International Journal of Science and Healthcare Research
Vol.1; Issue: 2; April-June 2016
Website: www.gkpublication.in/ijshr
Original Research Article *ISSN: 2455-7587*

Hydrochemical Evaluation of Water Resources in Umuoghara and its Environs, Near Abakaliki, South Eastern Nigeria

V. O. Ezeh[1], M. O. Eyankware[1], O. O. Irabor[2], P. N. Nnabo[1]

[1]Department of Geology, Ebonyi State University, P.M.B. 053, Abakaliki, Ebonyi State.
[2]Department of Earth Science, Federal University of Petroleum, Effurn Delta State.

Corresponding Author: V. O. Ezeh

Received: 08/04/2016 | Revised: 16/05/2016 | Accepted: 16/05/2016

ABSTRACT

A total of twelve (12) water sample were randomly sampled from six hand-dug well, four boreholes and two ponds close to quarry site and were analyzed for different hydrochemical qualities. The following 16 parameters have been considered viz: electrical conductivity, pH, turbidity, temperature, colour, and total dissolved solid, total hardness, sulphate, nitrate, chlorine, sodium, carbonate, Bicarbonate, potassium, calcium, magnesium, iron and lead. On comparing the results against water quality standards laid by World Health Organization and Nigeria Industrial Standard (NSDWQ, 2007). It was observed that some of the analysed physical and chemical parameters were above the (WHO, 2011 and NSDWQ, 2007) permissible limit at various sample location. The Hydrogeochemical trend Ca> Cl >SO_4>HCO_3+CO_3>Mg. From the research carried is hereby recommended that the state government should enforce strict rules on illegal mining activities; farmer should be well trained about the fertilizer application on their farmland, periodic surface and groundwater monitoring and treatment.

Keywords: *Asu River Group, water Quality, WHO, 2011, Domestic use and NSDWQ, (Nigeria Standard for Drinking Water Quality).*

1. INTRODUCTION

Water quality analysis is one of the most important aspects in water studies for domestic, agricultural and industrial use. Determination of physicochemical characteristics of water is essential for assessing the suitability of water for various purposes like drinking, domestic, industrial and irrigation. Ground and surface water quality may also vary with seasonal changes and is primarily governed by the extent and composition of dissolved solids (Vikas Tomar, *et al*., 2012). Generally, the quality of water passing through the hydrologic cycle is affected by factors such as soil, vegetation, geomorphology, geology and anthropogenic activities. The influence of these factors either improves or degrades water quality (Olobaniyi, *et al*., 2007), and also the physical and chemical characteristics of water are important parameters as they may directly or indirectly affect its quality. Suitability of groundwater for domestic use is determined by its geochemistry (Eyankware, *et al*., 2014). Since chemical contaminants occur in drinking water throughout the world which could possibly threaten human health. This has led to the assessment of water potability of the study area (Eyankware *et al*., 2015). Population increase within the area in the past three years as a result of quarrying activities has put enormous strain on the available water resources. The health conditions of the residents in the area will depend greatly on the quality of water available for domestic use.

Moreso access to potable water has been a problem in the area in the past years. At the peak of dry season when the Ebonyi State Rural Water Supply and Sanitation Agency, Abakaliki (EB-RWASSA) have problem with supplying water to the inhabitant of the area, They have no other choice rather than to relies on hand-dug well and ponds as source of water for domestic and agricultural use see Plate.1.This problem has been surpassed but to some certain extent, sequel to the drilling of borehole within the area. The study aim at assessing the quality of water resources and comparing it with recommended standard of WHO, 2011 and NSDWQ, 2007 to determine their potability, possible remedial measure to improve the quality of water will also be recommended in this paper. Previous research has been carried on hydrogeology and geochemistry of south eastern part in certain part of Asu River Group of Nigeria (Egboka, 1983 and 1985; Uma and Egboka1985; Obasi, *et al*, 2015; Ofomata *et al*, 2005).But emphasis has not be laid on the study area probably because the area is remote.

Description of the Study Area

The study area lies between latitude $6^{0}17^{1}$N - $6^{0}22^{1}$N and longitude $8^{0}06^{1}$E - $8^{0}11^{1}$E. It covers area such as Ndigba, Ndiaguazu Umuoghara, Ezza Abia, Ndiba, Okuwfunke, Amagu, Umueze Okoha, Umueze Akwa, Eka, Okpura Egbu and Amuzo and Umuome (Fig. 1). It covers approximately 81km. The major sources of water are stream, hand-dug well, manual borehole and motorized borehole. Despite how cheap and fairly distributed surface water resources could their usage has been limited by seasonal fluctuations and un-hygiene behaviour of the rural communities.

Plate.1: Inhabitant of the area sourcing for water at Ndibeazu Umughara Pond.

1.1 Geology of the Study

The Asu River group is known to be the oldest formation within the study area and they unconformably overlie the crystalline basement of Pre-Cambrian age (Nwachukwu, 1972) (Fig. 2). The oldest sediments present belong to the Albian marine transgression. Albian sediments constitute the Asu River group and its lateral equivalents (Agumanu, 1989; Ojoh, 1990). The deposits consist of alternating shales and siltstones with occurrence of sandstone. The Asu River group is locally tightly folded trending N60^{o}E with local deflections due to the influence of transcurrent faulting. The deformations from the South East basin edge towards the centre are a diversity of structural styles which include; fracturing, slumping, folding, tight folding with associated cleavages.

1.2 Hydrogeology of the Study Area

The movement and storage of groundwater within the area are generally controlled by lithology, thickness and structure of rock formation (predominantly shales of the Asu River Group). Shale is an aquiclude and does not permit reasonable transmission of water, especially when fresh and unweathered. There are, however, intercalations of clays and sand clays which have led to artesian conditions in the study area. Moreso, groundwater in the areas generally exists in fractured zones within the Asu River Group, sandstone and limestone layers or members, weathered zones, and bedrock interfaces with shale group (Nweke, *et al*., 2013).

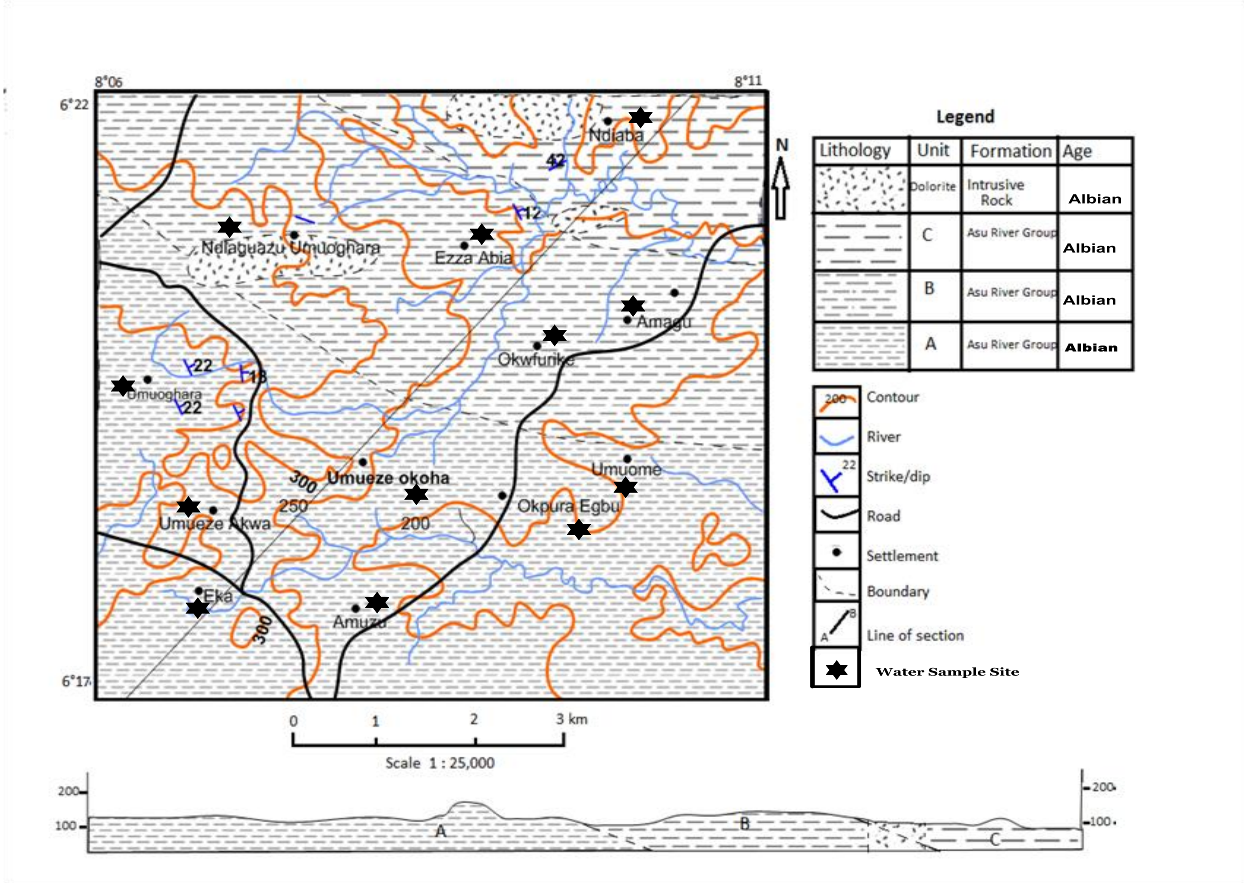

Fig.1: Geology of the Study Area and Water Sample Collection Sample.

2. MATERIALS AND METHODS

2.1 Laboratory analyses

A total of twelve sample were collected as shown in Fig.1 and analyzed for physicochemical properties [pH, electrical conductivity (EC), turbidity, total dissolved solids (TDS), total hardness (TH), temperature cations (Ca^{2+} ‚ Na^{2+} and Mg^{2+}), anions (SO_4^{2-}, Cl^-, CO_3^{2-}, $HCO_3^-$and NO^{3-})and trace metals Fe^{2+} and Pb^{2+} (Table 1).

2.2 Statistical analyses

Relevant statistical packages (SPSS Version 17, Microsoft Excel 2007 Statistical Tool Pack) were used to analyze the data obtained and their levels of significance. Descriptive statistics were some of the analyses carried out in this study.

Table 1: Summary of analytical methods used for the analyses of groundwater samples. Parameter measured Standard Analytical Method used.

Parameters Measured	Standard Analytical Method used
pH	pH Meter
Temperature	Thermometer
Electrical Conductivity	Conductivity Meter DDS 307 model
Fe^{2+}, Ca^{2+}, Mg^{2+} and Pb^{2+}	Spectrophotometric
Total dissolved solids	Filtration and Evaporation
Total Hardness, CO_3^{2-}, $HCO_3^-$and Cl^-	Titrimetric
Turbidity, NO^{3-}	Spectrophotometric
SO_4^{2-}	Turbidimetric

3. RESULTS AND DISCUSSION

3.1 Electrical Conductivity

The ability of water to conduct electric current is due to the presence of solids in solution which is referred to as total dissolved solid (Obasi, *et al.*, 2015). Concentration of electrical conductivity ranges from 11.67 to 1100µS/cm. (Fig.3 and Table.2), with an mean value of 331.75 µS/cm. The concentration of E.C is 1100 at EVO/WS/01 is higher than the (WHO, 2011 and NSDWQ, 2007) permissible limit at EV/ WS/01 this could be attributed to washing away of the fertilizer from the soil into water source.

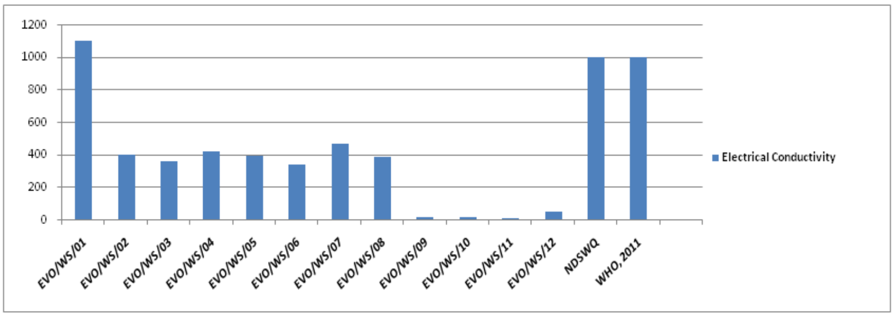

Fig. 2: Graphical Representation electrical conductivity compare to NSDWQ, 2007 and WHO, 2011.

3.2 pH, Turbidity, Temperature and Colour

pH concentration depicts the balance between acids and bases in water. The concentration of pH ranges from 5.27-7.21 the concentration falls below (WHO, 2011 and NSDWQ, 2007) permissible limit (Fig.3 and Table.2). With mean value of 6.49 see Table.3. The measurement of turbidity is a key test of water quality. The concentration of turbidity in the area ranges between 0.01 - 25 NTU (Fig.3 and Table. 2). Location EV/WS/01, 03, 04 and 05 has high concentration of turbidity that is above (WHO, 2011 and NSDWQ) permissible limit. With mean value of 7.07 see Table.3. High concentration of turbidity can be attributed to floating algae, soil washing from the banks into the water, fires, or from industrial activity such as mining, logging or dredging (U.S.E.P.A.). Temperature ranges from 20.65 - 26.81^{0}C with mean value of 22.69^{0}C see Table.3 The concentration of colour ranges from 3- 15 the concentration falls (WHO, 2011) permissible limit. With mean value of 7.45 see Table.3.

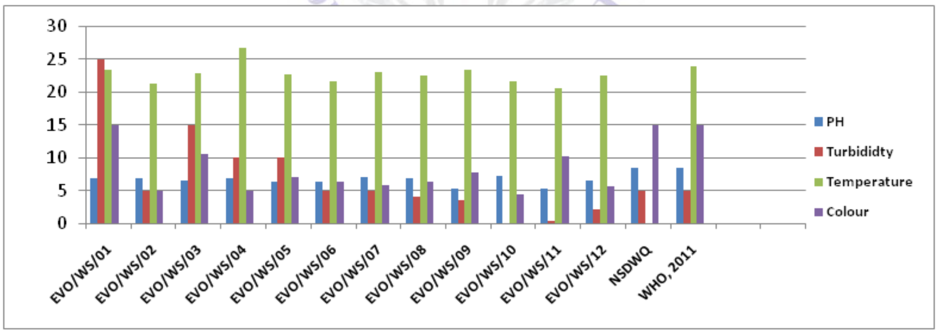

Fig. 3: Graphical Representation, pH, Turbidity, Temperature and Colour compare to NSDWQ, 2007 and WHO, 2011.

3.2 Total Dissolved Solid (TDS) and Total Hardness (TH)

TDS measures the total concentration of all mineral constituents dissolved in water and is related to the problem such as excessive hardness. TDS ranges from 0.34 - 687.55, with mean value of 202.95 see Table.3. At location EV/WS/01the concentration of TDS is above (WHO, 2011) permissible limit see (Fig.4) it is attributed to anthropogenic activities (human activities and agricultural activities) that finally have their way into water source thereby increasing the concentration of total dissolved solid.

Total hardness ranges from 56 – 330 mg/l, with mean value of 196.5mg/l see Table.3. At location EV/WS/03, 05 and 08 are above (WHO, 2011) permissible limit

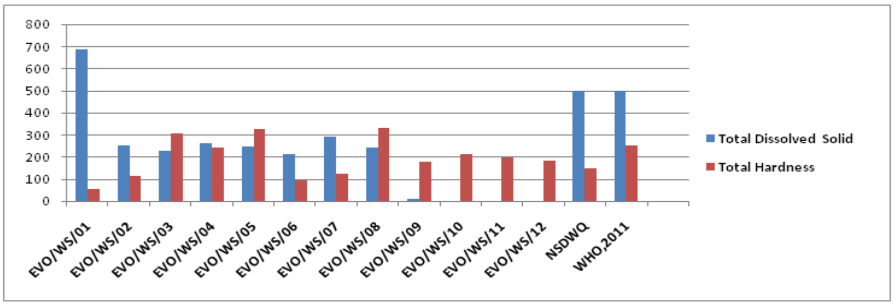

Fig. 4: Graphical Representation of Total Dissolved Solid and Total Hardness compare to NSDWQ, 2007 and WHO, 2011.

Table.2: Result of Hydrochemical Parameters of Water Sample from Umuoghara and its Environs, Ebonyi State.

Sample	E. C µS/ cm	pH	Turbidity NTU	Temperature O^0C	Color (^oH)	TDS (mg/l)	TH mg/l	SO_4^{2+} mg/l	NO^{-3} mg/l	Cl^- mg/l	Na^{2+} mg/l	K^+ mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	Fe^{2+} mg/l	Pb^{2+} mg/l	CO_3^{2-} mg/l	HCO_3^- mg/l
EVO/WS/01	1100	6.9	25	23.4	15	687.5	56	3.1	74	22.69	7.57	6.23	120.4	38.7	0.32	0.04	0.74	15.5
EVO/WS/02	400	6.8	5	21.4	5	250	112	78	63	9.93	7.195	7.01	116.8	27.6	0.4	0	5.67	9.84
EVO/WS/03	360	6.5	15	22.09	10.64	225	304	65	50	5.67	6.07	5.03	100	16.2	6.49	4.29	3.81	14.65
EVO/WS/04	420	6.9	10	26.81	5	262. 5	242	2.8	39	8.508	5.894	5.84	47.2	37.2	0	0	0.85	3.72
EVO/WS/05	395	6.3	10	22.8	7.1	246.9	328	0.1	2	7.09	8.351	8.32	78.4	39.6	4.1	3.2	1.23	0.07
EVO/WS/06	340	6.4	5	21.75	6.3	212.5	94	45	3.4	14.18	8.951	6.54	88	11.6	6.43	2	7.98	2.21
EVO/WS/07	470	7	5	23.07	5.8	293.8	123	99	0.34	8.503	6.525	8.30	70	26.1	0.93	4.19	11.05	13.63
EVO/WS/08	390	6.8	4	22.54	6.4	243.8	330	56	0.57	9.926	5.623	1.623	120	9	0.54	2.73	21.87	18.40
EVO/WS/09	20.17	5.27	3.5	23.43	7.8	12.22	178	72	0.14	444	8.58	7.57	49.97	0	0.14	2.77	34.23	9.54
EVO/WS/10	17.44	7.21	0.01	21.75	4.5	0.44	210	91	0.53	236	8.267	1.624	21.4	0	11.4	2.26	0.75	0.32
EVO/WS/11	11.67	5.27	0.31	20.65	10.3	0.42	197	45	0.14	74	8	7.57	10.41	10.589	1.57	2.43	6.32	4.32
EVO/WS/12	56.8	6.54	2.04	22.65	5.6	0.34	184	23	11.8	17.3	1.178	1.63	33.11	0	55	2.76	27.87	11.59
NSDWQ, 2007	1000	6.5-8.5	5	Ambient	15	500	150	100	50	250	200	N/A	N/A	0.20	0.3	1.88	N/A	N/A
WHO, 2011	1000	6.5-8.5	5	24	15	500	250	100	3	250	200	100	100	0.2	0.3	0.01	N/A	-

NOTE: mg/l- Milligram per litre T.H - Total Hardness, N/A - Not available or detected and TDS - Total dissolved solids, E.C – Electrical Conductivity, WHO- World health Organization, NSDWQ- Nigeria Standard for Drinking Water Quality

Table. 3: Descriptive statistics of analyzed groundwater samples compared with NSDWQ and (WHO, 2011) Standards for Drinking Water Quality.

PARAMETERS	MININUM	MAXIMUM	MEAN	MEDIAN	STANDARD DEVIATION	NSDWQ	WHO,2011
EC(µS/cm)	11.67	1100	331.7517	375	302.1117	1000	1000
pH	5.27	7.21	6.490833	6.67	0.62744	6.5-8.5	6.5-8.5
TURBIDITY (NTU)	0.01	25	7.071667	5	7.118517	5	5
TEMP (^0C)	20.65	26.81	22.695	22.595	1.542115	Ambient	24
COLOUR	4.5	15	7.453333	6.35	3.086974	15	15
TDS (mg/l)	0.34	687.5	202.9517	234.4	193.6345	500	500
TH (mg/l)	56	330	196.5	190.5	91.55773	150	250
SO_4^{2+} (mg/l)	0.1	99	48.33333	50.5	34.73815	100	100
NO^{-3} (mg/l)	0.14	74	20.41	2.7	27.99796	50	3
Cl^- (mg/l)	5.67	444	71.48308	12.055	134.3095	250	250
Na^{2+} (mg/l)	1.17	8.95	6.825	7.38	2.116071	200	200
K^+ (mg/l)	1.623	8.32	5.60725	6.385	2.584687	N/A	100
Ca^{2+} (mg/l)	10.41	120.4	71.3075	74.2	38.96302	N/A	100
Mg^{2+} (mg/l)	0	39.6	18.04833	13.9	15.29613	0.20	0.2
Fe^{2+} (mg/l)	0	55	7.276667	1.25	15.44415	0.3	0.3
Pb^{2+} (mg/l)	4.29	0	2.2225	2.58	1.497987	1.88	0.01

Table. 4: Water Sample Collection Site.

S/N	SAMPLE NAME	WATER SOURCE
1	EVO/WS/01 (Ndibia)	Hand-Dug Well
2	EVO/WS/02(Ezza Abia)	Borehole
3	EVO/WS/03(Ndibeazu Umughara)	Pond Close to mining site
4	EVO/WS/04(Amagu)	Borehole
5	EVO/WS/05(Okwfunke)	Borehole
6	EVO/WS/06(Umughara)	Hand-Dug Well
7	EVO/WS/07(Umueze)	Pond
8	EVO/WS/08(Umuome)	Hand-Dug Well
9	EVO/WS/09(Okpura Egba)	Hand-Dug well
10	EVO/WS/10 (Amuzu)	Borehole
11	EVO/WS/11(Eka)	Hand-Dug Well
12	EVO/WS/12(Umeze Akwa)	Hand-Dug Well

3.3 MAJOR CATIONS

3.3.1 Sodium, Calcium, Magnesium and Potassium

Sodium ranges from 1.178 - 8.951mg/l, with mean value of 6.825mg/l(Table.3). Its concentration falls below (WHO, 2011 and NSDWQ, 2007) permissible limit. Calcium is the most abundant of the alkaline-earth metals and is a major constituent of many common rocks minerals. Calcium is present in groundwater due to its easy solubility and abundance in most rock types. The concentration of calcium ranges from 10.41 - 120.4 mg/l, with mean value of 71.30 mg/l(Table.3). At sample location EVO/WS/01, 02 and 08 the concentration of calcium is above (WHO, 2011) permissible limit (Fig.5 and Table.2) this could be attributed to illegal mining activities.

Magnesium can enter the environment from discharge and emissions from industries that use or manufacture magnesium. Rainwater falling on rocks can also increase the levels of magnesium in river and sea water. The concentration of magnesium in groundwater is generally less than calcium due to slow dissolution of magnesium bearing minerals and greater abundance of calcium ions in earth's crust. Magnesium is a silvery white metal that is insoluble in water; however magnesium salts are able to dissolve in water. It is found in rocks and mineral deposits present in the earth's crust. It is also naturally present in sea water and salt deposits and is the eighth most abundant metal on the planet. The concentration of magnesium ranges between 0 - 38.7 mg/l see (Fig.5 and Table.2). With mean value of 18.04 mg/l. The concentration of the analysed sample were above (WHO, 2011 and NSDWQ, 2007) permissible limit except for EVO/WS/09, 10 and 12. The high concentration can be attributed to rainwater falling on rocks can also increase the levels of magnesium in river and sea water. Occupational exposure to magnesium may occur during mining. In most natural water, the concentration of potassium is much lower than that of sodium. Potassium is an essential element for both plants and animals. Very high potassium concentration may be harmful to human nervous and digestive system (WHO, 2011 and NSDWQ, 2007). Potassium concentration ranged between 1.63 - 8.32 mg/l its concentration falls below (WHO, 2011 and NSDWQ, 2007) permissible limit.

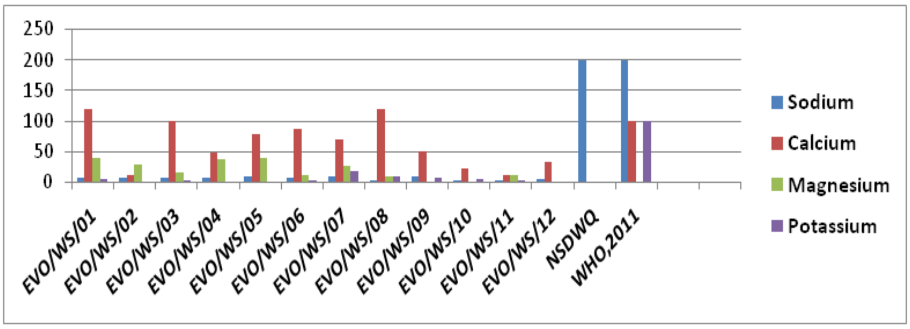

Fig. 5: Graphical Representation of Calcium, Magnesium and potassium NSDWQ, 2007 and WHO, (2011).

3.4 MAJOR ANIONS

3.4.1 Sulphate, Nitrate, Carbonate, Bicarbonate and Chloride

Sulphate (SO_4^{2-}) can be naturally occurring or the result of municipal or industrial discharges. The principle natural sources include rock weathering, input from volcanoes and input from biological or biochemical process. The concentration of sulphate ranges from 0.1 - 78 mg/l. Nitrate the major sources in water are through organic matter from man-made pollutants such as agricultural fertilizers. In the study area, nitrates concentration ranges 0.14 - 74 mg/l. (see Fig.6 and Table.2).

Carbonate: The concentration of carbonate ranges from 0.74 – 34.23 mg/l. Its values falls below (NSDWQ, 2007 and WHO, 2011) permissible limit. (Fig. 6 and Table. 2).

Bicarbonate: The concentration of bicarbonate ranges from 0.32 - 18.40 mg/l and the value range fall below (WHO, 2011) permissible limit.

Chloride: Chloride is one of the major inorganic anions in water and waste water. The concentration of chlorine ranges from 5.67 - 444 mg/l (Fig. 6 and Table. 2). The concentration of chloride is above (NSDWQ, 2007 and WHO, 2011) permissible limit at sample location EVO/WS/09.

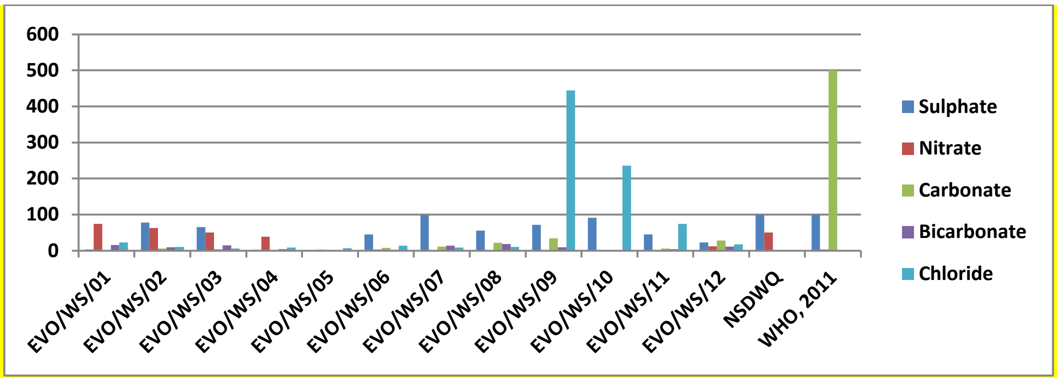

Fig. 6: A Graphical Representation of Chlorine, Sulphate and Nitrate against NSDWQ, (2007) and WHO, (2011).

TRACE ELEMENTS

Lead and Iron

The amount of dissolved lead in surface water and groundwater depends on pH and the concentration of dissolved salts and the types of mineral surfaces present. In surface water and groundwater systems, a significant fraction of lead is undissolved and occurs as precipitates ($PbCO_3$, Pb^2O, $Pb(OH)_2$, $PbSO_4$) sorbed ions or surface coatings on minerals, or as suspended organic matter. The concentration of lead ranges from 0 - 4.29 mg/l at EVO/WS/ 03, 07, 08, 09, 10, 11 and 12 the concentration of these sampled location were above (WHO, 2011 and NSDWQ, 2007) permissible limit. This could be attributed to mining activities within the area. Lead infiltrate into the groundwater and surface water (ponds) through to leaching processes. (Fig.7).

Lead has mean value of 2.22mg/l (Table.3)

Iron

Iron is a metallic element found in earth crust. Water percolating through soil and rock dissolved mineral containing iron and hold them in solution, occasionally pipe are also main source of iron in water. Concentration of iron ranges from 0 - 11.4 mg/l, with mean value of 7.27mg/l see Table.3. At EVO/WS/01, 02, 03, 05, 06, 07, 08, 10 and 12 the concentration of iron is above (WHO, 2011 and NSDWQ, 2007) permissible limit see Fig. 7. It attributed to local miner that carry out their mining activities without take consider of disposal of some of waste material on the environment these element have their way into water bodies through weathering activities mostly during the reason.

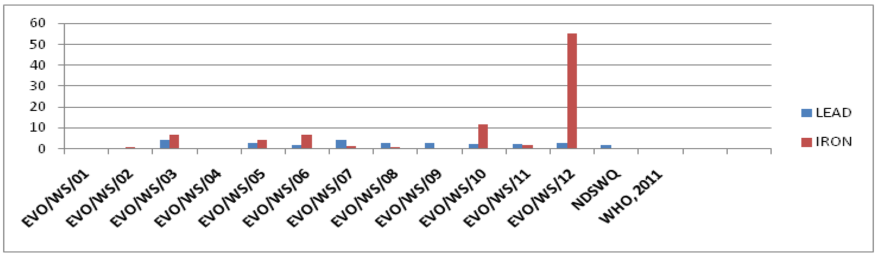

Fig. 7: A graphical representation of Iron and Lead against NSDWQ and WHO, (2011).

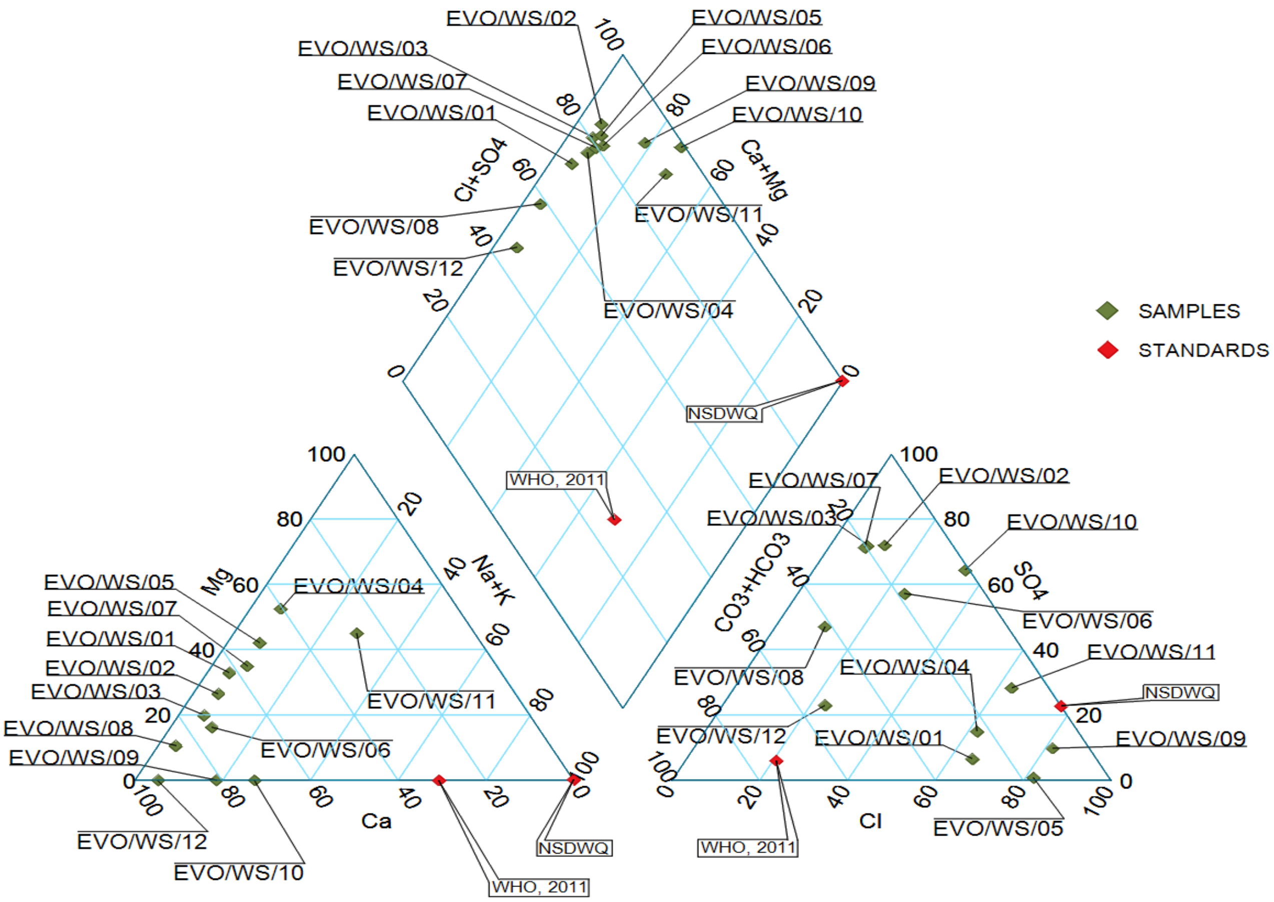

Fig. 8: Piper Diagram.

From Fig.7 the cation area are EVO/WS/01, 02, 03, 07, 08, 09, 10 and 12 are of Ca water type; EVO/WS/04 is of Mg water type, while EVO/WS/05 and 11 has no dominant ionic specie. Also, on the anion area EVO/WS/01, 04, 05, 09 and 11 are of Cl water type, EVO/WS/02, 03, 06, 07 and 10 are of SO_4 water type, EVO/WS/12 is of HCO_3+CO_3 water type while EVO/WS/08 has no dominant ionic specie. The Hydrochemical trend Ca> Cl >SO_4>HCO_3+CO_3>Mg.

CONCLUSION

The major cause of groundwater and surface pollution is as a result of mining activities which has rendered water for domestic use of poor in quality. The study showed that water resources in the study area is not of best/ desirable quality with respect to some dissolved geochemical constituents such as: lead, iron, electrical conductivity, nitrite, total dissolved solid, total hardness, magnesium, calcium, temperature, chlorine and turbidity. The contamination is believed to have been impacted by natural source as water flows from the mining site into the water source of the area. Recommendations include; government should effect strict rules on illegal mining activities, farmer should be well trained on the use of fertilizer application on their farmland and finally there should be periodic surface and groundwater monitoring and treatment.

REFERENCES

- Agumanu, A.E., (1989). The Abakaliki and Ebonyi Formations: subdivisions of the Albian Asu River Group in the southern Benue Trough, Nigeria. *Journal African Earth Sciences*. 9. 195-207.
- Domenico, P. A and Scheartz, F. A. (1990). Physical and Chemical

Hydrogeology. J. Wiley and Son's New York. Pp 23-64.

- Egboka, B.C.E. (1983). Analysis of the Groundwater resources of Nsukka Area and Anambra State. Nigeria. *Journal Mining Geology*. 20: 1-2
- Egboka, B.C.E.,(1985). Water Resources Problems of Enugu Area, Anambra State Nigeria. IAHS Publications.153: 95-96.
- Eyankware, M. O and Obasi, P. N. (2014). Physicochemical Analysis of Water Resources in Selected Part of Oji River, Enugu State South Eastern Nigeria. *International Journal of Innovation and Scientific Research.* 10(1): 171-178.
- Eyankware, M. O., Ufomata, D. O., Effam, C.S., Akakuru, O.C. (2015). Physicochemial and Bacteriolgical Assessment of Groundwater Quality in Ughelli and its Environs. *International Journal of Innovational and Scientific Research.* (14)2: 236-243.
- Nwachukwu, S.O., (1972). The Tectonic Evolution of Southern Portion of Benue Trough, Nigeria Geol. Mag. 107: 417- 419.
- NIS (2007). Nigerian Industrial Standard. 2, ICS 13.60.20, pp. 16-20.
- Nweke, O. M., Aghamelu, O. P. and Obasi, I. A. (2013). Hydrogeochemical analysis and quality evaluation of groundwater from Onicha-Uburu, Southeastern Nigeria for irrigation purposes. *African Journal of Environmental Science and Technology*. 7(5). 222-228
- Obasi, Philip. N., Eyankware, Moses. O., Akudinobi, Benard, B. E. and Nweke, Mathias. O. (2015). Hydrochemical Investigation of Water Resources around Mkpuma Ekwaoku Mining District, Ebonyi State Southeastern Nigeria. *African Journal of Geo-Science Research*. 3(3): 01-07.
- Olobaniyi, S. B. Omo-Irabor, O. O. (2007). Investigation of the Hydrological Quality of Ethiope River Watershed, Southern Nigeria. *Journal of Applied Science Environment Management*. 11(2): 13-19.
- Ofomata, A.E., Omwuka, O.S. and Egbu, O. S. (2005). Groundwater Quality Lekwesi/Umuchieze Area. Southeastern Nigeria. *Pacific Journal of Science and Technology*. 6(2): 170-176.
- Ojoh, K.A., (1990). Southern part of the Benue Trough (Nigeria) Cretaceous Stratigraphy, Basin Analysis, Paleo - Oecanography and Geodynamic Evolution in the Equatorial domain of the South Atlantic NAPE . 7: 131-152.
- U. S. E. P. A. Turbidity. http://water.epa.gov/type/rsl/monitoring/vms55.cfm
- Vikas Tomar, Kamra S.K, Kumar S, Kumar Ajay, Vishal Khajuria. (2012). Hydro-chemical analysis and evaluation of groundwater quality for irrigation in Karnal district of Haryana state, India. *International Journal of Environmental Sciences.*3: 756.
- WHO (World Health Organization). (2011). Guideline for drinking water quality Recommendations, 4th Edition. 1: 219-230.

How to cite this article: Ezeh VO, Eyankware MO, Irabor OO et al. Hydrochemical evaluation of water resources in Umuoghara and its environs, near Abakaliki, south eastern Nigeria. International Journal of Science & Healthcare Research. 2016; 1(2): 23-31.

******