Global Science Research Journals

ISSN: 2449-1861 Vol. 5 (3), pp. 408-413, March, 2017.

http://www.globalscienceresearchjournals.org/

Global Journal of Geosciences and Geoinformatics

Full Length Research Paper

Chemical composition and quality profile with respect to the environmental setting of Orlu, Southeastern Nigeria

Ebiomeh H. O. Kalu

Department of Geosciences, Federal University of Technology, Owerri Imo State, Nigeria.

Accepted 18 February, 2017

Hydrogeochemical assessment of surface water Resources of Orlu and its environs was carried out in order to evaluate the chemical composition and quality profile with respect to the environmental setting of the study area. A total of six samples were collected, from different rivers and streams traversing different communities in the area, and analyzed for major cations and anions as well as trace elements like Fe, Mn, Zn, Pb and As. The major cation concentrations determined were in the order of Ca^{2+}> Na^{+}> K^{+}> Mg^{2+} with mean values of 4.14, 3.78, 1.60 and 1.19 mg/L respectively and that of the major anion concentration of the surface water is of the order HCO_3^{2-}> Cl^{-}> SO_4^{2-}> NO_3^{-} with mean values of 19.83, 11.67, 3.45 and 0.24 mg/L respectively. Two major water groups were identified based on characterization on the Piper Trilinear diagram. They include Ca-(Mg)-Na-HCO_3 and Ca-Mg-(SO_4)-HCO_3. This reflects diverse effects of bedrock lithologies, base exchange processes, precipitation and weathering. The pollution index (PI) value of 9.10 (which is greater than the critical value of unity) shows that the surface water bodies in the area are slightly polluted by the trace elements and as such not fit for domestic use as those parameters exceeded the maximum permissible level set by the Nigerian Industrial Standard (2007) and the World Health Organization (2006) Standard. Finally the electrical conductivity (EC) values of 13.0 to 97.0 µs/cm and total dissolved solids (TDS) values of 8.0 to 66.0 mg/L, alongside the estimated sodium absorption ratio (SAR) of 1.74 revealed a fresh water grade that is fairly suitable for agricultural purposes.

Key words: Hydrogeochemistry, pollution index, water facies, water quality.

INTRODUCTION

Water is an essential resource and forms the primary need of man in his environment. It is a vital component of life for both plants and animals. It is available in forms of rain and snow thereby making rivers, oceans, streams, lakes, springs etc (Ibeneme et al., 2013). Water, is most readily available to man in the flow of stream and river.

These flows show wide variation both in time and place. Throughout ages, mankind has been faced with the problem of providing suitable water of sufficient quality for his use. Water pollution is one of the most serious environmental problems facing the world today as most industrial wastes are channeled directly to water bodies thereby affecting the qualities of the surface water systems (Nganje et al., 2010). The availability of large volumes of water is not on its own enough guarantee that the water is potable. The presence of objectionable tastes,

*Corresponding author: E-mail: henry.kalu@hotmail.co.uk

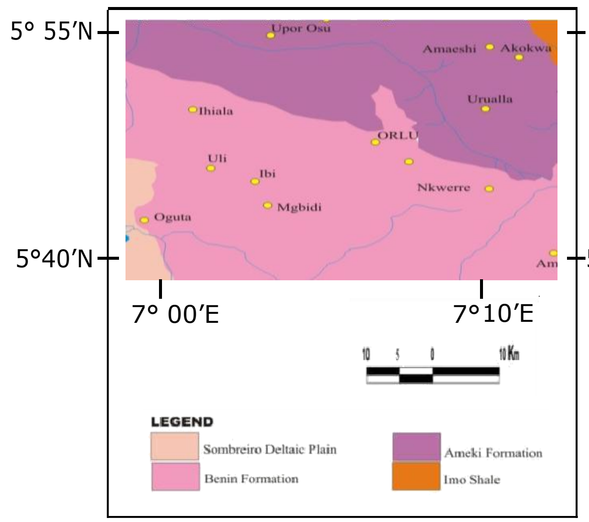


Figure 1. Geological map of the study area.

odour, colour as well as harmful substances in such water no matter how abundant it is, renders it unsuitable for domestic, industrial and agricultural uses (Okeke and Igboanua, 2003). Geochemical determination of surface water is one of the principal criteria for assessing the quality of water. Geology, particularly rock types, their weathered products and precipitation from rainfall contribute greatly to the chemistry of surface and ground water (Abimbola et al., 2002). The primary purpose of water analyses is therefore to determine the suitability of water for a proposed use; the main classes of use being domestic, agricultural and industrial purposes (Opara et al., 2005). This study is therefore carried out to ascertain the portability and suitability of the surface water resources of Orlu and environs for municipal use.

GEOLOGY AND PHYSIOGRAPHY OF THE STUDY AREA

The study area is located between latitudes 5°43'N to 5°51'N and longitudes 7°00'E to 7° 09'E (Figure 1). It is part of the Anambra sedimentary Basin, and is characterized by three major geologic formations with Bende-Ameki formation being the oldest. Bende-Ameki formation is overlain by Ogwashi-Asaba formation which in turn is overlain by the Benin Formation. The geology and hydrogeology of these units have been extensively studied by various authors (Reyment, 1965; Uma, 1989; Whiteman, 1982). The Benin formation comprises of a thick sequence of poorly consolidated to unconsolidated sandstones that are friable with sorting ranging from poorly to fairly sorted (Onyeagocha, 1980). Several grain sizes occur within the unit and the coarse and fine unit alternate along the vertical sequence. The thick sandy units are frequently separated by thin and discontinuous clay streaks and lenses. The clay beds are thin (less than 1 m) and sometimes occur as lamination lining the bedding plane of the unconsolidated sandstone beds. The formation starts as a thin edge at its contact with the Ogwashi/Asaba formation in the north of the area and thickens southwards (Avobovbo, 1978). The Ogwashi–Asaba formation is identified within the Palaeocene Anambra Basin (Afikpo geosynyncline) (Oboh – Ikuenobe et al., 2005). The formation is characterized by alternation of clays, sands, grits and lignites (Bassey and Eminue, 2012). The formation occurs mainly in Benin, Asaba, Onitsha and Orlu areas, Reyment (1965) suggested Oligocene–Miocene age for this formation, but palynological results by the work of Cherie et al. (1978) assigned a Middle Eocene age to the basal part. The Ogwashi–Asaba formation is a surface lateral equivalent of the Agbada formation which occurs in the subsurface of the Niger Delta (Assez, 1989; Akpoborie et al., 2011). The Bende-Amaki formation of Eocene to Oligocene age consists of medium to coarse-grained white sandstone, which may contain pebbles, graygreen sandstone, bluish calcareous silt, with mottled clays and thin limestone. Considerable lateral variation in lithology has also been observed. The lower part of the formation consists of fine-coarse-grained lenses of sandstone with abundant calcarceous shales and thin shelly limestone. The Bende-Ameki formation overlies the impervious Imo shale group of Paleocene age, which is characterized by lateral and vertical variations in lithology (Akaninyene, 2012). The physiography is dominated by a segment of the NW-SE trending Awka-Orlu cuesta which rises to about 350 m above mean sea level and to about 200 m above the surrounding plains. These undulating ridges and plains are somewhat related to bedrock underlying the area. The drainage pattern in Orlu and environs is the dendritic type indicative of lithological, structural and topographic differences and also typical of alluvial rocks, which is typical of the geology of the area that consists mainly of sedimentary rocks (Figure 1).

MATERIALS AND METHODS

The study aims at determining the physico-chemical characteristics of the surface water resources in order to assess their quality and usability. Six water samples were collected from different rivers traversing different communities in the study area. *In-situ* measurements of temperature (°C), electrical conductivity (EC), total dissolved solids (TDS) were carried out in the field while samples were collected in clean new white plastic bottles (1.5 L) which were first rinsed with part of the water samples to avoid contamination. For unclear water sample, a filter membrane was used to filter off suspended particulate and then subjected to further detailed analyses. The TDS was measured using a specially calibrated TDS meter, with a small container where the water sample can be poured. The EC was measured using a WPACMD 400 m which can measure conductivity over the range of 10^{-2} to10^{-6}

μ Siemens/cm^2 with an accuracy of 0.1 μ S/cm^2. The coordinates (longitude, latitude and elevation/altitude) of each sample location

Table 1. Results of geochemical analysis of water samples of Orlu and environs compared with NIS (2007) and WHO (2006) standard.

Parameter	Sw1	Sw2	Sw3	Sw4	Sw5	Sw6	WHO 2006	NIS 2007	Undesirable effects at higher levels
Temperature (°C)	28	29	21	27	21	20	25	Ambient	-
pH at 24°C	6.4	6.5	6.7	6.2	6.7	6.7	6.5-8.5	6.5-8.5	High pH-Corrosion; Low pH-Taste/Soapy feeling.
Colour (apparent)	97.0	88.0	46.0	69.0	50.0	44.0	15	15	Appearance.
Turbidity (FTU)	12.0	25.0	38.0	16.0	6.0	23.0	5	5	Appearance.
Conductivity (μs/cm)	21.0	28.0	24.0	13.0	76.0	97.0	100	1000	-
TDS	11.0	15.6	16.2	8.0	38.0	66.0	500	500	Taste.
Hardness (mg/L)	8.9	8.0	15.0	19.0	14.0	16.0	-	-	High-Scale deposit and scum formation; Low-Possible corrosion.
Iron (mg/L)	2.03	1.67	0.14	0.07	0.52	2.63	0.3	0.3	Stain of Laundry and Sanitary wares.
Calcium (mg/L)	1.7	3.6	6.88	1.36	2.11	9.20	75	100	Scale Formation.
Magnesium (mg/L)	1.60	0.08	1.55	2.51	0.80	0.57	20	0.2	Hardness and Gastrointestinal Irritation.
Potassium (mg/L)	0.05	0.24	1.00	1.65	1.06	5.58	200	200	-
Sodium (mg/L)	2.5	6.8	2.30	1.70	3.30	6.10	200	200	Taste.
Sulphate (mg/L)	3.60	0.04	5.08	3.39	0.20	8.40	250	100	Taste and Corrosion.
Nitrate (mg/L)	0.15	0.13	0.15	0.18	0.40	0.40	10	50	Physiological problems.
Chloride (mg/L)	8.34	12.1	10.7	6.67	12.3	19.9	200	250	Taste and Corrosion.
Bicarbonate (mg/L)	12.8	17.8	21.9	13.4	16.5	36.6	500	500	-
Total hardness ($CaCO_3$) (mg/L)	4.4	4.9	24.0	3.4	5.44	23.0	100	150	High-Scale deposit and scum formation; Low-Possible corrosion.
Lead (mg/L)	0.42	0.22	0.05	0.32	0.06	0.08	0.01	0.01	Irritability, Acute Psychosis and reduced dermal sensitivity.
Arsenic (mg/L)	0.09	0.01	0.04	0.12	0.02	0.10	0.01	0.01	Toxic, Liver damage.
Zinc (mg/L)	2.10	2.02	1.18	2.12	1.38	1.35	0.01	0.01	Appearance and Taste.
Manganese (mg/L)	0.3	0.13	0.26	0.4	0.17	0.31	0.01	0.2	Stain of Laundry and Sanitary wares, Neurological disorder.

Sw1=Orashi River, Sw2=Njaba River, Sw3=Ezize River, Sw4=Ogidi River, Sw5=Ngakwu Stream, Sw6=Mgbede Stream.

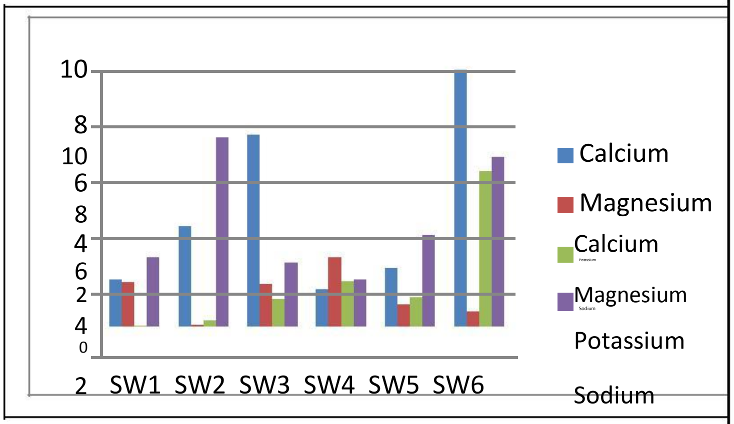
in the study area was determined using the GARMIN GPSmap76CSx. These samples were labeled Sw1-Sw6 (Table 1). All the water samples were preserved in a refrigerator to exclude microbial activity and unwanted chemical reaction until analysis was completed within 2 days. The determinations of other physico-chemical properties of the water samples were performed within 2 days of sampling. HACH DR 2800 Spectrophotometer was used in the determination of different hydro geochemical properties such as Na, K, HCO_3, Cl, NO_3, SO_4, Fe, Mn, Zn, Pb and As. Analytical water test tablets prescribed for HACH DR Spectrophotometer 2800 using procedures outlined in the HACH DR 2800 Spectrophotometer manual were used for the examination of the water quality. Other analyses such as the determination of Mg and Ca concentrations were done by complexometric titration method.

RESULTS

The results of the analyses and the summary of the physico-chemical parameters in mg/L are presented (Table 1).

DISCUSSION

From the results, the total dissolved solids (TDS) for the surface water samples ranged from 8.0 to 66.0 mg/L with a mean value of 25.80 mg/L. The calcium content ranged from 1.36 to 9.2 mg/L with an average of 4.14 mg/L, while that of magnesium was from 0.08 to 2.51 mg/L. Magnesium ion (Mg^{2+}) concentration is generally low. The availability of magnesium ion in surface water systems of the area could be explained by occurrence of magnesium with calcium carbonate cement in detrital sedimentary formation. Similarly the sodium and potassium content on the other hand ranged from 1.70 to 6.10 mg/L and 0.05 to 5.58 mg/L respectively (Figure 2). Sodium must have entered the water system through natural system (that is, rainwater) (Egbunike, 2007). Other natural sources include weathering of feldspars (albite) and leaching of clay minerals (Spears and Reeves, 1975; Ogbukagu, 1986). For the anions, bicarbonate was the dominant anion in the surface water samples and ranged from 12.8 to 36.6 mg/L with a mean value of 19.83 mg/L. This was followed by chloride, with a range of 6.67 to 19.9 mg/L. The chloride concentrations are comparatively low because of the fact that chloride does not show any correlation with the components of pore water derived from mineral breakdown (Spears and Reeves, 1975). The concentration of rain water by evapotranspiration may be an important source of chloride in the area. Nitrate



Figure() 2. Major cations in the analyzed samples expressed as a bar chart.

SW1 SW2 SW3 SW4 SW5 SW6
40
35

Figure 3. Major anions in the analyzed samples expressed as a bar chart.

Figure 3. Major Anions in the Analyzed Samples Expressed2007)and asthisamayBartoChartattributed.

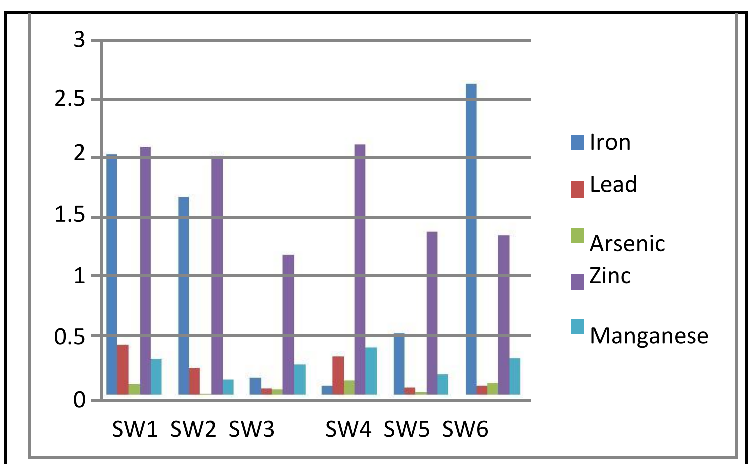


Figure 4. Trace elements concentration in the analyzed samples expressed as a bar chart.

Figure 4. Trace Elements Concentration in the Analyzed Samples Expressed as a

Bar Chart.

generally was low for all locations and had a range of 0.13 to 0.40 mg/L (Figure 3). Nitrate concentration falls within the accepted limit. The potential source of nitrate in the area may include legume, animal excrement, and

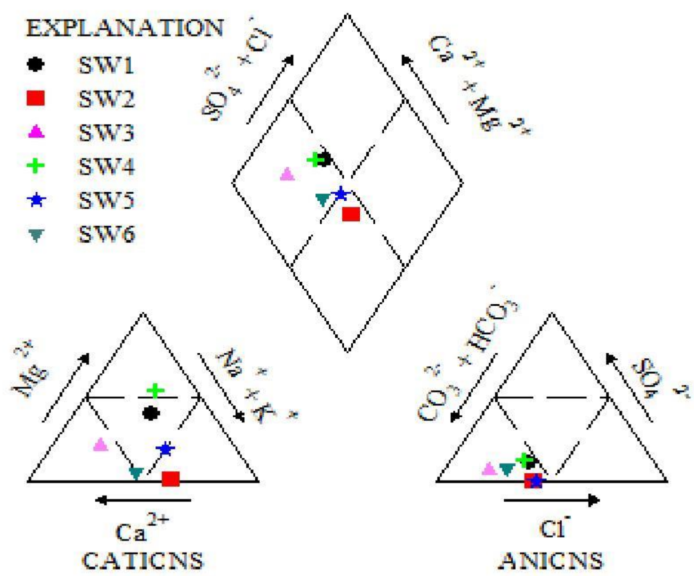


Figure 5. Piper trilinear diagram of the studied water samples.

probably the atmosphere. Sulphate concentration ranges from 0.04 to 8.4 mg/L with an average of 3.45 mg/L. The major source of sulphate in the area may result from gypsum and oxidation of sulphide ores. The pH ranged from 6.2 to 6.7 with a mean value of 6.53, which clearly showed the water to be slightly acidic.

ExpressedTheaverage**asa**concentrations**BarChart.** of all the trace elements (Pb, Zn, Mn, Fe, As) (Figure 4) are higher than the NIS and WHO standard for drinking water (WHO, 2006; NIS, to possible infiltration of

petroleum products from the petrol stations, discharge from surface waste disposal sites, wastes from automobile workshops as well as the chemical composition of the bedding rock via which the water flows. The human health effects are linked to irritability, acute psychosis, reduced dermal sensitivity, highly toxic to infants and pregnant women (for Pb); liver and kidney damage (for As); neurological disorder (for Mn). Fe as well as Mn can cause stain of laundry and sanitary wares, while excess of Zn in water gives it unpleasant taste and appearance (NIS, 2007).

The water resources of the area were found to have two dominant hydrochemical facies according to the piper Trilinear diagram (Figure 5). These include Ca-(Mg)-Na-HCO_3 and Ca-Mg (SO_4)-HCO_3. According to Lohnert (1973) and Onyekuru et al. (2010), the former facies group has appreciable amount of $NaHCO_3$ which is an indication of cation exchange water. One of the characteristics of this water type is the higher carbonate hardness as compared to the total hardness. This in effect means that there is more HCO_3 than the available alkaline earth metal ions (Ca^{2+} and Mg^{2+}) in equivalent concentration (Lohnert, 1970). These excess bicarbonate ions then release the alkaline (notably Na^+) into the solution by exchange reaction with the cation exchangers

Table 2. Physico-chemical parameters of water resources of orlu for pollution index determination.

Parameter	Surface water		WHO 2006	C_{ij}
	Range	Mean (C_{ij})	(W_{ij})	W_{ij}
Temperature (°C)	21-29	24.33	25	0.9732
pH at 24°C	6.2-6.7	6.53	6.5	1.0046
Colour (apparent)	44.0-97.0	65.67	15	4.378
Turbidity (FTU)	6.0-38.0	20.00	5	4.000
Conductivity (µs/cm)	13.0-97.0	43.17	100	0.4317
Total dissolved solids	8.0-66.0	25.80	500	0.0516
Hardness (mg/L)	8.0-19.0	13.48	-	-
Iron (mg/L)	0.07-2.63	1.18	0.3	3.933
Calcium (mg/L)	1.36-9.2	4.14	75	0.0552
Magnesium (mg/L)	0.08-2.51	1.19	20	0.0595
Potassium (mg/L)	0.05-5.58	1.60	200	0.008
Sodium (mg/L)	1.70-6.10	3.78	200	0.0189
Sulphate (mg/L)	0.04-8.4	3.45	250	0.0138
Nitrate (mg/L)	0.13-0.40	0.24	10	0.024
Chloride (mg/L)	6.67-19.9	11.67	200	0.0584
Bicarbonate (mg/L)	12.8-36.6	19.83	500	0.0397
Total hardness ($CaCO_3$) (mg/L)	4.4-23.0	10.86	100	0.1086
Lead (mg/L)	0.05-0.42	0.19	0.01	19.00
Arsenic (mg/L)	0.01-0.12	0.05	0.01	5.00
Zinc (mg/L)	1.35-2.12	1.69	0.01	169.00
Manganese (mg/L)	0.13-0.40	0.26	0.01	26.00
Total				**234.16**
Mean				**11.71**

such as clay minerals. The Ca-Mg (SO_4)-HCO_3 type falls within normal alkaline water and is predominantly hydrogen carbonate sulphate (Piper, 1953). Assessing the water samples suitability for domestication pollution index computation using the method of Horton (1965) was utilized (Table 2). To determine the pollution index of the water samples, the formula below was used:

$$PI = \frac{\sqrt{IMax(Cij/Wij))]^2 + [Mean(Cij/Wij)]^2}}{2} \quad \text{................ (1)}$$

The pollution index (Horton, 1965) obtained using the above relation is 9.10. This shows that the surface water resources of Orlu and its environs are slightly polluted by trace elements. The source of these pollutants could be from the open solid waste dumpsites disseminated in different localities (like Ugwu Mgbee and TESAC dumpsites from which leachate and other substances seep to join the Orashi River and Mgbede stream), effluent discharge from automobile workshops ("Mgbuka" in Amaifeke that empty their wastes directly into the Ogidi River) and the geology of the underlying bedrocks along the river channel (made up of predominantly sedimentary rocks). For agricultural purposes, sodium content of water was used for this purpose. The sodium absorption ratio (SAR) estimated this. The two principal effects of sodium are reduction in soil permeability and hardening of the soil (Etu-Efeotor, 1981). For the study area, SAR lies between 0.79 to 3.55 with an average of 1.74, which revealed a class of water suitable for irrigation purposes (Wilcox, 1955).

Conclusion

All the physico-chemical parameters measured conform to the standard set by the regulatory bodies except pH and the trace element. The electrical conductivity (EC) values of 13.0 to 97.0 µs/cm, total dissolved solids (TDS) of 8.0 to 66.0 mg/L and sodium absorption ratio (SAR) of 1.74 revealed a class of water suitable for agricultural purposes. High concentrations of trace element as observed in the rivers sampled rendered the water unfit for domestic uses. Thus, the water resources of the area need to be treated for heavy metals prior to domestication.

REFERENCES

Abimbola AF, Odukoya AM, Olatunji AS (2002). Influence of bedrock on the Hydrogeochemical characteristics of groundwater in Northern part of Ibadan metropolis. W. Res. 13:1-6.

Akaninyene OA, Igboekwe MU (2012). Preliminary Lithologic Deductions for Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria, using Vertical Electrical Sounding Method. Arch. Phy. Res. 3(4):292-302.

Akpoborie NA, Nfor AA, Etobro I, Odagwe S (2011). Aspects of the Geology and groundwater conditions of Asaba, Nigeria. Arch. Appl. Sci. Res. 3(2):537-550.

Assez LO (1989). In: Kogbe (ed). Geology of Nigeria. Rockview Publ., Jos, pp. 311-334.

Avobovbo AA (1978). Tertiary Lithostratigraphy of Niger Delta. Bull. Am. Assoc. Pet. Geol. 62:295-306.

Bassey C, Eminue O (2012). Petrographic and stratigraphic analyses of Palaeogene Ogwashi-Asaba formation, Anambra Basin, Nigeria NAFTA 63(7-8):247-254.

Cherie R, Onyike MS, Sowumi MA (1978). Some new Eocene pollen of the Ogwashi – Asaba formation, Southeastern Nigeria. Rev. Esp. micropateont. 10:285-322.

Egbunike ME (2007). Hydrogeochemical Analysis of Water Samples in Nando and Environs of the Anambra Basin of South Eastern Nigeria. Pac. J. Sci. Technol. 8(1): 32-35.

Etu-Efeotor JO (1981). Preliminary Hydrochemical Investigations of Subsurface Water in Parts of the Niger Delta. J. Min. Geol. 18(1):103-105.

Horton RK (1965). An Index Number System for Rating Water Quality. J. W. Poll. Cont. 37(3):12-16.

Ibeneme SI, Ukiwe LN, Essien AG, Nwagbara JO, Nweze CA, Chinemelu ES, Ivonye CA (2013). Assessment of the Chemical Characteristics of a Spring Water Source at Ife-Owutu, Ezinihite-Mbaise, Southeastern Nigeria. Am. J. Eng. Res. 2(10):282-290.

Lohnert EP (1973). Austauschwaesser In H Schneider (Hrsg) Die Grunwasserchliessung, Vulkan Verlag Essen 2nd Edition, pp. 138-144.

Lohnert EP (1970). Grundwasserchemismus und kationentaush im norddeutschen Flachland Z dt geol Ges, Sonderheft. Hydrgeol Hydrogeochem, Hannover, 139-159.

Nganje TN, Adamu CI, Ntekim EEU, Ugbaja AN, Neji P, Nfor EN (2010). Influence of mine drainage on water quality along River Nyaba in Enugu South-Eastern Nigeria. Afr. J. Environ. Sci. Technol. 4(3):132-144.

NIS (2007). Nigerian Indusrial Standard. 2, ICS 13.60.20, pp. 15-17.

Oboh-Ikuenobe FE, Obi CG, Jaramillo CA (2005). Lithofacies, Palynofacies, and Sequence Straigraphy of Paleogene strata in Southeastern Nigeria. J. Afr. Earth Sci. 41:79-101.

Ogbukagu IKN (1986). Water Supply of Njikoka and Awka Areas of the Anambra Basin, Nigeria. J. Afr. Earth Sci. 5(5):519-526.

Okeke OC, Igboanua AH (2003). Characteristics and quality assessment of surface water and groundwater resources of Awka Town, SE Nigeria. W. Res. J. 14:71-77.

Onyeagocha AC (1980). Petrography and Depositional Environments of the Benin Formation. J. Min. Geol. 17 (2):147-150.

Onyekuru SO, Nwankwor GI, Akaolisa CZ (2010). Chemical Characteristics of Groundwater Systems in the Southern Anambra Basin, Nigeria. J. Appl. Sci. Res. 6(12):2164-2172.

Opara AI, Onyekuru SO, Nwokei KI (2005). Hydrogeochemical study of surface and Groundwater Systems in Parts of Okigwe, Southeastern Nigeria. J. Sci. Eng. Technol. 12(2):6233-6242.

Piper AM (1953). A Graphic Procedure in the Geochemical Interpretation of water Analysis. Washington D.C, US. Geol. Surv. ISBN ASIN: B0007H2Z36.

Reyment RA (1965). Aspects of Geology of Nigeria University Press, Ibadan, Nigeria, pp. 24-29.

Spears DA, Reeves MJ (1975). The Influence of Superficial Deposit on Groundwater Quality in the Vale York. Q. J.Eng. Geol. 8:255-270.

Uma KO (1989). Appraisal of the groundwater resources of the Imo River Basin, Nigeria. J. Min. Geol. 25(1&2):305-315.

WHO (2006). Revision of the World Health Organization guide lines for drinking water quality: Report of the Final Task Group Meeting WHO, Geneva, p. 307.

Wilcox LV (1955). Classification and use of irrigation waters. U.S. Dept of Agric, Cire 967, Washington D.C.P. 19.

Whiteman A (1982). Nigeria, its petroleum Geology, Resources and Potentials. 2. Graham and Trotman Publ., London, pp. 234-241.