health problem to the consumers.

4. Conclusion and Recommendations

4.1 Conclusion

Solid waste disposal is considered as one of the main environmental problems. Most of the generated solid waste amount to household waste and is buried in landfill or dumpsite. The dumped solid waste produce large amount of leachate that can contaminate groundwater and becomes a potential harm to the environment. This would adversely affect industrial and agricultural activities that depend on groundwater.

This study has employed Schlumberger VES and Dipole-Dipole electrical profiling techniques to map the surface and delineate possible contamination of the groundwater in the vicinity around Emirin-dumpsite in Ado-Ekiti, Southwestern Nigeria. The interpretation of the data has provided information as regards the subsurface geoelectric layers, the bedrock topography, groundwater potential and possible groundwater contamination in the study area. Four geoelectric layers were identified and were depicted as the topsoil, the weathered layer, the partly weathered layer and the fractured/fresh basement.The geoelectric curve types indicate high groundwater potential in the area.

Distinct low resistivity zones corresponding to contamination plumes were delineated from the dipole sections within station 5 and 7at depth 2m to 6m (weathered layer from geoelectric section), these stations were depicted as VES 1 and VES 2 in Schlumberger array. Similar result were also observed within station 9 and 10 (VES 3 and VES 4), this low Resistivity (14ohm-m –110 ohm-m) within the weathered basement and the bluish zone (as shown in fig 4.5 above) shows evidences of pollution from the contaminant. The fractured basement beneath VES 5 which possess a higher resistivity and the Characteristics of a good aquifer unit is under a threat of being contaminated due to its interconnection with the polluted fractured zones. The mode of migration of contaminant plumes was also identified to be independent of the layers overlying the polluted fractured basement.

Furthermore, physicochemical parameters of pH, EC, TH, TS, TSS, TDS, Ca^{2+}, Mg^{2+} , Cl^- ,SO_4^{2-} ,carried out on water samples from the study area shows that almost all the measured parameters were within the standard drinking water quality given by World Health Organization. But the concentration of Mg^{2+}, in well 3, which was the closest to the site was found a little bit higher than standard value of World Health Organization, which suggest the presence of dissolved salt, probably from the dumpsite, the sample should therefore, be well treated before usage.But the total hardness varied in between 80 to 110 mg/L which indicates that water in the study area is moderately hard.

In addition to this, the level of TH, TS, TSS, TDS, Ca^{2+}, Mg^{2+} , Cl^- ,SO_4^{2-} in well 3 was also found higher, but within the maximum permissible limit of World Health Organization, which indicate that the level of these parameters will likely increase in time to come. In general the present investigation found that the well water is not highly polluted, this is due to the fact that, the dumpsite has not spanned more than five (5) years.

4.2 Recommendation

Based on the results obtained from both geophysical and physiochemical analyses of samples from Emirin Dumpsite in Ado Ekiti, the following are hereby recommended;

- People should desist from carrying out activities such as reckless dumping of wastes which could seriously threaten surface and groundwater in the vicinity.
- Since the wetlands in the vicinity of this dumpsite could promote leachate migration especially during the rainy season, this could as well lead to severe contamination of the groundwater resources of the area, so more proper analysis should be carried out before consumption.
- Citing of a dumpsite should be far from residential area.

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