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Water Quality Assessment of Ugwueme Surface and Ground Water System

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Abstract: ***The assessment is aimed at the determination of the water chemistry of groundwater and surface water in Ugwueme and to characterize the elemental values in order to deduce the source, the similarities and differences of the two water systems. The analytical study involved the sampling of both surface and groundwater bodies in order to conduct a comparative and qualitative study of the hydrogeochemistry of the area. Groundwater samples were obtained from Isiovu spring, Ogwumba spring, Iyiahia spring and Iyiokuka spring. Also surface waters were sampled from Obae stream and Iyiohimiri stream and analyzed for mineral species. The result ranges thus: SO_4^{2-} = 0.00 to 19.6, HCO^{3-} = 10.21 to 24.88, NO^{3-} = 2.9 to 4.6, Cl^{-} = 40.8 to 109.6, PO_4^{3-} =1.2 to 3.4, Na^{+} = 0.88 to 1.62, Mg^{2+} = 0.32 to 1.45, Ca^{2+} = 1.02 to 3.32, Fe^{3+} = 0.30 to 1.62, and Mn^{+} = 0.0028 to 0.052. This result is in the form of $Cl>HCO^{3-}>NO^{3}->PO_4^{3-}>SO_4^{2-}$ for the anions and $Ca^{2+}>Na^{+}>Mg^{2+}>Fe^{3+}>Mn^{+}$ for the cations with few exceptions. The geochemical assessment of the spring and stream samples using Atomic Absorption Spectrometry for the Cations and Volumetric Analysis for the anions indicates a Ca-Na-Cl water type; which is typical of marine and deep groundwater sources. The systematic source rock deduction indicates that the relatively high chloride concentration observed in all the water samples might have come from possible brine water and the tar sand of the Owelli Sandstone. Comparative study of ion content of these water samples with already established standards for Drinking Water Quality revealed that both the groundwater and surface water of Ugwueme are safe for drinking.***

Keywords: Ugwueme, saline, groundwater, Sodium chloride and bicarbonate

1. Introduction

It is a known fact that without water, the biosphere cannot be sustained; water is life. The water accessible to humans are basically surface and ground water. The surface water are usually contaminated due to exposure to agents of contamination and pollution. Ugwueme has been a site of geological interest due to features which includes the geomorphology, basin transition and the spring system which are contact and fault related. The oil shale observed by Reyment [1] which migrated towards the coarse sandstone of Owelli Sanstone is also of hydrogeological interest.

Over the years, various authors; [1],[2],[3],[4], and [5] considered various geological studies ranging from lithological studies, sedimentological analysis and paleontological studies] in the study area. Non of these authors considered the hydrogeology or the inorganic geochemistry of Ugwueme water system, hence the need for this research paper. [6] and [7] identified the geochemical processes controlling ground water quality.

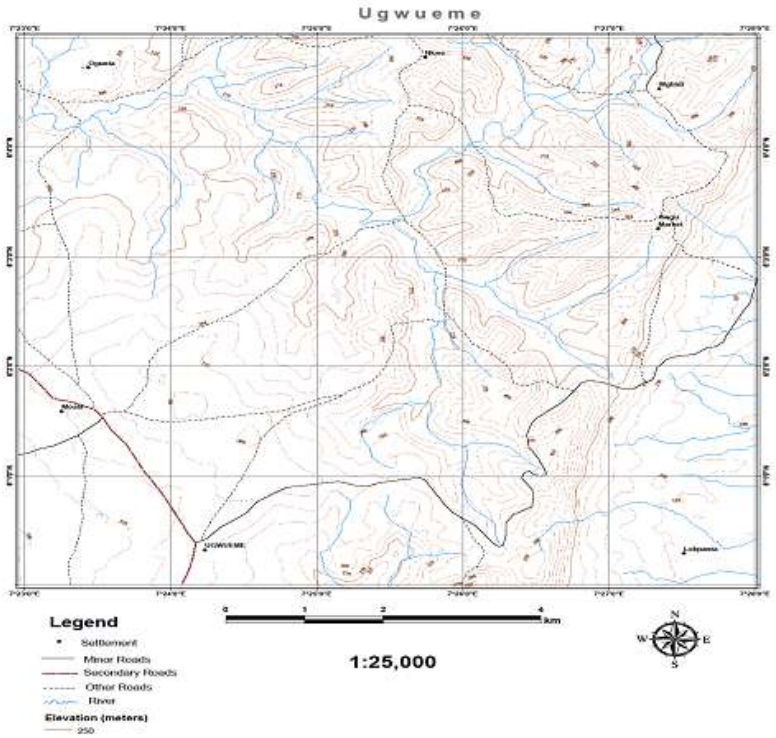

Figure 1.0: The physiographic map of Ugwueme, Enugu state Nigeria

2. The Study Area

Location and Study extent

The study area, Ugwueme and it's environs is situated at latitude $6^{1}0^{11}$ to $6^{1}5^{11}$ and longitude $7^{1}23^{11}$ to $7^{1}28^{11}$[fig 1] covering an areal extent of about 85.6km.This borders Awgu town and Onoli town towards the east, Nkwe and Mgbidi to the North with little fringes extending to Lokpanta [Abia state] to the South West. It has an estimated population of about 15,000 people [8] and found at the hill /top of the Awgu escarpment, about 7.5km south of Awgu market in Awgu town which host the local government headquarters of the area. The mapped area is accessible through the Ugwueme- Amuda road by the Enugu-Porthacourt express road. Ugwueme is about 2km east of the Enugu-Portharcourt express road, making a haphazard link to Ugwueme-Amuda-Mbala road through the Y junction along the express road. The Lokpanta axis could be rightly accessed via Awgu-Orji river road which passed through Mgbidi town. Ugwueme town is strategically located on top of the Awgu cuesta and is underlain by iron stone beds with other sedimentary facies.

Physiography, Climate and Vegetation

The study area has steep highlands at the escarpment area which includes Ezere, Nkwe, Mbala and Ugwueme towns of the study and also low lying plains. The low lying plains are basically found within the Lokpanta and Awgu axis of the map. The area is dominantly characterized by high, rugged and undulating topography which are in place due to the area's geomorphology and the tectonic folding and faulting of the Santonian age. The peak height is at Achara (350m, $N6^{0}0^{1}53^{11}$ and $E7^{0}23^{1}49^{11}$) while the lowest is located around the Obae stream (100m, $N6^{0}0^{1}22^{11}$ and $E7^{0}27^{1}54^{11}$). The major climatic conditions are the wet season [April to September] and the dry season [November to March]. The average mean annual rainfall data in the area [2009 - 2015] recorded is 1750mm to 2000mm [9]. The dry season which is characterized by little or no rainfall, high sunshine and dryness is associated to the North-easterly trade wind of the Sahara [10]. The study area is enveloped by the woodland and tall grasses of the Guinea Savanna [11]. Plants show luxuriant growth at the base of the valleys and spurs, and progressively become sparse at the escarpment. The luxuriant growth is dominated by grasses and few trees. Over the years, the vegetation in the area has supported cultivation of crops such as cassava, vegetables, cashew and root tubers. The area is drained by several streams such as Obae, lyiohimiri, Ngene Uhie, Ogwunnu, Ndumoku and Echie streams in a dendritic pattern, which took its source from the top of the escarpment [Fig.1.0]. They all drain into the surface water flow of the NE-SW trending water shed created by the Awgu-Lokpanta escarpment hence, flowing westward into Igwu River, Abia state and eastward into the Ivo River in Ebonyi state.

The Geology

The geology of Ugwueme is elucidated in the geologic map [fig 2.0]. Ugwueme is underlain by five major lithological facies and four formations. These facies are; the dark gray shale, coarse grained sandstone, medium grained sandstone, heterolith sediments and white cross bedded sandstone while the formations are Awgu Shale, Owelli Sandstone, Mamu Formation and Ajalli Formation. Dark gray carbonaceous fissile shale with inclusions of sandstone and limestone cobbles are obvious along the stream sections southeastern part of the map. The shales are fissile, bluish grey, pyritic, calcareous, micaceous and occasionally gypsiferous [5]. The coarse grained sandstone are poorly sorted angular to sub-angular in shape with incidence of quartz pebbles which are positively skewed. It appears dark coloured in some places. This lithologic unit is obvious around the border lines [elevations] between Ugwueme and Lokpanta maintaining a peak value [height of 300m]. Ripple marks, orphiomorpha burrows and pelecipod inoceramus impressions are found within this facie [1]. This coarse grained sandstone is extended to Awgu town. There is the presence of oolitic iron stone in this unit. The medium grained is poorly sorted while the heterolith facies is an assemblage of siltstone, clay, shale, mud and ironstone. The friable unit is poorly sorted and angular to sub-angular in shape.

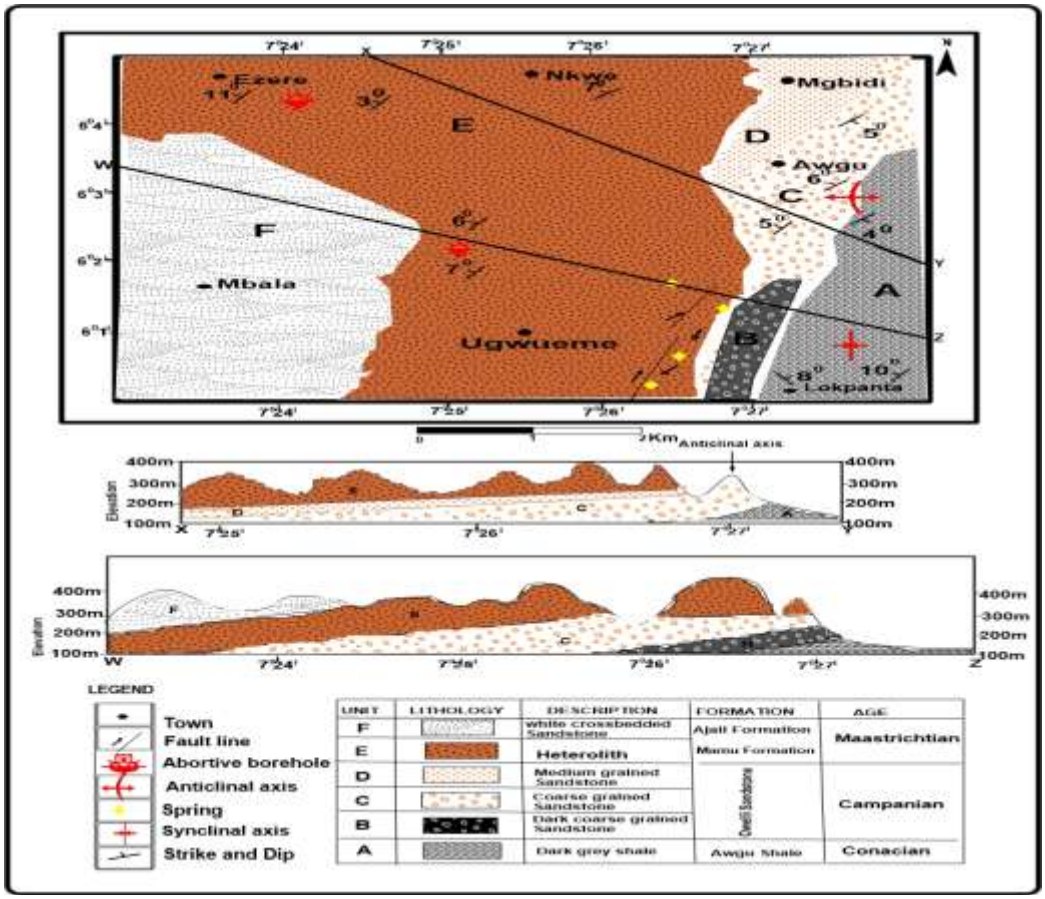

Figure 2: Geologic map of Ugwueme, Enugu state Nigeria

At some points [e.g $N6^{0}0^{1}28^{11}$ and $E7^{0}26^{1}53^{11}$], the coarse sandstone reveals resemblance of dark colouration possibly due to oil stain. This is supported by [1]. According to him, at a distance of 6km south of Awgu, oil seepage issues at the base of Owelli Sandstone, which he described at that point as coarse grey, basal bed which rests uncomformably on the folded shales. This is located at the escarpment, between the Awgu Shale and Owelli Sandstone just before Lokpanta town. The regional trend is NE-SW trend with an average dip of 8^{0} and a synclinal fold around Lokpanta. The heterogeneous facies are obvious at the Mmamo stream section. The afore mentioned facies are correlatable to the Awgu Shale, Npkoro Shale/Owelli Sandstone, Mamu Formation and Ajali Formation of [1] and [12], Fig [2.0]. The study area is dissected by a NE-SW trending watershed of the Awgu-Lokpanta escarpment. This is drained by Obae, Ngene-Uhie, Ogwunnu, Oyiohimiri and Echie streams which took its source from the sandstone unit at the scarp face of the escarpment and washes into the Ivo river in Ebonyi state. The Mmamo and Ngene meander through spurs and valleys into Awgu river in Mbala Isuochi Abia state. Ogwumba spring and Iyiokuka spring to a NE-SW trend fault system while Iyiahia spring issues from a NW-SE trending fault. The positions of the springs are shown in Table [1.0]. The elevations reveals that the streams are gaining streams which are dominantly recharged by the springs.

Table 1: Water Sample Locations, coordinates and elevations

Sample Names	Coordinate Positions
Isiovu Spring	$N6^{0}01^{1}00^{11}$,$E7^{0}26^{1}03^{11}$ Elevation:300m
Ogwumba Spring	$N6^{0}01^{1}32^{11}$,$E7^{0}26^{1}15^{11}$ Elevation:400m
Iyiokuka Spring	$N6^{0}01^{1}10^{11}$,$E7^{0}26^{1}30^{11}$ Elevation:420m
Iyiahia Spring	$N6^{0}01^{1}29^{11}$,$E7^{0}26^{1}20^{11}$ Elevation: 350m
Obae Stream	$N6^{0}00^{1}22^{11}$,$E7^{0}27^{1}54^{11}$ Elevation:100m
Inyiohimiri Stream	$N6^{0}01^{1}49^{11}$,$E7^{0}27^{1}50^{11}$ Elevation:110m

3. Materials and Method

Desk study of the area was conducted, followed by field work and laboratory analysis of water samples. The desk studies involved gathering all available published and unpublished works on the area in order to obtain sufficient background information on Ugwueme and it's environs. The field work involved the delineation of lithological facies and identification of the stream channels and springs in the study area. Both the surface water and ground water of the study area were sampled with the US EPA standard for sample collection[13]. Obae stream and Inyiohimiri stream represents the surface water while Isiovu, Ogwumb, Iyiahia and Iyiokuka springs represents the ground water. The physio-chemical and hydrochemical analysis of the water samples were conducted with Hanna pH meter, Exerter kit for obtaining ORP, electrical conductivity[E.C], total

dissolved solids[TDS]. Atomic Absorption Spectrometer [AAS] was used for obtaining the cations values and Volumetric analysis for the anions in the laboratory.

4. Results and Discussion

The physio-chemical results obtained from the analysis are tabulated in Table 2.0. The results in mg/l shows that the SO_4^{2-} value ranges from 0.00 to 19.6, HCO^{3-} 10.21 to 24.88, NO^{2-} 2.9 to 4.6, Cl^- 44.0 to 90.4,PO_4^{3-} 1.2 to 3.4, Na^+ 0.88 to 1.62, Mg^{2+} 0.32 to 1.45, Ca^{2+} 1.02 to 3.22, Fe^{3+} 0.30 to 1.62, and Mn^{2+} 0.0028 to 0.050. Also the temperature, salinity, Ph and TDS were also given. The SO_4^{2-} , NO_3^-, Cl^-, Na^+, Fe^{3+} and conductivity values of the spring waters are lower compared to that of the streams except for Inyiahia Spring, possibly due to mixing (fig.5.0) and ion exchange. This high TDS could also be linked to the impact of Ca2+,Mn+,salinity and HCO3-. This also reflects in its pH of 10.2. This is a spring located at Umueke clan in Ugwueme. The host formation is Mamu Formation which has a heterolith lithology thus influencing the physico-chemical values of the spring. The aquiferous units of the area from which the spring waters issues from is the contact between Owelli Sandstone and Mamu Formation and fault lines within the Mamu Formation (fault springs). The salinity of Obae stream [59.8ppm] the TDS [80.3ppm] and the ph [8.98] show high figures possibly due to various domestic and agricultural activities around the stream and its low elevation of 100m, hence being recharged by the other streams and springs. Also high values of phosphate and nitrate are found in the streams (surface waters); and this is also attributed to the fertilizer applications in close by farmlands. Surface water especially rainfall infiltrates into the earth hence adding both to the water and the chemistry.

The dominant water type (fig.5.0) is Ca^+, Na^+ and Cl^- and which according to [14] is typical of saline or/and deep ground water source. The chemical composition of ground water is the combined result of water composition that enters the groundwater reservoir and the reactions with minerals present in rocks [15 and 16]. The Na^+ percentage in the saline water is 32.5% as deducted from [14] and shown in equ.1 while the Cl^- is 65% (equ.2). Ca^+ value shows an almost insignificant value of 2.5% (equ.4).

% Na^+ in the saline water
1.3cm/4cm * 100% = 32.5%.....Equ.1

% Cl^- in the saline water
2.6cm/4cm * 100% = 65%.....Equ.2
Hence NaCl = 32.5 + 65 = 97.5%.....Equ.3
Ca = 100% – 97.5% = 2.5%.....Equ.4

The chemical composition of the ground water could be altered by rock weathering, evaporation and aeration as it travels through the pore spaces of rocks [17]. During rock weathering Ca^{2+}, Mg^{2+}, SO_4^{2-}, HCO_3^- and SiO^2 are added to the water hence affecting the initial chemistry [18]. This is invariably dependent on the rock mineralogy. The stream water indicates higher sulphate values compared to the calcium likely due to ion exchange reaction; unlike the spring which has higher Ca compared to SO_4 revealing calcite precipitation. The source rock deduction could be further deduced from Water interpretation mass balance [19]. The iron content of the waters could be associated to the ferrogenization of the Mamu Formation and the sand units which shows a goethite, hematite and siderite mix in the soil. The piper reveals that Isiovu Spring is a Mg-Na-HCO_3, Inyiahia, Iyioku, and Ogwumba springs are Cl^--HCO_3 while the streams are basically Cl- in nature. The sudden change from Ca-HCO3 type to Na-HCO3 and gradually to Na-Cl-Ca indicates that fresh water changes slowly to saltwater both in the surface and ground water in the study area [20]. The results obtained also indicates that Cl^- value is greater than Na^+ hence suggesting that the chloride content of Ugwueme ground and surface water is of brine origin[18] oil seepage in the area and rock type. Also the constant less Na^+ compared to Cl^- confirms reverse softening [18]. The source of the Na^+ and Ca^+ in the water is also associated with plagioclase feldspar present in the sandstone lithology of the study area. Bar charts were used to give a pictorial comparison as shown in figure 3.0 and figure 4.0. The Cl- values are high in both surface and ground water. Other values such as Mg^{2+},PO_4^{3-} and Cl^- are higher in springs than the streams except for Obea stream.

When the results where compared to Nigerian Industries Standard [NIS] 554;2007's Nigeria standard for drinking water quality, it was observed that Fe and Mg were the elements which exceeded the acceptable unit mildly without any negative impact. Also the P.H value from the analysis exceeds the NIS standard although without any negative health impact as well.

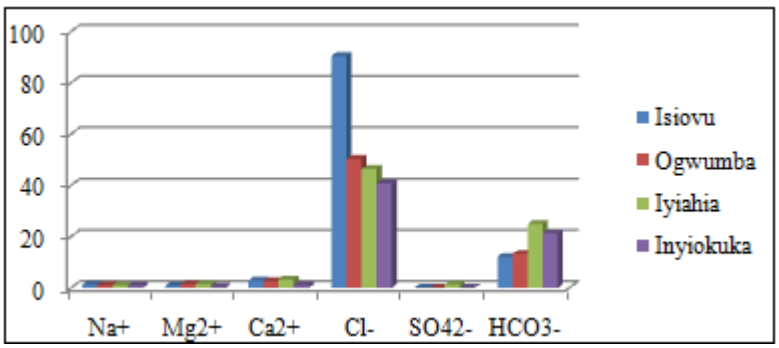

Figure 3: A bar chart showing the major element concentrations in the Spring

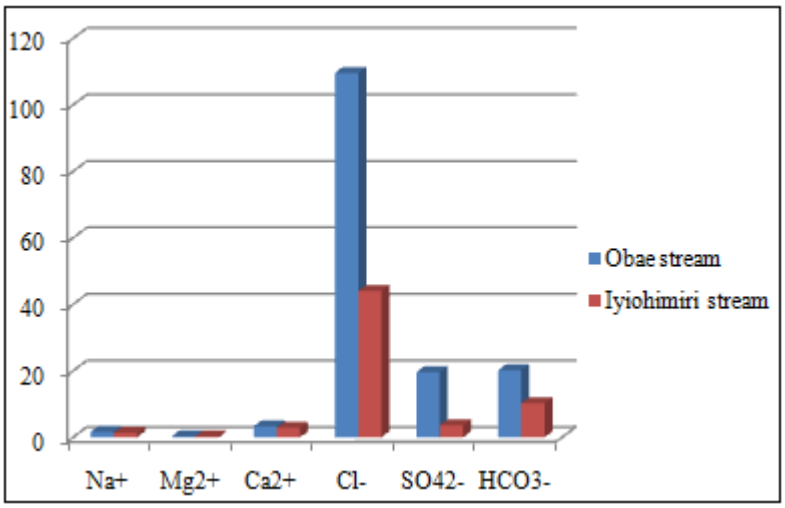

Figure 4: A bar chart showing the major element concentrations in the streams

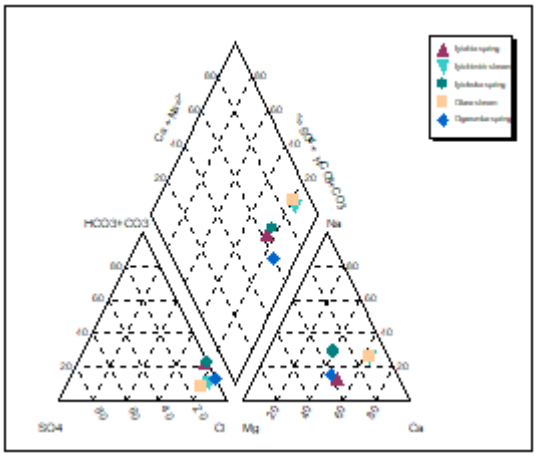

Figure 5: Ugwueme Stream and Spring Piper

Table 2: Physico-Chemical analysis of Springs and Streams in Ugwueme, Enugu State (Volume of Ions presented in Mg/L)

Water Bodies	SO_4^{2-}	HCO^{3-}	NO_3^-	Cl^-	PO_4^{3-}	Na^+	Mg^{2+}	Ca^{2+}	Fe^{3+}	Mn^+	Cond.	Temp.	Salinity	PH	TDS
Isiovu spring	0.00	12.12	2.9	90.4	3.4	1.26	0.91	2.9	0.35	0.0028	2.8µs	26°c	1.4ppm	9.8	1.8ppm
Ogwumb spring	0.00	13.26	3.0	50.4	2.3	1.11	1.45	2.68	0.30	0.039	6.2µs	25.8°c	3.5ppm	9.35	4.7ppm
Iyiahia spring	1.3	24.88	3.0	46.4	1.7	0.97	1.42	3.24	0.45	0.052	47.3µs	24.8°c	22.5ppm	10.02	30.6ppm
Iyiokuka spring	0.00	21.30	3.2	40.8	1.4	0.88	0.50	1.02	1.62	0.050	2.9µs	28°c	1.5ppm	9.46	2.0ppm
Obea stream	19.6	20.16	3.6	109.6	1.2	1.62	0.36	3.32	1.37	0.042	116.8µs	27.5°c	59.8ppm	8.98	80.3ppm
Iyiohimirir stream	3.6	10.21	4.6	44.0	2.4	1.33	0.32	2.81	1.62	0.050	9.3µs	24.5°c	4.8ppm	9.95	6.4ppm

5. Conclusion

The surface and groundwater analysis shows that the water type is Ca – HCO_3 and gradually moves to Na-Cl-Ca which is attributed to brine, oil seepage effect and the various rock types present in the area. The research also reveals that although the values of the spring tends to be moderate compared to the stream, yet the both are affected by the ancient environment and weathering of rocks. The entire results were compared with NIS standard for drinking water(2007) and it was observed that only few parameters exceeded the maximum permitted limit though with no negative health impact.

References

[1] Reyment, R.A. (1965). Aspects of the Geology of Nigeria. University of Ibadan press. P.48-60.

[2] Agagu, O.k., Fayose, E.A. and Petters, S.W. (1985). Stratigraphy and sedimentation in the Senonian Anambra Basin of Eastern Nigeria. J. min and Gest. V. 22,p. 25-36.

[3] 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.

[4] Obaje, N.G. (2009). Geology and Mineral Resources of Nigeria. Springer- Verlag Berlin Heidelberg. 201 pp.

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

[6] Afsin M. (1997). Hydrochemical evolution and water quality along the groundwater flow path in Snadikli plain, Afyon, Turkey. Environmental geology 31(3-4); 2212230.

[7] Stuytzand, P.J. (1999). Pattern in groundwater chemistry resulting from groundwater flow.

Hydrogeology journal 7:15-27.DO1;0.1007/S100400050177.
[8] National Population Commission of Nigeria(web).
[9] Rain data (2015), Geography and meteorology department, Enugu State University of Science and Technology, Agbani, Enugu, Nigeria.
[10] Viessman, Harbaugh,T.E., Knapp, J.W.,(1972). Introduction to hydrology. Intext education publishers, New York.
[11] Igbozuruike, M. U. (1975). Vegetation types of Nigeria in maps: Eastern States (Ed: Ofomata, G. E. K). Ethiope Publishing Benin, Nigeria.
[12] Ojoh, K.A. (1992). Southern part of the Benue Trough (Nigeria) Cretaceous Stratigraphy, Basin analysis, Paleo-oceanography and Geodynamic Evolution in the equatorial domain of the South Atlantic. NAPE bulletin. 7.p. 131-152.
[13] Martin, M.T., Judson, R.S. and Dix, D.J.(2009). Profiling chemicals based on chronic toxicity results from U.S. EPA ToxRef. Database.Environmental Health Prospect.v.117(3);392-399.
[14] Piper, A.M. (1944). A graphical procedure in the geochemical interpretation of water analysis. Am. Geophysics union Trans. 25.p.914-923.
[15] 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.
[16] Zhu, C. (2002). Environmental application of geochemical modeling: Cambridge: Cambridge University Press.
[17] Meisler, H., Beacher, A.E. (1967). Hydrological significance of calcium- magnesium ratio in groundwater from carbonate rocks in the Lancaster Quadrangle, Southeastern Pennsylvania. U.S. Geological Survey, professional paper.575, p.232-235.
[18] Hounslow A.W. (1995) water quality data analysis and interpretation. Lewis' publication, boca raton, New York, USA.
[19] Garrel, R.M., Mackenzie, F.T. (1967). Origin of chemical composition of some springs and lakes in Stumm,W.,ed.,Equilibrium concepts in natural water systems.Am. Chemical society Adv. In chemistry ser. 67.p.222-242.
[20] Black W. (1996). Hydrological facies and groundwater flow patterns in northern parts of Atlantic coastal plains. U.S geological survey, professional papers.498A;42.
[21] Kurata, N., Mori, K .and Ikeda K.(1958). Groundwater research for fabric industry in the eastern and northern part of Tokyo. Bulletin of geological survey Japan 8:1-26(in Japanese).
[22] Nigeria Industrial standard,(2007). Nigeria standard for drinking water quality. Nig. Nis; 554.P.14-30.

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