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Assessment of Some Physicochemical Properties of Groundwater Quality in Ikwuano Region of Southeastern Nigeria

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ABSTRACT: The objective of this study has been carried out to assess the ground water quality of Ikwuano region southeastern Nigeria for drinking and irrigational purposes using standard method. Data obtained show that, the pH and levels of electrical conductivity, total hardness, alkalinity, calcium, magnesium, sodium, potassium, nitrate,ortho-phosphate, fluorides and SAR ranged from 7.50-8.00, 500-1000µS/cm, 150-400mg/l, 55-110mg/l, 130-250mg/l, 8.50-37.00mg/l, 5.00-52.00mg/l, 2.00-22.00mg/l, 20.00-120mg/l, 10-100µg/l, 0.40-2.00mg/l and 0.80-13.00meq/l respectively. Percentage Na values range between 5.00-48.00%. Sodium adsorption ratio (SAR) values showed a range of 0.80to13.00meq/L. The maximum concentration of SAR 13.00meq /L was recorded at Umugo and minimum concentration of 0.80meq /L was recorded at Ndoro. The calculated values of SAR integrated with the Electrical Conductivity indicated that the ground water in the study area can be utilized for irrigation purpose without any threat of imposition of any hazard (saline or alkaline hazard) to crop soils. Thus, the analytical data from the study area confirms that ground water present in the study area is suitable for domestic and irrigational purposes.

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Keywords: Cations, SAR, Percent Sodium, Fluorosis.

The importance of ground water for the existence of human society cannot be overemphasized. Ground water is the major source of drinking water in both urban and rural areas. It is the major source of drinking water in Nigeria. Even in advanced countries such as United States of America and United Kingdom about 70% of drinking water comes from ground water (Duynisveld *et al.,* 1988). Ikwuano has rich deposits of ground water in both confined and unconfined aquifer system, but its occurrence is highly uneven due to diverse geological formations (Singh and Sharma, 1999; Uzoegbu, 2018; Uzoegbu and Agbo, 2018). Although groundwater development in Ikwuano area is at its early stage, but its demand is expected to increase over in future due to population pressure and urban sprawl. Ground water crisis is not the result of natural factors, but it has been caused by has been falling rapidly due to an increase in extraction and dry weather conditions especially during autumn, giving rise to drought like situation. This has decreased not only the level of surface waters but also reduced the discharge from many perennial springs (Bhat *et al.,* 2010) and in some areas springs and wells have even a drawdown completely. Despite its vastness and significance, in Ikwuano, the information available about ground water resources is scanty. The notable ones are found in (Jeelani, 2004; Pandit *et al.,* 2005). Earlier studies have attributed their genesis and growth to the influence of human activities on geomorphological processes and qualitative and semi-quantitative methods were employed to produce suggestions for solving the problems (Grove, 1951). However investigations carried out by Egboka and Nwankwo (1985) and Obiefuna *et al.,* (1999) have shown that the primary causes of gully genesis and growth lie in the hydrogeological and geotechnical properties of complex aquifer systems. The high hydrostatic pressure in the aquifers produce a reduction in the effective strength of the unconsolidated coarse sands in the walls of gullies leading to intense erosion (Egboka and Okpoko, 1984; Obiefuna and Nur, 2003).

Most of the major streams are Onu-Inyang River and controlled by clay and limestone lithology (Jeelani, 2007). Some of the important springs and streams are Onu-Inyang, Iyinta-Ocha, Akoo, Iyi-Oba etc. The Ikwuano region has also a number of thermal springs (Jeelani, 2004); possessed with chemical affinity containing ball clay, bentonite, kaolin, phosphate, etc and agro raw materials such as Cassava, Palm

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Produce, Maize, Vegetable, Cocoa, Ginger, Cocoyam, Melon, etc.

River Onu-Inyang is the principle river of the valley, flows from Bende (the north boundary) through the study area in a south-westerly direction (Mehmood *et al.,* 2017). The prevalent vegetation is the rain forest and mangrove swarms with two distinct seasons: the dry season which last from November to March; and a wet season which last from April to October (NIMET, 2000-2015). The mean annual rainfall is about 2145.89 mm most of which falls between the months of June to September (Table 1). Thus, the irrigational and domestic water supply can be met by developing the groundwater resources of the area.

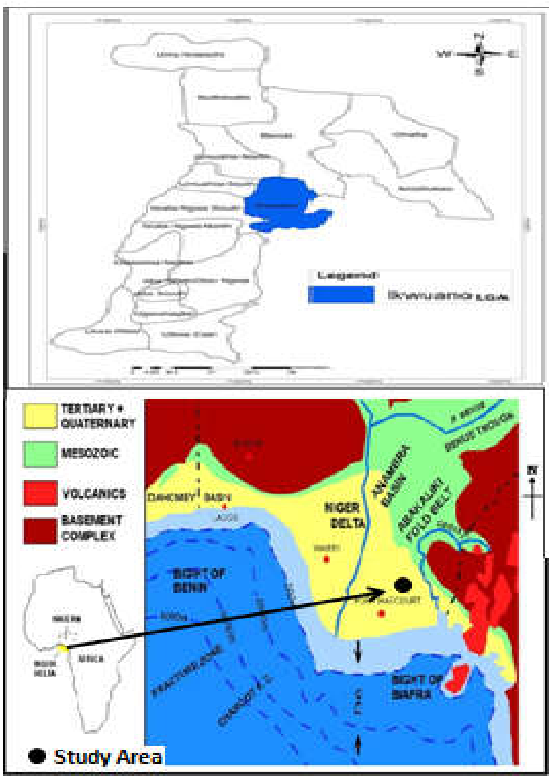

Fig. 1: Map showing location of study area modified (in set: map of Abia State with Ikwuano LGA)

In view of the widespread and large-tapping of groundwater along in northern Ikwuano and dearth of literature on ground water quality of Ikwuano area the assessment of physico-chemical characteristics of ground water of Ikwuano region is necessary. The objective of this study is to investigate and to assess the ground water quality of Ikwuano region southeastern Nigeria for drinking and irrigational purposes.

MATERIALS AND METHODS

The study area lies between latitude 5°19ˈ to 5°29ˈN and longitude 7°32ˈ to 7°40ˈE (Fig. 1). It has a total landmass of approximately 281km^2 and population of about 137, 993 (NPC, 2006 Census).

The area is endowed with natural spring and streams including Onu-Inyang River which flows from Bende (the north boundary) through the study area in a south-westerly direction; while Iyinta-Ocha River flows from the central part (Isiala) through south-western part (Ogbuebule) into AkwaIbom State on the western flank. Akoo River and Iyi-Oba River flow southerly from the eastern part of the study area.

The present investigation on the ground water of Ikwuano area was conducted from April to July 2016.Samplingwas done once a month. Representative groundwater samples were collected from 20 sampling areas. The water samples were collected in clean two liter polythene bottles, which were first cleaned by rinsing with distilled water. Prior to sample collection, bore wells were flushed for about 5-10 minutes to obtain the representative groundwater samples. The physicochemical analysis was carried out as per the standard methods(APHA, 2005). While temperature was analyzed on spot, other parameters were analyzed within 24hrs of sampling following the standard methods.

RESULTS AND DISCUSSION

Hydrology: The meteorological data from the Nigeria Institute of Meterology, Umudike shown on Table 1 include the rainfall data for the study area. The average annual precipitation occurring almost entirely as rainfall over a sixteen water year period (April to March) amounted to 95,971,200m3 volume of water. The value of actual evapotranspiration estimated from Turc model based on the mean annual rainfall is about 83,726,749m^3 or 85% of the atmospheric precipitation (Obiefuna and Nur, 2003; Uzoegbu, 2018; Uzoegbu and Agbo, 2018). An estimate of the surface runoff of 18,545,899m^3 or 19% of the atmospheric was achieved employing the Veisman (1972) rational formula. Thus based on Bell (1983) the infiltration was estimated by subtracting the sum of actual evapotranspiration and the surface runoff from the total precipitation. Accordingly when this is done for the study area an average infiltration value of 65,180,850 m^3 was obtained. Potential sources of surface water supply are streams and rivers Onu-Inyang, Iyinta-Ocha, Akoo, Iyi-Oba and Ahi which are largely perennial located to the south and east of the study area (Fig. 1). They have their peak discharges between the months of August and September and the minimum discharges in the months of April and May (Uzoegbu, 2018; Uzoegbu and Agbo, 2018).

The thick unconsolidated sand with lignite streaks and wood fragments gives rise to multi-aquifer systems. The unconsolidated weathered overburden aquifer is derived from the weathering of the underlying sedimentary rocks and consists of residual soils such as gravels, sands, silts and clays. The sediment aquifer directly underlies the unconsolidated weathered overburden aquifer and consists of sediments that have been subjected to weathering due to surface processes (Uzoegbu, 2018; Uzoegbu and Agbo, 2018). Furthermore while the hand-dug wells are tapping the unconsolidated weathered overburden aquifer, the boreholes are tapping the thicker and deeper part of the sedimentary aquifer unit (Uzoegbu, 2018; Uzoegbu and Agbo, 2018).

The hydraulic properties as determined from statistical methods (Hazen, 1893; Harleman *et al.,* 1963 and Uma *et al.,* 1989) indicate a mean hydraulic conductivity K, value of 5.02m/s and a mean transmissivity, T, value of 6.35m^2/s. Comparisons were made for K to the Todd (1995) and T to the Gheorghe (1978) classification and were found to be relatively high (Table 2).

Table 1: Meteorological data for Ikwuano and environs monthly rainfall (mm) from 2000/2001- 2014/2015 water year (NIMET, 2016).

Year	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar	Total
2000/01	164.5	153.6	265.5	265.2	216.9	277.5	228.4	75.9	3.8	0.0	7.8	175.9	1835.0
2001/02	224.1	194.3	511.7	273.5	179.0	317.2	277.1	18.6	0.0	3.1	107.1	68.5	2185.2
2002/03	259.0	436.3	240.1	359.8	333.7	238.5	247.5	57.0	0.0	0.0	37.9	119.5	2329.3
2003/04	159.8	231.4	282.4	447.5	372.6	340.8	180.2	69.2	0.0	0.2	11.9	22.4	2118.4
2004/05	134.5	217.6	279.4	309.5	304.3	324.9	249.1	52.5	5.1	17.3	126.7	64.0	2084.9
2005/06	141.3	222.4	264.4	277.0	225.0	336.7	323.0	45.4	8.6	76.6	81.9	131.9	2134.2
2006/07	136.0	202.8	237.3	303.4	133.7	483.1	237.4	14.2	0.0	0.0	62.9	35.5	1846.3
2007/08	78.4	444.9	354.0	187.6	464.8	319.9	335.6	112.1	425.0	13.4	0.0	168.4	2504.1
2008/09	219.8	373.5	352.3	310.2	327.4	404.0	211.0	6.7	8.9	62.8	62.8	47.8	2387.2
2009/10	100.5	416.2	236.0	306.3	287.4	205.5	311.1	23.7	0.0	0.0	78.2	34.7	1999.6
2010/11	126.0	213.5	459.0	276.9	420.7	309.3	349.2	78.2	4.6	0.0	60.8	111.4	2409.6
2011/12	105.8	347.7	239.5	236.5	345.1	424.7	242.6	12.0	9.6	0.0	88.2	57.0	2108.9
2012/13	142.0	233.7	213.0	362.0	161.8	349.0	244.6	58.5	0.0	75.4	36.5	40.8	1917.3
2013/14	92.8	466.1	239.1	280.9	237.1	318.0	184.8	99.5	90.8	0.0	43.7	138.8	2191.6
2014/15	78.7	249.2	281.8	144.4	44.2	405.3	165.1	147.4	0.0	8.4	81.7	130.5	2136.7
Mean Value	144.2	293.6	297.8	289.4	296.9	337.0	252.5	58.1	10.4	17.15	59.2	89.8	2147.9

Table 2: Hydraulic conductivity and Transmissivity values estimated from statistical grain size methods (after Gulzar *et al*., 2017).

Sample Location	Hydraulic Hazen 1893	Conductivity Harleman et al. (1963)	(cm/s) Uma et al. 1989	Transmissivity Hazen 1893	Harleman et al. (1963)	Cm2/s Uma et al. 1989	Thickness (cm)
Ariam	1.0×10^3	6.4×10^2	3.8×10^1	1.5×10^5	9.6×10^4	5.7×10^3	150.0
Iberenta	6.4×10^2	4.1×10^2	2.4×10^1	1.5 x 105	9.4×10^4	5.5×10^3	230.0
Ndoro	4.0×10^2	2.5×10^1	1.5×10^0	$5,2 \times 10^3$	3.3×10^3	2.0×10^2	130.0
Okwe- Obuohia Road	8.1×10^0	5.2×10^0	3.1×10^{-1}	8.9×10^2	5.7×10^2	3.4 x 101	200.0
Ogbuebule	1.0×10^{-1}	6.4×10^{-2}	3.8×10^{-4}	1.0×10^1	6.4×10^0	3.8×10^{-2}	150.0
Amawom	3.6×10^2	2.3×10^2	1.3×10^1	7.2×10^4	4.6×10^4	2.6×10^3	200.0
Iyalu	3.6×10^2	2.3×10^2	1.3×10^1	7.6×10^4	4.8×10^4	2.7×10^3	210.0

Groundwater Quality: The quality of ground water as determined by its chemical constituents is of great importance in determining the suitability of a particular ground water for a certain use. The physico-chemical characters of ground water play a significant role in assessing water quality. The results of physico-chemical parameters of ground water samples are given as Water temperature remained low throughout the study period at all sites of ground water. The temperature of ground water fluctuated from a minimum of 17^{0}C at Umugo in the month of April to a maximum of 25^{0}C at Ahaba in July. The average value is 20.33^{0}C (Table 3). In the four-month study period, all the areas depicted neutral to alkaline pH with values very close to 7, except at Ahaba and Ndoro 7.30 and 8.00, in the month of May and June respectively. During investigations highest pH 8.00 was recorded at Ndoro and Iyalu in the month of April and lowest value 7.30 at Ahaba in the month of June. The average value is 7.68 (Table 3). The lowest conductance value 500.00 µS/cm was recorded at AriamAlala in the month of May and highest value of 1000µS/cm was recorded at Iberenta and Nchara in the month of July. The average value is 720.83µS/cm ±199.0 (Table 3).During the present study, the alkalinity of ground water samples was due to the bicarbonates. The alkalinity has been found in the range of 60 to 110mg/L, with lowest value of 60mg/L at Amaoba in the month of April and highest value of 110mg/L at Nnono, Iyalu, Ahaba and Awomukwu in the month of June. The average value is 92.25 mg/L ±32 (Table 3).It is a measure of variable complex mixtures of anions and cations. In fresh water, the principle cations that impart hardness are Ca and Mg. The total hardness of the ground water samples varied from 150 to 400mg/L. The maximum value of 400mg/L was recorded at Nnono and Umugo in the month of July and minimum value of 150mg/L at Awomukwu in the month of June. The average value is 272.92 mg/L ±5.9 (Table 3).One of the most pronounced minerals (calcium), the concentration of which was observed to vary from 150.00 to 250.00mg/L. The maximum concentration of 250.00mg/L was recorded at Nnono in the month of June and minimum concentration of 130.00 mg/L was recorded at Awomukwu in the month of June. The average value is ranged from 195.83 mg/L ±1.5 (Table 3).The concentration of magnesium was observed to vary from 8.50 to 37.00mg/L. The maximum concentration of 37.00mg/L was recorded at Umugo in the month of June and minimum concentration of 8.50mg/L was recorded at Ariam Alala in the month of April.

Table 3: Indicates the laboratory results of water samples from the Ikwuano region.

Parameters	OBORO			IBERE			OLOKO			ARIAM			Mean Value
	Amaoba	Ndoro	Nnono	Amauro	Iyalu	Iberenta	Nchara	Ahaba	Umugo	Ariam Alala	Awomukwu	Ariam Eluelu	
Temperature (ºC)	20.0	18.0	18.0	21.0	23.0	18.0	20.0	25.0	17.0	20.0	20.0	24.0	20.3
pH	7.50	8.00	7.60	7.70	8.00	7.70	7.70	7.30	7.70	7.70	7.60	7.70	7.68
Conductivity (µS/cm)	550	550	950	700	950	1000	1000	700	600	500	600	550	721
Alkalinity (mg/l)	60.0	55.0	110	62.0	110	105	95.0	110	100	90.0	110	100	92.3
Total Hardness (mg/l)	275	325	400	300	250	225	325	200	400	200	150	225	273
Ca (mg/l)	210	240	250	225	200	175	200	180	240	150	130	150	196
Mg (mg/l)	16.0	20.0	35.0	17.5	15.0	12.5	35.0	12.5	37.0	12.5	8.50	20.0	20.1
Na (mg/l)	30.0	5.00	41.0	35.0	41.0	35.0	46.0	40.0	52.0	35.0	41.0	36.0	36.4
Nitrate –N (µg/l)	40.0	50.0	45.0	20.0	120	80.0	70.0	35.0	35.0	40.0	20.0	60.0	51.3
Ortho-Phosphate (µg/l)	20.0	40.0	30.0	10.0	100	67.0	60.0	20.0	20.0	28.0	19.0	42.0	38.0
Fluoride (mg/l)	0.40	0.50	2.00	0.80	0.30	0.90	1.10	1.00	0.20	0.50	0.59	0.80	0.76
K (mg/l)	20.0	2.00	20.0	4.00	9.0	16.0	22.0	8.00	18.0	8.00	10.0	14.0	12.6
SAR (meq/l)	5.90	0.80	9.00	6.00	7.00	6.00	7.00	6.70	13.0	6.00	8.00	10.0	7.12
Na (%)	32.0	5.00	43.0	26.0	28.0	30.0	37.0	33.0	50.0	26.0	35.0	48.0	32.8

The average value is 20.13 mg/L ±1.7 (Table 3). Sodium is important for both domestic and agricultural use of water. In the present study, the concentration of Na varies from 5.00 to 52.00mg/L. The maximum concentration of 52.00mg/L was recorded at Umugo in the month of June and minimum concentration of 5.00 mg/L was recorded at Ndoro in the month of April, May and June. The average value is 36.42mg/L ±17.8 (Table 3). The nitrite-nitrogen of ground water samples ranged from 20.00 to 120.00µg/L. The minimum value 20.00µg/L was found in the month of April at Awomukwu and the maximum value 120.00µg/L was reported in July at Iyalu. The average value is 51.25µg/L ±47.8 (Table 3). The orthophosphate-phosphorus of ground water samples ranged from 10.00 to 100.00µg/L. The maximum concentration of Orthophosphate-Phosphorus 100.00µg/L was recorded at Iyalu in the month of June and minimum concentration of orthophosphate-phosphorus 10.00 at Amauro in the month of July. The average value is 38.00µg/L ±24.9 (Table 3).The Fluoride concentration of ground water samples ranged from 0.40 to 1.10mg/L. The maximum concentration of Fluoride 1.10µg/L was recorded at Nchara in the month of July and minimum concentration of 0.40mg/L was recorded at Amaoba in the month of April, May and June. The average value is 0.76mg/L ±0.2 (Table 3). Potassium is usually found as ions in natural waters. The concentration of potassium under the present study ranges from 2.00 to 22.00 mg/L. The maximum concentration of 22.00mg/L was recorded at Nchara in the month of July and minimum concentration of 2.00mg/L was recorded at Ndoro in the month of June. The average value is 12.58mg/L ±2.3 (Table 3).The sodium adsorption ratio (SAR) of ground water samples recorded a range of 0.80 to 13.00meq/L. The maximum concentration of sodium adsorption ratio

13.00meq /L was recorded at Umugo and minimum concentration of 0.80meq /L was recorded at Ndoro (Table 3). The percent sodium of ground water samples ranged from 5 to 50%. The maximum concentration of percent sodium 50 was recorded at Umugo and minimum concentration of 5 was recorded at Ndoro (Table 3).Ground water chemistry differs depending on the source of water, the types of rocks, topography and climate, and the degree towhich it has been evaporated and mineral it has encountered (Gulzar *et al*., 2017; Uzoegbu, 2018; Uzoegbu and Agbo, 2018).The groundwater quality may yield information about the environments through which the water has circulated. The temperature range (17 to 25^{0}C) suggested that most of the areas contain water of shallow type as near surface ground. Direct influences on the groundwater temperature includes all heat inputs to the groundwater through the sewage network, district-heat pipes, power lines and such underground structures as auto and metro tunnels, underground garages, etc.

Anthropogenic heat generation such as domestic heating, industry and transport also contribute to enhance ground water temperature (Miller, 1997). Conductivity is a measure of the ability of water to conduct an electric current. It is used to estimate the amount of dissolved salts. It increases as the amount of dissolved mineral (ions) increases. The larger variation in electrical conductivity is mainly attributable to lithological composition and anthropogenic activities prevailing in this region (Khodapanah *et al*., 2009). Higher conductivity at Iberenta and Nchara areas may be due to the accumulation of dissolved solids from the upland areas by rain water and leaching of dissolved solids from effluents through the alluvial deposits (Ravindra and Garg, 2007; Uzoegbu, 2018; Uzoegbu and Agbo, 2018). The pH is a measure of the hydrogen ion concentration in water. The pH value of water indicates whether the water is acidic or alkaline. The slightly alkalinity pH (7.3) at the Ahaba may be due to the microbial load decomposition in soil and water, while Neutral to Alkaline pH (>7) may be due to limestone rich lithology of the valley, liberating Ca and Mg into the solution (Yongjin *et al*., 2006). Alkalinity refers to the quantity and kinds of compounds which collectively shift the pH into the alkaline range (pH over 7). Bicarbonates, carbonates and hydroxides are mainly responsible for alkalinity (Cole, 1983). Alkalinity in waters is due to any dissolved ions that can accept or neutralize protons. In the present ground water samples, alkalinity was mainly contributed by bicarbonates which is a characteristic feature of the region lithology (Gulzar *et al*., 2017). Its concentration remained moderate (55mg/l to 110mg/L). Large amount of alkalinity may impart a bitter taste, harmful for irrigation as it damages soil and hence reduces crop yields (Yongjin *et al*., 2006). The most common problem associated with ground waters is hardness, largely associated to calcium or magnesium rich lithology. Hard water causes no health problems, but can be a nuisance as it may form soap curds on pipes and other plumbing fixtures. During the present study, total hardness values indicated that these ground water sources fall between hard (150 to 400mg/L) and very hard (>300mg/L) as per Shrivastava *et al.,* 2009and are not fit for domestic purposes. High hardness values may be due to the presence rich deposits of limestone and is very common in the region. Among cations, calcium was dominant followed by magnesium. The major source of Ca and Mg in the valley ground waters may be due to the lacustrine deposits as limestone, calcite, gypsum and dolomite. The dominance of Ca ion over Mg ion is attributable to the abundance of these rocks in the study area (Sawyer and McCarthy, 2007). Sodium on the other hand is another important cation for both domestic and agricultural purpose. Its concentration in the present study is quite appreciable, which might have resulted to cation exchange of calcium and magnesium ions by mineral water interaction. The main problem with sodium is its conservative nature once it enters into the system and its effect on the physical properties of soil (Gulzar *et al*., 2017). The concentration of potassium was recorded low at majority of the sites, thus contributing very little towards the quality of ground water. However, at certain areas its concentration was high, may be due to the use of fertilizers. The overall cationic composition at the study area depicted the sequence Ca>Na >Mg>K. Nitrogen is a major constituent of the earth's atmosphere and occurs in many different gaseous forms such as elemental nitrogen, nitrate and ammonia. Natural reactions of atmospheric forms of nitrogen with rainwater result in the formation of nitrate and ammonium ions. While nitrate is a common nitrogenous compound due to natural processes of the nitrogen cycle, anthropogenic sources have greatly increased the nitrate concentration, particularly in groundwater. The largest anthropogenic sources are septic tanks, application of nitrogen-rich fertilizers to turf grass, and agricultural processes (Uzoegbu, 2018; Uzoegbu and Agbo, 2018).

Levels of nitrates in groundwater in some instances are above the safe levels proposed by the EPA and thus pose a threat to human health. Particularly in rural, private wells, incidence of methemoglobinemia appears to be the result of high nitrate levels. Methemoglobinemia, or blue baby syndrome, robs the blood cells of their ability to carry oxygen. Due to the detrimental biological effects, treatment and prevention methods must be considered to protect groundwater aquifers from nitrate leaching and high concentrations (Gulzar *et al*., 2017). Treatment through ion-exchange and other processes can rehabilitate already contaminated water, while prevention, such as reduced dependence on nitrogen-rich fertilizers can lower the influx of nitrates. Higher concentration of nitrogen compounds at majority of the sites may be related to domestic sewage, plant debris, animal excreta and the use of nitrogenous fertilizers for agricultural use (Voznaya, 1981). Phosphorus is an essential nutrient for plant and animal growth. The high concentration of total phosphorus especially at Iyalu indicated that domestic wastes and fertilizers from agricultural use have entered the ground water system (HEC, 1972). The phosphorus also passes through cycles of decomposition and photosynthesis. The water samples of the study area did not contain any physico-chemical parameter above the WHO international standards, 2004, except total hardness and Fluoride concentration which were higher than the permissible limits of WHO standards, indicating that these waters are hard and contain significant concentration of fluoride. Hence, the water in the study area could be said to be portable for human consumption with few exceptions. Fluoride exists naturally in water sources and is derived from fluorine, the thirteenth most common element in the Earth's crust. It is well known that fluoride helps prevent and even reverse the early stages of tooth decay. Tooth decay occurs when plaque that sticky film of bacteria that accumulates on teeth breaks down sugars in food. The bacteria produce damaging acids that dissolve the hard enamel surfaces of teeth. If the damage is not stopped or treated, the bacteria can penetrate through the enamel causing tooth decay (also called cavities or caries). Cavities weaken teeth and can lead to pain, tooth loss, or even wide spread infection in the most severe cases.

Fluoride combats tooth decay in two ways: It is incorporated into the structure of developing teeth when it is ingested. It also protects teeth when it comes in contact with the surface of the teeth.

Fluoride has been found to have a significant mitigating effect against dental caries and it is accepted that some fluoride presence in drinking water is beneficial. Optimal concentrations are around 1mg/l. However, chronic ingestion of concentrations much greater than 1.5mg/l (the WHO guideline value) is linked with development of dental fluorosis and, in extreme cases, skeletal fluorosis. High doses have also been linked to cancer. Health impacts from long-term use of fluoride-bearing water have been summarized as: <0.5mg/l:dental caries, 0.5-1.5mg/l promotes dental health, 1.5-4mg/l dental fluorosis, >4mg/l dental, skeletal fluorosis, >10mg/l crippling fluorosis Dental fluorosis is by far the most common manifestation of chronic use of high-fluoride water. As it has greatest impact on growing teeth, children under age 7 are particularly vulnerable. Fluoride is considered as an essential element though health problems may arise from either deficiency or excess amount. Much of the fluoride entering the human body is obtained from drinking water. Fluoride concentration of 0.4ppm in drinking water causes mild type of dental fluorosis (Dinesh, 1999). Nnono samples showed very high concentration of fluoride and as a result the residents are suffering from dental fluorosis. Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric volcanic particles.

Fluoride can also come from: Runoff and infiltration of chemical fertilizers in agricultural areas. Liquid waste from industrial sources

The suitability of groundwater for irrigation depends on the ionic concentration of Ca, Mg and Na. In fact, salts can be highly harmful. They can limit growth of plants physically, by restricting the taking up of water through modification of osmotic processes. Also salts may damage plant growth chemically by the effects of toxic substances upon metabolic processes. Good quality of waters for irrigation is characterized by acceptable range of sodium adsorption ratio and percent sodium. Sodium concentration plays an important role in evaluating irrigational quality of ground water because irrigation with Na-enriched water results in ion exchange reactions: uptake of Na^+ and release of Ca^{2+} and Mg^{2+}. This causes soil aggregates to disperse, reducing its permeability (Tijani, 1994). All the study areas had very low sodium adsorption ratio (SAR) values, indicating that groundwater samples had excellent quality forirrigation with no danger of exchangeable sodium except Umugo. On the basis of % sodium all the areas belong to good water class category (20-50%) except Ndoro (< 20%) which belongs to excellent category (Todd, 2003). Low SAR and %Na may be due to the presence of significant quantities of divalent cations like Ca and Mg which are more strongly bonded and tend to replace monovalent ions like sodium and potassium. The combination of electrical conductivity and SAR had also been used to determine the suitability of water for irrigation. According to US salinity hazard diagram, almost all sites fall under C_2S_1 category indicating medium salinity and low alkali hazard except Nnono and Iyalu areas which fall underC_3S_1 indicating high salinity and low alkali hazard. In addition to this Umugo has been found to fall under C_2S_2indicating medium salinity and medium Alkali hazard. These groundwater sources can be used to irrigate all types of soils with little danger of exchangeable sodium but ground water of Nnono and Iyalu areas which fall C_3S_1 (high salinity) category may not be fit for irrigation purposes. While plotting %Na against electrical conductivity, it was found that Amaoba, Ndoro, Awomukwu, Ariam Alala areas had water quality varying from good to permissible while others had water quality not fit for irrigation.

*Conclusion***:** The chemistry showed that these waters are hard and highly mineralized. Calcium and magnesium are the dominant cations and bicarbonate is the dominant anion. The excess of alkaline earths imparts hardness to the ground water of the area. The samples of the study area did not contain any physico-chemical parameter above the limits prescribed by WHO Standards, 2004 except total hardness and Fluoride. Thus, the analytical data from the study area confirms ground water present in the area is suitable for domestic and irrigational purposes.

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