Hydrochemical Analysis of Surface and Ground Waters of Emu-Kingdom in Ndokwa Land Area of Delta State, Nigeria.

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ABSTRACT

The results presented in this paper arise from a study of the surface and groundwater potential of Emu-Kingdom. The study was initiated by a desire to determine the availability of sufficient and good quality water for a proposed expansion of the human and industrial establishments without jeopardizing the existing domestic water supply in the area. The quality of water is determined by its chemical composition and therefore its ultimate usability, assessment and the parameters examined depends on the envisaged usage. In some cases, water quality is far more important than its availability. It is almost impossible to set a rigid standard of chemical quality, however, a range of chemical values of some elements have been established for domestic and specialized industrial uses.

Earlier studies {23 and 22} have set international drinking water standards. The Nigerian Federal Environmental Protection Agency {6} has adopted the WHO drinking water standards and has added its own standard for various classes of industry in the country. Water samples were collected from nine (9) hand-dug wells and five (5) existing and productive boreholes (fourteen locations) evenly distributed within Emu-kingdom and analyzed for twenty-two (22) parameters. Where possible, the well history and characteristics were noted.

The result of the analysis revealed that water in Emu-Kingdom is acidic, soft, and low in dissolved constituents. It also has high iron content when compared with the World Health Organization Standard for drinking water. Apart from the acidic condition and the high iron content, none of the parameters studied exceeded the stipulated standards showing that the water is potable if treated for high iron concentration and acidity.

(Keywords: groundwater, surface water, water quality, potable, aquifer, Ebendo, Obodoeti, Obigo, Lyasele, Etevie, Ikosa quarters, Emuno)

INTRODUCTION

The abundance of surface water in Emu Kingdom has in the past retarded research into and possible full exploration of ground water resources of the area. Until recent times, only a few hands dug wells served inhabitants in the area distant from the slow running streams and creeks. The search for potable water has lead to hydrogeophysical survey for water and hydrochemical analysis of the available water for domestic purposes.

Water is of fundamental importance to life that is both plants and animals particularly man. It is very vital in maintaining life processes and growth. Water has no substitute and potable water is not commonly found while its provision limits the setting up of villages and towns to places where supply exists {20 and 11}. Access to a secured, safe and sufficient source of fresh water is a fundamental requirement for the survival or well-being of man.

Groundwater is commonly understood to mean water occurring beneath the earth surface; that is water occupying the voids within a geologic stratum {4}. Groundwater is not static but flows through the rock. The ease with which water can flow through a rock mass depends on a combination of the sizes of the pores and the degree to which they are interconnected {13}. Most local ground supply in Emu kingdom comes from a leaky or semi confined aquifer made up of extensive loosed soil materials such as sand in Ebendo and Obodoeti, while at Etevie and Ikosa quarters in Emu-Uno and Obiogo medium grained sand such as, gravel are prominent. This is

because Emu-kingdom has only an overlying confined bed without an underlying confined layer. The thickness of the aquifer at Emu-kingdom is greater in Ebendo and Obodoeti, hence in the event of pollution, groundwater at Ikosa and Etevie in Emu-Uno and Obiogo are highly contaminated. {14, 15, 16, 17}.

Groundwater usually flows towards and eventually drains into streams, rivers, lakes, creeks, ponds and boreholes. The flow of groundwater in the aquifer does not always reflect the flow of water on the surface {7}. It is therefore necessary to know the direction of groundwater flow and take steps to ensure the land use activities in the recharge areas will not pose a threat to the quality of groundwater. The water elevation map of Emu-kingdom revealed that groundwater flow toward the south and southeastern region of the Kingdom {18}.

Furthermore, it is important to know if the groundwater system is a recharge or discharge system that is a gaining or loosing type. Groundwater moved down gradually to recharge the Ase creek and her tributaries; Olor, Atur, Utaniko and Odibo. Therefore, the Ase creek is a gaining creek Although, from the eastern part of the kingdom, the Ase creek could be described as a losing creek since it lose water to the locations around there {18}.

The quality of water is affected by the quality of groundwater entering the system of water supply in the borehole {21}. Consumption of water, which did not meet up with the internationally accepted standard, could lead to an attack by any water borne diseases such as typhoid and cholera among others. In the study area, relevant human activities in the river or surface water are mainly subsistence fishing, domestic washing and bathing and no individual activities have been considered. Among the sources of groundwater pollution are lecheates from dump sites and the health of the inhabitants stand at risk if lecheates are allowed to contaminate with groundwater {18}.

Hence the need for hydrochemical analysis cannot be overemphasized in getting background information on the most abundant parameters and to access the groundwater quality in Emu-Kingdom in order to determine the suitability of water within the region for domestic, agricultural and industrial purposes.

LOCATION OF THE STUDY AREA

Emu-Kingdom is Located within the Ndokwa Land area of Delta State, Nigeria. It is comprised of five communities: Emu-Uno, Emu-Obiogo, Emu-Obodoeti, Emu-Iyasele, and Emu-Ebendo. It is in the south eastern region of the state situated in the south- south region of Nigeria. It lies between latitudes 5^0 35^1 N to 5^0 48^1 N and longitudes 6^0 10^1 E to 6^0 20^1 E and bounded in the North by Ogume Kingdom; the south by Aredhe Community in Isoko North Local Government Areas of Delta State; the east by Ashaka and Umuseti Communities; and in the west by Owhelogbo in Isoko North and Abbi Community.

The important streams in the region are Olor, Atur, Utaniko, and Odibo and these are the tributaries to Ase creek. The area is accessible by network of roads and footpaths that are not tarred. The Ozoro/Kwale express road that leads to Asaba is the major tarred road within the study area. However, the Emu/Abbi road that leads to Abraka is another major road though still under construction. The bases map of Emu-Kingdom showing the five clans of Emu-Kingdom and her neighboring communities is presented in Figure 1 below.

METHODOLOGY AND DATA ACQUISITION

Water samples were collected from fourteen (14) locations evenly distributed within Emu-kingdom and analyzed for twenty-two (22) parameters. Samples were collected from nine (9) hand-dug wells and five (5) existing and productive boreholes and where possible, the well history and characteristics were noted. The need for correct sampling is to ensure the reliability of data acquired from the representatives of the water under investigation. The samples were collected in to fourteen (14) plastic jerry cans of 2 liters each with covers. These jerry-cans were thoroughly rinsed with the water to be collected and then well stopped.

Water samples were collected from open wells by means of rope and bucket (bail method). In each case the bucket was allowed to sink some distance without disturbance so as to get a clear representative of the water in question. Once the jerry can is filled with water, it is covered and labeled to minimize oxygen contamination and the escape of dissolved gasses.

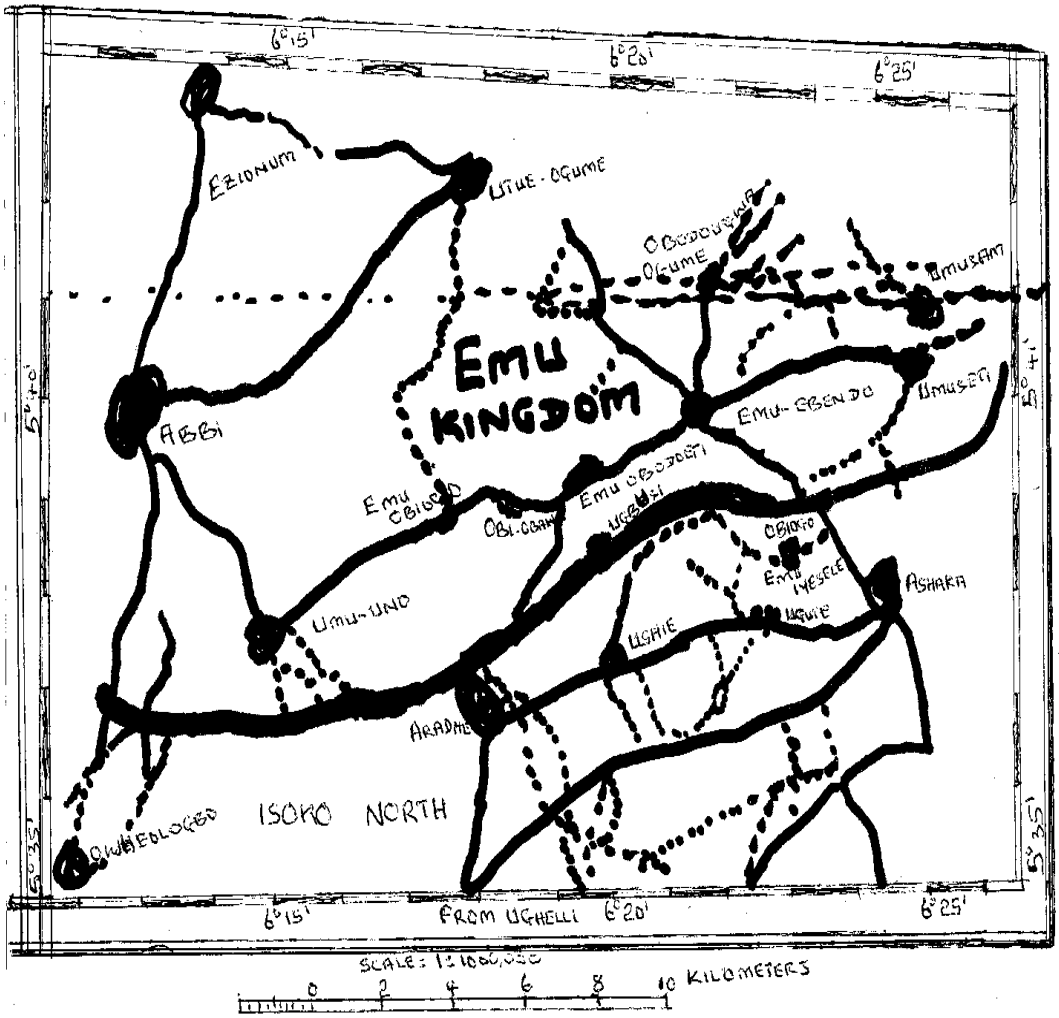

Figure 1: Emu-Kingdom.

The hydrochemical data of the surface and groundwater in Emu-kingdom are presented in Tables 2 and 3, respectively. As much as possible, samples were analyzed soon after collection. Analysis was carried out mainly along the methods described in {2 and 1} and were preserved stored in accordance with the recommended preservation methods and holding period as given by {19}. Most of the Analysis was done in waterwell services limited with registration number 131,665 (waterwell.loss@alpha.linkserve.com), respectively.

Parameters such as temperature, conductivity, and pH were determined in the field due to their unstable nature. Temperature was measured with a mercury filled thermometer. Conductivity was estimated with a mark V electronic switch gear conductivity meter. pH was estimated with a pH meter. The hardness, magnesium, chloride, and sulphate of the water samples were determined by titration. Iron was determined calorimetrically. Nitrate, phosphates, and total dissolved solids (TDS) were determined gravimetrically. Sodium was estimated using flame photometer. Summary of the analytical methods used in this study is shown in Table 1.

However, when studying about the physiochemical characteristics of groundwater, certain parameters are to be taken into consideration. These include:

Color, Odor, and Appearance: Water is a transparent, colorless and odorless liquid. It has a blue tinge when seen in large bodies. It has no taste and has always the same composition whether in liquid, solid or form gaseous.

Table 1: Methods of Analysis Used in the Study.

PARAMETER	ANALYTICAL METHODS
Temperature	Thermometer
Conductivity pH	Conductivity meter pH meter
Hardness, Mg^{2}, Cl^{-}, SO_4^{2-} Iron, Lead, Mn, Cu. NO_3^{-}, PO_4, TDS	Titration Calorimetric Gravimetric
Na^{+} Color	Flame photometer Spectrophotometer
COD	Spectrophotometer

Turbidity: This is the pressure of suspended colloidal matter in water such as clay, salt, organic matter and micro-organism. The measurement of turbidity is based on the light that passes through water to cause an image of a flame of a standard candle to disappear. It is mostly associated with surface water; natural filtration through unconsolidated aquifer eliminates turbidity. The recommended limit of turbidity is 5 NTU and the tolerance limit is 10 NTU {2}.

Hydrogen Ion Concentration (pH): The pH value of substance usually ranges from 0 to 14. Pure water falls on a neutral pH of 7. Anything excessively below this ph is acidic and above is alkalinity meaning there could be a slight fall or increase but not in excess. Groundwater usually falls on the acidic side that is less than 7, hence P^{H} can be used to determine the level off acidity and alkalinity in water, high acidity suggests low alkalinity and level and has a narrow range of tolerance. These changes can be caused by an increase in decomposing matter dead fish or leaves which causes lower P^{H} or more acidity conditions.

Total Iron (Fe): Iron is a reactive chemical and pure iron tarnishes rapidly in air or water, iron is an essential metal to the human body, it is needed for body build up in biological system because of its ability to form complexes and to exist in different oxidation states. The blood pigment hemoglobin contains iron. The ratio of iron in water depends on the oxygen concentration in the water, the pH and other chemical properties of water. High concentration of iron in water causes reddish brown stains on white porcelain enameled ware, fixtures and fabrics. Water containing iron tends to impact unpredictable colors and therefore it is unsatisfactory for industrial purposes.

Total Dissolved Solids (TDS): Total dissolved solids refer to the total amount of all materials in solutions both ionized and unionized. Total dissolved solids plays a crucial role in controlling the degree of reactivity of water with other elements for example, the presence of excess calcium dissolved in water may lead to hardness and subsequent reduction of latter formation with soap. Therefore total dissolved solids comprise all forms of solids dissolved in water both chemically and physically. This implies that the addition of all values of test for all water parameters should add up to give an approximate value of the total dissolved solids. Groundwater is classified according to its total dissolved solid contents {10 and 9} as follows: fresh water => less than 1,000 mg/l, moderately saline water => 3,000-10,000 mg/l, vary solid water => 10,000-35,000mg/l and briny water => greater than 35,000 mg/l.

Sodium Content: Sodium is a metal, one of a group called the alkali metals. Among the alkali metals, sodium is the only one found in significant quantities in natural waters. It is the most abundant metallic ion in sea water. Sodium does not contribute to the hardness of water. However groundwater containing considerate quantities of sodium carbonate or sodium bicarbonate or alkaline and may have pH values of 9 or more. The world health organization suggests the sodium content for drinking water should not exceed 200 mg/L.

Chloride (Cl) Content: Chloride is chemically known as a salt hence chloride concentrations measures salinity in water samples. The presence of chloride salt in water produces a salty taste and its occurrences is more in groundwater. High chloride content may indicate pollution by contact with geological formations containing chloride salt, sewage or industrial waste or by intrusion of sea water or saline waster into a fresh water body or aquifer. A salty taste in water depends on the ions with which the chlorides are associated. High chloride content has a corrosive effect. However, salt in water aids corrosion of substance than usual. The WHO suggests that the chloride content for drinking water should not exceed 250 mg/L.

Nitrate Content: The variation in Nitrate content for different waters is great and many ground waters. It appears to be unrelated to any geologic formation. A high content of nitrate can be considered as an indicator and a warning that the water should be treated for the presence of harmful bacteria. Nitrate is a negatively charged ion which consists of a combination of nitrogen and oxygen in the proportions of 1 atom of nitrogen to 3 atoms of oxygen. Its chemical symbol is NO_3^-. It was suggested by the {22} that the nitrate content for drinking water should not exceed 10 mg/L.

Sulphate (SO_4^{2-}) Content: Sulphate in groundwater is derived principally from calcium sulphate. It may also be derived for iron sulphate, magnesium sulphate, and sodium sulphate. If present in sufficient quantities, will impact a bitter taste to the eater and the water may act as a laxative for people not accustomed to drinking it. Sulphate oxide is also contained in groundwater. WHO suggest that sulphate oxide (SO_4^{2-}) content should not exceed 400mg/L for drinking water.

Phosphate Content: Phosphate is chemically known as a salt of phosphorus that is insoluble in water, that is, it cannot dissolve in water. Therefore its presence in water can be detected with the physical eyes. Moreover, calcium phosphate salts like appetites are essential components of living matter. Bones and teeth have a very high percentage of calcium tetraoxosulphate (v). Phosphorus salts are needed in the body to an extent or of a certain quantity.

Chemical Oxygen Demand (COD): Chemical oxygen demand refers to the measure of oxygen equivalent of the materials present in water sample subjected to oxidation by a strong chemical oxidant. Chemical oxygen demand test is used to estimate the amount of organic matter in water samples which serves as pollutant.

Dissolved Oxygen: Dissolved oxygen is a measure of the amount of oxygen dissolved in water. Water is made up of hydrogen and oxygen in the ratio of 2:1. Dissolved oxygen in water is needed by microorganisms for their microbial or bacterial activities. The concentration of dissolved oxygen is measured in mg/L. {22}.

Total Alkalinity: Total alkalinity in water is a measure of the impurity in water which causes the pH scale to read above 7 which is the neutral point and normal pH value for pure water. If a red litmus paper is left or dipped in an alkaline water solution, the litmus turns blue.

Lead Content: Lead is a poisonous substance that accumulates within the body and can also be found in some water samples, they are barely detectable since their presence is almost insignificant. One source of lead is drinking water which was far more prevalent in the past due to wide spread use of copper tubing to avoid the corrosion of lead pipes. Lead and its compounds are poisonous and should be avoided to be in contact with food and water.

Biochemical Oxygen Demand (BOD): BOD is the amount of oxygen taken up by micro-organism to decompose organic waste matter that is present in water. BOD is used as an empirical measurement of the amount of certain biological degradable waste types of organic pollutants that are present in water. Thus BOD gives an indication of the amount of oxygen needed to stabilize or biologically oxidize the waste. It also indicates the amount of micro-organism consuming large amount of organic matter which suggest a high level of pollution.

Magnesium Content: Magnesium is one of the major elements whose salt causes hardness in water in the form of magnesium tetraoxosulphate (vi) and magnesium chlorides. Magnesium occurs as ferromagnetism mineral in igneous rocks and in metamorphic rocks. Water stored in the cracks of these rocks is hard or impure as a result of the magnesium ions present in them.

Electrical Conductivity (EC): The electrical conductance is the ability of a substance to conduct an electrical current. Chemically pure water has a very low electrical conductance; meaning that it is good insulator. It is only a very small amount of dissolved mineral that renders the water conductive. The conductivity of a water solution increases as the temperature rises (12).

Total Hardness of Water: Hardness of water was originally understood to be the ability of water

to destroy soap lather. It has become customary through to consider hardness as the total amount of calcium and magnesium is solution {3}. This is because the major cause of lather destruction in water is the presence of calcium and magnesium salts through other polyvalent metals like Al, Ba. Fe, Zn, and Mn will destroy lather also if present in certain concentration. Water is classified according to its hardness by {7} as follows:

Soft water	=>	0 - 60 mg/l,
Moderately hard	=>	61-120 mg/l
Hard water	=>	121-180 mg/l
Very hard water	=>	above 180 mg/l

The hydrochemical data of the surface and groundwater in Emu-kingdom are presented in Tables 2 and 3, respectively. Table 4 shows the range of the values of the chemical parameters in Emu-kingdom and the standards for drinking water. {22, 23 and 6} while the classification of water based on the hardness is presented in Table 5 below {7}.

RESULTS AND DISCUSSION

The temperature of the water in Emu-kingdom varied from 27.00^0 C to 29.10^0 C with an average of 28.06^0 C.

Conductivity value ranged from 73.83 NS/cm to 174.00 NS/cm with an average value of 123.90 NS/cm in the water. Conductivity usually indicates the presence of unstable ions. The groundwater has high conductivity and the values indicate that the borehole water is in contact with more inorganic constituents.

The pH value ranged from 4.25 to 5.89 with an average of 5.07. This result revealed that groundwater in the study area is acidic. The acidity is probably due to the presence of organic matter in the soils. Hence free CO_2 from the atmosphere can be allowed to enter the groundwater system as rain water percolates underground and reduces the pH of the water.

The cations determined in this study include Fe^{2+}, Na^+, Mg^{2+}. The values of Iron and Sodium in the water are in the range of 0.24 to 6.89 and 6.87 to 12.50 mg/L, respectively. The value of Iron is above the standard value for drinking water and sodium value is below the standard value as stated in {22, 23 and 6} for drinking water. The average concentration of magnesium in the water is 0.69 mg/L. This average, even the minimum value (0.13 mg/L) or the maximum value (21.25 mg/L) are too low to make the water not suitable for domestic or agricultural use but for industrial use. Treatments for any of the parameters depend on the industrial process in view.

Total Hardness ranges from 0.79 to 2.20 mg/L in concentration indicating that the water is soft when compared with the WHO standard for drinking water. This shows that the water is suitable for domestic use. This water will form lather easily with soap.

All the water in the area is tasteless and odorless. The color indices ranged from 54.00 to 75.00 Hazen units. The value correlates well with the Turbidity value of 0.12 – 0.84 FTU. This is shown by the turbid and brownish appearance of the water. The water are more turbid in the rainy season than in the dry season at which time, they appear to be relatively clear

Total Dissolved Solids (TDS) range in value from 38.20 to 76.92 mg/L with an average value of 62.85mg/L. This is far below the stipulated value of 500 mg/L {22, 23 and 6} for drinking water hence the water is not harmful in view of this parameter. This water is suitable for irrigation.

Biochemical oxygen demand (BOD) is one of the most valuable measures of the quality status of any water. {5}, a measure of organic matter in the water determined by the oxygen consumed by the micro-organisms in their metabolic decomposition of their substrate dissolved organics. The values obtained were 0.05 to 1.13 mg/L and when compared with {6} it is less than the doubtful value of 5 mg/L. In view of this parameter, the water is good.

The anions determined in this study include Cl^-, SO_4^{2-}, NO^{3-}, PO_4^3. The Chloride value ranges from 4.28 mg/L to 12.60 mg/L. These values are below the 250 mg/L stipulated standard for drinking water. The sulphate value ranges from 0.38 to 1.50 mg/L, these values are much lower than 400m g/L which is the stipulated value by W.H.O for drinking water. The level of phosphate ranges from 0.04 to 0.30 mg/L with an average value of 0.21 mg/L. the minimum value of nitrate is 0.10 mg/L while the maximum value is 2.02 mg/L.

Table 2: Hydrochemical Data of the Surface and Groundwater in Emu – Kingdom.

Wells & borehole no.	Temp. ◦C	Conductivity N/cm	pH	Total Iron (Fe)	Total Hardness	Color unit	Turbidity	TDS	Nitrate	Phosphate	Sulfate	COD
UMUODIO EMU-UNO	28.60±0.00	77.40±0.002	5.74±0.002	2.10±0.002	2.20±0.001	65.00±0.002	0.12±0.003	38.20±0.001	1.89±0.004	0.04±0.001	1.48±0.002	2.35±0.001
IKOSA EMU-UNO	28.71±0.002	165.00±0.003	5.74±0.002	6.40±0.003	1.10±0.002	54.00±0.001	0.25±0.001	67.10±0.002	0.16±0.001	0.25±0.001	0.52±0.003	2.17±0.002
OBIOGO BY THE MARKET	27.90±0.0001	160.00±0.001	5.10±0.001	6.35±0.001	1.07±0.004	59.00±0.001	0.20±0.001	65.10±0.001	0.20±0.002	0.30±0.003	0.38±0.002	2.20±0.001
OBIOGO TOWNHALL	27.50±0.006	74.35±0.004	5.89±0.001	6.35±0.002	2.15±0.003	65.00±0.002	0.15±0.004	39.17±0.004	1.99±0.001	0.05±0.002	1.45±0.001	2.40±0.002
EMU OBODOETI	28.00±0.004	160.00±0.002	5.48±0.001	6.51±0.001	1.12±0.002	59.00±0.001	0.77±0.002	65.15±0.005	0.30±0.003	0.22±0.001	0.51±0.002	2.21±0.001
EMU IYASELE	26.87±0.001	174.00±0.001	4.76±0.003	6.89±0.002	0.80±0.001	73.00±0.005	0.32±0.002	76.87±0.003	0.10±0.001	0.25±0.002	0.45±0.002	2.16±0.001
OGBE EZE-EMU EBENDO	26.89±0.002	172.00±0.002	4.25±0.002	6.78±0.003	0.79±0.002	70.00±0.002	0.35±0.002	76.72±0.002	0.12±0.001	0.29±0.002	0.38±0.001	2.12±0.002
ODO-OPO EBENDO	27.10±0.003	170.15±0.004	4.39±0.002	6.62±0.001	0.39±0.002	73.00±0.001	0.33±0.001	76.67±0.001	0.10±0.002	0.27±0.003	0.48±0.003	2.13±0.004
OLILEI AVEN, EBENDO	26.90±0.002	173.00±0.003	4.51±0.001	6.57±0.002	0.92±0.001	71.00±0.002	0.30±0.002	76.75±0.002	0.13±0.002	0.30±0.001	0.51±0.002	2.10±0.003
ETEVIE EMU-UNO	27.02±0,001	75.89±0.003	5.82±0.002	0.25±0.001	2.20±0.004	60.00±0.001	0.84±0.003	42.11±0.003	2.02±0.003	0.06±0.002	1.50±0.001	2.38±0.002
HEALTH CARE OBODOETI	29.00±0.003	170.00±0.002	5.10±0.003	6.28±0.003	1.10±0.002	58.00±0.003	0.22±0.002	69.70±0.004	0.25±0.001	0.29±0.002	0.40±0.002	2.18±0.001
DADP OBODOETI	29.10±0.001	163.00±0.003	5.22±0.001	6.32±0.001	1.08±0.003	57.00±0.002	0.24±0.001	66.18±0.004	0.22±0.001	0.27±0.003	0.42±0.001	2.16±0.003
SOLAR POWERED IYASELE	28.00±0.001	73.83±0.003	5.87±0.002	0.24±0.003	2.10±0.005	55.00±0.002	0.25±0.001	40.21±0.003	1.00±0.001	0.04±0.001	1.50±0.002	2.37±0.003
ECHEMPE HOUE EBENDO	27.80±0.002	170.00±0.005	4.65±0.004	6.77±0.004	0.87±0.005	75.00±0.003	0.35±0.002	76.92±0.002	0.12±0.002	0.27±0.002	0.50±0.003	2.13±0.002
Average Value	28.00±0.005	141.60±0.005	5.14±0.004	5.00±0.007	1.32±0.001	64.57±0.001	0.34±0.005	62.85±0.008	0.61±0.001	0.21±0.007	0.75±0.007	2.22±0.007
WHO	NS	NS	6.5- 8.5	0.3	500	-	5	500	-	NS	400	-

Hence the value of the parameters indicates that the water is not injurious .It should be observed that from Tables 2 and 3, the concentration levels of the parameters vary significantly form boreholes to boreholes and form well to well. This is because the boreholes and wells are produced from various depths in the aquifer and may be affected by local geochemical processes.

The contrast of the result obtained with the WHO standard shown in Table 4 revealed that the water sample in the study area contains higher concentrations of iron than the WHO recommended upper limit of 0.3 mg/L. This indicates that iron bearing minerals are common in the study area. The well waters and borehole water in the area require treatment to reduce the level of iron content in them. Exposure of the samples to air could cause ferrous Fe^{2+} ion in them to oxidize to ferric Fe^{3+} ion which would precipitate a rust colored ferric-hydroxide which stains plumbing fixtures, laundry and cooking utensils.

Table 3: Hydrochemical Data of the Surface and Groundwater in Emu – Kingdom.

Wells & borehole no.	Dissolved oxygen	Total Alkalinity	Sodium	Lead	Chromium	BOD	Chloride	Magnesium	Manganese	Copper
UMUODIO EMU-UNO	5.14±0.005	6.10±0.003	12.20±0.004	0.01±0.001	0.05±0.001	0.05±0.002	6.10±0.008	1.12±0.002	0.16±0.001	0.01±0,01
IKOSA EMU-UNO	5.05±0.002	13.50±0.001	6.87±0.005	0.01±0.001	0.01±0.001	1.08±0.001	12.50±0.001	0.13±0.001	0.05±0.007	0.02±0.001
OBIOGO BY THE MARKET	5.08±0.003	11.80±0.002	7.54±0.002	0.12±0.002	0.15±0.001	1.10±0.004	12.20±0.001	0.15±0.02	0.02±0.03	0.02±0.002
OBIOGO TOWNHALL	5.13±0.004	6.14±0.004	12.50±0.002	0.02±0.002	0.15±0.001	0.06±0.03	6.12±0.002	1.23±0.001	0.13±0.005	0.01±0.01
EMU OBODOETI	5.07±0.001	12.30±0.003	7.85±0.001	0.01±0.001	0.13±0.001	1.10±0.002	13.00±0.003	0.19±0.002	0.06±0.001	0.01±0.002
EMU IYASELE	4.05±0.002	13.20±0.001	7.88±0.003	0.0±20.001	0.04±0.001	1.10±0.002	4.49±0.002	0.18±0.002	0.03±0.002	0.02±0.002
OGBE EZE-EMU EBENDO	4.03±0.002	13.40±0.004	7.86±0.002	0.01±0.001	0.05±0.002	1.12±0.003	4.52±0.001	0.22±0.003	0.02±0.002	0.02±0.001
ODO-OPO EBENDO	4.05±0.003	13.20±0.002	7.59±0.002	0.01±0.002	0.03±0.001	1.10±0.002	4.60±0.002	0.18±0.001	0.02±0.003	0.01±0.001
OLILEI AVEN, EBENDO	4.03±0.001	13.40±0.001	8.00±0.003	0.01±0.001	0.05±0.001	1.16±0.001	4.35±0.002	0.20±0.001	0.05±0.001	0.01±0.001
ETEVIE EMU-UNO	5.12±0.002	6.15±0.004	12.50±0.002	0.01±0.002	0.04±0.001	0.06±0.003	6.13±0.002	1.10±0.001	0.13±0.002	0.02±0.001
HEALTH CARE OBODOETI	5.07±0.001	12.30±0.001	7.53±0.003	0.02±0.001	0.11±0.001	1.13±0.002	12.60±0.003	0.11±0.001	0.01±0.002	0.01±0.001
DADP OBODOETI	5.06±0.001	13.70±0.002	6.93±0.001	0.02±0.002	0.10±0.002	1.09±0.001	12.30±0.001	0.15±0.004	0.05±0.001	0.03±0.002
SOLAR POWERED IYASELE	5.16±0.003	5.80±0.003	12.47±0.004	0.02±0.001	0.07±0.002	0.05±0.001	6.17±0.001	1.25±0.002	0.05±0.001	0.01±0.001
ECHEMPE HOUE EBENDO	4.02±0.002	13.30±0.001	7.74±0.003	0.02±0.001	0.04±0.001	1.12±0.002	4.28±0.002	0.25±0.001	0.05±0.001	0.05±0.001
Average Value	4.71±0.008	11.02±0.001	9.00±0.001	0.02±0.001	0.07±0.001	0.81±0.002	7.81±0.001	0.46±0.001	0.07±0.007	0.020.007
WHO	-	-	200	0.05	-	-	200	150	-	

Table 4: Ranges in value of Chemical Parameters in Study Area and WHO Standard for Drinking Water {22, 23 and 6}.

PARAMETER	RANGE (in study area)	WHO Guidelines
Temperature ^{o}C	27.00 - 29.10	NS
Conductivity (Ns/cm)	73.83 – 174.00	NS
P^{H}	4.25 – 5.89	6.5-8.5
Total iron	0.24 – 6.89	0.3
Total Hardness (mg/L)	0.79 – 2.20	100
TDS	38.20 – 76.92	500
NO^{3-} (mg/L)	0.10 – 2.02	-
CL^{-} (mg/L)	4.28 – 12.60	250
Mg^{2+}(mg/L)	0.13 – 1.25	150
SO_4^{2-} (mg/L)	0.38 – 1.50	400
Phosphate(mg/L)	0.04 – 0.30	NS
Pb(mg/L)	0.00 – 0.02	0.05
Cu^{4+} (mg/L)	0.01 – 0.05	1.0
Turbidity (Tu)	0,12 – 0.84	5
Colour Unit (HN)	54.00 – 75.00	-
Sodium	6.87 – 12.50	200

NS means Not Stated.

Table 5: Classification of Water based on Hardness {Freeze and Cherry, 1977}.

HARDNESS RANGE	DESCRIPTION
0 - 60	Soft
61 - 120	Moderately hard
121 - 180	Hard
More than 180	Very hard

Apart from the acidic condition and the high iron content, none of the parameters studied exceeded the stipulated standards showing that the water is potable if treated for high iron concentration and acidity.

SUMMARY

Water samples collected from existing wells and boreholes in Emu - kingdom were analyzed and the water is found to be acidic, soft, low in dissolved constituent and has high iron content

when compared with the World Health Organization Standard for drinking water.

CONCLUSION

The results revealed that water within Emu - Kingdom is not only soft and low in dissolved constituents but acidic and has high iron content.

RECOMMENDATION

It is recommended that polyvinyl chloride (PVC) pipes and several tanks should be used for borehole and reservoir respectively. Furthermore, it is recommend that the water should be exposed to the atmosphere for oxidation to take place as shown in Figure 2.

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Figure 2: Water Treatment Plant for Domestic Purposes.

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SUGGESTED CITATION

Oseji, J.O. 2012. “Hydrochemical Analysis of Surface and Ground Waters of Emu-Kingdom in Ndokwa Land Area of Delta State, Nigeria”. *Pacific Journal of Science and Technology*. 13(1):673-682.

Pacific Journal of Science and Technology