IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 9, September 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

Irrigation Suitability of Surface Waters of Enyigba Ebonyi State, Southeastern Nigeria

Chinenye Florence Onyeabor[1] and Nneto Rex. Nwatalari[2]

Department of Geology and Mining, Enugu State University of Science and Technology, Agbani P.M.B. 01660, Enugu State Nigeria.

Abstract

Enyigba town and its environs lies within latitude $N8^0 05^1$ to $N8^0 10^1$ and longitude $E\ 6^0 09^1$ to $E\ 6^0 14^1$ covering an areal extent of $85.5km^2$.The area is underlain by the Abakaliki Formation. The study area's prominence is based on the pb-zn mineralization and to salt lake geochemistry. A total of six surface water samples were analyzed both for in situ and laboratory analysis. The in situ result shows an acidic water system except for Enyigba lake. The Enyigba lake and Amajim river have higher pH value of 9.98 and 6.08 respectively which is due to different chemistry compared to other surface waters and the elevations (46m and 58m respectively) which are higher than the others, hence recharging the other water bodies and receiving less contaminants. The hydrochemical results in mg/l were thus obtained.Na^+(0.06-2.26),mg^{2+}(0.02-0.90),Ca^{2+}(3.16-51.48),Fe^{2+}(0.1-0.82),Mn^+(0.02-0.05)SO_4^{2-}(1.8-46.8),No_3^-(4.0-25) and Cl^-(8.4-106.4).The sodium absorption ratio is found within the acceptable limit hence not affecting the surface water consumption for irrigation purposes. The source rock deduction obtained from the water analysis reveals a high brine type of water and a pyritic oxidation and calcite precipitation chemistry. The chemistry is acceptable for irrigation but not acceptable for drinking due to extreme values of Fe^{2+} in Enyigba salt lake, Ameka stream and Akpaara river. Also the Cl- values in Akpaara river and Ameka stream are very high for human consumption.

Keywords: Oxidation-reduction potential, irrigation, surface waters, brine water and elevation.

1. Introduction

Enyigba town is located in Ikwo local government area of Ebonyi state. Enyigba is a prominent town in the Abakaliki district due to the occurrence of lead - zinc mineralization in the area which is attributed to saline intrusion and the vein morphology and fracture origin. Presently, Royal salt is the major mining company outside the artisan miners still mining Pb-Zn in Enyigba. This is due to the depletion of Pb-Zn and liaison challenges. The chemical quality of water results from hydrogeochemical processes of solution or precipitation of solid minerals, reduction and oxidation of compounds, solution or evolution of gases, sorption or ion exchange, pollution, mixing of different waters (Appleo and Posma 1993). The waters in Enyigba have been contaminated and polluted due to saline intrusion, dissolution of contaminants from host rocks and improper mine activities that have gone on for a long period of time (Egboka and Uma1985). These wastes were exposed and oxidized, hence yielding heavy metals in the surface waters. According to Aucamp (2003), mining activities has contributed immensely to the increase in heavy metal concentration in the soils and groundwater vis-a-via the biosphere. Over the years, the total concentration of heavy metals in Enyigba has been the concern of most geochemists due to the influence of the mine activities in the soil, surface water and ground water. The oxidation - reduction potentials (ORP) of the target environment also contributes immensely to the availability of the metals into the biota resulting to most metal sulphide minerals remaining immobile in a chemically reducing environment (Davis et al.1999). Enyigba basic cations and anions would be analyzed to evaluate its portability and suitability for irrigation. The chloride concentration in adjoining towns are high (Obasi and Akudinobi 2013), hence the same could be obtainable in Enyigba especially the Enyigba lake. The work is aimed at evaluating the area to determine the oxidation-reduction state and its suitability of the waters for irrigation purposes.

2. Study Area

2.1 Location

The study area lies within latitude N8^{0}05^1 to N8^{0}10^1 and longitude E 6^{0}09^1 to E 6^{0}14^1 covering an areal extent of 85.5km^2.The towns in the study area includes Eluwaofe, Amajim, Ameka, Enyigba and Ishiagu. The area can be accessed through Abakaliki-Ngbo road. Nnabo et al. 2011 and Ezeh and Nnabo 2010 has studied various water bodies in Enyigba and consistently reported the high acidity due to the effects of the mines. The mines according to Orajaka (1965) are; Enyigba, Ameri, Ameka, Ikwo, Palmwine, Nine Pence and Portuguese lodes. These mines are presently being reworked and new one are dunged too.

2.2 Physiography, climate and vegetation

Enyigba is underlain by an undulating terrain. The area lies at an average elevation of 100m above the sea level. The surface drainage in the area is irregular and consists of ephemeral streams and rivers. They flow in a north-south direction into Ebonyi river. Surface waters include the Akpaara river, Ngele stream. All of these drains into the Ebonyi river and onward to Cross river. Offodile (2013) in his work in Cross river Basin shows that Ebonyi river tributaries flows from the Enugu Escarpment and drains the study area in a dendritic pattern before moving into the Cross River and thus part of the Cross River Basin. The average population is projected at 20,605 as at 2011 (NPC 2006).

The climate is basically constituted of wet season and dry season; the wet season spans from March to October while the dry season spans from November to February. The average rainfall of the area is about 1500 to 1800mm (Ofomata, 2002). The mean annual temperature of Enyigba is 27^{0}c.This area falls within the Guinea Savanna having luxuriant grasses and stunted trees (Igbozuruike, 1975). Some of the economic trees in the study areas are palm trees, citrus and mango. The soil type ranges from loamy clay to clay which is suitable for potato cultivation.

2.3 The Geology

The study area is underlain by the Abakaliki Shale of the Asu River Group which was described by Simpson (1954) as olive brown sandy shale, fine grounded micaceous sandstone and mudstone with a relative bed thickness of about 1500m. The shales are dark grey to fissile light brown and are well exposed at the Akpara river channel and Abakaliki-Enyigba road. These shales appear rich in clay minerals; smectite, illite and little fractions of kaolinite. The shales are highly consolidated and compacted to almost baked around Eluwaofe village. The dip amount ranges from 3^0 to 9^0 in a NW-SE direction. The study area could be grouped into two lithological units with one being underlain by pure shale and the other, sandy shale as shown in Fig1.The mineral veins were reported by Nnabo, P.N. (2015) to dip between 70^0 and 88^{0}w. The mineralization is post-Santonian paratectonic episode due to the overall structural setting of the Benue Trough (Uzuakpunwa,1974). This Santonian event led to the folding, faulting and fracturing of the formations from Albian to Turonian age. The Joints trends in the NW-SE direction. The Abakaliki Formation was considered to be deposited in a shallow marine environment by Reyment (1965), although Ojoh (1990) provided faunal evidence suggesting Albian depositional setting into Southern Benue Trough as deep marine environment.

3. Materials And Method

This study was conducted using a desk study, fieldwork and laboratory analysis procedure. The desk study involved a comprehensive review of earlier works done in the study area. The field work was conducted with an intense field mapping to delineate the lithological, structural and surface water exposures. The surface water samples were obtained and geo-tagged observing the USEPA (2012) standard for water sample collection. An insitu test involving pH, conductivity, oxidation- reduction potential, salinity and total dissolved solids (TDS) were conducted in the field using an Extech model WQ510 multipurpose analytical kit.

The samples were taken to the laboratory within 24 hours of collection. Six different surface water samples of Akpara river, Njele river, Enyigba lake, Ameka pond, Ameka stream and Amajim river were obtained. The coordinate positions where the samples were obtained are given in table 1.0. The samples cations were analyzed with Atomic Absorption Spectrometer while volumetric methods were used to analyse for anions.

Table 1.0 The positions and the elevation of the surface waters

Location Name	**Latitude**	**Longitude**	**Elevation**(m)
Akpaara river	$N6^{0}12^{1}48.1^{11}$	$E08^{0}06^{1}37.2^{11}$	40
Ngele river	$N6^{0}11^{1}54.3^{11}$	$E08^{0}34^{1}37.1^{11}$	30
Enyigba lake	$N6^{0}10^{1}40.9^{11}$	$E08^{0}08^{1}22.1^{11}$	46
Ameka Pond	$N6^{0}09^{1}54.5^{11}$	$E08^{0}08^{1}22.1^{11}$	44
Ameka stream	$N6^{0}09^{1}35.0^{11}$	$E08^{0}06^{1}09.1^{11}$	43
Amejima Ameka river	$N6^{0}10^{1}23.4^{11}$	$E08^{0}07^{1}09.1^{11}$	58

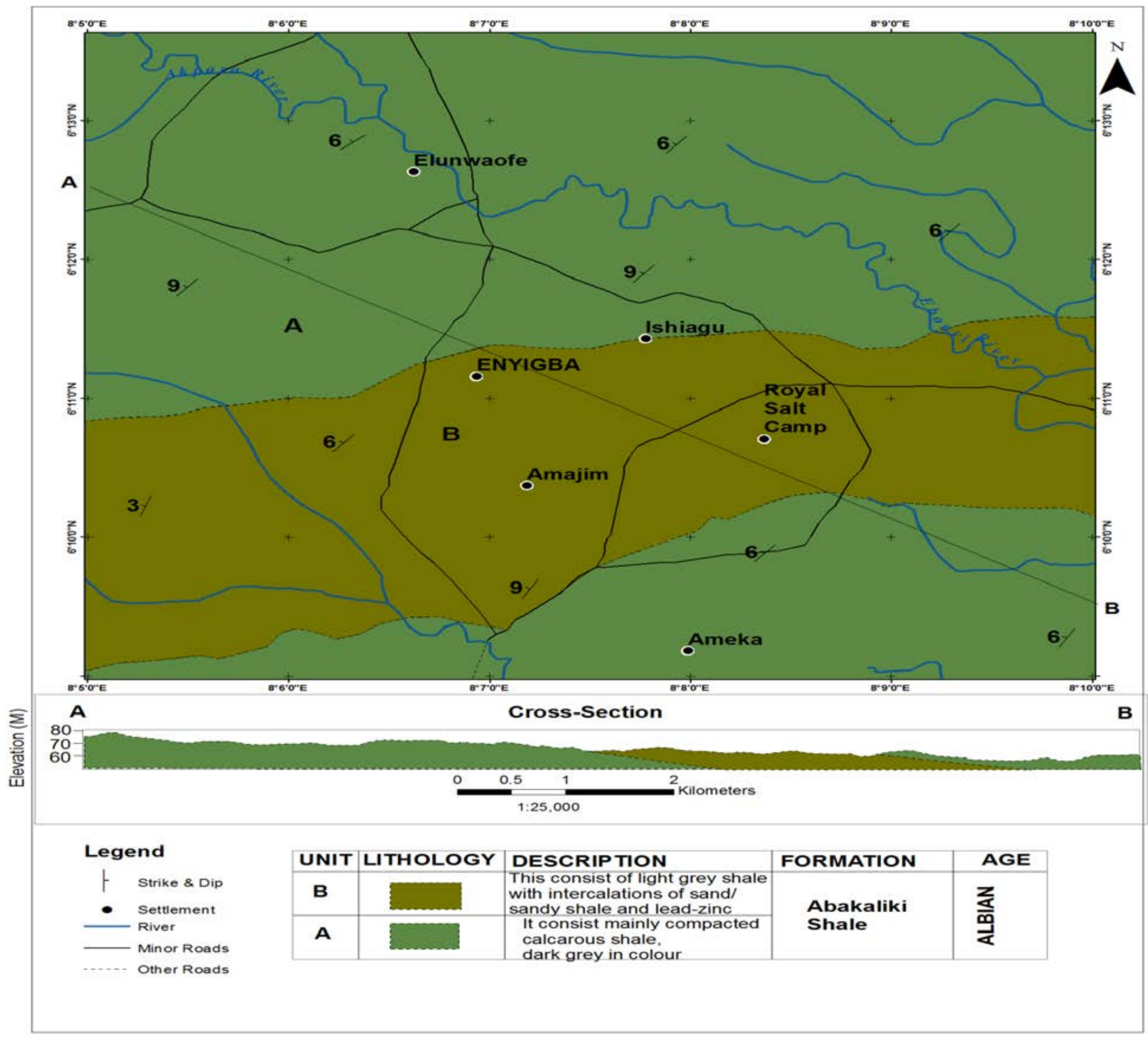

Fig.1.0 The geologic map of Enyigba, Ebonyi State Nigeria

4. Results And Discussion

Various hydrochemical processes affecting water chemistry could be identified with the aid of physical and chemical parameters of the water quality thus used for classification of water chemistry (Appelo and Postma,1993 and Schlumberger,2006). The results of the physical parameters are shown in table 2.0.The pH values of the water samples indicated an acid water environment except for Enyigba lake which is an already established salt lake influenced by the ancient sea (Nnabo 2015). The high pH value usually results to a reduced ORP value as seen in Enyigba lake and its reverse in Akpaara river. Amajim river which is located about 2km west of the Royal salt camp gives a slight acidic value. The elevation of the river is at 58m which is higher than the other water bodies (table1.0) thus serving as an ephemeral river system and not really polluted by the other streams. The conductivity value which is directly related to the total dissolved solids shows the highest value for Akpara river. This is due to the nearness to the source of contamination as shown in fig 1.0.The salinity value of the Enyigba lake shows the highest value due to the effect of the host rock. This confirms the earlier investigation of Orakaja (1965). He analysed the salt water resources of the defunct East central State of Nigeria and found out that the Ameri salt mine had a reasonable amount of salinity beyond the neighboring salt lakes of Uburu and Okposi. The chemical analysis results are tabulated in table 3.0 and in Schoeller diagram (fig.2.0). Figure 2.0 reveals the positions of the chemical parameters of the waters. This shows that the cation values (all in mg/l): Mg^{2+}(0.20-0.90),Fe^{2+}(0.1-0.82), Na^{+}(0.06-2.26), Ca^{2+}(3.16-51.48) and Mn (0.02-0.05). The Ca^{2+} value of Amajim river; 51.48 is the highest value of Ca^{2+} in the results which reveals a calcium carbonate source rock (Hounslow,1995). Enyigba lake gives Mg^{2+} value of 0.90 which is high when compared to the Nigerian Standard for Drinking water Quality (NIS 554:2007). Most of the values are beyond the NSDW:2007 limits but are within the irrigation water limit. The anions results show that Cl- in Akpara river and Ameka stream are very high 106.4 and 50.14 respectively. This high results not withstanding is less than the 250mg/l max acceptable limit of USEPA 2012 which otherwise could cause increase in cohesiveness of water. Allison et al. (1954) and Hounslow (1995) classified irrigation water into four categories with respect to salinity hazards based on conductivity: low salinity water (250μs/cm), medium salinity (250 – 750 μs/cm), high salinity water (750 – 2230 μs/cm), very high salinity water (> 2230 μs/cm). The conductivity values of the surface waters ranges from 115.6 to 847μs/cm. It could be deducted from Table 2.0 that Ngele river and Enyigba lake are within the low salinity water zone, Akpara river, Ameka stream and Amejima-Ameka river are within the medium salinity while Ameka pond which falls within the high salinity water is uncondusive for irrigation purposes. The Cl^{-} value in our analysis falls within the first category which is within the acceptable water for irrigation and cultivation. The sodium absorption ratios are less than 10 (table 2.0), hence having little or no effect on crops (Hounslow, 1995). Mn yield in all the surface water bodies are very minimal showing that pb-zn contamination and pollution has little or no relationship with the Mn level in the water. Using the mass balance technique, Cl-Na indicates brine sea water source. The Ca^{+} is generally less than SO_4^{2-} except for Enyigba lake and Ameka stream. This indicates pyrite oxidation or even removal of Ca^{2+} and calcite precipitation (Garrels and MacKenzie, 1967).

The result shows that despite the contamination and pollution of the surface water at Enyigba, the Na^{+},Mg^{2+},Ca^{2+},Fe^{2+},$SO4^{2-}$,$N0^{3-}$, Cl^{-} and Mn are within the acceptable limits of USEPA (2012) for irrigation water. Ezeh et al. (2007) observed that arsenic value in Enyigba is beyond 0.1mg/l which is considered alarming (Hamil and Bell 1986) for an agro based town like Enyigba. According to him, Pb, Zn and Cu shows alarming values at some points in the study area once oxidized. The values are beyond the acceptable limits. Nnnabo et al,(2011) further analyzed the contamination factor (C.F) and observed that cadmium shows a considerable contamination factor, confirming Obasi and Akudinobi(2005). This excess cadmium consumption from intake of the surface water directly or through cultivated crops can lead to kidney disorder and lung cancer (Sachdeva et l. 2015). Nnabo et al.(2011)'s geo-accumulation studies also confirms a high arsenic value and silver.

Table 2.0 Physical parameters of Enyigba surface waters

Sample Locations	**pH**	**Conductivity**(μs)	**TDS** (mg/l)	**Salinity**(ppm)	**ORP(mV)**	**S.A.R**
Akpaara river	4.25	266	15	13.3	425	2.574
Ngele river	4.06	169	11	15.2	321	4.400
Enyigba lake	9.98	115.6	10	62.9	234	0.560
Ameka Pond	4.31	847	8	7.7	232	0.004
Ameka stream	4.06	271	2	8.2	239	5.684
Amejima -Ameka river	6.08	386	9	12.3	284	3.019

Table 3.0 Result of Enyigba Chemical Analysis

Sample Locations	Na^{+}(mg/l)	Mg^{2+}(mg/l)	Ca^{2+}(mg/l)	Fe^{2+}(mg/l)	Mn^{+}(mg/l)	NO^{3-} (mg/l)	Cl^{-} (mg/l)	SO_4^{2-} (mg/l)
Akpaara river	1.11	0.30	4.31	0.30	0.02	4.0	106.4	46.8
Ngele river	2.0	0.20	4.91	0.27	0.03	4.2	37	14
Enyigba lake	1.89	0.90	3.16	0.82	0.05	4.4	80.4	2.8
Ameka Pond	0.06	0.28	15.51	0.1	0.04	12	28	21.2
Ameka stream	2.26	0.82	3.32	0.36	0.02	10	50.14	1.8
Amejima-Ameka river	1.2	0.40	51.48	0.24	0.02	25	26.3	21.2

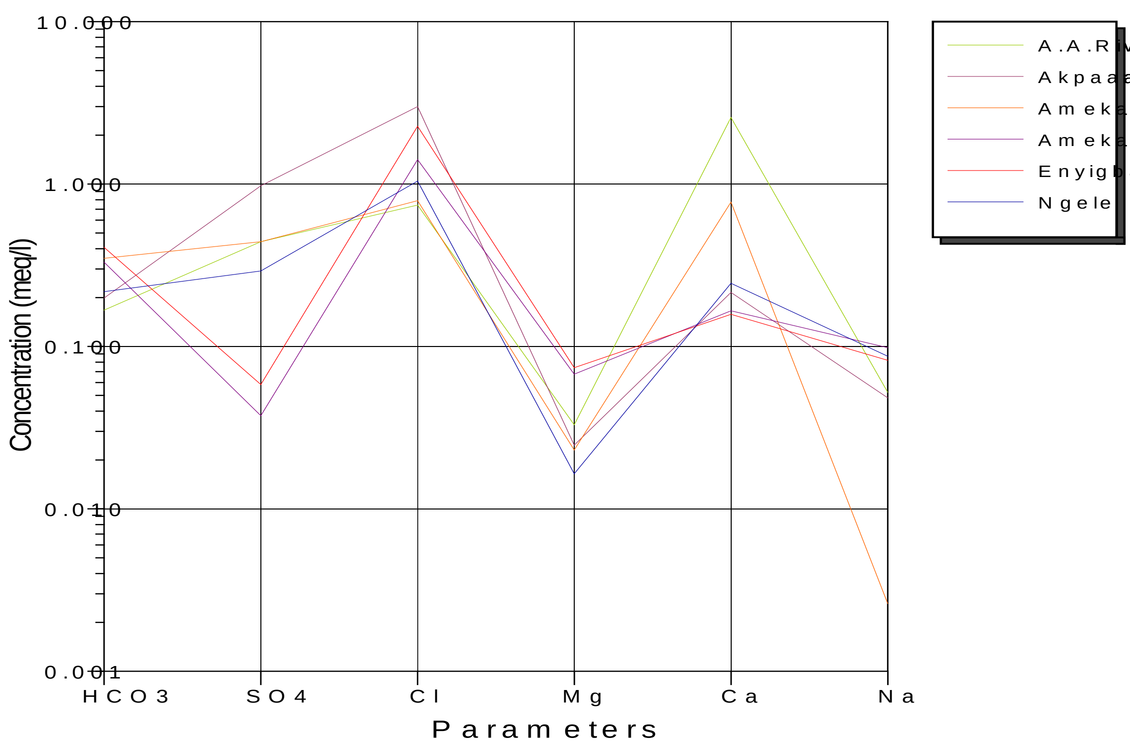

Figure 2.0 Schoeller Graph of Enyigba Surface Water Chemical Analysis

5. Conclusion

The non heavy metal chemistry reveals that the Enyigba surface waters are good for irrigation purposes except for Enyigba lake due to possible nutritional in-balance on plants due to its pH value. Ameka pond's conductivity value also falls within the unacceptable limit for irrigation. The O.R.P. influences the mobility of the elements especially the heavy metals. In Enyigba, the surfaces waters in the reducing environment are tolerable for irrigation, but are not in the oxidized environment.

References

[1] Allison, L., Brown, J., Hayward, H. (1954). Diagnosis and improvement of saline and alkali soils, Untied State, Washington D.C.U.S. Government Prating Office.

[2] Appelo, C.A.J. and Posma (1993). Geochemistry, Groundwater and Pollution, Rotterdam, Netherlands: A.A. BALKEMA.

[3] Aucamp, P. 2003. Trace-element pollution of soils by abandoned gold-mine tailings near Potchefstroom,
South Africa. Bulletin 130 of Council of Geoscience.

[4] Davis, P.A., Avadhanula M.R., Cancio, D., Carboneras, P., Coughtey P., Johansson, G. (1999). BIOMOVS II: an international test of the performance of environmental transfer models Journ. environ radioact. 42. p.117-130.

[5] Drinking Water Standards and Health Advisories, 2012. U.S. Environmental Protection Agency Washington, DC.

[6] Egboka B.C.E. and Uma K.O. (1985). Hydrogeochemistry, contaminant transportation and tectonic effects in Okposi – Uburu salt lake area of Imo State Nigeria. Water resources journal of hydrogeology.36,p.205 – 225.

[7] Ezeh, H.N., Anike, O.L., And Egboka, B.C.E. (2007). The distribution of some heavy metals in soils in areas around the derelict enyigba mines and its environmental implication.Current World Enviroment. 2(2), 99-106

[8] Hounslow, A.W. (1995). Water Quality Data, analysis and Interpretation. Untied State of America**:** LEWIS.

[9] Igbozuruike, M. U., 1975. Vegetation types. In Nigeria in maps: Eastern States (Ed: Ofomata, G. E. K). Ethiope Publishing Benin, Nigeria.

[10] Iliopoulos, V., Stamatis, G. and Stournaras, G. (2011). Marine and human activity effects on the groundwater quality of Thriassio Plain, Attica, Greece. (Advances in the Research of Aquatic Environment). Environmental Earth Sciences, 409-419.

[12] National Population Commission of Nigeria(web).

[13] Nigeria Industrial standard,(2007). Nigeria standard for drinking water quality. Nig. Nis; 554.P.14-30.

[14] Nnabo, P.N. (2015). Assessment of heavy metal distribution in rocks from Enyigba Pb-Zn District, Southeastern Nigeria. International journal of innovation and scientific research.17. p.175-185.

[15] Nnabo, P.N. Orazuike, D.M., and Offor, C.O. (2011). The Preliminary assessment of the level of heavy elements contaminations in stream bed sediments of Enyigba and Environs, South eastern Nigeria. Jour. of basic physical science.2(2). p.43-52.

[16] Nwajide C.S. (2013) Geology of Nigeria's Sedimentary Basin. C.S.S. Bookshops Limited. ISBN: 978-987-8410-67-4

[17] Obasi, P.N. and Akudinobi, B.E.B.(2015). Geology, water types and facie evolution of Ohaozara saline lake areas of Ebonyi state, Nigeria.

[18] Offodile, M.E. (1992). Hydrogeology: Ground Water Study and Development in Nigeria. Third Edition. Publisher: Mecon Geology & Engineering Services ltd.Jos Nigeria.

[19] Ofomata, G., 2002. "Relief, Drainage and Landforms" in Ofomata, G., A survey of Igbo Nation, Africana Publishers Ltd, Onitsha, p.83-98.

[20] Ojoh, K; (1990). Cretaceous geodynamic evolution of the Southern Part of the Benue Trough(Nigeria) in the equatorial domain of the South Atlantic : Stratigraphy, basin analysis and Paleogeography. Bull. Centers. Rech. Explor - Prod. ELF – Aquitaine, V. 4, p. 419 – 442.

[21] Orajaka, S. (1965). The Geology of Enyigba, Ameri and Ameka lead-zinc lodes Abakaliki division Eastern Nigeria. Jour. min. geol.2(2).p.65-70.

[22] Reyment, R. A; (1965). Aspects of the Geology of Nigeria: the Stratigraphy of the Cretaceous and Cenozoic Deposits. Ibadan University Press, 145p.

[23] Sachdeva, M., Mathew, A. and Lahoti, A. (2015). Chronic kidney disease (CKD) in cancer patients. Springer Science+Business Media New York. DOI 10.1007/978-1-4939-2659-6_2.

[24] Schlumberger. (2006). Aquachem v.5.1 Demo Tutorial (Version v.5.1). Kitchener, Ontario,

Canada: Waterloo Hydrogeologic, Inc.

[25] Simpson A.,(1954). The Nigerian coal field; the geology of part of Owerri and benue provinces. Bulletin of the geological survey of Nigeria No.24 P.85.

[26] Uzuakpuwa, A.B., (1974). The Abakaliki Pyro Clastics-Eastern Nigeria, New age tectonic

implications. Geol Mag. 3.p. 65-70.