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Research Article

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Determination of Aquifer Protective Capacity Using Dar-zorrouk Parameters: A Case Study of Umuogba in Omuma Local Government Area of Rivers State, Nigeria

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Abstract Six Vertical Electrical Soundings with Schlumberger configuration was carried out within Umuogba in Omuma Local Government Area to ascertain the protective capacity of the area using an Abem Terrameter SAS 300B. The data was plotted with a Win-resists software to generate first order geo-electric parameters which was used to evaluate the protective capacity of the study area. The Longitudinal Conductance and Aquifer Thickness maps was plotted with the spatial locations using a Sulfer8 software. The range of values for longitudinal conductance of 0.036402 -0.2386007mhos was observed in the study area. Majority of the areas in the North and West are weak protective areas (< 0.1mhos) while a few areas in the West are poorly protected (0.1 – 0.19 mhos). This implies that the aquifers within the study area are vulnerable to pollution.

Keywords Dar-zorrouk Parameters, Geo-electric layer, Longitudinal Conductance, Protective Capacity, Resistivity

Introduction

Omuma local Government is made up of three major towns viz; Ajuloke, Umuogba and Ohimoyoro and the manner at which boreholes are dug within the local government is very alarming especially in Umuogba town. For example in each of the villages, the least number of borehole you can find is three to four which are either abandoned, undeveloped or failed wells [1]. This research is pertinent in order to investigate the level of protection of aquifers in the area in terms of contamination.

Pump testing and surface geo-electrical methods are two ways in which aquifer protective capacity can be evaluated and estimating the protective capacity from pump testing method requires more time and it is very expensive when compared to the geo-electric methods which requires an empirical relations between hydraulic and parameters gotten from resistivity data [2].

Numerous researchers had successfully worked on protective capacity of different areas within the country for example, [3] classified protective capacity rating of Afe Babalola University in Ado-Ekiti as weak, moderate and good zones based on the values of Longitudinal conductance obtained [4]. In Ado-Ekiti observed that 60% of the area of study falls within a good and moderate rating. In Delta State, [5] investigated the level of protective capacity within parts of Effurun and reported that the areas are poorly protected [6]. Evaluated how protected Aquifers are in the Southern Parts of Akwa Ibom and he observed that the range of longitudinal conductance span from 0.003864 - 0.059655mhos which indicated that the area of study has a poor protective capacity.

In this study, the aquifer protective capacity of the study area was determine using Geo-electric data and Dr-Zorrouk parameters. The method used is reliable and the results can be used to improve the quality of groundwater flow in Umuogba town.

Location and Geology of The Study Area

Umuogba (Fig.1) is located at Latitude $05^0 21^I 27.3^{II}$ North and Longitude $007^0 13^I 08.21^{II}$ East. It is situated on the coastal plain of South Eastern Nigeria, underlain by the Benin formation. The unconsolidated sands and interfingering clays underlaying the study area have given rise to a system of three aquifers. The study area forms part of the Niger – Delta Complex with the usual Benin formation and low land zones of south- eastern Nigeria. It is made up of extensive riverrine area all the way through which the River Niger links the Atlantic, divided into several distribution which empty in the sea.The deltaic plains consists of sands that are not consolidated, and the sizes of grains ranges from coarse to medium forming lenticular layers with intercalation of peaty matter andlenses of soft, silt clay and shales. Gravelly layers that make up to about 10m in thickness have been recorded . The uppermost sediments are aerated, made up sandstones that are not consolidated and have a extremely unpredictable thickness all over the zone. Benin formation that is sandy and well connected to allow easily passage of water, the lying on top of the laterite earth and unconsolidated top of the formation coupled with the shale beneath that makes up the Bende – Ameki and Ogwashi – Asaba series provide the conditions hydrologically that favours the formation of acquifer in the locality.

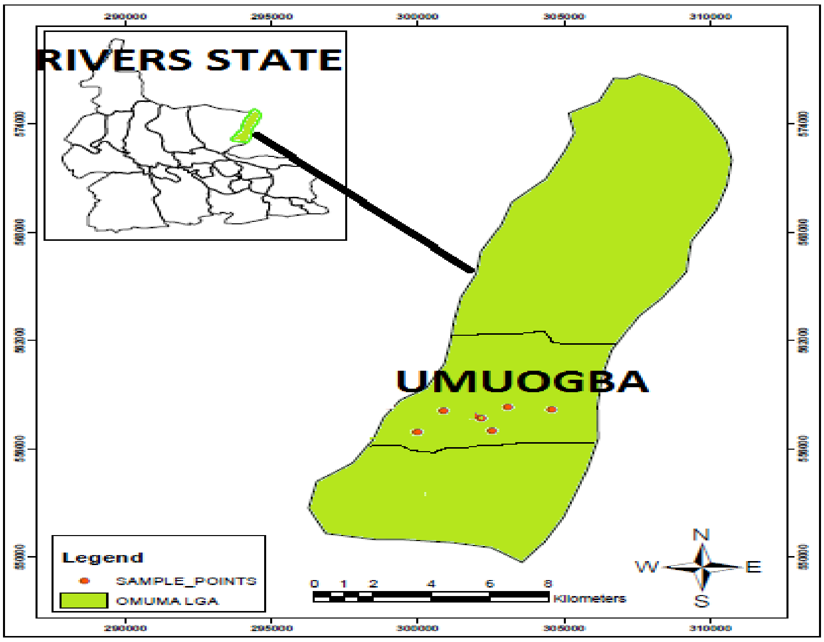

Figure 1: Map of the Study Area

Materials and Methods

Six Vertical Electrical Soundings was carried out in the study area by adopting Schlumberger configuration with the aid of an Abem 300B SAS Terrameter and a maximum spread of 300 – 400m. The field data was multiplied by equation 1 to derive apparent resistivity (equation 2). The values of apparent resistivity from each stations was then plotted with half electrode distance using a Win-resist software to generate the geo-electric curves that contains properties required for the evaluation of Dar-zourak parameters (Figure 2). The first order geo-electric parameters (resistivity and thickness) was then substituted into equations 2 and 3 to generate longitudinal conductance and transmissivity of the study area. The values obtained from equations 2 and 3combined with the spatial locations of the areas surveyed was plotted to generate the longitudinal maps of the area.

$$K = \pi\left(\frac{a2}{b} - \frac{b}{4}\right) \quad (1)$$

$$\rho_a = KR \quad (2)$$

$$\rho_a = \pi\left(\frac{a2}{b} - \frac{b}{4}\right) R \quad (3)$$

K = Geometric Factor

R = Resistance

a= half current electrode spacing

b= half potential electrode spacing

Longitudinal Conductance

$S = h/\rho a$ (4)

Transverse Resistance

$T = h.\rho a$ (5)

S = longitudinal conductance (Ωm^{-1})

T = Transverse Resistance (Ωm^2)

h = Thickness (m)

ρa = Apparent Resistivity of the Aquiferous layer (Ωm)

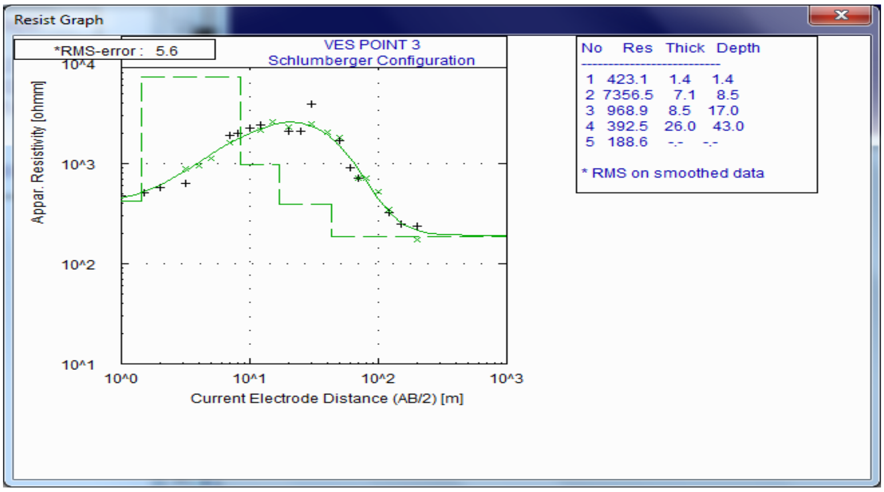

Figure 2: Geo-electric curve

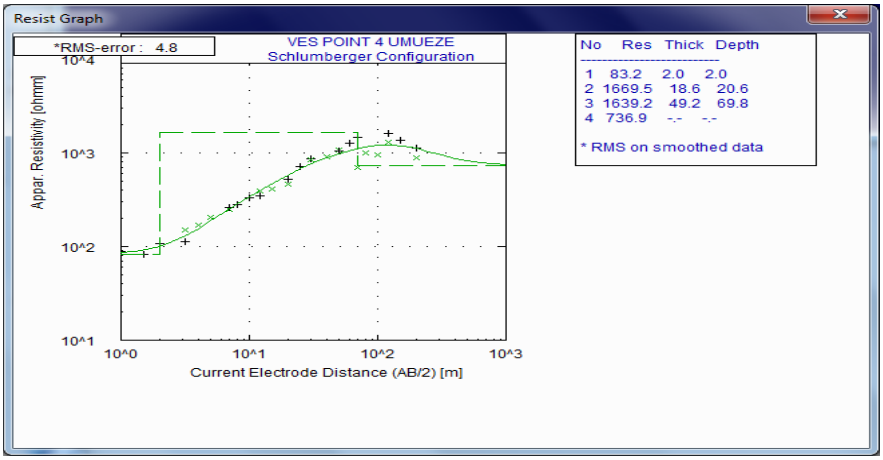

Figure 3: Geo-electric curve

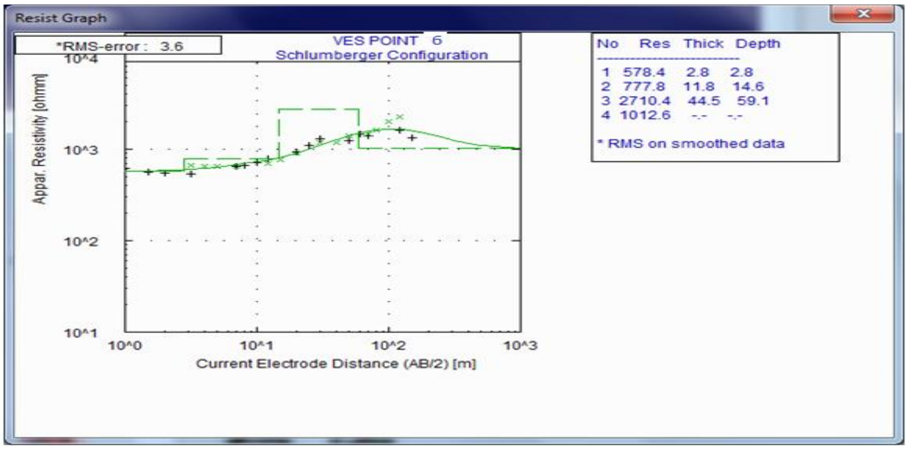

Figure 4: Geo-electric curves

Table 1: Summary of Geo-electric Parameters for Surveyed Areas

S/N	VES POINT	Latitude	Longitude	$\rho_a(\Omega m)$	h(m)	$S(\Omega m^{-1})$	$T(\Omega m^2)$
1	Umuofeke	562594.5	303787.9	115.8	11.2	0.096718	1296.96
2	Umuobali	560421.3	306865.5	392	26	0.066327	10192
3	Umueze	564015.1	302544.5	1639.2	49.2	0.030015	80648.64
4	Umuodiri	560091.3	301752.4	679	14.3	0.02106	9709.7
5	Umuokwa	556751.5	302250.7	244	40	0.163934	9760
6	Umuoyere	564645.3	282482.7	2710.4	44.5	0.016418	120612.8

4. Results and Discussion

4.1 Protective Capacity Rating of Umuogba Town

The map of the longitudinal unit conductance (Figure 3) was prepared from Table 1. The total longitudinal unit conductance values of the study area ranges from (0.030015) – (0.096718) mhos and it is useful when predicting protective capacity rating of an area. The total longitudinal unit conductance values (Table 1) were utilized in estimating the aquifer protective capacity because the earth medium acts as a natural filter to percolating fluid and that its ability to retard and filter percolating fluid is a measure of its protective capacity [7-8]. Clayey overburden, which is characterized by relatively high longitudinal conductance values, offers protection to the underlying aquifer [4].

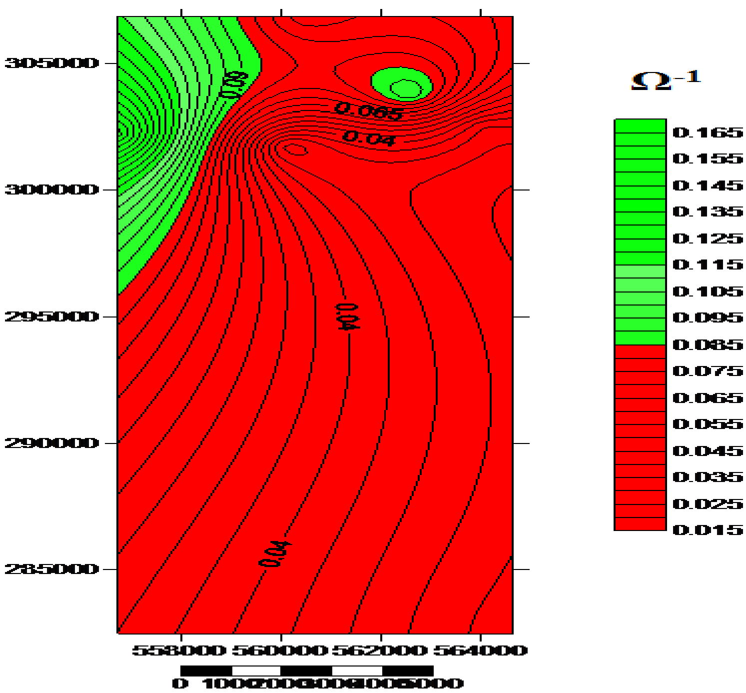

Figure 5: Protective Capacity Map of Umuogba

The protective capacity of Umuogba town (Table 2) is rated as poor and weak. The rating is after [3] (Table 2). The Northern, Southern, Eastern and few areas in the Western part are rated as poor protective capacity zones with longitudinal values less than 0.1mhos, while a few areas in the Northern and Western parts which corresponds to areas with Longitudinal conductance values within 0.1 – 0.19 mhos are rated weak protective capacity zones. The Area of study which are classified as poor and weak zones are vulnerable or susceptible to contamination. It also implies that the aquifers within the study area are vulnerable to contamination from infiltration of leachate from decomposed refuse dumps and possibly leakages of buried underground storage facility [9].

4.2. Isopach map of the overburden

Figure 3 is the depth of the overburden within the study area and it is characterized by category 1 and 2 overburden. Category1 overburden (10 - 32 m) is found at the Northern part of the study area and they correspond to area coloured blue. More so, category 2 overburden (32 - 50m) is found at the Southern, Eastern and Western parts of the study area and they correspond to the areas coloured brown. The presence of thick overburden favours the groundwater resources in the area particularly when underlain by weathered/fractured basement and fractured bedrock.

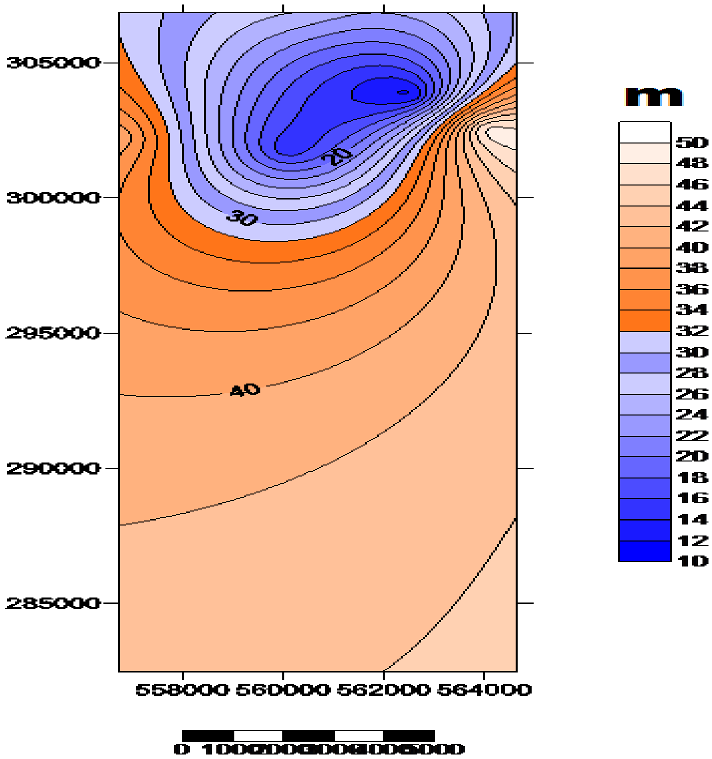

Figure 6: Aquifer Thickness Map of Umuogba

Table 2: Longitudinal conductance/ Protective Rating [3]

Longitudinal Conductance (mhos)	Protective Covering
> 10	Excellent
5 – 10	Very Good
0.7- 4.9	Good
0.2 – 0.69	Moderate
0.1 – 0.19	Weak
< 0.1	Poor

Table 3: Protective capacity/Longitudinal Conductance of Umuogba Town

VES Point	LC (mhos)	Rating
Umuofeke village	0.1	Weak
Umuobali village	0.07	Poor
Umueze village	0.03	Poor
Umuodiri village	0.02	Poor
Umuokwa village	0.16	Weak
Umuoyere village	0.02	Poor

Conclusion

The study is aimed at creating awareness on the productive aquifer for sustainable groundwater development in the study area. Results of Schlumberger Vertical Electrical sounding carried out in the area were used to determine the aquifer protective capacity zone in the area using the Dar-Zorrouk Parameters. The parameters were instrumental in the estimation of the longitudinal conductance which was used to infer the protective capacity zone .The longitudinal conductance ranges from 0.030015 to 0.096718 mhos. From the study it was observed that the protective capacity of Umuogba is classified as a poor and weak protective zones which implies that the aquifers in the areas are vulnerable or susceptible to contamination or pollution.

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