Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 6, No. 6, p. 214-224, 2015
http://www.innspub.net

INNSPUB
RESEARCH PAPER OPEN ACCESS

An empirical assessment of value-chain analysis and competitive water quality assessment in Ikot Akpa Nkuk community in Ukanafun local government area of Akwa Ibom state, Nigeria

M.A. Abua*, A.I. Afangideh, B.A. Ayiri, A.J. Akiang

Department of Geography and Environmental Science, University of Calabar-Calabar, Nigeria

Article published on June 17, 2015

Key words: Empirical assessment, value-chain analysis, physic-chemical properties, water samples, water quality and portability.

Abstract

Ground and surface water samples were analyzed for physico-chemical parameters with recourse to water quality assessment in Ikot Akpa Nkuk Community and its environs, Ukanafon Local Government Area of Akwa Ibom State. The aim of the study was to assess the level of portability for human consumption, as well as examine whether its salt contents constitute health related problems and alongside offer mitigation measures. Physico-chemical parameters were as follows: Electric Conductivity (63.1 to 79.6NS/cm); Turbidity (0.08 to 4NTU); Biological Oxygen Demand (BOD) (2.93 to 6.41mg/l); Chloride (6.31 to 65.8mg/l); and Nitrite (0.58 to 4.36mg/l); Sodium (0.06 to .00mg/l); Ammonium (0.58 to 4.36mg/l); Sodium (0.06 to 0.71mg/l) while total hardness varied from 17.81 to 23.10mg/l. The results indicate that the water is fit for drinking albeit not totally free of contaminations owing to non-zero values of the surface water quality statusfor drinking and other purposes when compared with the WHO And FEPA standards. Based on these results, it was therefore, recommended that the water be treated via boiling and filtering. While institutional and infrastructural support systems be constituted to provide a sustainable water supply in the area under investigation.

***Corresponding Author:** M. A. Abua ✉ ask4mossabua@yahoo.com

Introduction

Water is essential for growing food; for household water uses, including drinking, cooking, and sanitation; as a critical input into industry; for tourism and cultural purposes; and for its role in sustaining the earth's ecosystems. But this essential resource is under threat. Growing national, regional and seasonal water scarcities in most parts of the world pose severe challenges for National Governments and International Development and Environmental Communities (Rosegrant *et al* 2002). They are of the view that the challenges of growing water scarcity are heightened by the increasing costs of developing new source of water, degradation of soil in irrigated areas, depletion of groundwater, water pollution and degradation of water-related ecosystems, and wasteful use of already developed water supplies, often encouraged by the subsidies and distorted incentives that influence water use. Water, an absolute necessity for life, is a health promoting fluid. Apart from other intended uses such as agriculture, generator coolants and others, water is primary used for domestic and industrial purposes by man (Merck, 1974). Consequently, water for the latter purpose must unavoidably be aesthetically acceptable. Thus, it must be absolutely free from apparent turbidity, odour, colour and undesirable taste. Historical records show that up to and including most of the 9th century, water quality standards were based mainly on aesthetics (Asuquo and Okorie 1987). Even today, most of the people, mainly of the rural domain, first on receiving a glass of water, look to see if it is palatable. In many cases, such water is acceptable and consumed as potable water without any fear of risk of adverse effects (FEPA, 1973). These practices are also obtained even in the urban areas, especially when there are occasional water shortages, making the stream or well water an alternative source. Man's reliance on taste, odour and other physically observable water quality parameter has not been an infallible means of judging the acceptability of water (Korol, 1983; FEPA, 1987; Eze and Abua, 2003; Abua *et al.*, 2011; Abua and Ajake, 2014).

However, water plays a very important role in the evolution of biological systems and are so enormous due to urbanization and consequently the growing demand by communities for water as major food source. The establishment of Environmental Protection Agencies (EPA) and other developments has given new impetus for water purification (Edet, 1993). The Coca-Cola Company in their Technical Training Programme submitted that quality of water is not only affected by the total amount of impurities but affects the way the water is being used (Audiovisual, 1995). The quality of water is determined by its physico-chemical and biological composition and therefore its ultimate usability. Its assessment and the parameters examined depends on the envisage usage. In some cases, water quality is far more important than its availability. Ample evidence are seen in the Niger Delta where in some communities, there are lot of water but it is so salty that fresh water has to be 'brought' from other areas for use (Etu-Efector, 1996). However, on account of the wide varieties of water physico-chemical and biological characteristics, and the consequent different standards of potability, it is impossible to set rigid standards of chemical quality. According to Akpaekon (1997), quality of our environment is determined by the intricate process of the human activities involving the utilization of water for essential services such as domestic and industrial uses. These activities, however, alter the quality of water therefore making it unfit for continuous usage.

The present study area has few streams and groundwater located within the human settlements. Thus, it became necessary to assess the physico-chemical characteristics of the water sources in the area so to adjudge it "unsuitable" for human consumption.

Researchers over the years have made concerted efforts in the assessment of water quality prior to consumption in the world. For instance, the international agencies have shown genuine interest in water quality standards. The World Bank Water sponsored scheme initiated and completed in Cross

River State and other States of the country are pointers to the fact that water quality is undoubtedly unfit for human consumption in many areas. The key problem is that water quality classification scheme is not rigidly upheld thereby culminating in some water borne disease especially among the ruralites who have been victims of water borne diseases. Suffice it to say that lack of potable water means lack of health, lack of hygiene and lack of water leisure. In fact poor water quality causes public heath problems such as malaria, cholera, typhoid, scistosomiasis (Guinea worm), Onchocerceiasis (river blindness), diarrhea among others (Eze and Abua, 2003). Furthermore, surface and groundwater sources are located in a variety of landuses including residential yards, farm yards, agricultural cropland and pasture and motor-park. In between are home sewages, feed lots, refuse dump sites, pit toilets/latrines etc. Since the geological setting of Calabar flank is vulnerable and susceptible to rapid influx and vertical mixing of seepage water with shallow ground water systems, the obvious thinking is that these wastes will go a long way in contaminating the hydro-geological environment. And so, water sources from streams/rivers, well and boreholes in the area may, as well, be contaminated.
As a response to these problem(s), an increasing interest in water and sanitation has been observed in the literature over the past three decades. Thus, majority of the works have centred on water quality assessment around human and animal dungs in Calabar and Ibadan (Abua and Ajake, 2014; Adebisi, 1980; Asuquo, 1998). Other studies on water quality in Nigeria focused on physico-chemical assessment of Calabar River (Akpanekon, 1997; Adebisi, 1980; Asuquo, 1998), seasonal variation of water quality in Ibadan (Asuquo and Okorie, 1987; Akpan and Offem, 1989) and groundwater quality assessment in parts of Eastern Nigeria (Edet, 1993). Little or no attention has been given to an assessment of value-chain analysis and competitive water quality assessment by looking at both surface and groundwater. A critical look at this studies above shows a regional and ecological bias as none of the studies was carried out in the study area.

These problems have warranted an urgent need to assess the quality status of water in the study area hence the need for this work. The study is aimed at examining an empirical assessment of value-chain analysis and competitive water quality assessment in the study area.

To determine the physical and chemical properties of water samples and examine the water quality status for human consumption as well as recommend mitigation measures against undesirable substances.

Materials and methods

Study Area

Ukanafun Local Government Area was carved out of the then Abak Division of the former South-eastern State of Nigeria. Originally, it comprised three county councils: Western Annang, Southern Annang and Annang county council. The study area occupies a land area of about 254.8sq.km. The area has a population of about 100,000 persons based on the 1991 population estimates. It is located at the South-Western part of Uyo, Akwa Ibom State capital and shares geographical boundaries with Etim Ekpo and Oruk Anam Local Government Area in Akwa Ibom State as well as Abia and Rivers States (Fig. 1).

The present study area enjoys a favorable climatic condition. The dominant vegetation is green foliage of trees as well as shrubs. It is linked by access roads to other Local Government Areas in the state.

However, the primary occupation of the natives is farming while civil service is secondary. The study area has a plethora of untapped minerals while soil type is coastal plain sands.

Sampling Technique

Data for the study were obtained from surface water sample streams (Ikot Inyang Abia stream and Iko Ukpong stream) and boreholes located at Ikot Akpa Nkuk all in Ukanafun Local Government Area of Akwa Ibom State (Fig. 1). The water samples for physico-chemical analysis were collected in one litre polyethylene bottles and stored in a cool box at appropriately 4ºC for analysis in the Laboratory.

The physico-chemical characteristics analyzed include: turbidity, total suspended solids (TSS), Biochemical Oxygen Demand (BOD), nitrite, nitrate, phosphate, chloride, sulphate, calcium, magnesium and salinity.

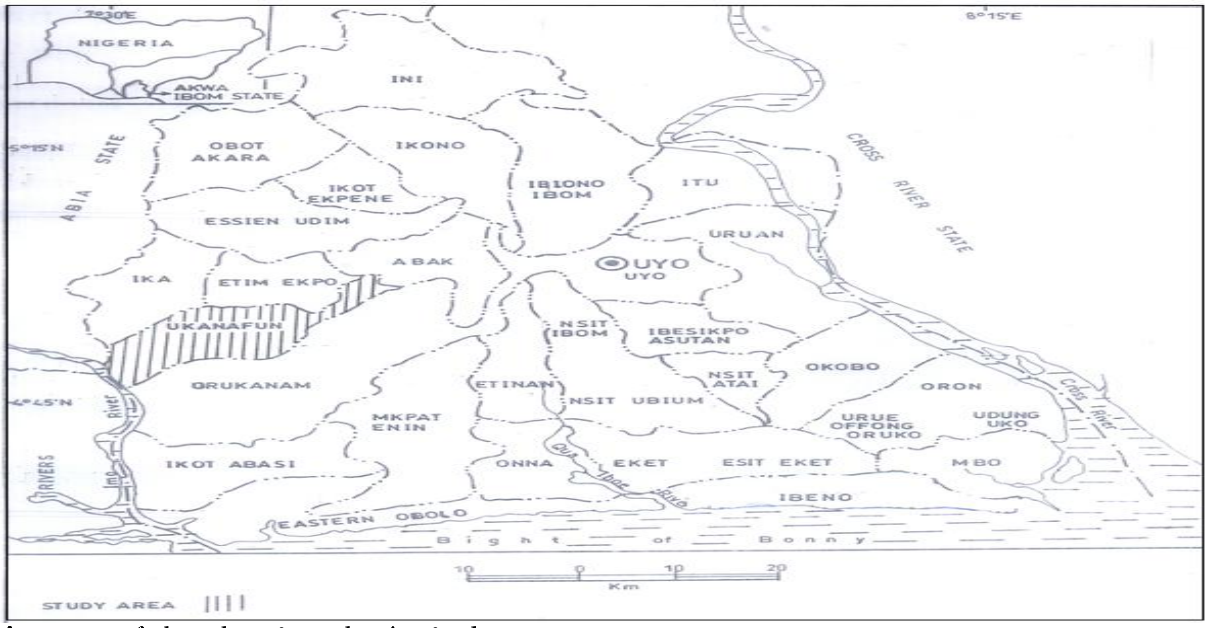

Fig. 1. Map of Akwa Ibom State showing Study Area.

During the field sampling survey, two surface water samples and one groundwater sample were collected from Ikot Inyang Abia and Ikot Ukong streams (surface water) while the groundwater was obtained from Ikot Inyang Abia adjacent to the Ukanafun main motor park located at Ikot Akpan Nkuk in Ukanafun Local Government Area of Akwa Ibom State.

In the laboratory, standard methods outlined by American public Health Association (APHA, 1989) were used to determine water parameters such as Biological Oxygen Demand (BODs) total hardness, alkalinity, salinity, sulphate, Hydrogen sulphide (H_2S), Calcium (Ca) and Magnesium (Mg). Ammonium (NH_4^+), Nitrate (NO_3^-) nitrite (NO_2^-) and phosphate (PO_4^{2-}) were determined by method outlined by parsons *et al*, (1984) while chloride (Cl^-) was analysed by APHA (1989) method (Tables 1).

Quality Control and Assurance

The samples collected were taken to the laboratory on the same day of collection; the sample obtained from both the surface and groundwater were stored and well corked in plastic bottles and kept in a cooler at 4ºC to avoid possible variations in the parameters, as a result of contact with the environmental conditions during transportation.

Appropriate analytical methods were employed for both qualitative and quantitative assessment of all the parameters sought for. The former indicates the degree of the various substances of interest while the later depicts their concentration or amount in milligrams per litre of sample (mg/l).

Data Analysis

Descriptive statistics namely means, range, frequency distribution tables were used to present and analyse the data of the study. Details of analytical techniques and methodology are presented in Table II.

Results and discussion

The physico-chemical characteristics of ground and surface water samples collected from the study area are presented in Table II and IV in relation to drinking water quality standards of WHO (1984, 2006) and EEC 1975).

Physical properties

The physical parameters considered in this study include: pH, dissolved oxygen, temperature and electrical conductivity, others include: turbidity, total suspended solids, total dissolved solids and Biological Oxygen Demand (Bod measured in milligram per liter (Table II and IV).

Table 1. Methods and Equipment Used For Physico-Chemical Analysis.

S/N	Analytical Equipment/Method and Reference	Parameters
1.	Cyberscan pH 20 meter	Ph, E_h
2.	Cyberscan low 20 conductivity meter	Conductivity, TDS
3.	Microprocessor oximeter 196	Dissolved oxygen (DO)
4.	Spectrophotometrical methods	
	(a)Turbidity using barium chloride (APHA, 1989)	SO^{2-}_4
	(b) Diazotization method (parsons *et al*, 1984)	
	(c) As nitrite after reduction in a calcium reduction system (parsons et, al, 1984).	Nitrite (NO_2^-)
	(d) Molybdenum blue method (parsons *et al*, 1984)	Nitrate (NO_3^-)
	(e) Formazine standards according to HACH	Phosphate (PO_4)
	(f) Nesslenization method	Turbidity (NTU)
	(APHA, 1989).	Ammonium (NH_4^+)
5.	Titrimetrical methods:	Chloride (Cl^-)
	(a)Silver nitrate and potassium dichromate as indicator (Rodier, 1975).	
	(b) Complexometric technique using EDTA as titrant (APHA, 1989).	Calcium (Ca),
	(c) Titration using indicators like	Magnesium (Mg)
	muraxide, etc.	Total hardness, bicarbonates
	(d) Difference between initial oxygen concentration in sample and concentration after 5	and alkalinity Biochemical
	days incubation in DO bottles at 20°C (APHA, 1989).	Oxygen Demand (BODs).

Researchers' Field Survey, 2009.

pH

The pH values ranged from 6.0 to 6.5 with a mean of 6.3 for the groundwater (borehole) and surface water (streams) collected from Ikot Inyang, Abia stream (borehole and stream) and Ikot Ukpong stream all within Ikot Akpa Nkuk of the study area (table 4). The pH of the water samples collected from the prescribed study locations were allowable pH range limit values of 6.5 to 8.5 for drinking water standard (FEPA, 1988; WHO 1984, WHO, 2006) except water obtained from Ikot Inyang Abia Stream with pH 6.0 below the permissible limits (Table II and IV). This range of pH does not impair the portability of the stream water in the area except that water samples obtained from Ikot Inyang Abia stream that could repair its portability. The concentration of pH can cause corrosion when pumped via steel pipes to household consumers.

Dissolved oxygen (DO)

The dissolved oxygen (DO) values (range, 3.20 to 6.14mg/l) with mean of 4.78mg/l exceeded the allowable limits of 5.0mg/l (WHO, 2006) but within FEPA (1988) permissible limits in all the surface water except that of the borehole water in the area. such levels of dissolved oxygen (DO) can induce biochemical process in the aquatic media.

Biological Oxygen Demand (BOD)

The BOD values were not detached in the borehole water sample (Table IV). Conversely, BOD values for stream water of Ikot Inyang Abia and Ikot Ukpong stream were 6.41 mg/l and 2.93mg/l respectively

(Table IV). This range of concentration values exceed zero levels established for drinking water quality standards (FEPA, 1988). With this dose of concentration above zero critical limit, the stream water (Ikot Inyang Abia and Ikot Ukpong) are unfit for human consumption with exception to the zero standard level of FEPA (1988). Thus, the borehole water is suitable for human consumption.

Table 2. Summary of results for the physical and chemical characteristics of ground and surface water samples around Ikot Akpa Nkuk, Ukanafun Local Government Area, Akwa Ibom State.

		Maximum Allowable Limits		
	Range	Mean	FEPA[a]	WHO/EEC[b]
Physical Parameters:				
Ph	6.0-6.5	6.3	6.5-8.5	6.5-8.5
Dissolved Oxygen (DO) (mg/l)	3.20-6.14	4.78	7.5	5.0
Temperature (°C)	25-28	26	30.0-35.0	25
Electrical conductivity (Ns/cm)	63.1-79.6	70.4	4000	4000
Turbidity (NTU)	0.08-1.24	0.71	1.0	5.0
Total suspended solids(TSS) (mg/l)	0.021-0.148	0.08	30	NL
Total Dissolved solids (TSS)(mg)/l	43.14-52.91	47.58	500	NL
BODs 20-25°C (mg/l)				
Major Ions and Nutrients (mg/l):				
Chloride (Cl^-)	6.31-65.8	39.44	250	250
Nitrite (NO_2)	0.03-0.05	0.04	1.0	0.1
Nitrate (NO_3)	3.50-4.00	3.74	10.0	45.0
Ammonium (NH_4^{++})	0.01-0.08	0.04	1.0	0.5
Phosphate (PO_4^+)	0.05-0.32	0.14	>5	5.0
Sulphate (SO_4)	3.10-26.00	10.76	500	400
Calcium (Ca)	3.31-26.00	13.77	NL	75
Magnesium (Mg)	0.58-4.36	2.68	NL	30-150
Potassium (K)	0.61-5.90	3.27	NL	12
Sodium (Na)	0.06-0.71	0.46	200	200
Total Hardness	17.18-23.10	20.33	200	200

Researchers' Field Survey, 2009.

Legend:

a = Federal Environmental Protection Agency Gidelines (1988);

b= World Health Organization (WHO) (1984); European Economic Community (EEC) Guidelines (1975); NL = No Limit.

Temperature

Temperature is one of the physical (in-situ) parameters that determine the tendency of changes in water quality standards. The temperature of 25°C was recorded for the borehole water at Ikot Ukong stream while 28°C was recorded for Ikot Inyang Abia stream (Table IV). This level of temperature were within the normal range for drinking water quality standards established by FEPA, 1988; WHO, 2006). These levels of temperature values render the water potable for use by humans (Table IV).

Turbidity

Turbidity is the degree of cloudiness of water. The turbidity values recorded for the borehole water Ikot lnyang Abia and Ikot Ukpong streams were 0.08 NTU and 1.24 NTU respectively (table 4).Turbidity levels for the borehole (0.08 NTU)at Ikot lnyang Abia stream were within the permissible limits of 1.0 NTU (FEPA,1988). In contrast, water obtained from Ikot Ukpong stream (1.24 NTU) were above the limits (1.0 NTU) established by FEPA (1988). Thus, the water collected from Ikot Ukpong stream as drinking water for the natives of the area showed presence of particulate matter, an indication of presence of disease causing organisms such as bacteria and viruses. This situation often culminated in diarrhea and headache. (WHO, 2006).

Table 3. Sodium Absorption Ratio (SAR) and Water Quality Standards.

Location	SAR value	Quality
Borehole	0.40	Good
Ikot Ukpong stream	0.16	Good
Ikot Inyang Abia stream	0.007	Good

Researchers' Field Survey, 2009

Note: SAR > 13 is not safe for drinking.

Chemical characteristics

Ions

Cations and anions dissociated in water determine electrical conductivity values (range, 63 to 79.6MS/CM) with a mean of 70.4MS/cm were lower than the FEPA (1988) and WHO (2006) allowable limits of 400MS/cm for the water samples collected from the study locations (Table II and IV). This concentration indicates low amount of dissolved salts in water.

Table 4. Physical and Chemical Characteristics of Water quality around Ikot Akpa Nkuk, Ukanafun Local Government Area, Akwa Ibom state.

Parameters	1	2	3	FEPA[a]	WHO/EEC[b]
Physical Parameters:					
pH	6.3	6.0	6.5	6.5-8.5	6.5-8.5
Dissolved Oxygen (DO) (mg/l)	6.14	3.20	5.0	7.5	5.0
Temperature (°C)	25	28	25	30.0-35.0	25
Electrical Conductivity (NS/cm)	68.4	63.1	79.6	4000	4000
Turbidity (NTU)	0.08	0.08	1.24	1.0	5.0
Total suspended solids (TSS) (mg/l)	0.061	0.021	0.148	30	NL
Total dissolved solids (TDS) (mg/l)	52.91	46.68	43.14	500	NL
BODS @ 20 – 25°C (mg/l)	ND	6.41	2.93	0	NL
Major Ions and Nutrients (mg/l):					
Chloride (Cl^-)	46.2	65.8	6.31	250	250
Nitrite (NO_2)	0.03	0.05	0.05	1.0	0.1
Nitrate (NO_3)	3.50	3.71	4.00	10.0	45.0
Ammonium (NH_3)	0.04	0.01	0.08	1.0	0.5
Phosphate (PO_4)	0.06	0.32	0.05	> 5	5.0
Sulphate (SO_4)	26.00	3.19	3.10	500	400
Calcium (Ca)	3.31	12.01	26.00	NL	75
Magnesium (Mg)	3.1	4.36	0.58	NL	30-150
Potassium (K)	0.61	5.90	3.31	NL	12
Sodium (Na)	0.17	0.06	0.60	200	200
Total hardness	23.10	17.18	20.08	200	200

Researchers' Field Survey, 2009.

1 = Borehole Water; 2 = Ikot Inyang Abia stream; 3 = Ikot Ukpong stream

a = Federal Environmental Protection Agency Guidelines (1988);

b = World Health Organization (WHO) 1984); European Economic Community (EEC) Guidelines (1975); ND = Not detected; NL = No Limit.

The major ions (chemical substances) are Chloride, Nitrites (NO_2) and Nitrate (NO_3), Ammonium (NH_3^+), Phosphate (PO) and Sulphate (SO_4). Others include: Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na) and total hardness.

Chloride contents were low (range 6.31 to 65.8 mg/l) when compared to FEPA (1988) and WHO (2006) allowable limit of 250mg/l (Table II). Chloride contents of 46.2mg/l 65.8mg/l and 6.31mg/l were recorded from the borehole water Ikot Inyang Abia and Ikot Ukpong streams respectively (Table IV). Thus, chloride concentrations above the critical limits of 2.50 mg/l can give detestable effect on taste in drinking water.

The concentration of Nitrite (range, 0.03 to 0.05 mg/l were low when compared with water quality standards allowable limits of 1.0mg/l (FEPA, 1988) for respective anions (Table 2). Excess Nitrates in potable water can cause health problem in infants called methaemoglobinaemia; a condition that inhibits transportation of oxygen around the body (WHO, 2006).

Ammonium contents recorded in the borehole water sample was 0.04 mg/l, Ikot Inyang Abia streams 0.01 mg/l while 0.08 mg/l was recorded for Ikot Ukpong stream (Table IV). These concentrations were low when compared to the maximum tolerable limit of 1.0 mg/l (FEPA, 1988) and 0.5 mg/l established by WHO (2006), EEC (1975). Excess ammonium impact taste to water and effects its acceptability for drinking.

Phosphate (range, 0.05 to 0.32 mg/l) and sulphate (range, 3.10 to 26.00 mg/l) were low in both the groundwater (borehole) and surface water when compared to the established allowable limits of > 5 mg/l and 5.0 mg/l (FEPA, 1988) and 500 mg/l and 400 mg/l (FEPA, 1988; WHO, 2006; EEC, 1975). Phosphate concentration of organic substances into inorganic forms. Excess sulphate can impair drinking water quality.

Total Suspended Solids (TSS)

The Total suspended solids (TSS) range from 0.021 to 0.148mg/1 with a mean of 0.08 mg/l (Table II and IV). Thus, the TSS for the borehole, Ikot lnyang Abia and Ikot Ukpong streams were low when compared with 30 mg/l for drinking water quality standards (FEPA, 1988). The low range values of TSS below the threshold limits of 30mg/l indicates potability of the water in terms of drinking and other purposes (FEPA, 1988).

Total Dissolved Solids (TDS)

The Total Dissolved Solids (TDS) for the surface water and groundwater (range, 43.14 to 52.91 mg/l) were lower when compared to the allowable limits of 500mg/l for FEPA (1998). These low values can exerts adverse effect on the acceptability of the water for drinking. Although TDS exceeding 500mg/l affect the potability of water (Table II).

Exchangeable bases

The concentrations of Ca (range, 3.31 to 26.00 mg/l), Mg (range, 058 to 4.36 mg/l), K (range, 0.61 to 5.90 mg/l) and Na (range, 0.06 to 0.71 mg/l) were lower than the threshold limits established by FEPA (1988), EEC (1975) and WHO (2006) of 75 mg/l, 30 mg/l, 12 mg/l and 200 mg/l for the respective cations (Table II and IV). These ions are essential health nutrients and will not pose any severe health problems. Concentrations of these nutrient elements above the threshold limits could impair taste which is intolerable to humans.

Hardness

Total hardness indicates that magnesium and calcium salts are present in the water sources. Sometimes low values in the wet season are probably due to dilution from rain water. Total hardness varied from 17.81 to 2.0 mg/l with a mean value of 20.33 mg/l. These range of values are within permissible limits of 200 mg/l outlined by FEPA (1988), WHO (1984) and EEC (1975) water quality standards (table 2 and 4). Given the foregoing analysis, the safest water in the study area most suitable for human consumption in terms of drinking is the borehole water while the stream water could be considered if properly treated prior to consumption. In order of quality, the borehole water ranked first followed by Ikot Ukpong stream and Ikot Inyang Abia stream owing to the level of contaminants (see BODS) (Table II and IV).

Sodium adsorptive ratio (SAR)

Water quality evaluation sometimes are based on criteria of salt contents, particularly the one that has to do with sodium (Na^+) hazards. Thus, the adoption of Sodium Adsorption Ratio (SAR) were used to determine the saltiness of water standard in the prescribed study locations.

SAR = Na^+

$$\sqrt{Ca_2{}^+ Mg_2{}^+ /2}$$

From Table III, Ikot Inyang Abia stream had the lowest salt contents, followed by Ikot Ukpong stream and borehole water in that order. The increased salt content of the borehole even though adjudged potable in terms of human consumption needs, could be potable due to salt beds in the area at certain depth. Generally, the water in the study location is adjudged potable based on the SAR ratings. Thus, the water could be used for irrigation purpose should the need arise.

The study sought to examine the water quality status for human consumption. The analysis reveals that all the water bodies were safe for human consumption and other purposes due to non-pollutants and contaminants. The borehole water was adjudged potable due to non-pollutant but shows appreciable amount of saltiness unharmful for human health. Comparatively, other sources of water particularly the stream water were not as good as the groundwater in terms of quality. The degrees of saltiness were low in Ikot Ukpong stream and appreciable high in Ikot Inyang stream. In sum, all the water bodies show evidence of potability based on ratings WHO (1985; 2006) FEPA (1991) and EEC (1975) water quality standards.

Conclusion

The results indicated that all water samples in the study locations are safe for human consumption and other purposes. The level of contaminants in most cases were slightly above critical limits of FEPA, WHO and EEC guidelines as indicated in BODs level in surface water bodies in the study area. Thus, it could be concluded that the water is potable in terms of drinking, washing and other domestic uses.

Based on the findings and conclusion arising from this study, it could be recommended that both institutional and infrastructural support systems be advocated to guarantee water quality and adequacy to guard against shortages. Giving the prevailing scenario, it could be recommended that:

(a) Water bodies found to show evidence of impurities be boiled and filtered before drinking.

(b) Institutional measures like establishment of water boards should be encouraged to ensure regular supply of potable water to stamp out water borne diseases.

(c) Water monitoring exercise should be instituted to guarantee quality standards that conform with conventional threshold limits of FEPA, WHO and EEC standards.

References

Abua MA, Ajake AO. 2014. Water Quality Around Animal Dung in Adiabo Catchment of Odukpani Local Government Area of Cross River State – Nigeria. International Multi-disciplinary Journal **1(1),** 1-5.

Abua MA, Iwara AI, Ibor UW, Deckor TD, Ewa EE, Lasisi CJ. 2011 A Critical Assessment of Quality Status of Selected Water in Calabar Municipality, Nigeria. International Journal of Biosciences (IJB), **2(2),** 19-26.

Adebisi AA. 1980. Physico-Chemical Hydrology of a Tropical Seasonal River Upper Ogun River 157-165.

Adesigun AA. 1983. Studies on Well Water and Possible Health, Umoh J. U. Nadarajils M. Risk in Katsina, Nigeria Journal of Hygiene **2(1)** 90-199 p.

Ajar P. 1999. Applied Aquatic Microbiology. (An Unpublished Study Material for the Student).

Akpan ER, Offem JO. 1989. Seasonal Variation in Water Quality of the Cross River, Nigeria. Annual report on.

Akpanekon MP. 1997. Physico-Chemical Studies of Groundwater Quality.

Apha NA. 1965. American Public Health Association: Standard Methods for the Examination of Water and Waste Water (12th Edition).

Apha NA. 1989. Water Pollution Method for the Examination of Water and Waste Water, 18th Edition. Washington D. C.

Asuquo FE. 1998. Physico-Chemical Characteristics of Calabar River, Nigeria. PP 595-600.

Asuquo FE. 1998. Water Quality of Calabar. Nigeria Tropical Ecology. 31 – 40 p.

Asuquo FE, Okorie DA. 1987. The Variation of Dissolved Phosphates in Awba Dam Water, University of Ibadan: An Indication of Microbial Activity. Proceedings of the 2nd Annual symposium of the Nigeria Water and Sanitation Association, Victoria Island, Lagos, 16.1-16.2.

Audiovisual Script. 1995. The Coca Cola Company Overview of Water Treatment. 4-5 (TTP).

Edet AE. 1993. Groundwater Quality Assessment in Parts of Eastern Nigeria. Environmental Geology. **22,** 41-46.

Edet AE, Ntekim EU. 1996. Heavy Metals Distribution in Ground Water From Akwa Ibom State, Eastern Nigeria. A Preliminary Pollution Assessment. Global Journal of Pure and Applied Science **2(5),** 63-68.

EEC. 1975. European Economic Community. In Laboratory Manual Examination of Water, Waste and Soil, Edited by Rump and Krist (1988).

Etu-Effetor JO. 1981. Preliminary Hydro Chemical Investigations of Subsurface Waters in Parts of the Niger Delta. Nigeria Journal Mining & Geology **18(1),** 103-105 p.

Eze BE, Abua MA. 2003. Water Resources Management, Ushie Printers and Publishers, Calabar.

FEPA. 1988. Federal Environmental Protection Agency National Interim Guidelines.

FEPA. 1991. The Nigeria Federal Environmental Protection Agency Water Analysis.

FEPA. 1992. Federal Environmental Protection Agency. National Guidelines and Standards, Gaseous Emission and Hazardous Water management.

JEPA. 1973. Clean Water Report **11(10),** 93.

Korol FF. 1983. Determination of Dissolved Phosphates in "Methods of the Water Analysis" by Grasshoff K. *et al.*, 2nd Edition 125-131 p.

Mathuthus AS, Zarayika FM, Jonnalagadda SB. 1992. Monitoring of Water Quality in Upper Mukuvisi river in Harare, Zimbabwe. 51-60.

Merck E. 1974. The Testing of Water. 10th Edition, Darmstadt, Weat Germany. 37 p.

Parsons TB, Maita Y, Lall CM. 1984. A Manual of Chemical and Biochemical Methods of Seawater Analysis. Oxford: Pergamon Press.

Rodier J. 1975. Analysis of Water. Jerusalem: Kete Publishing Houses. 926 p.

Roger. 1982. Seasonal Variation in Water Quality of West Africa River Jong in Sierra Leone.

Rosegrant MW, Ximing Cai I, Cline SA. 2002. World Water and Food to 2025: Dealing with Scarcity. International Food Policy Research Institute, Washington, D. C. USA.

WHO. 1971. International Standards for Drinking Water Geneva, World Health Organization; 70 p.

WHO. 1984. Guidelines for Drinking Water Quality (iii) Health Criteria and Supporting Information. World Health Organization, Geneva, 62-315.

WHO. 2006. World Health Organization Guidelines for Drinking Water Quality (iii) Health Criteria and Supporting Information. World Health Organization, Geneva, 1-515.