

# Aquifer Characterization and Quality Assessment of Groundwater in Umuahia-South Area of Abia State, Southern Nigeria.

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## ABSTRACT

The present work is a review on the geoelectrical characteristics and physico-chemical parameters of groundwater in Umuahia-South Local Government Area of Abia State, Nigeria. The aim was to collate, synthesize and analyze geoelectrical and hydrogeochemical data from available literature in order to evaluate the geophysical and physico-chemical character of the aquifer systems and subsequently determine the quality of groundwater in the area. The study shows that the Formation Factor ranges from 0.72 to 2.26, and the groundwater is naturally potable. Total Hardness (TH) values range from 0.40mg/l to 25.00 mg/l, Sulphate ( $\text{SO}_4^{2-}$ ) and Nitrate ( $\text{NO}_3^-$ ) were not detected while concentrations of major cations and anions are far below WHO permissible limit. With respect to agricultural and irrigation purposes, the groundwater samples are excellent, SAR values range from 0.17 to 1.44 with an average value of 0.394 while RSC values are less than 2.5epm.

(Keywords: physico-chemical parameters, formation factor, groundwater quality, irrigation)

## INTRODUCTION

Water beneath the ground surface in soil pore spaces and in the fractures of rock formations is usually referred to as groundwater. A unit of rock or a layer of porous substrate that contains groundwater and transmits it in appreciable amounts (yield a usable quantity of water) is called an aquifer.

Groundwater is considered to be the largest reservoir of drinkable water and plays a major role in augmenting the water supply to meet the ever increasing demands for domestic, agricultural and industrial usage. Due to the long

retention/residence time of groundwater and natural filtration capacity of aquifers; groundwater is less contaminated as compared to surface water. Over-dependence on it for many purposes and the indiscriminate disposal of domestic, industrial or agricultural waste slowly makes groundwater susceptible to pollution.

Water is said to be polluted when water in its original sources is contaminated to such an extent that the usage is rendered unacceptable. Contaminants that may be in untreated water include microorganisms such as viruses and bacteria; inorganic contaminants such as salts and metals; organic chemical contaminants from agricultural practices and industrial processes.

Consumption of contaminated or polluted water can give rise to many diseases and even death when contaminated with organic and/or chemical pollutants (Bartran and Balance, 1996). Water quality being the physical, chemical and biological characteristics of water is mainly assessed with reference to a set of standards; and the most common standards used to assess water quality relate to human welfare and health of ecosystems. The emphasis on the availability and quantity of groundwater has extended to the quality of groundwater (Edet and Okereke, 2005; Nguyet, 2006; Amos-Uhegbu et al., 2012); but accounting fully for the physical, chemical and biological interactions between soil, water, nature and society is quite complex.

So, the parameters for water quality are determined by a specific usage and interest such as human consumption, agricultural use, industrial use, etc. In other words, water quality is neither a static condition of a system, nor can it be defined by the measurement of only one parameter. This is because it is dependent on the local geology and ecosystem, as well as human

uses such as sewage dispersion, agricultural/ industrial pollution and over-exploitation.

It is variable both in time and space, and requires routine monitoring to detect spatial patterns and changes over time. A range of chemical, physical, and biological components affect water quality and many variables could be examined and measured. Some of the variables provide a general indication of water pollution, whereas others enhance the direct tracking of pollution sources.

Rapidly increasing population, rising standards of living and exponential growth in industrialization and urbanization tends to add pressure on natural resources. An Industrial/ Technology Village, Cattle market, Electricity Sub-station, River Basin Development Area, Refuse Dumpsite and a proposed World Bank Housing Estate are planned/situated in Umuahia–South Local Government Area. The resulting increase in population and the less availability and non-acceptance of surface water; together with the comatose nature of the municipal water supply has made almost every sector in the area to depend on groundwater for their various purposes. This will greatly stress the groundwater

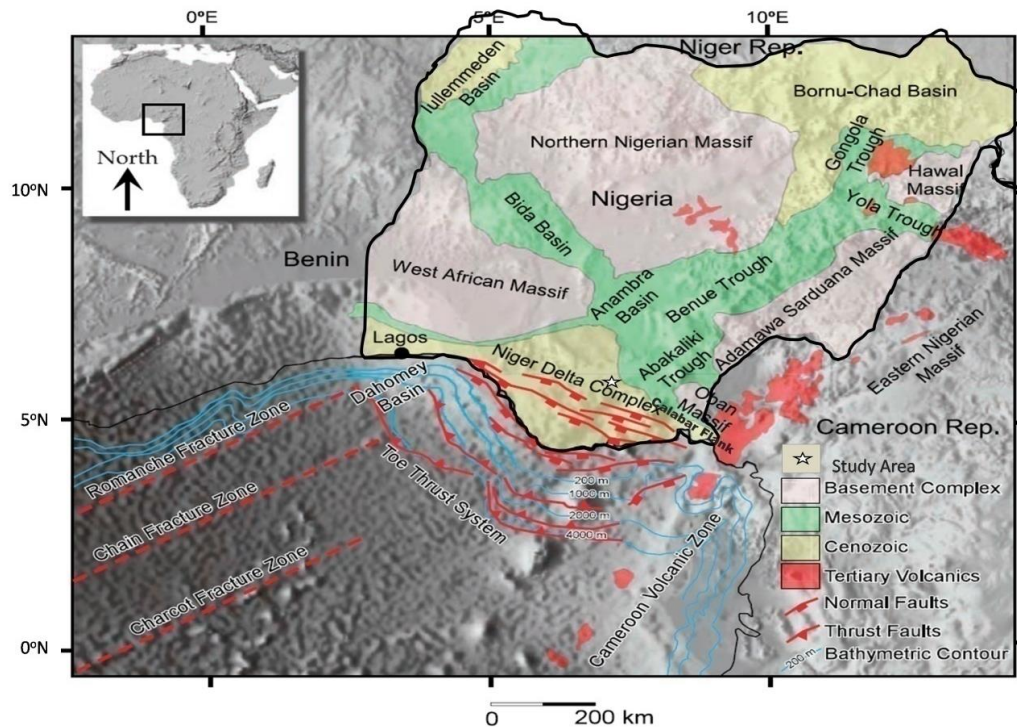
resources and possibly render it prone to quality degradation.

An understanding of the quality of groundwater is as important as its quantity because it is the main factor determining its suitability for domestic, drinking, agricultural and industrial purposes.

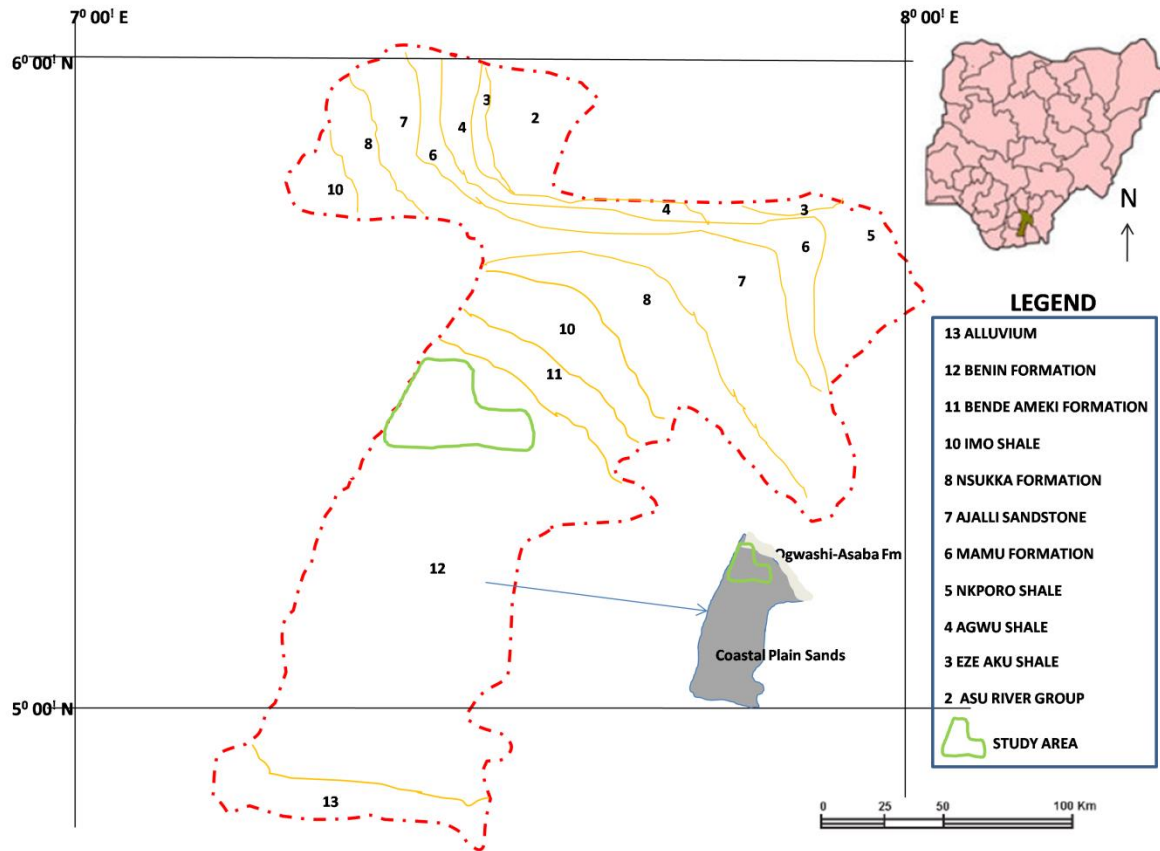
### LOCATION OF THE STUDY AREA

The study area is geologically situated in the Eastern Niger Delta (Figure 1) and lies within latitudes  $5^{\circ} 26'$  and  $5^{\circ} 34' N$ , and longitudes  $7^{\circ} 22'$  and  $7^{\circ} 33' E$  (Figure 2). It has high relative humidity values over 70%, and is characterized by high temperatures of about  $29^{\circ} - 31^{\circ} C$ . The area is part of the sub-equatorial belt with average annual rainfall of about 4000mm per annum.

The wet season starts from Mid-April to October and dry season from November to Mid-April, and has double maxima rainfall peaks in July and September with a short dry season of about three weeks between the peaks locally known as the August break.



**Figure 1:** Location Map of Niger Delta Region showing Main Sedimentary Basins and Tectonic Features.



**Figure 2:** Geologic Map of Abia State showing the Study Area.

Umuahia-South Local Government Area of Abia state, Nigeria is bounded in the north and north-east by Umuahia North, in the south by Isiala Ngwa North, in the east by Ikwuano Local Government Areas respectively and the Imo River demarcates it with Imo State in the western part (Figure 3).

The area is endowed with natural springs and streams including Imo River on the western flank which flow in a southerly direction and empty into the Atlantic Ocean. On the other hand, Anya River (though small compared to the Imo River) traverses the Southeastern flank of Umuahia-South. This Anya River is a main tributary of the great Kwa Ibo river of Akwa Ibom and Cross River States of Nigeria.

### **GEOLOGY AND HYDROGEOLOGY**

The geology of the area is consistent with the general geology of the Niger Delta complex which has been extensively described by Allen, (1965);

Reyment, (1965); Short and Stauble, (1967); Assez, (1976); Wright et.al, (1985); Kogbe, (1989); and others, indicating that there are three lithostratigraphic units in the Niger Delta. These units are Marine Akata Formation, Paralic Agbada Formation, and the Continental Benin Formation (Figure 4).

The overall thickness of these Tertiary sediments is about 10,000 meters. The Akata and Agbada Formations are the source and reservoir rocks respectively for petroleum in the Niger Delta. However, all boreholes in the Tertiary Niger Delta tap water from the Benin Formation.

The Oligocene to Recent Benin Formation which is the surface outcrop of Umuahia-South area serves as the aquifer for all the boreholes (Figure 2 and Figure 4). The study area is the only Benin hydrogeological setting in Abia State that comprises sediments of the Oligocene to Recent Ogwashi-Asaba Formation and Miocene to Recent Coastal Plain Sands.

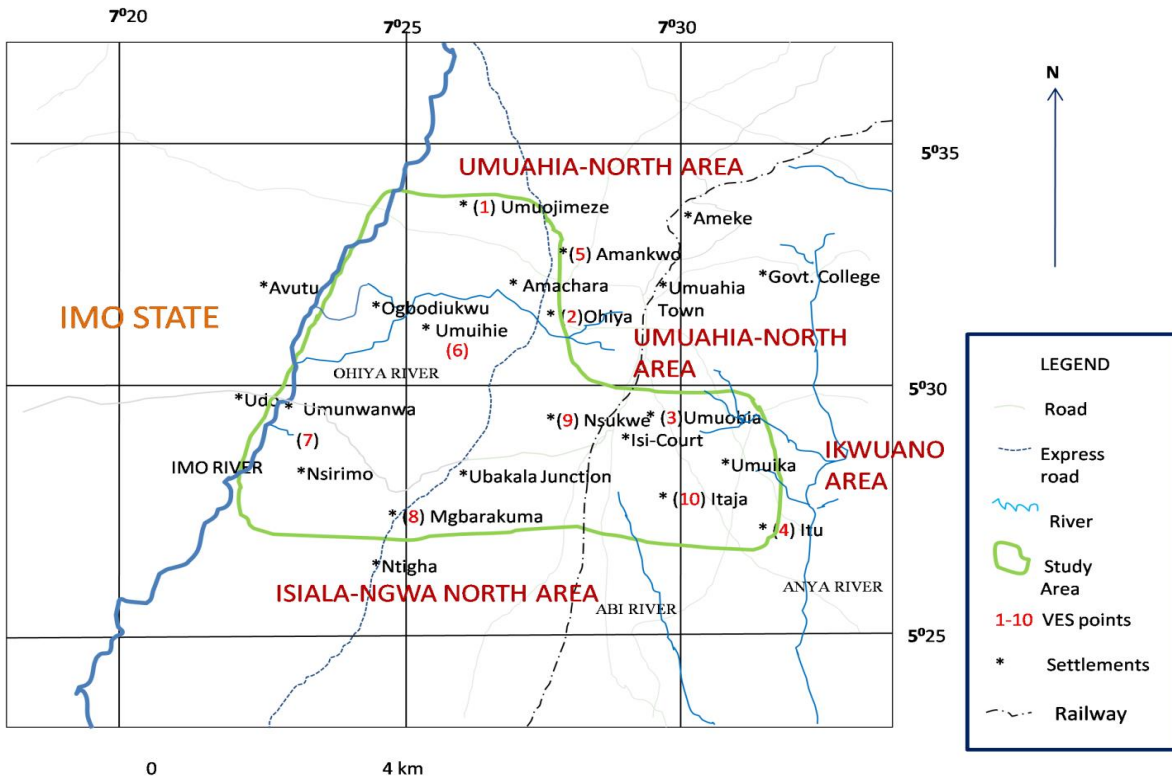


Figure 3: Map of the Study Area showing VES Points (Adapted from Amos-Uhegbu et al., 2012b).

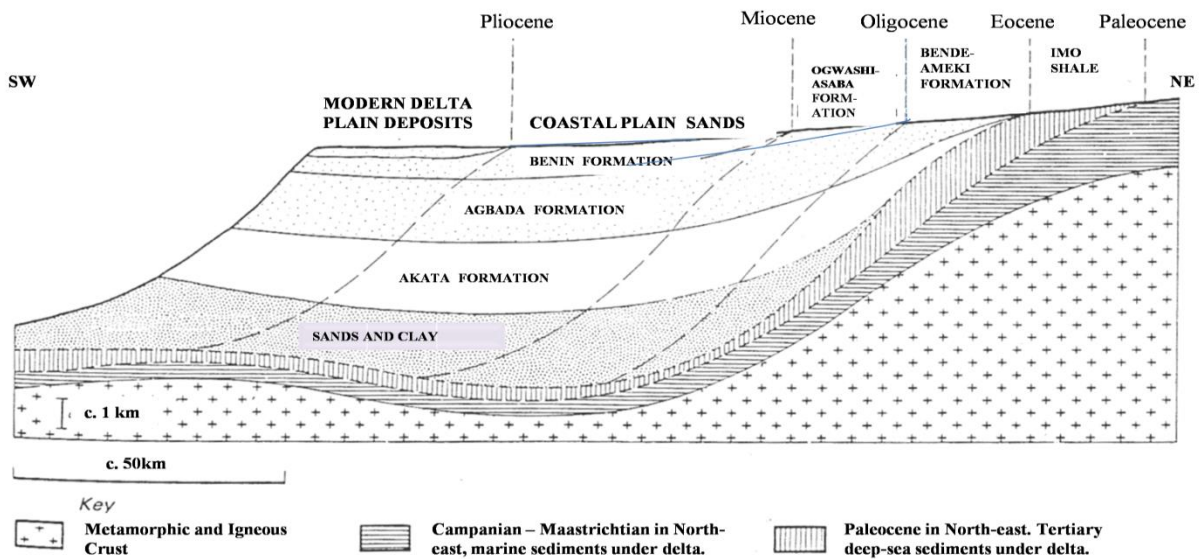


Figure 4: A Schematic Longitudinal Cross Section Showing the Diachronous Nature of Common Lithofacies of Anambra Basin and Niger Delta. (\*Curved broken lines represent successive positions of the delta front with time).



The Miocene to Recent Coastal Plain Sands consists of thick unconsolidated sands which are mostly medium- to coarse-grained, pebbly, moderately sorted with inter-fingering of local lenses of poorly cemented sands and clay, thus giving rise to multi-aquifer systems separated by aquitards.

The petrography analysis shows that the rocks composition is about 95-99% of quartz grains; 1-2.5% of Na+K mica; 0.5-1.0% of feldspar, and 2.3% of dark-colored minerals (Onyeagocha, 1980).

Etu – Efeotor and Akpokodje (1990) were able to delineate five regional levels of aquifers in the Niger Delta by using lithological and geophysical logs.

The first aquifer occurs under phreatic conditions between depths of 0 and 45 m. The second and third aquifers are semi-confined occurring within the depth of 45 to 130m and 130 to 212m respectively. The fourth aquifer is 219 to 300m deep while the fifth level of aquifer is more than 300m deep. In this present study, the boreholes investigated ranged between 40m and 150m, thus revealing the existence of a third aquifer.

## DATA ACQUISITION

In this present work, literature of geoelectrical and hydrogeochemical parameters were gotten from the works of Amos-Uhegbu et al. (2012b) and only the aquifer parameters from geoelectrical data were taken for this study as shown in Table 1. Also, a geoelectrical parameter of Amos-Uhegbu et al. (2012a) was used in the study.

While in Table 2, only hydrogeochemical parameters with complete physical (temperature, electrical conductivity, total dissolved solids and pH), basic cation (sodium, potassium, calcium and magnesium) and anions (chloride, bicarbonate, sulphate and nitrate) were selected; and then used to determine the source of ions in groundwater and also used to assess their suitability for domestic, industrial and agricultural applications with reference to international standards. Further hydrogeochemical parameters were also obtained from Ukandu et.al (2011) and used in the study.

**Table 1:** VES location points and their corresponding Aquifer Characteristics.

VES Station Location	GPS Reading			Aquifer Resistivity ( $\Omega$ m)	Aquifer Thickness (m)	Longitudinal Conductance S (Siemens)	Aquifer Conductivity $\sigma$	Aquifer Transverse Unit Resistance R ( $\Omega$ m <sup>2</sup> )	Source
	Elevation (m) m.s.l	Latitude °N	Longitude °E						
2 Ohiya	139	5°31.304'	7°27.508'	483.5	218.5	S <sub>3</sub> = 0.4519	0.0021	105644.75	Amos-Uhegbu et.al (2012b)
3 Umuobia (Isi Court)	151	5°29.273'	7°28.931'	811.5	226	S <sub>4</sub> = 0.2785	0.0012	183399	„
4 Okwu	141	5°28.106	7°30.803'	1007.2	98.0	S <sub>2</sub> = 0.0973	0.0010	98705.6	„
5 Amankwo	138	5°32.516'	7°27.503'	776	27.0	S <sub>4</sub> = 0.0348	0.0013	20952	„
7 Umunwanwa	122.9	5°29.320'	7°24.156'	450.3	224.1	S <sub>3</sub> = 0.4977	0.0022	100912.2	„
8 Mgbarakuma	151	5°28.324'	7°25.160'	473	196.0	S <sub>3</sub> = 0.4144	0.0021	92708	„
9 Nsukwe	146	5°29.224'	7°26.960'	475.9	172.0	S <sub>3</sub> = 0.3614	0.0021	81854.8	„
10 Itaja	150	5°28.132'	7°30.526'	855 340	52.0 77.0	S <sub>5</sub> = 0.0608 S <sub>6</sub> = 0.2265	0.0012 0.0029	44460 26180	„
Abam	130.4	5°27.832'	7°24.656'	442.4	35.00	S <sub>2</sub> = 0.0791	0.0022	15484	Amos-Uhegbu et.al (2012a)

**Table 2: Physico-Chemical Parameters of Groundwater Samples in the Study Area.**

Data Location/ Number	Well Depth (m)	Temp (°C)	Cond. (µs/cm)	pH	TDS (mg/l)	TSS (mg/l)	Fe <sup>2+</sup> (mg/l)	Ca <sup>2+</sup> (mg/l)	Mg <sup>2+</sup> (mg/l)	Na <sup>2+</sup> (mg/l)	K <sup>+</sup> (mg/l)	HCO <sub>3</sub> (mg/l)	Cl <sup>-</sup> (mg/l)	SO <sub>4</sub> <sup>2-</sup> (mg/l)	NO <sup>3-</sup> (mg/l)	Source
Umunwanwa (GW1) 5°29.799'N 7°23.915'E	40.0	29.5	41.3	4.50	20.50	ND	0.01	0.40	0.05	2.15	0.09	30.00	5.30	ND	ND	Amos-Uhegbu et.al (2012b)
	97.3	28.5	30.6	4.50	15.20	1.5	0.12	0.60	0.12	2.40	0.54	30.50	5.86	ND	ND	„
	110.0	29.0	28.8	4.96	14.30	ND	0.07	0.60	0.16	2.56	0.17	38.00	5.67	ND	ND	„
Okwu Olokoro 05°28.108'N 07°30.801'E	150.0	28.0	7.14	6.48	2.28	25.50	0.10	7.70	1.40	3.55	2.54	20.00	0.01	ND	ND	„
Umuobia (Isi-Court) 05°29.273'N 07°28.931'E	100.6	30.5	14.7	4.87	7.30	1.02	0.02	0.50	0.08	2.40	0.15	30.00	5.30	ND	ND	„
Mgbarakuma Junction 5°28.395'N 7°25.966'E	82.0	30.5	13.9	4.97	7.00	1.02	0.02	0.40	0.05	2.10	0.12	30.00	5.50	ND	ND	„
Amachara 05°32.446'N 07°27.323'E	73.1	27.5	20.6	4.59	10.30	ND	0.06	0.45	0.06	2.00	0.15	30.50	6.00	ND	ND	„
Nsukwe 5°30.079'N 7°26.563'E	72.0	30.5	21.0	4.56	10.70	ND	0.01	0.54	0.08	3.10	0.14	45.50	5.65	ND	ND	„
	91.4	30.0	19.0	5.40	9.50	1.0	0.11	0.30	0.07	2.30	0.12	30.50	5.67	ND	ND	„
Itaja 5°28.132'N 7°30.526'E	90.0	30.0	33.0	4.80	16.40	1.0	0.02	0.50	0.08	3.00	0.14	30.50	5.30	ND	ND	„
	94.5	30.0	42.0	5.10	21.00	3.0	0.40	1.70	0.60	3.10	0.60	45.00	5.30	ND	ND	„
Abam 05°27.834'N 07°24.652'E	-	29.0	27.3	5.07	13.60	BDL	0.02	0.44	0.07	2.12	0.11	30.50	4.96	BDL	BDL	Ukandu et.al (2011)
Ohiya 05°31.304'N 07°26.938'E	-	29.5	46.8	4.39	23.40	1.0	0.10	1.07	0.26	3.05	0.91	30.50	5.32	BDL	BDL	„
<b>WHO LIMITS</b>		<b>25</b>	<b>&lt; 500</b>	<b>6.5-8.5</b>	<b>50-750</b>	<b>10-25</b>	<b>&lt; 0.3</b>	<b>&lt;500</b>	<b>&lt; 50</b>	<b>&lt; 5</b>	<b>&lt;75</b>	<b>&lt;250</b>	<b>&lt; 50</b>	<b>NS</b>	<b>NS</b>	

\*ND = Not Detected, NS = Not Stated, BDL – Below Detection Limit, All units of measurement are in “mg/l” except otherwise stated in the table.

## RESULTS AND DISCUSSION

### Groundwater Resistivities and Formation Factor

An inventory of the boreholes was carried out as shown in Table 3 whereby Groundwater resistivities in the area were determined from the obtained measurements of specific conductance of groundwater at wells by taking the reciprocal of groundwater specific conductance.

The result was further used in determining the values of formation factor of each borehole. Formation Factor (FF) is calculated using the aquifer resistivity ( $\rho$ ) estimated from VES and water resistivity of the formation ( $\rho_w$ ) using Archie's law.

$$FF = \rho/\rho_w \quad (1)$$

Where  $\rho_w$  = resistivity of water.

The water resistivity is calculated by using the equation:

$$\rho_w = 10,000/\text{electrical conductivity of water} \quad (2)$$

### Determination of the Quality of the Groundwater for Drinking and Domestic Purposes

**Physical Parameters:** Table 2 illustrates the various physico-chemical parameters of groundwater of Aba Metropolis. The temperature was ranging from 27.5°C to 30.5°C during the study period. Lowest water temperature was observed at Amachara while the highest was at Umuobia (Isi-Court) and Nsukwe.

The pH values of groundwater ranged from 4.39 to 6.48 with an average value of 5.40.

**Table 3:** Aquifer Parameters of the Study Area.

VES Station/Data Locality	Aquifer Resistivity ( $\Omega\text{m}$ )	Aquifer Thickness (m)	Longitudinal Conductance S (Siemens)	Aquifer Conductivity $\sigma$	Transverse Resistance R ( $\Omega\text{m}^2$ )	Electrical Conductivity ( $\mu\text{s}/\text{cm}$ )	Resistivity of water ( $\Omega\text{m}$ )	Formation Factor
2 Ohiya	483.5	218.5	0.4519	0.0021	105644.75	46.8	213.7	2.26
3 Umuobia (Isi Court) *	811.5	226	0.2785	0.0012	33777	14.7	680.3	1.19
4 Okwu	1007.5	98.0	0.0973	0.0010	98705.6	7.14	1400.6	0.72
5 Amankwo/Amachara	776	27.0	0.0348	0.0013	7872	20.6	485.4	1.60
7 Umunwanwa	450.3	224.1	0.4977	0.0022	100912.2	41.3 30.6 28.8	242.0 326.8 347.2	1.86 1.38 1.30
8 Mgbarakuma *	473	196.0	0.4144	0.0021	92708	23.2	431.0	1.10
9 Nsukwe	475.9	172.0	0.3614	0.0021	13136	21.0	476..2	0.99
10 Itaja *	855 340	52.0 77.0	0.0608 0. 2264	0.0011 0.0029	44460 26180	33.0 42.0	303.0 238.1	2.82 1. 43
Abam	442.4	35.00	0.0791	0.0022	15484	27.3	366.3	1.21

This shows that the groundwater of the study area is slightly acidic in nature and all the samples did not meet the permissible limit prescribed by WHO (2004). Acidic water corrodes pipe and plumbing materials of iron and steel thus clogging the distribution pipes which may stain clothes and rust cooking utensils, and also cause objectionable taste of drinks and food. Exposure to extreme pH values results in irritation to the eyes, skin, and mucous membranes. In sensitive individuals, gastrointestinal irritation may also occur.

The TDS value ranged from 2.28 to 23.40 with a mean of 14.67. Total Dissolved Solids indicate the salinity behavior of groundwater and since all the samples are below 100mg/l, thus indicating that the groundwater of the area is recharged mainly through rainfall. Water containing more than 500 mg/l of TDS is not considered desirable for drinking, and all samples fall within the standard permissible limit.

Electrical Conductivity (EC) is a measure of the ability of water to conduct electricity. It signifies the amount of total dissolved salts in the water. The value of EC varied from 7.14  $\mu\text{s}/\text{cm}$  to 46.8  $\mu\text{s}/\text{cm}$  with an average value of 28.04  $\mu\text{s}/\text{cm}$ . All samples are within the WHO permissible EC standard for drinking water.

### **Chemical Parameters**

**Cations:** The dominant cation in the water samples of the study area is Sodium ( $\text{Na}^{2+}$ ) followed by Sodium except at Okwu where Calcium ( $\text{Ca}^{2+}$ ) dominated. Also Potassium ( $\text{K}^+$ ) was present in all the samples. So the sequence is as follows:  $\text{Na}^{2+} > \text{Ca}^{2+} > \text{K}^+ > \text{Mg}^{2+}$ .

Iron  $\text{Fe}^{2+}$  ranged from 0.01 to 0.40, all the samples met the WHO standard for iron in drinking water except the deeper aquifer of Itaja. Higher iron at these locations could cause objectionable tastes and staining of laundered clothes and plumbing fixtures.

**Anions:** The major anions in all of the samples was the Carbonate group ( $\text{CO}_3^{2-}$ ) followed by chloride ( $\text{Cl}^-$ ) whose levels are satisfactory with an average of 5.42mg/l, and no sample exceeded the permissible limit of 50mg/l for drinking water. Chloride ( $\text{Cl}^-$ ) contents greater than 40.0mg/l in aquifers indicate salt water contamination (Trembley et al., 1973) and salt water intrusion has been reported in coastal aquifers of the Niger Delta by Udom and Acra, (2006).

Chloride ( $\text{Cl}^-$ ) is known in the maintenance of acid-base balance, and hence excess of it may

cause oedema (Ekpete, 2002), and laxative effects. Phosphate ( $\text{PO}_4^{3-}$ ) and Chloride ( $\text{Cl}^-$ ) concentrations serve as indicators of pollution by sewage and detergent (Murhekar, 2011).

Sulphate ( $\text{SO}_4^{2-}$ ) and Nitrate ( $\text{NO}_3^-$ ) concentrations are found naturally in groundwater, and human activities can introduce them, therefore their non-detection in all samples used for the study is an indication that the groundwater samples have not been contaminated.

### **Total Hardness**

Hardness of water mainly depends on the amount of calcium or magnesium salts; it is the concentration of Calcium and Magnesium ions expressed as equivalent of Calcium carbonate. This property of water prevents formation of lather with soap and increases the boiling points and can be calculated by using the formula:

$$(\text{CaCO}_3) = 2.5(\text{Ca}^{2+}) + 4.1 (\text{Mg}^{2+}) \quad (3)$$

Total Hardness (TH) values range from 0.40mg/l to 25.00 mg/l. The borehole at Okwu Olokoro which has the highest value of Calcium and Magnesium has also the highest value of hardness.

The World Health Organization (WHO) International Standard for Drinking Water (2004) classified water with a total hardness of  $\text{CaCO}_3 < 50\text{mg/l}$  as soft water, 50 to 150 mg/l as

moderately hard water and above 150 mg/l as hard. Based on this classification, all the water samples are soft water.

### **Determination of the Suitability of the Groundwater for Agricultural Purposes**

**Electrical Conductivity (EC):** EC is a good measure of salinity hazard to crops. Excess salinity reduces the osmotic activity of plants and thus interferes with the absorption of water and nutrients from the soil (Saleh et al. 1999). All the groundwater samples are suitable for irrigation purposes with minimal likelihood that soil salinity will develop (Table 4).

**Sodium Absorption Ratio (SAR):** SAR is also an important parameter for determining the suitability of groundwater for irrigation because it is a measure of sodium hazard to crops. SAR can be estimated by the formula (Karanth 1987):

$$\text{SAR} = [\text{Na}^+] / \{([\text{Ca}^{2+}] + [\text{Mg}^{2+}]) / 2\}^{1/2} \quad (4)$$

Where all ionic concentrations are expressed in meq/l.

SAR values ranges from 0.17 to 1.44 with an average value of 0.394. All the sampling stations fall in the excellent category because none of the samples exceeded the value of  $\text{SAR} = 10$  (Table 5). So, the samples are suitable for all types of soils

**Table 4:** Quality of Irrigation Water based on Electrical Conductivity.

Salinity hazard class	Specific Conductance ( $\mu\text{mho/cm}$ )	Characteristics	Samples
Low	0-250	Low-salinity water can be used for irrigation on most soil with minimal likelihood that soil salinity will develop.	All Samples
Medium	251-750	Medium-salinity water can be used for irrigation if a moderate amount of drainage occurs.	Nil
High	751-2,250	High-salinity water is not suitable for use on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required.	Nil
Very high	More than 2,250	Very high-salinity water is not suitable for irrigation under normal conditions.	Nil



**Table 5:** SAR Values can then be Compared to Characteristics of the Four Sodium-Hazard Classes as Follows.

SAR	Water-suitability for Irrigation
0-10	Suitable for all types of soils except for those crops which are highly sensitive to Sodium
10-18	Suitable for coarse-textured or organic soil with good permeability. Relatively unsuitable in fine-textured soil.
18-26	Harmful for almost all types of soils. Requires good drainage, high leaching and gypsum addition.
>26	Unsuitable for irrigation

A further classification system to evaluate the suitability of water for irrigation use is graphically plotted with the values (EC and SAR) on the US salinity diagram (Richards, 1954). The plots of groundwater chemistry of study areas in the USSL diagram are shown in Figure 5. The range of values on the horizontal axis starts from 100 (Low) to 5000 (Very High)  $\mu\text{mho/cm}$ , while the vertical axis values range from 0 (Low) to 30 (Very High).

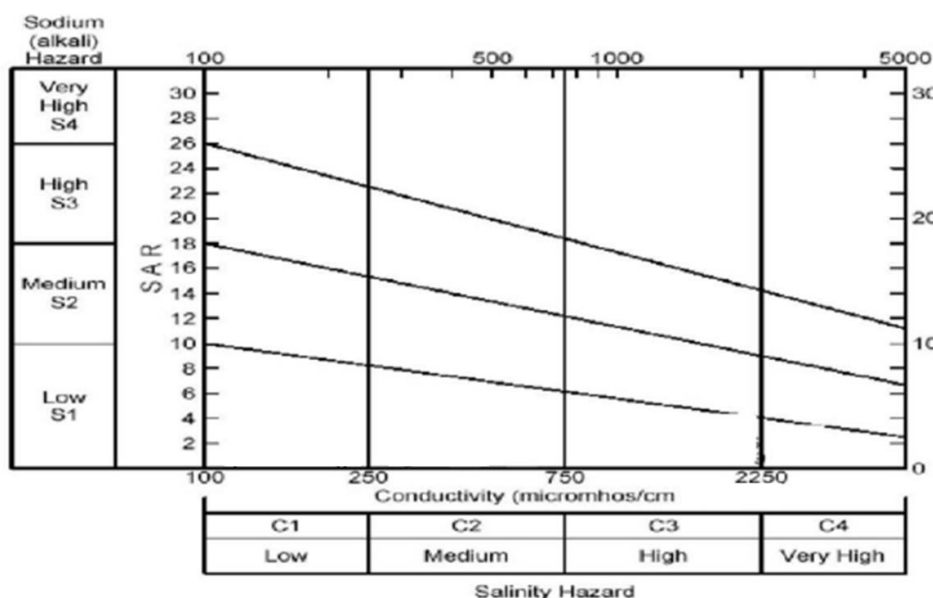
The analytical data plotted on the US Salinity diagram illustrates that all the groundwater samples are indicating low alkalinity hazard S1 and very low salinity hazard and so could not be plotted in diagram. The results therefore indicate

that all the water samples can be used for irrigation on almost all types of soil with little danger of exchangeable Sodium.

**Residual Sodium Carbonate (RSC):** has been calculated to determine the hazardous effect of carbonate and bicarbonate on the quality of water for agricultural purpose (Eaton 1950) and has been determined by the formula:

$$\text{RSC} = [\text{HCO}_3^{2-} + \text{CO}_3^{-}] - [\text{Ca}^{2+} + \text{Mg}^{2+}] \quad (5)$$

Where all the ionic concentrations were reported in meq/L.



**Figure 5:** Classification of Irrigation Waters using U.S. Salinity Diagram.

**Table 6:** Quality of Groundwater Based on Residual Sodium Carbonate.

RSC	Remark the quality	Samples
>2.5	Unsuitable	Nil
< 1.25	Good	Okwu Olokoru Borehole
1.25-2.5	Doubtful	All except Okwu Olokoru borehole

**Table 7:** The Values of SAR and RSC.

Samples	SAR	RSC
Ohiya	0.97	0.88
Umuobia (Isi Court)	1.15	1.44
Okwu	0.44	0.48
Amankwo/Amachara	1.06	1.47
Umunwanwa	1.20	1.45
	1.04	1.46
	1.07	1.83
Mgbarakuma	0.17	1.46
Nsukwe	1.44	2.22
	0.96	1.48
Itaja	1.02	1.47
	0.62	2.08
Abam	1.10	0.97

The classification of irrigation water according to the RSC values is presented in Table 6. According to the US Department of Agriculture, water having more than 2.5 epm of RSC is not suitable for irrigation purposes while those having 1.25-2.5 epm are marginally suitable and those with less than 1.25 epm are safe for irrigation (Table 6) and the results shows that all the samples are marginally suitable for irrigation except Okwu water sample which is good and safe for irrigation.

## CONCLUSION

From the observation, it may be concluded that naturally the groundwater of the study area is potable except for the slightly acidic nature of most of the samples and relatively high Iron content in some of the samples.

The high iron concentration could be treated through aeration and filtration method. Though Nitrate ( $\text{NO}_3^-$ ) and Sulphate ( $\text{SO}_4^{2-}$ ) are naturally occurring in groundwater but their non-detection, and the concentrations of other cations and

anions being far below WHO permissible limit indicates that the groundwater of Umuahia – South Local Government Area is safe for domestic and drinking purposes.

From the observation, it may be concluded that all the sampling station considered are suitable for irrigation uses according to EC, SAR and RSC values. Therefore, the groundwater samples of the study area are naturally satisfactory for agricultural (irrigation) purposes.

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