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Assessment of Surface Water Quality in Parts of Northern Andoni Communities Rivers State

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Abstract: *The quality and suitability of surface water in parts of Andoni Local Government Area were assessed for potability and irrigation purposes by analyzing the water for physicochemical parameters, Heavy metals (Mg, Mn, Fe and Pb), microbial contents and irrigation indices using standard methods. The results obtained were compared with permissible limits for drinking water provided by World Health Organization, Standard Organization of Nigeria and National Agency for Food and Drugs Administration and Control. The results were 233.3mg/l Mg^{2+}, 0.041 – 0.213mg/l Fe^{+}, <0.001mg/l Pb, 0.022 – 0.73mg/l Mn^{2+}, 7.6 – 7.8 pH, 18400 – 22700µS/cm EC, 2.54 – 23.0NTU Turbidity, 11.0 – 13.8‰ Salinity, 22.2 – 30.2°C Temperature, 12880 – 15890mg/l TDS, 7.3 – 11.4mg/l DO, 0.4 – 6.1mg/l BOD, 262 – 369.6mg/l SO_4^{2-}, <0.05mg/l PO_4^{3-}, <0.05mg/l NO_3^-, <0.02mg/l NH_4^+, 5928 – 7657mg/l Cl^-, 1969 – 2874mg/l Hardness, 24.0 – 28.0mg/l Alkalinity, 383.3 – 766.5mg/l Ca^{2+}, <0.02 – 0.07mg/l THC, 6.544 –7.369mg/l Na^{2+}, 23.83 – 27.89mg/l HCO_3^-, 0.09 – 0.141mg/l CO_3^{2-}, 102.22 – 107.753mg/l K^+. The concentrations of EC, TDS, Total Hardness, Ca^{2+}, SO_4^{2-}, Cl^-, K^+ and Mg^{2+} exceeded permissible limits. Microbial contents of the water were high and therefore pose serious health concerns. The surface water was considered contaminated, highly mineralized and not potable but suitable for irrigation. Since the inhabitants use the surface water for domestic, drinking and aesthetic purposes regular monitoring was suggested to avoid serious pollution problems especially water borne diseases in the area.*

Keywords: *Surface water, Andoni, Heavy metals, irrigation indices, potable*

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I. Introduction

Water is considered absolutely essential to sustain life [1]. It is increasingly recognized that the provision of good quality water is central to any meaningful human development [2]. People can survive days, weeks or even longer without food, but only about few days without water. Water is one of the essential commodities of everyday life and is placed in position just after air.

Water is contaminated day by day due to different anthropogenic sources (human activities). These pollutions are mainly due to rising standard of living, expansion of agriculture and increase in population, which indicate the large demand of water for domestic purpose. The ill heath in the developing and under-developing countries is mainly due to lack of quality drinking water.[3].

Water naturally contains minerals and microorganisms from the rocks, soil and air with which it comes in contact. Human activities can add many more substances to water, but drinking water does not need to be pure to be safe. In fact, some dissolved minerals in water can be beneficial to health [3]. Majority of the population in developing countries are not adequately supplied with potable water and are thereby compelled to use water from sources like shallow wells, streams and boreholes that render the water unsafe for domestic and drinking purposes due to high possibilities of contamination [4, 5]. In 1997, World Health Organization (WHO) reported that forty percent (40%) of deaths in developing nations occur due to infections from water related diseases [6]. Diseases contacted through drinking water kill about 5 million children annually and make one – sixth of the world population [7] and an estimated 500 million cases of diarrhorea occur every year in children below 5 years in parts of Asia, African and Latin American [5]. The chemical compositions of groundwater are influenced by many factors which include precipitation, mineralogy of water shed, aquifer, climate and topography.

For decades, the people depend solely on surface waters for drinking, domestic and fishing activities. There has been recent out break of cholera, skin and other water-borne diseases in the Andoni area of Rivers State. This study therefore aims to assess the quality of water by determining the levels of heavy metals (Mg, Pb, Mn, Fe), physicochemical parameters, bacteriological content and the suitability of the water for irrigation.

The Bonn international conference on fresh water in 2001 revealed that half of the people in Africa suffer water related diseases [8].

Chemical parameters of drinking water quality give an indication of water acceptability for human consumption, which can be for domestic, agricultural and industrial use [9].

II. Materials And Methods

STUDY AREA

The study area is located in the Northern part of Andoni local government area of Rivers State. Andoni lies between latitude 4º 32′ 57″ N and longitude 7º 26′ 47″ E, with total land area of 233km^2 and a population of 211,009 million people [10]. Andoni is bounded by the Altantic Ocean in the South, the Ogoni in the North, Bonny in the West, and Akwa-Ibom State in the East. (Fig1).

It is characteristically bordered by vegetation comprising 98% Nipa palm and Red mangrove. The climate of the zone is basically that of tropical monsoon with rainfall occurring almost all through the year except the months of December, January and February, which are not completely free from rainfall in some years [11]. The zone experiences diurnal ebb and flow of the tides with maximum values obtained during the once a year spring tide [11].

SAMPLING SITE LOCATION

Surface water samples were collected from five stations. The identification and geographical positions of the stations are shown in Table 1. The water samples were properly labeled and taken to the laboratory in a cool box containing ice blocks.

Table 1: Geographical Location of the Sampling Stations.

Station No.	Station Name	Geographical Locations	
		East (long)	North (lat)
1	ASARAMA –IJA	007º 26′ 886″	04º 33º 229″
2	IWOMA	007 º 26′ 940″	04º 33′ 288″
3	INYONG-ORONG	007º 27′ 370″	04º 33′ 563″
4	ASARAMA TOWN	007º 27′ 044″	04º 31′ 834″
5	EBUKUMA	007º 27′ 902″	04º 30′ 890″

SAMPLE COLLECTION

The water samples from Asarama Rivers (Ebon-Okwan Asarama and Udong-Okwan Asarama) were collected into 1.5 litre plastic containers after recording the temperature using thermometer. Samples for total hydrocarbon (THC) were collected into THC bottles while samples for Heavy metals and microbiology were collected into sterile vials. The containers were rinsed thoroughly with the sample twice before collection.

ANALYTICAL METHODS

Physicochemical Parameters and Heavy Metals

Winkler solutions I and II were added to the water samples *insitu* for Dissolved oxygen (DO) and kept under laboratory condition at 30ºC. Conductivity and salinity were determined using Horiba water checker U-10. Turbidity was determined using Lamotte TC 3000wi Trimeter 1969 – ISO while Extech Dissolved Oxygen meter (Water proof series) DO 700 was used to determine pH and Total Dissolved solids (TDS).

The chemical analysis was done using standard laboratory methods suggested by the American Public Health Association [12]. Nitrate was determined using the Brucine method, Sulphate was determined by the Turbidimetric method, Phosphate was determined using the stannous chloride method, Chloride was determined by the Argentometric methods, Total Alkalinity was determined by Acid-Base Titration method, Dissolved Oxygen and BOD_5 were determined by the modified Azide or Winkler method, Calcium was determined by the EDTA Titration method and Ammonia was determined by the phenate method. Heavy metals (Fe, Pb, Mg, and Mn) were analyzed using Atomic Absorption Spectrophotometer (AAS) by GBC Avanta Version 2.02.

MICROBIOLOGICAL ANALYSIS

Heterotrophic plate count was performed using the pour plate method. Serial ten-fold dilutions of the samples were prepared using sterile normal saline as diluents. Nine milliliters of normal saline was dispensed into each tube and sterilized using autoclave. After cooling, one milliliter of the water sample was transferred with the aid of a sterile pipette into nine milliliters normal saline to obtain 10^{-1} dilution. This was well mixed manually using the same sterile pipette; 1ml of the mixture (10^{-1} dilution) was transferred into the second tube (10^{-2} dilution). The same procedure was repeated until 10^{-7} dilution was prepared.

An aliquot (0.1) of the suitable dilution 10^{-4} to 10^{-7} was aseptically transferred into sterile petri dish and cooled sterile nutrient agar was added. The mixture was allowed to solidify and then incubated at 37ºC for 48h. Bacterial colonies on each plate was counted and multiplied by the reciprocal of the appropriate dilution.

IRRIGATION INDICES

(a) Sodium Adsorption Ratio (SAR) was calculated by the equation given below [13].

$$SAR = \left[Na^{+}\right] / \left\{ \left(\left[Ca^{2+}\right] + \left[Mg^{2+}\right] \right) / 2 \right\}^{\frac{1}{2}}$$

Where, all the ions are expressed in meq/L.

(b) Soluble sodium percentage (SSP) was calculated by the equation of [14].

$$SSP = \left[Na^{+} / \left(Ca^{2+} + Mg^{2+} Na^{+}\right)\right] \times 100$$

Where, all the concentration of Ca^{2+}, Mg^{2+}, and Na^{+} are expressed in meq/L.

(c) The Residual Sodium Bicarbonate (RSBC) was calculated according to Gupta and [15].

$$RSBC = HCO_3^{-} - Ca^{2+}$$

Where, all RSBC and the concentration of the constituents are expressed in meq/L.

(d) The Permeability Index (PI) was calculated according to the equation given by [16].

$$PI = \frac{\left(Na^{+} + \sqrt{HCO_3^{-}}\right) \times 100}{Ca^{2+} + Mg^{2+} + Na^{+}}$$

Where, all the ions are expressed in meq/L.

(e) Magnesium Adsorption Ratio (MAR) was calculated by the equation given by [17].

$$MAR = \frac{Mg^{2+} \times 100}{Ca^{2+} + Mg^{2+}}$$

Where, all the ionic concentrations are expressed in meq/L.

(f) The Kelly's Ratio was calculated using the equation by [18].

$$KR = Na^{+} / Ca^{2+} + Mg^{2+}$$

Where, all the ionic concentrations are expressed in meq/L.

III. Results And Discussions

The results of the parameters measured in the area are presented in Table 2 and Figs. 2a-h. Correlation matrixes showing the relationship between the parameters are presented in Tables 3 and 4.

pH

The pH of surface water from the study areas ranged from 7.6 at Iwoma and Asarama to 7.8 at Inyong-Orong and Ebukuka with a mean value of 7.7±0.1. This shows that the surface water of the study area is alkaline in nature and all the samples are within the guideline range recommended by [4, 19, 20] guidelines (Table 3).

pH is an important parameter for determining the quality of drinking water. It indicates the balance between the acids and bases in water and is a measure of the hydrogen ion concentration in solution. As an index of hydrogen ion concentration, a value of 7 indicate a neutral condition; values less than 7 indicate acid condition and values greater than 7 indicates alkaline conditions in water. Surface water generally tends to be alkaline, whereas groundwater tends to be acidic. [21].

The correlation matrix for the surface water showed high significant but negative correlation between pH and DO (r = - 0.8474), BOD (r = - 0.6372), K^{+} (r = - 0.8828), Na (r = - 0.9889) and very high significant correlation between pH and CO_3^{2-} (r = 0.9510).

Table 2: Levels of Physico-chemical Parameters in Surface Water Samples from the Study Area

Stations	pH	EC µS/cm	Tub NTU	Sal ‰	Temp °C	TDS mg/l	DO mg/l	BOD mg/l	SO_4^{2-} mg/l	PO_4^{3-} mg/l	NO_3^- mg/l	NH_4^+ mg/l	Cl^- mg/l	TH mg/l	∑Alk mg/l	Ca^{2+} mg/l
ASARAMA-IJA	7.7	18400	17.1	11	22.2	12880	7.3	0.8	285.2	<0.05	<0.05	<0.02	6669	1916	28	383.3
IWOMA	7.6	18600	9.12	11.1	34.4	13020	10.4	4.1	262	<0.05	<0.05	<0.02	5928	2874	28	766.5
INYONG-ORONG	7.8	18500	23.0	11	30.2	12950	7.3	3.7	282	<0.05	<0.05	<0.02	5928	1916	24	383.3
ASARAMA	7.6	9000	4.31	11.3	29.3	13300	11.4	6.1	302	<0.05	<0.05	<0.02	6175	1916	24	383.3
EBUKUMA	7.8	22700	2.54	13.8	30.0	15890	8.1	0.4	369.6	<0.05	<0.05	<0.02	7657	2874	24	766.5
MINIMUM	7.6	18400	2.54	11	22.2	12880	7.3	0.4	262	<0.05	<0.05	<0.02	5928	1916	24	383.3
MAXIMUM	7.8	22700	23.0	13.8	30.2	15890	11.4	6.1	369.6	<0.05	<0.05	<0.02	7657	2874	28	766.5
AVERAGE	7.7	19440	11.21	11.64	29.22	13608	8.9	3.02	300.2	<0.05	<0.05	<0.02	6471.4	2299.2	25.6	536.6
WHO	6.5-8.5	1200	5.0	-	-	1000	-	-	500	-	50	-	250	500	100	-
SON	6.5-8.5	100	5.0	-	-	500	-	-	100	-	10	-	100	100	100	75
NAFDAC	6.5-8.5	100	5.0	-	-	500	-	-	100	-	10	-	100	100	100	75

Stations	Mg^{2+} mg/l	THC mg/l	Mn^{2+} mg/l	Fe^+ mg/l	Na^+ mg/l	HCO_3^- mg/l	CO_3^{2-} mg/l	K^+ mg/l	Pb^{2+} mg/l
ASARAMA-IJA	233.3	<0.02	0.030	0.213	7.087	27.83	0.131	106.602	<0.001
IWOMA	233.3	0.07	0.071	0.178	7.369	27.89	0.104	107.753	<0.001
INYONG-ORONG	233.3	0.04	0.047	0.133	6.544	23.89	0.142	102.222	<0.001
ASARAMA	233.3	<0.02	0.073	0.124	7.353	23.88	0.09	107.304	<0.001
EBUKUMA	233.3	<0.02	0.022	0.041	6.619	23.83	0.141	104.862	<0.001
MINIMUM	233.3	<0.02	0.73	0.041	6.544	23.83	0.09	102.22	<0.001
MAXIMUM	233.3	0.07	0.22	0.213	7.369	27.89	0.141	107.753	<0.001
AVERAGE	233.3	0.09	0.049	0.138	6.994	25.46	0.122	105.75	<0.001
WHO	20	-	0.4	0.3	200	100	-	-	0.01
SON	0.20	-	0.05	0.3	200	-	-	10.0	0.01
NAFDAC	20	-	2	0.3	-	-	-	10.0	0.01

Table 3: Bacteriological Content of Surface Water

Stations	THB (cfu/ml)	TCB (MPN/100ml)	FCB (MPN/100ml)
ASARAMA-IJA	$5.0x10^3$	ND	ND
IWOMA	$4.1x10^3$	11	ND
INYONG-ORONG	$11.0x10^3$	11	ND
ASARAMA	$10.0x10^3$	7	ND
EBUKUMA	$2.9x10^2$	4	ND
MINIMUM	$2.9x10^2$	4	-
MAXIMUM	$11.0x10^3$	11	-
AVERAGE	$6.078x10^3$	6.6	-
WHO	<1000	0-10	0

ND: Not Detected

ELECTRICAL CONDUCTIVITY (EC)

Electrical conductivity is the ability of an object to conduct electric current. It gives the total concentration of the electrolytes; it depends upon the presence of various ionic species. The electrical conductivity of the surface water ranged from 18400µS/cm at Asarama-ija to 22700µS/cm at Ebukuma with a mean of 19440±1836.5 µS/cm. These indicate high content of mineral salts in the water. Electrical conductivity increase with increase in chloride, Hardness, calcium, magnesium and total dissolved solids. Correlation matrix shows high significant correlation in surface water EC with salinity (r = 0.9995), TDS (r = 1), Ca^{2+} (r = 0.6014),

SO_4^{2-} (r = 0.9557), Cl^- (r = 0.8888), hardness (r = 0.6014) and negative correlation with turbidity (r = - 0.6385), Fe (r = - 0.8743), SAR (r = - 0.7171), KR (r = - 0.7074), SSP (r = - 0.6011), MAR (r = - 0.6006), PI (r = - 0.6970) and RSBC (r = - 0.6037).

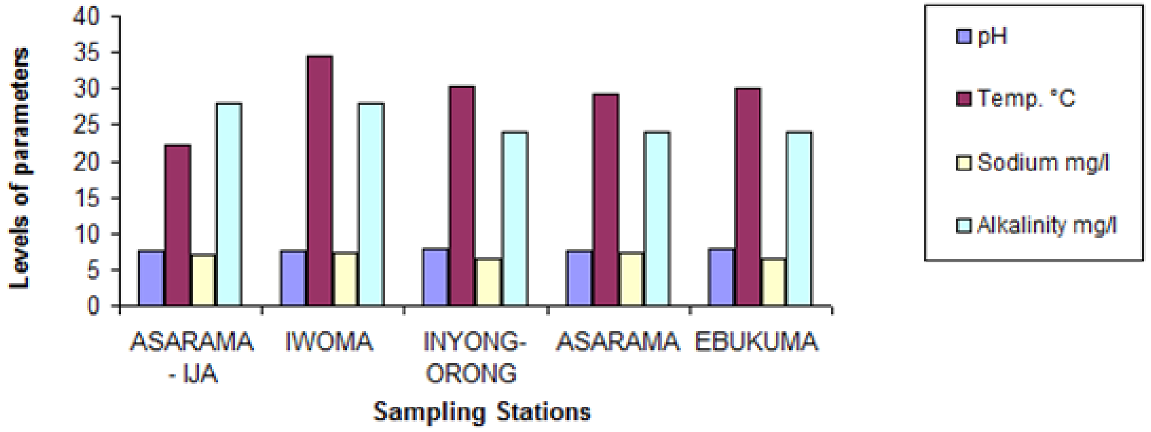

FIG. 2a Variations in levels of parameters in Surfacewater

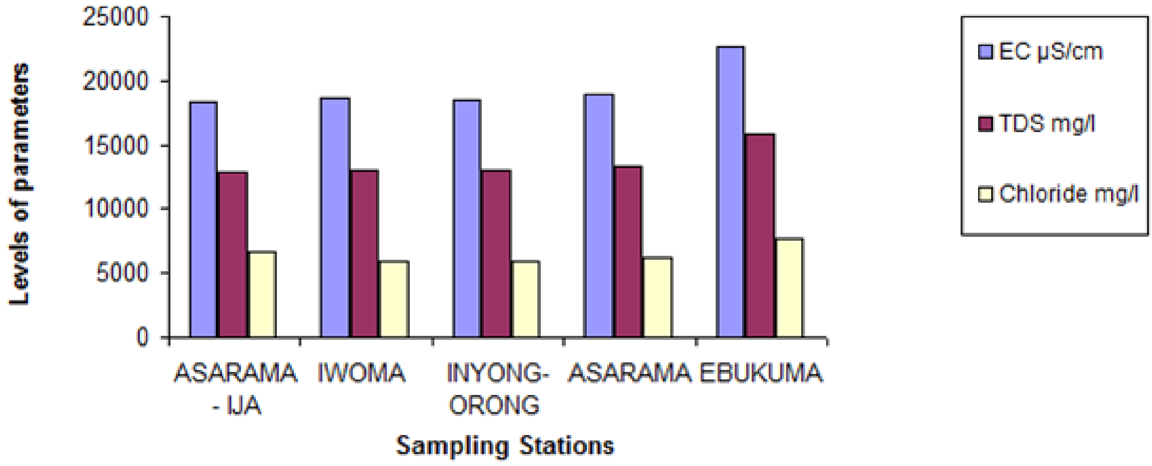

FIG. 2b Variations in levels of parameters in Surfacewater

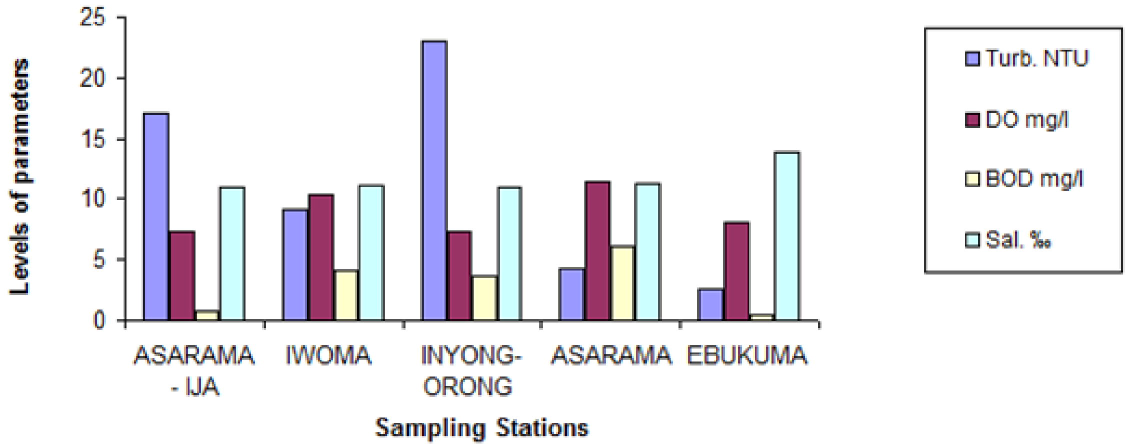

FIG. 2c Variations in levels of parameters in Surfacewater

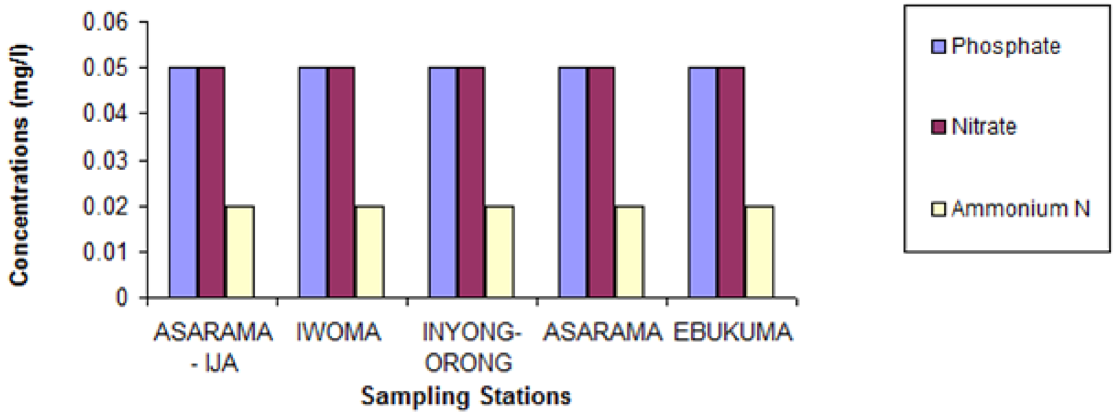

FIG. 2d Variaqtions in concentrations of Posphate, Nitrate and Ammonium N in Surfacewater

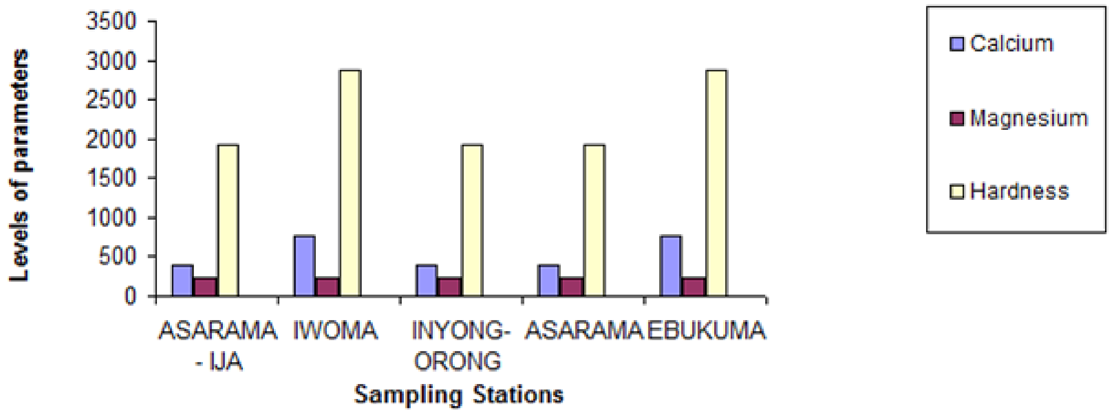

FIG. 2e Variations in levels of Calcium, Magnesium and Hardness in Surfacewater

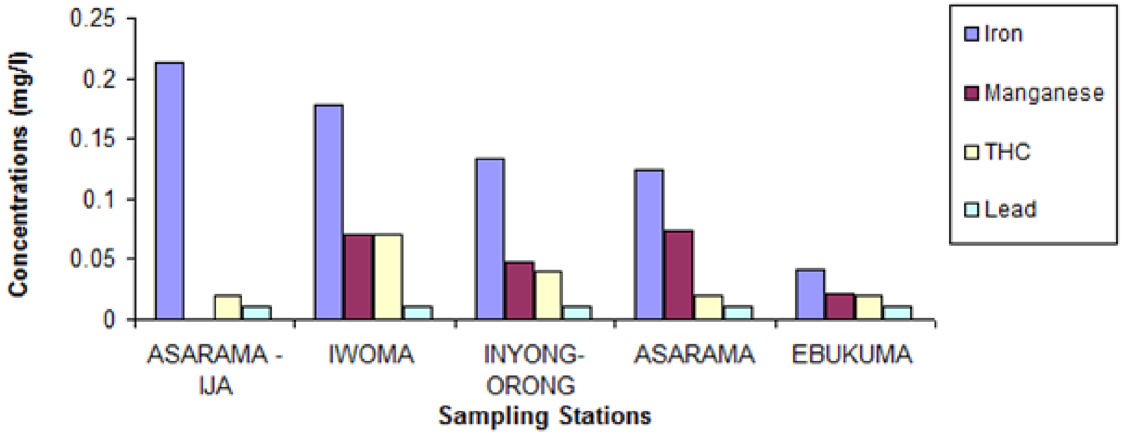

FIG. 2f Variations in concentrations of Iron, Manganese, THC and Lead in Surfacewater

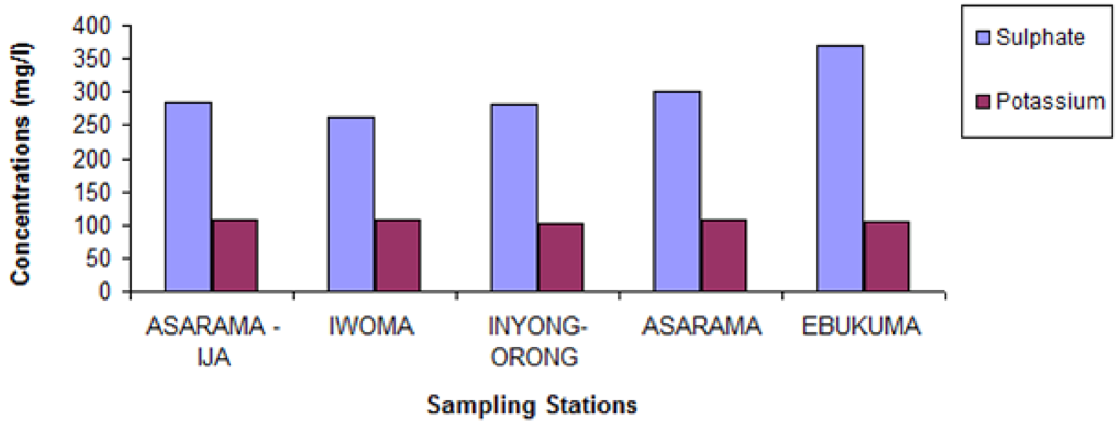

FIG. 2g Variations in concentrations of Sulphate and Potassium in Surfacewater

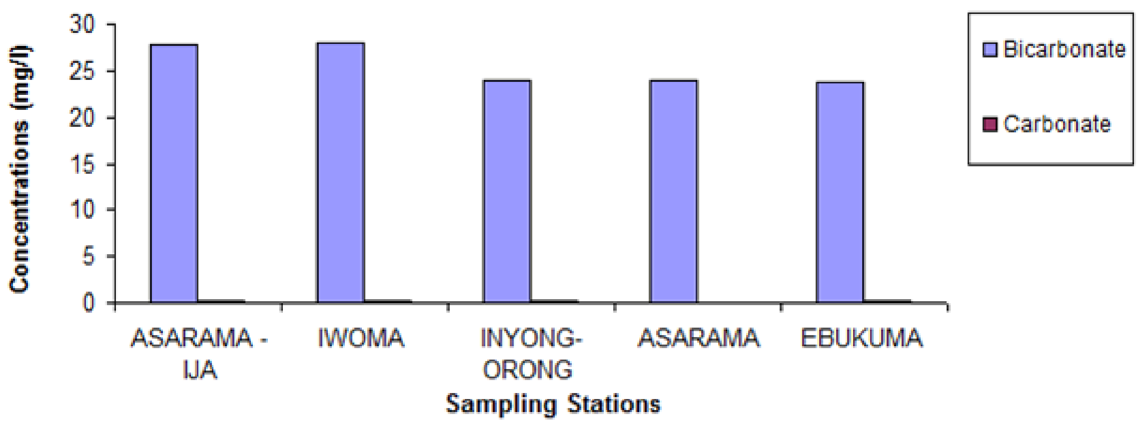

FIG.2h Variations in concentrations of Bicarbonate and Carbonate in Surfacewater

TEMPERATURE

The temperature of the surface water ranged between 22.2ºC at Asarama-ija and 30.2ºC at Inyong-Orong with a mean value of 29.2 ± 4.4°C. Public Drinking waters should be of a Temperature that is refreshing to the consumer. Physical, biological and chemical processes in the aquatic environment are affected by temperature; for example increasing water temperature decreases the solubility of oxygen in water while increasing the oxygen demand of fish [21].

The temperature of surface water is a function of latitude, elevation, seasons, time of day, rate of flow, depth, etc. Surface water temperature varies from 0ºC under ice cover to 40ºC in hot springs [21]. Surface water Temperature showed high significant correlation with Hardness (r = 0.6172), THC (r = 0.7213), Ca^{2+} (r = 0.6172), Mn (r = 0.7846), significant but negative correlation also exist between Temperature and SSP (r = - 0.9600), MAR (r = - 0.6238), PI (r = - 0.6567) and RSBC (r = - 0.6115).

SALINITY

The values of salinity in the surface water ranged from 11 to 13.8‰ with a mean of 11.64 ± 1.21‰. The EC of water is a useful and easy indicator of its salinity. In this study, it was discovered that the EC of the surface water were quite high, which could be due to some soluble minerals from the bedrocks in agreement with the report of [23]. The salinity values are less than 1000mg/L set by the World Health Organization [24]. This implies that the water salinity is within limit.

TURBIDITY

Turbidity was high in the surface water at stations 1 (17.1 NTU), 2 (9.12 NTU) and highest at station 3 (23.0 NTU) with a mean value of 11.214±8.672 NTU while the level at stations 4 and 5 are within the limit. The high turbidity at stations 1, 2 and 3 could be as a result of erosion and runoff, although humans could also contribute to such effects. High turbidity adversely affects domestic, industrial and recreational uses of water. Turbidity is a measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms in water which are usually held in suspension by turbulent flow and Brownian movement [21].

Turbidity did not show correlation with other parameters. Correlation matrix showed high but negative significant correlation exist between Turbidity and salinity (r = - 0.6310), TDS (r = - 0.6385) and DO (r = - 6372).

TOTAL DISSOLVED SOLIDS (TDS)

Total Dissolved solids (TDS) are index of the amount of dissolved substances in the water [21]. In natural water dissolved solids are composed of carbonates, bicarbonates, chlorides, sodium, sulphate magnesium and phosphate. Concentrations of dissolved solids are important parameter in drinking water. The total dissolved solids (TDS) indicate the general nature of salinity of water [25]. The Surface water TDS ranged between 12880mg/l at Asarama-ija and 15890mg/l at Ebukuma with a mean value of 13608±1285.6mg/l. These values exceeded the permissible limit prescribed by WHO, SON and NAFDAC. The high TDS levels in the surface water could be attributed to municipal and industrial effluents, agricultural runoff, and aerosol fallout. Fishing activities in the communities and runoffs from surrounding swamps could have also contributed to the high TDS values in the area.

TDS showed very high significant correlation with SO_4^{2-} (r = 0.9557), Cl^- (r = 0.8888), Hardness (r = 0.6014) and Calcium (r = 0.6014) and high significant but negative correlation with Fe (r = - 0.8744), SAR (r = - 0.7171), KR (r = - 0.7074), SSP (r = - 0.6011), MAR (r = - 0.6006), PI (r = - 0.6970) and RSBC (r = - 0.6037) in surface water.

DISSOLVED OXYGEN (DO)

The DO in the surface water varied from 7.3mg/l at Asarama-ija and Inyong-Orong to 11.4mg/l at Asarama with mean value of 8.9±1.8mg/l. Oxygen is one of the gases that are found dissolved in natural surface water. The amount of dissolved oxygen in natural water varies since it is dependent upon temperature, salinity, turbulence (mixing) of the water and atmospheric pressure (decreasing with altitude). Dissolved oxygen concentrations produce no adverse physiological effect on man; however, adequate amounts of dissolved oxygen must be available for fish and other aquatic organisms [21].

Many aerobic organisms cannot survive below certain levels of dissolved oxygen. Drinking water criteria do not specify any guidelines for dissolved oxygen. However, waters saturated with dissolved oxygen are preferable for drinking as improved palatability results from dissolved oxygen's ability to precipitate substances such as iron and manganese, which produce undesirable tastes [21]. The surface water DO showed high significant correlation with DO and BOD (r = 0.7679), Mn (r = 0.8226), Na (r = 0.7832), K^+ (r = 0.6968) and high significant but negative with CO_3^{2-} (r = - 0.9542).

BIOCHEMICAL OXYGEN DEMAND (BOD)

The BOD value at station 5 was 0.4mg/l and 6.1mg/l at station 4 with a mean value of 3.02±2.39. Water with high BOD values may be unsuitable for irrigation purposes, since they may restrict plant growth. The biochemical oxygen demand of water is the amount of oxygen required to oxidize the organic matter by aerobic microbial decomposition to a stable inorganic form [21]. No specific guidelines for BOD have been proposed by [4, 19, 20] but values in literature show that water with BOD levels less than 4mg/l are deemed reasonably clean, waters with levels greater than 10mg/l are considered polluted since they contain large amounts of degradable organic materials [21]. This implies that the surface water in the study area does not contain large amount of organic matter and are relatively unpolluted. Correlation matrix shows no high significant correlation between BOD and other parameters in surface water.

SULPHATE (SO_4^{2-})

Sulphate is the stable, highly oxidized form of sulphur. It can be produced by bacterial oxidation of reduced sulphur compounds, including metallic sulphides and organo-sulphur compounds; the sulphate ion is readily soluble in water [21]. The concentrations of sulphate (100mg/l) with a mean value of 300.16±41.33mg/l in the study area were below the permissible limit recommended by WHO (500mg/l). Sulphate showed high significant correlation between sulphate and Cl^- (r = 0.9084) and high significant but negative correlation with Fe (r = - 0.8682).

PHOSPHATE (PO_4^{3-})

Generally, the permissible limit found in literature ranged between 0.05 and 1.0mg/l [26]. In this study phosphate level was <0.05 in all the samples. This indicates the acceptability of the water for drinking with respect to phosphate. Phosphate did not correlate with other parameters.

NITRATE (NO_3^-)

Nitrate is the principal form of combined nitrogen found in natural waters. The highly soluble nitrate ion, which is the most stable form of combined nitrogen in surface water, results from the complete oxidation of nitrogen compounds. The consumption of waters with high nitrate concentrations decreases the oxygen-carrying capacity of the blood [21, 22]. The concentration of nitrate in the study area was less than 0.05mg/l, indicating that it does not pose serious health concern. Nitrate in surface water showed no correlation with other parameters in this study.

AMMONIUM - NITROGEN

Ammonia is the most reduced inorganic form of nitrogen in water and it is a non-persistent, non-cumulative toxic substance and its typical low concentrations in water present non physiological detriment to man or livestock. Ammonia-nitrogen in drinking water should not exceed 0.5mg/l [27]. Fish cannot tolerate large quantities of ammonia since it reduces the oxygen-carrying capacity of the blood and thus the fish may suffocate. In all the stations the concentrations of ammonia was <0.02mg/l. This indicates that the water is not polluted with respect to Ammonia. Correlation matrix shows no correlation between ammonia and other parameters in this study.

CHLORIDE (Cl^-)

Chloride ions are generally present in natural waters and its presence can be attributed to dissolution of salts. The concentration of chloride in the surface water ranged between 5928mg/l at Iwoma and Asarama and 7657mg/l at Ebukuma with a mean value of 6471.4±728.5mg/l, which exceeded the 250mg/l guideline set by WHO and 100mg/l by NAFDAC and SON. The high chloride value in surface water samples could be due to the weathering and leaching of sedimentary rocks and soils and dissolved salts [21]. Chloride contamination can originate from sewage and industrial effluents and saline intrusion [28]. High significant but negative correlation exist between Cl^- and Mg^{2+} (r = - 0.6484) and Fe^{2+} (r = - 0.6082) in the surface water.

TOTAL HARDNESS (TH)

Total Hardness in surface water at the study area were high and varied from 1916mg/l at Asarama-ija to 2874mg/l at Iwoma with a mean of 2299.2±524.7mg/l and is attributed to high presence of calcium, magnesium, carbonate, and hydrogen-carbonate in the water. Hard water results in the formation of scale on boilers and pipes and it adversely affects textiles, plating, and canning industries and also results in increased soap consumption, which affects both domestic and industrial cleaning and laundering activities [21]. Total Hardness show very high significant correlation with Ca^{2+} (r = 1) and high significant but negative with SAR (r = - 0.8989), KR (r = - 0.9444), SSP (r = - 0.8402), MAR (r = - 0.9998), PI (r = - 0.9797) and RSBC (r = - 0.9999).

ALKALINITY

Alkalinity is a measure of the capacity of water to neutralize strong acid. It indicates the presence of carbonates, bicarbonates, and hydroxides, and less significantly, borates, silicates, phosphates, and organic substances. It is expressed as an equivalent of calcium carbonate ($CaCO_3$). The species composition of alkalinity is affected by pH, mineral composition, temperature, and ionic strength; however, alkalinity is normally interpreted as a function of carbonates, bicarbonate, and hydroxides [21]. Total Alkalinity in the study area was low, with mean value of 25.6±2.1. This is much below the standard value of 100mg/l set by [4]. When water with high alkalinity is boiled over an extended time period, either a deposit may be formed or an unpleasant taste is created depending upon the chemical reaction. However, total alkalinity in this study is low and can corrode pipes and plumping. Alkalinity showed high significant correlation with Fe (r = 0.8114) and HCO_3^- (r = 0.9988) in surface water.

CALCIUM (Ca^{2+})

The concentrations of calcium in surface water showed high concentration range from 383.3mg/l at stations 1, 3 and 4 to 766.5mg/l at station 5; with a mean value of 536.58±209.8mg/l. Although WHO has no standard for calcium, the concentration in surface water is above the permissible limit of 75mg/l by SON and NAFDAC. The main source of calcium in natural water is leaching of rocks in the catchments [29]. The values of calcium in surface water measured at all stations were higher than 75mg/l, which is an indication that the water is polluted with calcium. Calcium in surface water correlates significantly but negative with SAR (r = - 0.8989), KAR (r = - 0.9444), SSP (r = - 0.8402), MAR (r = - 0.9998), PI (r = - 0.9797) and RSBC (r = - 0.9999).

MAGNESIUM (Mg^{2+})

Magnesium, an alkaline-earth metal, is an abundant element and a common constituent of natural water. Natural sources clearly outweigh all cultural inputs of this constituent to the natural environment. Ferromagnesian minerals in igneous rock and dolomitic sedimentary rocks are the principal contributors of magnesium to water [21]. The magnesium values in surface water were very high (233.3mg/l) in all the stations which is ten times more than the permissible limit (20mg/l) of WHO and NAFDAC. The high concentration of magnesium indicates that the surface water in the study area is polluted. No correlation exists between Mg^{2+} and all other parameters in surface water.

MANGANESE (Mn^{2+})

The values of Manganese in the surface water ranged from 0.022mg/l at Ebukuma to 0.073mg/l at Asarama with a mean value of 0.042±0.031mg/l. However, the surface water from the study area are within the permissible limit of (0.4mg/l) by [4,] and (2.0mg/l) by [20]. This is an indication that the surface water is good. However, the surface water from Iwoma and Asarama exceeded the permissible limit of (0.05mg/l) by [19]. Manganese is an essential element for the nutrition of both humans and animals. A manganese deficiency may inhibit growth, disrupt the nervous system, and interfere with reproductive function. It is an essential element for plant metabolism [21]. Manganese in surface water showed high significant but negative correlation between CO_3^{2-} (r = 0.7345).

TOTAL IRON (Fe)

Iron concentrations in the surface water ranged between 0.041mg/l and 0.213mg/l with a mean of 0.13±0.06mg/l. The concentrations of Fe in the surface water were below NAFDAC, SON and WHO guidelines for Iron (0.3mg/l). In water, Iron can discolor cloths, plumbing fixtures, and cause scaling which encrusts pipes. Iron is highly objectionable for drinking water because of the stringent taste [27]. Iron showed high significant correlation with HCO_3^- (r = 0.8152) and SSP (r = 0.6678) in surface water.

POTASSIUM (K)

The concentrations of potassium in the surface water ranged between 102.222mg/l at Inyong-Orong and 107.755mg/l at Iwoma with a mean value of 105.748 ± 2.257mg/l which is higher than the value prescribed by [4]. The higher values recorded in the surface water indicate that the water is polluted with respect to potassium. Although potassium is an essential nutrient for plant and animal life, very high concentrations may be harmful to the human nervous and digestive systems. The correlation matrix showed high significant but negative correlation between K^+ and CO_3^{2-} (r = - 0.7836) in surface water.

LEAD (Pb)

Lead is the most significant toxin and if released into the environment can bio accumulate and enter the food chain. Lead has damaging effects on body nervous system. Lead is frequently used in the construction of water supply distribution systems like pipes, brass, and bronze fixtures. These contaminate drinking water as a result of the corrosion that takes place when water comes in contact with Fe [30]. The concentration of lead in this study was <0.001mg/l which is below the limit value of 0.01mg/l by WHO, NAFDAC and SON and therefore do not pose concern.

SODIUM (Na^+)

The concentration of sodium in this study was generally low with a mean of 6.99±0.39mg/l in surface water. These levels are below the limit (200mg/l) set by SON and WHO. Sodium, the principal alkali metal is found in an ionic form in all surface waters. Nearly all sodium compounds are readily soluble in water and tend to remain in aqueous solution. Sodium showed negative correlation with CO_3^{2-} (r = 0.9090) and significant correlation with K^+ (r = 0.9297) in surface water.

BICARBONATE (HCO_3^-)

The concentrations of bicarbonate in the study area are less than 100mg/l which is the standard set by [4]. Bicarbonate combines with calcium carbonate and sulphate to form heat retarding, pipe clogging scale in boilers and in other heat exchange equipment. It was observed that below pH of 6, especially all dissolved carbonate species are in the form of H_2CO_3 and above 7, the ratio of CO_3^{2-} and H_2CO_3 increase [31]. Therefore, the surface water in the study area can be regarded as free from bicarbonate pollution due to low presence of carbonate rocks and species in the area.

TOTAL HYDROCARBON (THC)

Hydrocarbons are important environmental pollutants, particularly in marine environments. Crude oils may contain thousands of organic compounds with varying physical, chemical, and toxicological properties. Natural plant and animal hydrocarbons are ubiquitous in both the terrestrial and aquatic environments. N-alkanes have been found in plant waxes, marine bacteria and in benthic and planktonic algae [21].

Public water supplies should be virtually free of oil and grease, particularly because of the tastes and odour that emanate from petroleum products. Although the ingestion of petroleum oils is dangerous to health, these oils cause objectionable tastes and odour at concentrations well below those that constitute health hazard. It is desirable that the oil content of drinking water do not exceed 0.2mg/l [32]. Thus, the concentration of Total hydrocarbon in this study is less than 0.2mg/l, with a mean value of 0.03±0.02mg/l in surface water indicating that the water is only contaminated with THC. Correlation matrix for surface water showed high significant correlation between THC and Mn^{2+} (r = 0.7213).

MICROBIOLOGY

Total heterotrophic bacterial content ranged from $0.7x10^1$ to $14.0x10^4$cfu/ml with a mean value of 29415.4±6185.59cfu/ml in the surface water. Total coliform bacterial count ranged from 4 to 11 in surface water with no value recorded at Asarama-ija. Faecal coliform result for the surface water samples had either no coliforms or very low values where present. The water in the study area contained high total heterotrophic bacteria and total coliform bacteria. The presence of these contaminations is an indication that high health risk exists for individuals exposed to the water.

ASSESSMENT OF WATER QUALITY FOR IRRIGATION

The surface water quality of the area was accessed to determine the suitability for agricultural purposes. Water for this purpose is required to meet certain safety standards that have been set by WHO and other agencies [33].

Table 4: Levels of Irrigation Indices for Irrigation.

S/No	LOCATION	SAR	SSP (%)	MAR (%)	KR (meq/L)	PI (%)	RSBC (meq/L)
1.	Asarama-Ija	0.07	1.065	50.36	0.007	2.529	-18.708
2.	Iwoma	0.059	0.550	33.65	0.005	1.724	-37.853
3.	Inyong-Orong	0.065	0.732	50	0.007	2.343	-18.773
4.	Asarama	0.073	0.819	50.36	0.008	2.429	-18.774
5.	Ebukuma	0.053	0.494	33.65	0.004	1.571	-37.934

SODIUM ADSORPTION RATION (SAR)

The sodium adsorption Ratio is important in evaluating the suitability of water used for agricultural irrigation. This ratio is an estimate of the degree to which sodium will be adsorbed by soil from water. The value is calculated from the ionic concentration of sodium, calcium, and magnesium. The SAR less than or equal 10 are said to be excellent quality; 10-18 are good, 18 to 26 are fair and about 26 are said to be unsuitable for

irrigation [34]. Sodium adsorption ratios of the water in all the stations are less than 10 indicating excellent quality of the water for irrigation.
There are significant relationships between SAR values of irrigation water and the extent to which sodium is absorbed by soil. If the water used for irrigation is high in sodium and low in calcium, the cation-exchange complex may become saturated with sodium [35]. SAR shows high significant with KR (r = 0.9738), SSP (r = 0.8509), MAR (r = 0.9040), PI (r = 0.9461) and RSBC (r = 0.8997) in the surface water.

KELLEY'S RATIO (KR)

A Kelley's Ratio of more than one (1meq/l) indicates an excess level of sodium in waters. Hence, waters with a Kelley's Ratio less than one are suitable for irrigation [25]. The values of Kelley's Ratio in all the stations were less than 1 and are suitable for irrigation. KR showed high significant correlation with SSP (r = 0.7768), MAR (r = 0.9463), PI (r = 0.9520) and RSBC (r = 0.9447) in the surface water.

SOLUBLE SODIUM PERCENTAGE (SSP)

The soluble sodium percentage values less than 50% or equal to 50% indicates good quality water and if it is more than 50% indicates unsuitable water quality for irrigation [25]. The soluble sodium percentage values for all stations were less than 50% and indicate good quality water in agreement with previous studies by [25]. SSP showed high significant correlation with MAR (r = 0.8461), PI (r = 0.9132) and RSBC (r = 0.8417) in the surface water.

MAGNESIUM ADSORPTION RATIO (MAR)

Magnesium content of water is considered as one of the most important qualitative criteria in determining the quality of water for irrigation. Generally, calcium and magnesium maintain a state of equilibrium in most waters. High magnesium in water will adversely affect crop yields as the soil becomes more saline [36]. The values of magnesium adsorption ratio of the surface water ranged from 33.65 to 50.36% with Iwoma, Inyong-Orong and Ebukuma having low values of 33.65%, 50% and 33.65% respectively which are within the acceptable limit. However, the value of MAR (50.36%) in Asarama-Ija and Asarama Town were slightly above the acceptable limit and may be considered unsuitable and require monitoring. High magnesium adsorption ratio (> 50%) causes harmful effect to soil. MAR in surface water showed high significance with PI (r = 0.9816) and RSBC (r = 0.9998).

RESIDUAL SODIUM BICARBONATE (RSBC)

The residual sodium bicarbonate value of the surface water samples from the study area was less than 3.0 meq/L and considered safe for irrigation purposes, this is in agreement with the studies by [37]. The concentration of bicarbonate and carbonate in water influences the suitability of water for irrigation purpose. The water with high RSBC has high pH. Therefore, land irrigation with such water makes the land infertile owing to deposition of sodium carbonate [38].

PERMEABILITY INDEX (PI)

The soil permeability is affected by long – term use of irrigation water and the influencing constituents are the total dissolved solids, sodium bicarbonate and the soil type. In this study the permeability index values of the surface water ranged from 1.571% at Ebukuma to 2.529% at Asarama-Ija. The results of the surface water therefore suggest that the water samples fall within class I and class II and can be categorized as good irrigation water which is in accordance with the work by [33].

TOTAL DISSOLVED SOLIDS (TDS)

Salts of calcium, magnesium, sodium, potassium present in irrigation water may prove to be injurious to plants. When present in excessive quantities, they reduce the Osmotic activities of the plants and may prevent adequate aeration [33]. The TDS values of surface water in the study area varied from 12880 to 15890mg/l with a mean value of 13608 ± 1285.6mg/l which is higher than 1000mg/l and is classified as very saline and poor for irrigation.

IV. Conclusions And Recommendation

The findings of this study showed that the microbial content of the surface water was high. Surface water in the study area showed high concentrations of EC, TDS, SO_4^{2-}, Cl^-, Total Hardness, Ca^{2+}, K^+, Mg^{2+} and turbidity at stations 1,2 and 3 and exceeded their permissible limits and thus considered to be contaminated and highly mineralized. The contamination of the water can lead to contamination of aquatic lives on which the inhabitants depend and therefore the water in the area is not potable but suitable for irrigation. This study is presumed the first of its kind in the study area and has provided baseline data and created awareness.

Recommendations

Based on the findings of this study, the following recommendations are made:-

1. The water in the area should be monitored regularly to avoid serious pollution problems (epidemics) especially water borne diseases.
2. Further studies should be carried out to evaluate sea foods in the area which could have been contaminated as fishing is the predominant occupation of the inhabitants of the area.

References

[1]. Hiremath S.C; Yadawe M.S; Pujeri U.S, Hiremath D.M, Pujar A.S (2011) Physico-chemical Analysis of ground water in munipal Area of Bijapur (Karnataka). Curr World Environ. Vol. 6(2), 265 – 269.

[2]. Ahmed Q.K. (2003). Towards poverty Alleviation: The water sector perspectives. Int. J. water Resource Dev. 19 (2): 263 – 277.

[3]. DILIP L.B. and Nagarrnaik P.B. (2011): Assessment of physico-chemical parameters of well water of kalmeshwar Town, Nagpur maharashtra (India). Current world environmental; Vol. 6(1), 109-114.

[4]. WHO (World Health Organization) (2006): Guidelines for drinking water quality. First Addendum to 3rd Edition Vol. 1. Geneva. WHO Press pp. 515.

[5]. WHO (World Health Organization) (2011): Guidelines for drinking water quality. 4th Edition WHO Press, 2011, pp. 564.

[6]. Olutona O.G, Emmanuel A.A, John A.O, Seun A.A, (2012): Physico-chemical quality assessment of Shallow well waters in Imo, south western Nigeria. Journal of Environmental science and water Resources Vol. 1 (6), pp 127-132.

[7]. WHO (World Health Organization) (2004). Water sanitation and Health programme. Managing water in the home: Accelerated health gains from improved water sources. World Health Organization. www. WHO. Int.

[8]. McFeters G.A. (1990): Drinking water microbiology, Springer velag, New York.

[9]. Chatwell, G.R. (1989): Environmental water pollution and control, Anmol publication, New Delhi.

[10]. Census (2006): National Population Commission Rivers State.

[11]. Calmano, W. and Forstner U. (1996): Sediments and toxic substances. Springs Germany pp 56-78.

[12]. APHA (1995). Standard Methods for the examination of Water and Waste water, 18th ed.APHA-AWWA-WPCF. Washington DC.

[13]. Richard, L.A. (1954): Diagnosis and improvement of saline and Alkali soils agric Handbook 60, USDA and IBH PUB. Coy Ltd; New Delhi, India, pp:98-99.

[14]. Todd, D.K 1995. Ground water Hydrology J. 3rd Edn. Wiley and sons Inc; New York, U.S. U.S Salinity lab. Staff; Diagnosis and improvement of saline and alkali soils. U.S. Dept. Agric. Handbook – 60, P.160, 1954.

[15]. Gupta, S.K and Gupta I.C. (1987): Management of saline soils and water, Oxford and IBH Publication Coy, New Delhi, India, pp 399.

[16]. Doneen, L.D., (1964). Notes on water quality in agriculture, published as a water science and engineering paper 4001, Department of water science and Engineering, University of California.

[17]. Raghunath, I.M (1987): Ground water, 2nd Edn; Wiley Eastern Ltd; New Delhi, India.

[18]. Kelley, W.P; (1963): Use of saline irrigation water. Soil sci, 95(4):355-391.

[19]. SON, (2007): Nigerian standards for drinking water quality. Nigeria industrial standard NIS: 554.//www.unicef.org/Nigeria/ng. Publications.Nigerian.standard for.Drinking.water.quality. Pdf.

[20]. NAFDAC (2001): National Agency for food and Drug Administration and control in Nigeria. Drinking water Regulations. In NAFDAC consumer Bulletin Oct-Dec, No 1:9.

[21]. McNeely R.N. Neimanis V.P and Dwyer L. (1979): Water Quality Sourcebook, A Guide to water Quality parameter. Inland waters Directorate, Water Quality Branch;Ottawa, Canada.

[22]. C.D.C (Centers for Disease control and prevention) (1996): spontaneous Abortion possibly related to ingestion of Nitrate – contaminated well water – LaGrange county, Indiana, 1991-1994. Mobility and mortality weekly Report, 45 (26): 569 – 572.

[23]. Oluyemi E.A, Adekunle A.S, Adenugu A.A and Makinde W.O, (2010): Physico-chemical properties and heavy metal content of water sources in North Local Government Area of Osun State, Nigeria. African Journal of Env. Sci. and Tech. vol. 4(10), pp 691 – 697.

[24]. WHO (1979): Sodium chloride and conductivity in Drinking waters. World Health Organization, Copenhegen.

[25]. Aher K.R and Deshpande S.M (2011): Assessment of water Quality of the maniyad Reservoir of parala village, district Aurangable: Suitability for multipurpose usa1ge. Inter, Journal of Recent trend in science and technology, volume 1 pp. 9-95.

[26]. Fadiran, A.O, Dlamini Sc, Mavuso, A. (2008). A Comparative study of the phosphate levels in some surface and Ground water Bodies of Swaziland. Bull. Chem. Soc. Ethlopia 22(2): 197-206.

[27]. Department of National Health and Welfare, (1969)). Canadian Drinking water standard and objectives.

[28]. Vengosh A, Pankratov 1 (1998): Chloride / Bromine and chloride / Fluoride Ratios of Domestic sewage Effluents and Associated contaminated Ground water. Groundwater 36(5): 815-824.

[29]. Rajeshekhar A.V, (2007): The studies on water quality parameters of a minor reservoir, Nadergul, Rangaraddy district, A.P. Jour. of Aua. Biology. Vol. 22 (1), 118-122.

[30]. Bakarji. E.H, Krajo .J. (1999): Determination of heavy metals in Damascus drinking water using total reflection X-ray fluorescence quality research water J. Canada. 34, 305.

[31]. Drever, J.I. (1988): The Geochemistry of Natural water Engiewood Cliffs. Prentice Hall, New Jersey, pp: 437.

[32]. Hart, B.T (1974): A compilation of Australian water Quality criteria. Caulfield Institute of Technology. Australian water Resources council, Technical paper No. 7. Australian Government publishing service, Canberra.

[33]. Obiefuna G.I and Sheriff A. (2011): Assessment of Shallow groundwater Qulity of Pindiga Gombe Area, Yola Area, NE, Nigeria for Irrigation and Domestic purposes. Research Journal of Env. Earth Sci. 3(2): 132-142.

[34]. USDA (1954). U.S Salinity lab. Staff; Diagnosis and improvement of saline and alkali soils. U.S. Dept. Agric. Handbook – 60, P.160.

[35]. Tatawat, R.K.and Singh-Chandel, C.P. (2007). Quality of Ground water of Jaipur city, Rajasthan (India) and its Suitability for Domestic and Irrigation Purpose. Applied Ecology and Environmental Research 6(2): 79-88.

[36]. Joshi, D.M. Kumar A. and Agrawal N, (2009). Assessment of irrigation water quality of River Ganga in Haridwar District India. J. chem.., 2(2): 285-292.

[37]. Talabi, A.S., Afolagboye,O,L., Tijani, M.N., Aladejana,J.A and Ogundana,A.K .(2013). "Hydrogeochemical Assessment of Surface Water in the Central Part of Ekiti-State, Southwestern Nigeria." American Journal of Water Resources 1,no.4:56-65.doi:10.12691/ajwr-1-4-1.
[38]. Eaton, F.M; (1950): Significance of carbonate in irrigation water. Soil sci., 67(3): 128-133.

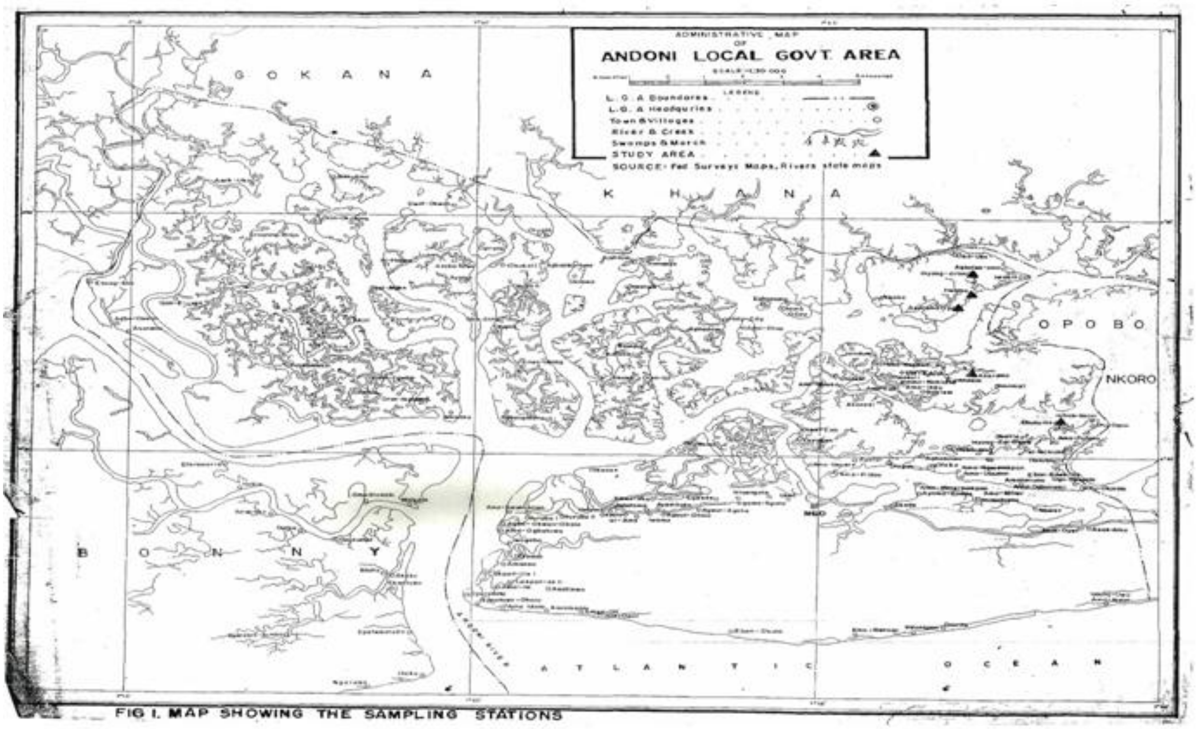

FIG I. MAP SHOWING THE SAMPLING STATIONS

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