International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 14, Issue 12, December 2025)

Assessment of Saltwater Contamination at the Peak of Raining Season Using Geophysical and Geochemical Techniques in Opume, Bayelsa State, Nigeria

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Abstract*-- The study investigate saline contamination in Opume, Ogbia Local Government Area, Bayelsa State, Nigeria, Using 1D Vertical electrical sounding, 2D electrical resistivity imaging and Geochemical analysis, aimed at assessing saltwater contamination into freshwater. The field data is processed and interpreted with the IP12win and RES2DIN software. The result show five geoelectric layers for the Schlumberger array; shows vertical depth and Wenner array; which shows the lateral spread length of top soil, sand, clay, sandy clay within the study area. The resistivity of the fresh basement ranges from 45.9 – 429 Ωm.. The overburden thickness in the study location varies from 0.8 – 18 m and aquifer is within the fifth layer as indicated far below 24 m from the Geoelectric model. The study revealed the geochemical parameters of PH; 6.13, Salinity; 88mg/L, Electrical conductivity; 177µ/cm and Chloride; 33.24mg/L for surface water, while borehole concentration parameters are PH; 6.08, Salinity; 32mg/L, Electrical conductivity; 65µ/cm and Chloride; 43.24mg/L when compared with the permissible limit for WHO and EPA, it could be concluded that groundwater potential in the study area is consider safe of saline water contamination for the period of the raining season.

***Keywords*-- Contamination, Geoelectric, Resistivity, Parameters, Saline**

I. INTRODUCTION

Potable water supply to inhabitants in some of the communities in the coastal zones has been a major problem due to salt water intrusion. Availability and access of fresh water is very critical in the social economic development for sustainable growth all over the world.

The demand for quality fresh water is of the increase due to increase in human population and industrial growth. Groundwater free from contamination either by micro bacterial effect or mineral in high concentration presence is reliable water supply for domestic consumption and agricultural purposes. The understanding and management of groundwater of saline intrusion into aquifer is still very weak and investment in borehole projects is inadequate quantitative/qualitative in data resulting in massive borehole failures of Opume community. However, electrical resistivity methods are the most unique because of their ability to detect increases in pore- water conductivity (Abdul Nassir et al, 2000; Adepelumi et al, 2008).This research work is center on the collection of data necessary to delineate saltwater contamination to freshwater during the raining season..

II. LOCATION AND ACCESSIBILITY OF STUDY AREA

The study location Opume, Ogbia local environment, Bayelsa State, is one the last communities to the east of Ogbia local government area close to Nembe L.G.A of Bayelsa State. It lies approximately 10km from the administrative headquarter of Ogbia Local Government Area. Due to the flow of the freshwater from Oloibiri to Nembe river axis, the communities have seasonal freshwater and saltwater periodical; notable, during the dry season, it's saltwater until when it gets to the peak of the rainy season, and then freshwater comes due to density difference between freshwater and saltwater.

TABLE 1.0:
SHOWING LOCATION POINTS

Location	1D and 2D Sounding	Surface Water (SW)	Bore Hole (BH)
LATITUDE (N)	4.671345	4.660336	4.657817
LONGITUDE (E)	6.348640	6.347530	6.348516

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III. Geoelectric Theory

The resistivity is expressed in ohm-meter, where the earth resistivity is estimated by using the relationship between resistivity, an electric field, and current density (ohm's law) and the geometry factor, spacing of current and potential electrodes.. Where the earth is not homogeneous and isotropic, this estimate is called the apparent resistivity,, which is an average of the true resistivity in the measured section of the earth. The fundamental theory of the resistivity approach is well expanded (Maillet, 1947) and it has adequately covered (Keller and Frischknecht, 1966). From the Maxwell's equation for earth materials having dielectric and magnetic properties is given (Feynman et al., 1965) below.

From Ohm's law, the relationship of E and J, equivalent to current density of proportionality to electric field strength.

$$J = \sigma E \qquad (1)$$

This proportionality constant is known as the conductivity (σ) in equation (1), which is inverse of resistivity (ρ).

For the geometric factor relationship for a linear element of potential difference (V) in Volts, the electrical current (I), in Amperes and Resistance (R) in Ohms. If a conductor carries a current over a cross sectional area (A) then its resistivity (ρ) is given below;

$$\rho = RA/L \qquad (2)$$

$$I = V/R \qquad (3)$$

$$I = VA/\rho L \qquad (4)$$

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

$$\rho = VA/IL \qquad (5)$$

And it can be written as:

$\rho = KR$, where R is from Ohms 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.

IV. Methods And Materials

GEOELECTRIC TECHNIQUE: The geophysical field data was acquired using the 1D and 2D with SAS ABEM 1000 terrameter by sending current into the ground with two electrodes and two potential electrodes to read the potential of the earth (Bunonyo et al., 2022). This method was used because of it responds to measureable parameters that can easily differentiate the aquifer from other subsurface formation. The resistivity variation of sub-soil will enable one delineate the different layers.

GEOCHEMICAL: Water samples were collected in plastic bottles from the available water source both Surface Water (SW) and Borehole (BH) water. The plastic was first rinsed with the water to be collected before the water samples were collected. The parameters measured were PH, Salinity (mg/L), Electrical conductivity (u/cm) and Chloride (mg/L), when taken to the laboratory for Hydrochemical analysis using the Atomic Absorption Spectrometer (AAS).

V. Results And Discussion

TABLE 1.1:
RESULT OF WATER SAMPLES DURING THE PEAK OF THE RAINY SEASON

Location	PH	Salinity (mg/L)	Electrical conductivity(u/cm)	Chloride (mg/L)
Opume(SW)	6.13	88	177	33.24
Opume (BH)	6.08	32	65	43.24
WHO	6.5- 8.5	250	1400	250
EPA	6.5 – 9	1000 – 3000	<1000	250

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TABLE 1.2:
SUMMARY OF THE INTERPRETED VES RESULTS WITH INFERRED LITHOLOGY

VES No	LAYERS	RESISTIVITY (Ωm)	THICKNESS (m)	DEPTH (m)	CURVE TYPE	LITHOLOGY
1	1	122.9	0.8	0.8	**KQH** $\rho_1 < \rho_2 > \rho_3 > \rho_4 < \rho_5$	Topsoil
	2	429.0	2.0	2.8		Sand
	3	317.0	3.8	6.6		Sand
	4	45.9	18.0	24.6		Clay
	5	151.2	---	---		Sand
2	1	73.8	0.8	0.8	**AKH** $\rho_1 < \rho_2 < \rho_3 > \rho_4 < \rho_5$	Topsoil
	2	457.6	1.4	2.2		Sand
	3	589.3	4.1	6.3		Sand
	4	135.9	15.3	21.6		Clayey Sand
	5	742.5	---	---		Sand

Figure 1.2 presents the geoelectric section along profile A with Five geoelectric layers of the different curve types in table 1.2. Layer one is the topsoil with resistivity and thickness value 122.9 ohm-m and 0.8 m respectively. The second geoelectric layer is likely sand with resistivity and thickness value 429.0 ohm-m and 2.0 m respectively. The third layer connotes sand with resistivity value of 317.0ohm-m and layer thickness of 3.8 m. The fourth geoelectric layer depicts clay. The clay has resistivity and thickness value of 45.9 ohm-m and 18.0 m respectively. The fifth horizon is symptomatic of sand with resistivity value 151.2 ohm-m but whose thickness could not be determined as a result of the probing currents terminated point. The sand in this zone is the likely aquifer unit where groundwater could be tapped.

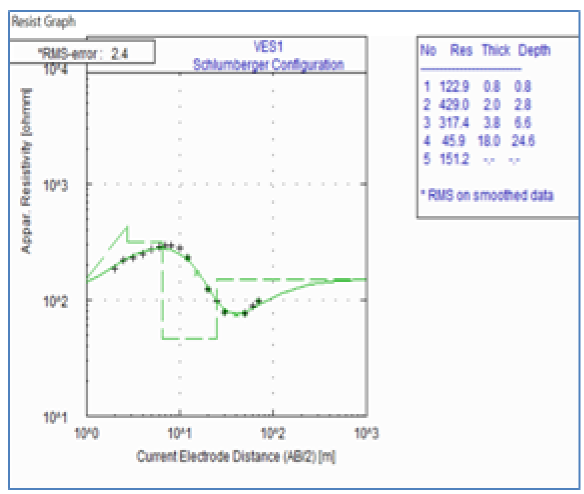

FIG. 1.1: VES 1 SHOWING GEOELECTRIC MODEL

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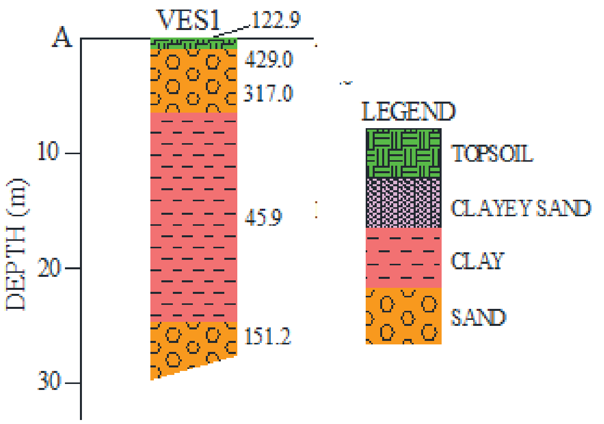

FIG 1.2: GEOELECTRIC LAYER FOR VES 1

Figure 1.4 presents the geoelectric section along profile B-B'. Five geoelectric layers which are the topsoil, clayey sand and sand are delineated (Fig. 1.4). Layer one is the topsoil having resistivity and thickness value 73.8 ohm-m and 0.8 m respectively. The second geoelectric layer is representative of sand. The sand has resistivity and thickness value 457.6 ohm-m and 1.4 m respectively. The third substratum connotes sand with resistivity value of 589.3 ohm-m and layer thickness of 4.1 m. The fourth geoelectric layer depicts clayey sand. The clayey sand has resistivity and thickness value of 135.9 ohm-m and 15.3 m respectively. The fifth horizon is symptomatic of sand with resistivity value 742.5 ohm-m but whose thickness could not be determined because the probing currents terminated at that point. The sand in this zone represents an aquifer unit where groundwater could be tapped.

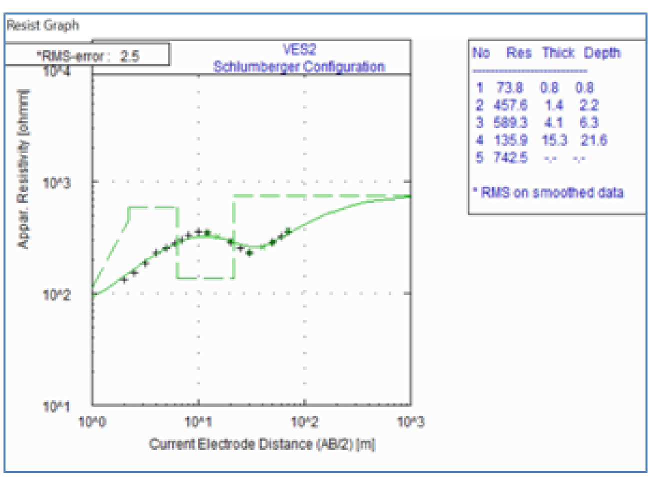

FIG. 1.3: VES 2 SHOWING GEOELECTRIC MODEL

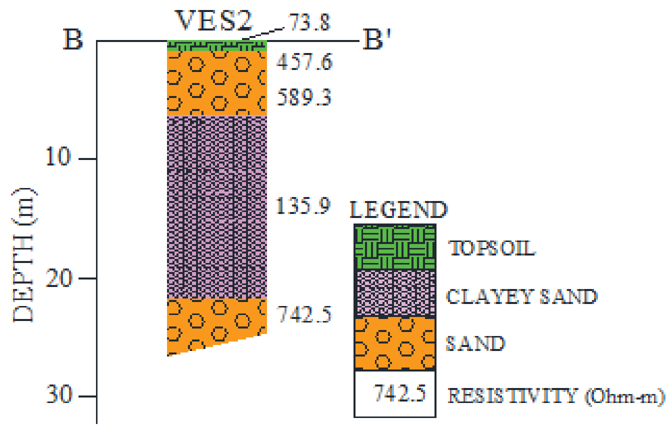

FIGURE 1.4: GEOELECTRIC SECTION FOR VES 2

2-D ELECTRICAL IMAGING

The results of the 2-D resistivity imaging are presented in a colour coded format as shown in Figures 1.3. The2-D section shows the subsurface resistivity distribution with respect to depth. The horizontal scale on the section is the lateral distance while the vertical scale is the depths which are both in meters. A maximum spread of 100 m was covered and depth of 25 m was investigated.

2-D RESISTIVITY SECTION ALONG TRAVERSE ONE

A total spread of 100 m was covered along traverse 1 and depth of 25 m was investigated. The resistivity values of the section ranges from 8 – 385ohm-m (Figure 1.3). Three distinct Geoelectric section were delineated which connotes the clay, sandy clay and sand. The clay layer occurs at lateral distance of 15 – 45 m, 10 – 65 m and 60 – 90 m having resistivity values ranging from 12 – 45 ohm-m with corresponding depth of 0 – 2 m, 12 – 25 m and 0 – 25 m respectively. The sandy clay occurs at lateral distance of 10 – 55 m and 65 – 90 m having resistivity values ranging from 55 – 69 ohm-m with corresponding depth from 12 m, 0 – 10 m, 0 – 25 m and 3 – 5 m respectively. The sand is distinctive at lateral distance of 10 – 55 m and 70 – 90 m having resistivity values ranging from 106 – 386 ohm-m with corresponding depth of 3 – 10 m and 5 – 25 m.

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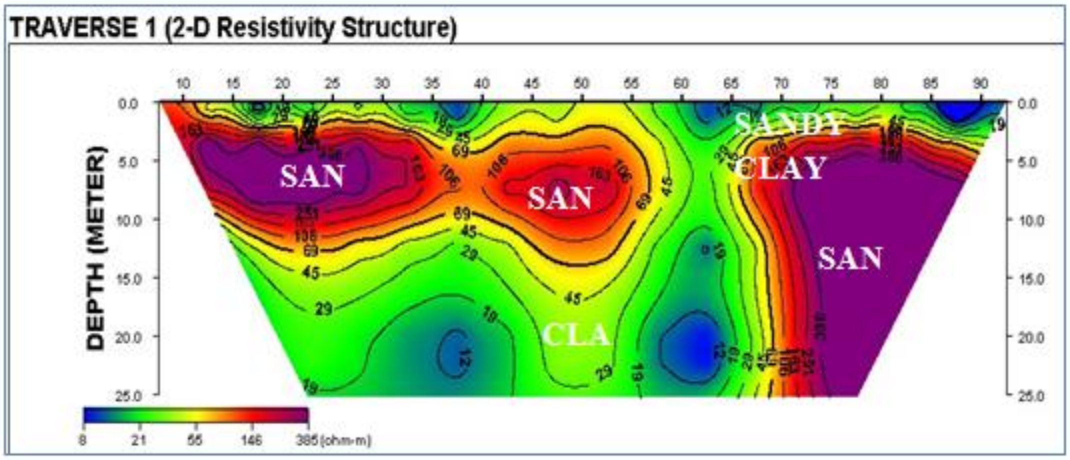

FIGURE 1.3: 2-D ELECTRICAL RESISTIVITY STRUCTURE ALONG TRAVERSE 1.

VI. Conclusion

Geophysical resistivity method has enable us have a knowledge base on the subsoil of likely top soil, sand, clay, and sandy clay. Aquifer was indicated at the fifth layer from the VES location (fig 1.1) and at depth of about 18 m down below the ground, where saline intrusion can easily penetrate as a result of the lithology and depth of the water bearing level**.** Comparison of all analysed parameters with national and international standards (EPA and WHO) from the geochemical analysis, Shows that all the parameters are within the minimum permissible limits and consider the water as potable, at the peak of the raining season when this research was carried out; which may be due to dilution of the salt water intrusion level. The blue colour extending to the sand bottom probably indicate accumulation of saline water in the absence of clay in the sediment.

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