

GEOELECTRIC AND PHYSIOCHEMICAL METHODS TO CHARACTERIZE SUBSURFACE CONTAMINATION IN PART OF KOLOKUMA/OPOKUMA ENVIRONS, NIGER DELTA, NIGERIA

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ABSTRACT

Three (3) Vertical Electrical Soundings (VES) were carried out using Schlumberger array to obtain geophysical data in the study location, acquired with the ABEM SAS 1000 terrameter earth meter, to characterize contamination in relation to the depth and thickness of viable aquifer of the subsurface lithology. Two (2) water samples were collected from the study area, analyzed to determine the concentration of contaminant, using the Atomic Absorption Spectroscopy (AAS). Result revealed high contaminant contents of Cobalt (Co) as 0.3015 mg/kg in sample A and 0.2439 mg/kg in sample B, exceeded the World Health Organization (WHO) permissible limit, which indicates that aquifer is likely below 2 m down the subsurface, may likely be polluted and geoelectric layers of topsoil, sand and clay traces. It is advisable to carry out proper water treatment from source; for potable drinking water, and the result clearly show that the geophysical and physiochemical method was very effective for the interpretation of the contamination in subsurface.

Keywords: Aquifer, Contaminant, Electrical, Concentration.

INTRODUCTION

In nature, water occurs in oceans, ice and glaciers, underground and on land. However, fresh water is constantly recharged through hydrological cycle. It controls the temporal and spatial distribution of water in the form of evaporation, precipitation and runoff. Ground water recharge is the process by which water percolates down the soil and reaches the water table, either by natural or artificial methods. The quantity and the rate of ground water recharge is naturally depends on efficient ground water resource management. Water is a key resource for Industrial and economic development. It is used for drinking, recreation, use in industry and growing crops. It also plays important role in sustaining the natural systems (Mishra and Pandey, 2008). The electrical resistivity technique is a geophysical tool for groundwater studies and can be used to determine the quality of groundwater and determine the aquifer thickness and depth to bedrock as well as to decipher the superficial stratification of subsurface layer. The method is routinely used in Engineering, Archeology, Environment, Mineral exploration, and Hydro-geological investigation to determine the shallow sub-surface geology (Keary and Brooks, 2002). Consequently, it has become imperative to carryout aquifer vulnerability assessment in order to predict areas at potential risk of contamination. Such vulnerable zones could then be forced with restricted land use or become a focus of

attention at preventing contamination of the underlying groundwater resources. Several studies on aquifer vulnerability have revealed that the protection of aquifer hinges on the permeability of the overlying media to the transportation of contaminants into underlying aquifer units (Dobrin and King, 1976). Metal pollution in groundwater is governed by the several aspects including the level of weathering of the different rock, quality of the aquifer and effect of the peripheral pollution sources that ultimately, create complex groundwater chemistry (Aksever *et al*, 2016).

THEORY OF ELECTRICAL RESISTIVITY METHOD

The direct current resistivity method uses a man-made source of electrical current that is injected into the earth through grounded electrodes. The resulting potential field is measured along the ground using a second pair of electrodes. The field between the electrodes is distributed only near the surface when the electrodes spacing is close but the electrical flux flows deeper when the electrodes are further apart (Griffiths and Barker, 1993). The flux will crowd into the more conducting layers and will not in the more resistive layers. Resistivity is best understood if thought of as a volume or bulk resistance measurement. It is based on Ohms law which is usually written as (Keller and Frischknecht, 1966).

$$V = IR \quad (1)$$

Where for a linear element is potential difference (V) in Volts, the electrical current (I) in Amperes and Resistance (R) in Ohm's. If a conductor carries a current over a cross sectional area (A) then its resistivity (ρ) is given by; (Keller and Frischknecht, 1966).

$$\rho = \frac{RA}{L} \quad (2)$$

Where R is the resistance measured between two surface separated by a distance (L). And the total current over the area (A) is given by (Keller and Frischknecht, 1966).

$$I = \frac{V}{R} \quad (3)$$

$$I = \frac{VA}{\rho L} \quad (4)$$

Making the resistivity the subject of the formula it yields:

$$\rho = \frac{VA}{IL} \quad (5)$$

The apparent resistivity is the result of combination of the resistivity of various materials that made up the subsurface at that point of measurement. Therefore, the expression becomes

$$\rho = \frac{VA}{IL} \quad (6)$$

and it can be written as:

$$\rho = KR \quad (7)$$

where R is from ohm's law, and K is the geometric factor depending on the electrode arrangement. Thus, based on the knowledge of the resistivity of a material, deductions can be made about the lithological structure of the subsurface.

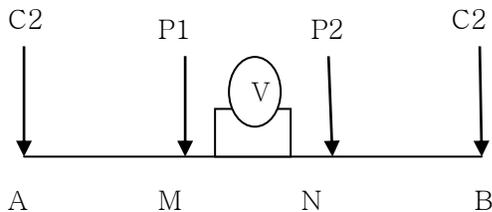


Figure 1: Schlumberger array

GEOLOGY OF THE STUDY AREA

The study area (Fig. 2) is within the basement complex terrain of Igbedi in Kolokuma/Opokuma local government area of Bayelsa State with coordinates of latitudes $7^{\circ}15'$ and $7^{\circ}09'N$ and longitude $3^{\circ}37'$ and $3^{\circ}61'E$.

METHODOLOGY

Geochemical

Atomic Absorption Spectroscopy (AAS) was used in this study, because of accessibility, high specificity, and simple sample preparation, ease of operation and low detection limits. The AAS technique involves the absorption by free atoms of an element of light at a wavelength specific to the element of interest, from which concentration of metals are measured. Water samples were collected into bottle container from an existing close by borehole for analysis in the laboratory, using the Atomic Absorption Spectrometer (AAS) machine to identify trace metals.

Geophysical Techniques

The electrical resistivity technique was adopted, using Schlumberger array, where $AB > 5MN$, moved along the profile. Three (3) vertical electrical sounding (VES) with Schlumberger electrode configuration was carried out in the study area, with a spread length of 200 m at each station. The field works required two current electrodes (C1 and C2), two potential electrodes (P1 and P2) into the ground, and the ABEM terrameter (SAS1000) for taking data readings as shown in Figure 1. Geoelectrical sounding data was calculated and analyzed digitally using IPI2WIN (1D resistivity sounding interpretation) software, used to model the field data in order to get the corrected resistivity values, thickness, depth, likely lithology and r.m.s. error.



Figure 2: Map of the Study Area

RESULTS AND DISCUSSION

Table 1: VES Interpretation Result

VE S	GEOELECTRIC LAYER	RESISTIVITY (Ω m)	DEPTH (m)	LITHOLOGY	REMARKS
1	1	2159	0	Top soil	Most likely that the clay is wet with saline water.
	2	0.3	0.5	Clay	
	3	6581	1.7	Sand	
2	1	0.03	0	Top soil	Most likely wet with saturation fresh water.
	2	111	0.5	Sandy clay	
	3	31	28.9	Clay	
3	1	430	1.02	Top soil	Layer 2 is most likely dry while 3 is saturated with fresh water.
	2	8326023	0.5	Sand	
	3	2905	1.64	Sand	

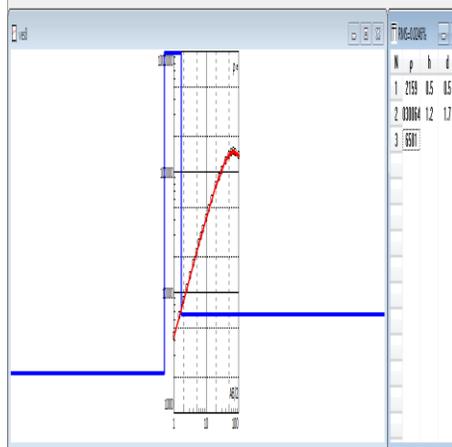


Figure 3: VES 1 geoelectric section

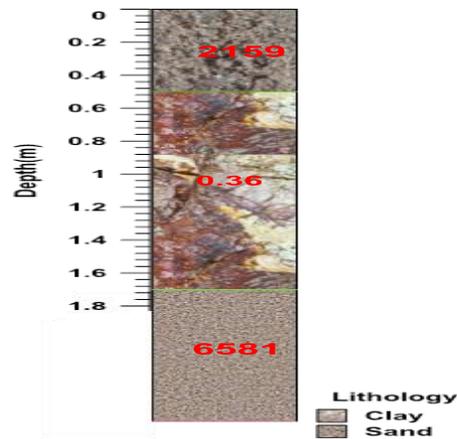


Figure 4: VES 1 Lithology

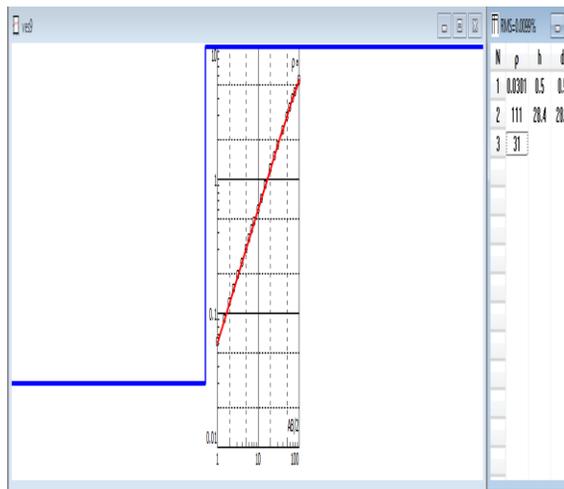


Figure 5: VES 2 geoelectric section

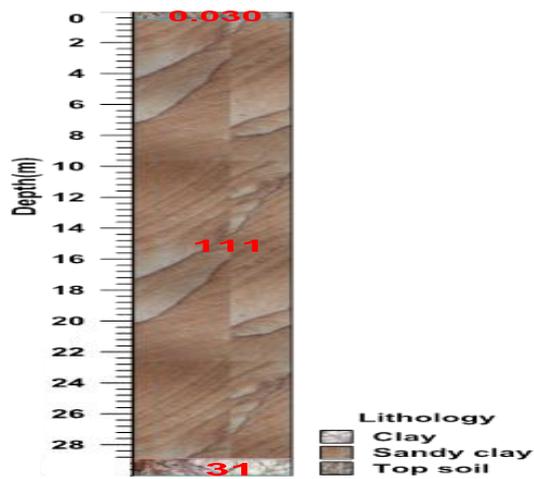


Figure 6: VES 2 Lithology

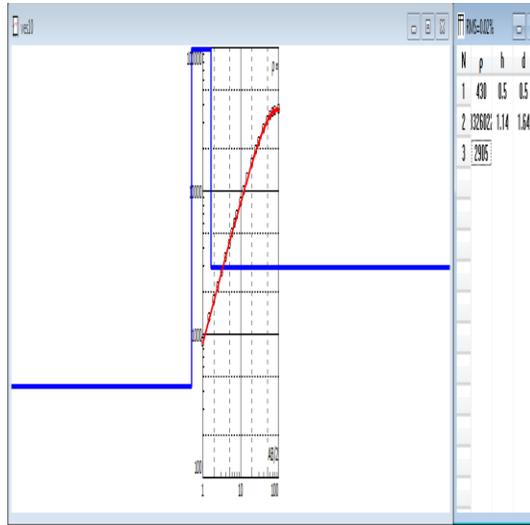


Figure 7: VES 3 geoelectric section

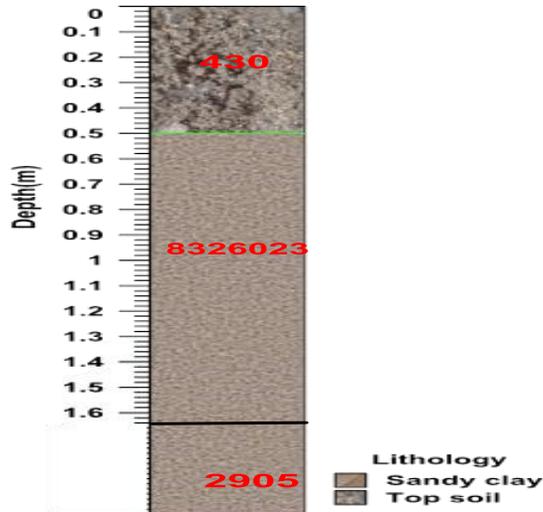


Figure 8: VES 3 Lithology

Table 2: Descriptive Statistics of Heavy Metals in the Study Area

Trace Metals	Sample A Actual concentration (ppm)	Sample B Actual concentration (ppm)	WHO limit on Actual concentration (ppm)
Zinc (Zn)	-0.9637	-0.9020	2.4
Nickel (Ni)	-0.0709	-0.0760	0.01
Manganese (Mn)	-1.8981	-1.9070	0.1
Lead (Pb)	-0.3323	-0.3263	0.01
Iron (Fe)	0.0034	-0.1834	1.00
Copper (Cu)	-0.1310	-0.1303	2.00
Cobalt (Co)	0.3015	0.2439	0.05

Geoelectrical method was carried out using Schlumberger array. The results of the study area as presented in Figures 3-8 and Tables 1 and 2, shows that the data were carried out at three (3) VES station which was converted into apparent resistivity by multiplying the resistant with the geometric factor, K and it was interpreted using the IPI2WIN software; the modeled curves obtained the interpretation of the field data revealed the presence of three (3) geoelectric layers in the subsurface, reflected that the plain was characterized by horizontal variations. The geoelectric layers are topsoil, clay, sand and sand mixed with clay, with resistivity values ranging from (0.529-2194508) Ωm . The apparent resistivity values are obtained by increasing the electrode spacing about a fixed point are plotted in a log to log scale against half the electrode spacing (AB/2) in order to get a few resistivity curves.

VES 1, showed sounding curve of Ak-Type ($\rho_1 < \rho_2 < \rho_3 > \rho_4$), while VES 2, showed curve A-Type ($\rho_1 < \rho_2 < \rho_3$) and lastly VES 3, curve to be A-Type ($\rho_1 < \rho_2 < \rho_3$). Groundwater is likely at a depth of 2m down below; an indication that water bearing layer is shallow, inferred that groundwater is prone to contamination. Table 2 represents the concentrations of heavy metals in groundwater of the study area. The values were also compared with WHO permissible standards; however, the mean concentration of the Zn, Ni, Mn, Pb, Fe, Cu, Co, where ppm is parts per million or milligrams per liter (mg/l).

CONCLUSION

Surface geoelectrical sounding method was used successfully to identify the subsurface and identification of heavy metals in groundwater. Range of Resistivity

values for different formations has been established using the interpreted VES results and resistivity standard values which could help to understand the subsurface lithological variation prevailing in the area, the following conclusion are drawn: the top layer consist of 2159 ohms m with depth of 0.5 and thickness of 0.5 m, this region is mostly clay which is wet with saline water. The depths to water table in the study area range from 1.14 - 28.4 m. The near surface part of the aquifer may be vulnerable to contamination as a result of the thin overlying geoelectric layer and clay layer; however the presence of clay lenses at different depths may play the role of forming confining layers. Water samples were analyzed indicates the concentration level of some heavy trace metals of the study area, which indicates that Cobalt (Co) of 0.3015mg/l and 0.2439mg/l were high contamination concentration at sample A and B respectively, when compared to the WHO standard permissible limit for water; which implies its possibility of harmful effect to humane and plant system (ecosystem) in the study location. The water of the area still needs some treatment before it can be suitable for use.

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