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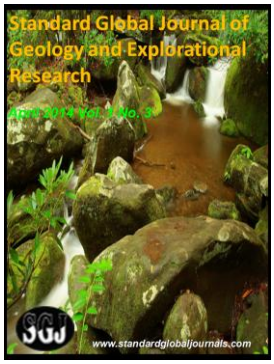

Research Article

Geoelectric investigation of the subsurface characterization and groundwater status in Emeyel, Bayelsa State, Nigeria

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Abstract

A geophysical investigation involving the vertical electrical sounding (VES) electrical resistivity method was carried out at Emeyel, Bayelsa State, South-south Nigeria to determine the subsurface layer parameters (resistivities, depth and thicknesses) with a view to determining the aquifer configurations which will assist in sitting high yield boreholes. Three VES points were probed in the survey area; spread at a distance of 160 – 200m apart using ABEM SAS 1000 Terameter to generate field data. The Schlumberger soundings were carried out with current electrode spacing (AB) ranging from 1 -200. The distance used for potential electrode spacing (MN) ranged from 0.2 – 10m .This array was employed in view of it reliability, easy operation and cost effectiveness. The field data was simulated using IP12WIN resistivity software. Two to three geoelectric layers were delineated and layer two is the horizon with high potentiality for groundwater occurrence and resistivity values in the range of 4.91 - 160Ωm with a corresponding thickness in the range of 0.81 – 30.9m and a total aquifer depth of 16.9m at VES 3.The result indicates that shallow aquifer exist at this depth, which is prone to contamination.

Keywords: Groundwater; Vertical electric sounding;Geophysical; aquifer; Geoelectric.

INTRODUCTION

In developed, developing and underdeveloped societies all over the world, the availability and accessibility to potable and quality water resources is of major concern. In the Niger Delta area of Nigeria, there is even a greater need for quality water due to increasing human population and pollution of water bodies associated with extensive exploratory activities of oil and gas industries. Attention here is placed on the exploitation of groundwater resource which is the largest available source of quality fresh water held in the subsurface within the zone of saturation under hydrostatic pressure below water (Ariyo and Banjo, 2008). The area under investigation in this paper is Emeyel, a community in the eastern part of Bayelsa State (Niger Delta) shown in Figure 1 below.

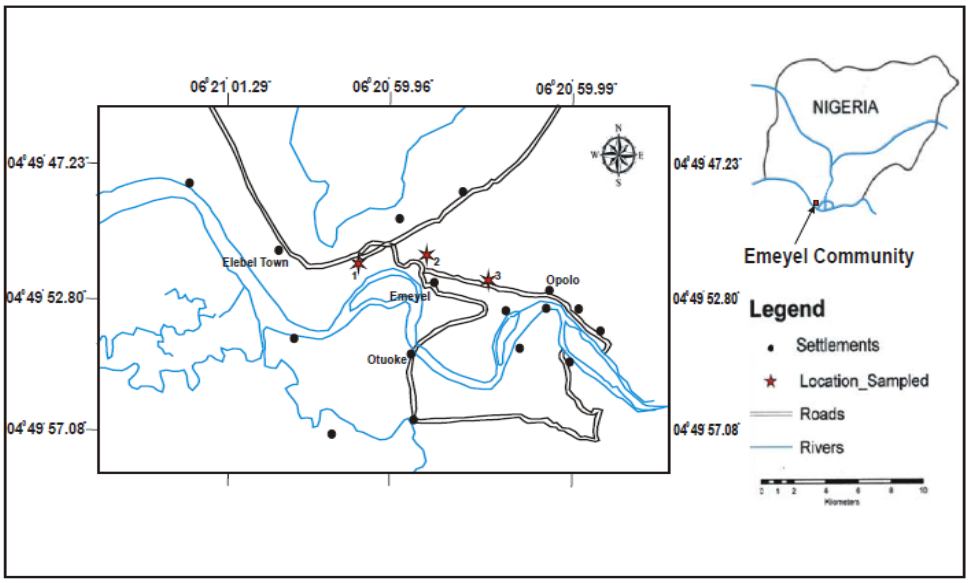

Figure 1. Map of the Community

Emeyel is characterized by fresh-water mangrove swamps synonymous with the coastal alluvium of Bayelsa State (Okiongbo and Ogobiri, 2011). Inhabitants of this town have individual boreholes that are sited without prerequisite geophysical and hydrogeological tests. This has resulted in boreholes that have failed over time due to the borehole not reaching the actual aquifer level. Also, we find out that the water from these boreholes tend to be brownish in colour as a result of a significant iron content in it (Okiongbo and Ogobiri, 2011). This is highly evident in the reddish colour of plumbings and casings, taste of the water and changes in colour of clothes after using the water for laundry purposes. Therefore, to advance the quality and quantity of water extracted from boreholes, electrical resistivity method is applied due to its non-destructive nature for appraising the subsurface.

The large variations in the electrical resistivity values of different rocks and minerals make the electrical resistivity method and specifically the vertical electrical sounding (VES) method very effective for analyzing the quality of groundwater in different lithological settings. Also, this method is relatively inexpensive, very direct and its analysis of data is not cumbersome when compared to others (Gnanasunder and Elango, 1999; Emenike, E.A., 2001). In our present study, attempt has been made to delineate the appropriate aquifer level with a view to giving a guide to siting high yield boreholes in the area.

Geology and hydrogeology of the study area

The study area has the same geology as Bayelsa state in general. It is located between latitude 4 49' 47.20" and longitude 6 20' 59.99" to 6 21' 01.25". Its geology is characterized by Benin formation (sediments and coastal plain sands) in which the sands are poorly cemented and slightly sorted from fine, medium to coarse grained sands. It has a relatively gentle topography whose elevation stands at 40m averagely above sea level. The area is swampy in nature and has streams which are inter-linked towards the Atlantic Ocean.

MATERIALS AND METHODS

The vertical electrical resistivity survey (VES) using the Schlumberger electrode array was done by simultaneously passing current to the ground via the current electrodes A and B and measuring the corresponding voltage created between the potential electrodes M and N which results in a resistance that was recorded by the Terameter. The apparent resistivity values were ascertained by multiplying the resistance gotten from the Terameter with an appropriate geometric factor, which depends on the current and potential electrode spacing(Telford et al., 1990) as shown in equation 1 below:

$\rho_a = k\frac{V}{I}$ ---------- (1)

Where;

K represents the geometric factor of the Schlumberger electrode array shown in equation 2 below:

$$k = \pi \frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN} \text{ ----------(2)}$$

As the current electrodes are expanded, it penetrates deeper and at a stage the signals on the Terameter becomes weak. The potential electrode spacing was extended but not more than one-fifth of the distance between the current electrodes A and B. The Schlumberger electrode array was employed due to its simplicity, being faster and required fewer number of field workers.

Due to the marshy nature of the area and much dense vegetation, a total number of three (3) VES sites were made use of along existing roads and foot path in the locality. Current electrode array spread ranges from 160 - 200m. The ABEM SAS/1000 Terameter was used for the field data collection. The result from the three (3) VES soundings was got and the apparent resistivity computed. The resistivity survey was carried out with a maximum current electrode spacing (AB) 200m (AB/2 = 100m). The apparent resistivity values were imputed into IP12WIN resistivity analysis software, giving rise to three layers and thicknesses of each layer. The subsurface lithology at the three (3) locations is given in table 2.

RESULTS AND DISCUSSION

A total number of three (3) VES were carried out. Using the IP12WIN resistivity analysis software and modeled, a total number of three layers were discovered. Table 3 shows an overview of the VES results as obtained by the interpretative models for each VES station. Table 2 shows a slightly irregular variation in resistivity laterally and vertically which shows the different and related sedimentary layers of the zone. Taking a look at the three VES points, we see that the resistivity of the surface layer ranges between 3.44 – 18.4Ωm while its thickness varies from 0.5 – 5.23m indicative of damp deposits (clay, silt clay). Underlying this topsoil is the second layer with a resistivity of 4.91 - 160Ωm, while its thickness ranges from 0.81 – 30.9m.

Table 1. VES points and their coordinates

VES STATION NUMBER	LAT. N	LONG. E	ELEV.(m)	Remarks
1	04° 49' 47.23"	06° 21' 01.29"	22	Close to the junction
2	04° 49' 52.80"	06° 20' 59.96"	31	Secondary School Road
3	04°49' 57.08"	06° 20' 59.99"	37	Behind Secondary School

Table 2. resistivity, thickness, depth and lithology of the VES points

VES STATION NUMBER	LAYER RESISTIVITY	THICKNESS	DEPTH	LITHOLOGY
	$\rho_1/\rho_2/----/\rho_n$	$h_1/h_2/----/h_n$	$D_1/D_2/----/D_n$	
	(ohm-m)	(m)	(m)	
1	3.44/74.4/4134	0.5/30.9	0.5/31.4	Clay/siltyclay, sand
2	21.6/4.91/99.4	1.49/0.81	1.49/2.3	Siltyclay, clay, silt
3	18.4/160	5.23/11.6	5.23/16.9	Siltyclay, clayey sand

This layer reaches its lowest resistivity at VES 2 with a resistivity of 4.91Ωm. The water table in this area varies between 2-6m (Okiongbo and Ogobiri, 2011). Also for the second layer, VES 1 has a maximum thickness of 30.9m. There was variation in thickness in the second layer from VES 1 – 3. The layer constitutes the clayey zone. The third layer shows resistivities in the range of 99.4 - 4134Ωm.

CONCLUSION

The results of the electrical resistivity sounding employed at a locality in Emeyel town, Bayelsa State, Southwest Nigeria is reported. From the survey, a total of three geoelectric layers were revealed to the depth of investigation. The resistivity of the first layer ranges from 3.44 – 18.44Ωm and its thickness within a range of 0.5 – 5.23m which is indicative of damp clay, silt clayey deposits. The second layer has resistivity values in the range of 4.91 - 160Ωm and is interpreted as wet clay. The low specific resistivity of the second layer in VES 2 is an indication of clay or water bearing clayey deposits.

The thickness of this layer falls within 0.81 – 30.9m. This is likely the aquifer region in this area at a cumulative depth of about 16.9m at VES 2. The resistivity of the third layer varies between 99.4 - 4134Ωm

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