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Research Article

BACTERIOLOGICAL AND BIOCHEMICAL MONITORING OF QUA-IBOE RIVER RESOURCES OF EKET COMMUNITY, AKWA IBOM STATE, NIGERIA

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Key words: Aquatic pollution, Bacteriological, Pathogens, Surface water quality, Biochemical properties.

ABSTRACT

The need to establish a broad base environmental monitoring and toxicological assessment of contaminants on water resources and public health gave rise to this investigation. Environmental contaminants monitoring is one of the key issues in understanding and managing hazards to human health and ecosystems. In many ways our modern day 'pollution wonder-environment' has turned into a contamination nightmare, and few examples are more startling than those caused by pathogens and other associated microorganisms. In this study, River water resources of Qua-Iboe River in Eket Community of Akwa Ibom State, was analysed. The analysed include biochemical, physicochemical and bacteriological quality. The results revealed that pH ranged from 4.66 to 7.51 with mean temperature 18 to 23 °C. Other physicochemical parameters including, biochemical oxygen demand, microbial characterization values exceeded the recommended level for surface water quality. Results of Bacteriological analyses such as total heterotrophic count, total coliform and thermo tolerant coliform counts revealed high degree of faecal pollution of the River. The microorganisms, *Serratia liquefaciens, Proteus vulgaris, Aspergillus flavus* and *Aspergillus niger* were detected. It's inferred that the Qua-Iboe River is polluted, bacteriologically contaminated and unsafe for human and animal consumption. Key words: aquatic pollution, bacteriological quality, water contamination, surface water monitoring and biosafety.

INTRODUCTION

Water is an indispensable resource for continued existence of all living things. Water is the source of all living organisms and their sustenance too depends on the same. The provision of an adequate supply of a safe drinking water was one of the eight components of primary health care identified by the international conference on primary health care in 1978. A clean and treated water supply to each house may be the norm in developed countries, but in developing countries, access to both clean water and sanitation are not the rule, and waterborne infections are common (Ferguson *et al*. 1996). According to (NIS, 2007), defines drinking water as all water either in its original state or after treatment, intended for drinking, cooking, food preparation or other domestic purposes, regardless of its origin (Stream, River and Borehole) and whether it is supplied from a drinking water system, or a tanker, or taken from a private well. Two and a half billion people have no access to improved sanitation, and more than 1.5 million children die each year from diarrheal diseases (Omo-Irabor, *et al*., 2008). According to WHO, the mortality of water associated diseases exceeds 5 million people per year (Cabral, 2010). Water for different purposes has its own requirements for the composition and purity and each body of water has to be analysed on a regular basis to confirm the suitability (Chapman, 1992; Cheesbrough, 2006; WHO, 2006; Williams, et al.,

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2004). Majority of the water withdrawn by man are being used in one application or the other. Following each use of water, various forms of pollution contributes to the degradation of the water quality of our inland water bodies (Fan, *et al*., 2010). With time such degradation could be temporal, that is, natural self-purification mechanism becoming enough to ultimately restore its quality, but often, either the pollutants is such that does not restore naturally or the share volume is sufficient to overload the self-purification mechanism, in which case the water is more permanently degraded. Declining water quality has therefore become an issue of global concern (May, *et al*., 2006). Contaminant as defined by (NIS, 2007; Obiakor, *et al*., 2014; Ogbonna, *et al*., 2008; Okorafor, *et al*., 2012) is any chemical or substance present or released or added into drinking water which is capable of being hazardous to health. The quality of water and the quality of life in all its infinite forms are critical parts of the overall, ongoing health of this world, not just Eket Community, but everywhere especially Nigeria. Surface water pollution with chemical, physical and biological contaminants by anthropogenic activities is of great environmental attention all over the world (Parinet, *et al*., 2004; Ouyang, *et al*., 2006). Surface water systems mean the waters naturally open to atmosphere, for example Rivers, lakes and reservoirs water (Ouyang, 2005). Rivers plays important role in carrying off municipal and industrial wastewater and run-off from farm land, and are one of the most susceptible water bodies to pollutants (Singh, *et al*., 2004; Singh, *et al*., 2005). The constant discharges of domestic and industrial wastewater and seasonal surface run-off due to the climate have strong effect on water quality. However, Rivers are the main water sources for domestic, industrial and agricultural irrigation purposes (Yu and Shang, 2003; Yusuf, *et al*., 2013), River water quality has important factors with health of human and living beings (Wang, *et al*., 2007). Therefore, it is imperative to have reliable information on water quality for effective pollution control and water resource management. There are needs to evaluate the River water quality (Bouza-Deaño, *et al*., 2008; Razmkhah, *et al*., 2010). Rivers and lakes in industry and agricultural areas may be contaminated with waste, pesticide, fertilizer and other contaminants. There concentrations may vary with time and seasons. Some contaminants that enter aquatic systems are capable of influencing the population of macro-invertebrates, aquatic animals and ends up in mammals that consume them as food (Otokunefor and Obiukwu, 2005; Trivedi, *et al*., 2009; Ubwa, *et al*., 2013). The increase in human population and economic activities has grown in scale; the demands for large-scale suppliers of fresh water from various competing end users have increased tremendously (Gholikandi, *et al*., 2012). The decline in the quality and quantity of surface water resources can be attributed to water pollution and the improper management of the resource (Mustapha and Nabegu, 2011; Tanrıverdi, *et al*., 2010). In recent years, there has been increasing concern about, surface water pollution and new approaches toward the sources of pollutants and achieving sustainable exploitation of water resources. It is correct to say that good water quality produces healthier humans than one with poor water quality (Balk, *et al*., 2003; Sinha, *et al*., 2000). Monitoring different aspects of water quality over time enables changes to the aquatic environment to be detected. Measuring a combination of these parameters allows for a complete picture the status of water resource to emerge. If only physical or chemical parameters are measured, it is difficult to gauge the impact they have on the life. If drinking water supplies become contaminated with microbial pathogens, there is a risk of microbiological toxicity, immediate action should be taken to protect public health.

Study Area

The research location was Eket local government area of Akwa Ibom State, Nigeria as shown in Fig 1. At the right, lies the map of Nigeria, stained with a dark ink and indicated by a blue arrow pointing to the map of Akwa Ibom State at the south-south direction (Fig. 2). The Akwa Ibom State map is carved out to show the map of Eket indicated by a green arrow. Eket is the second largest city in Akwa Ibom State, Nigeria. The name also refers to the indigenous

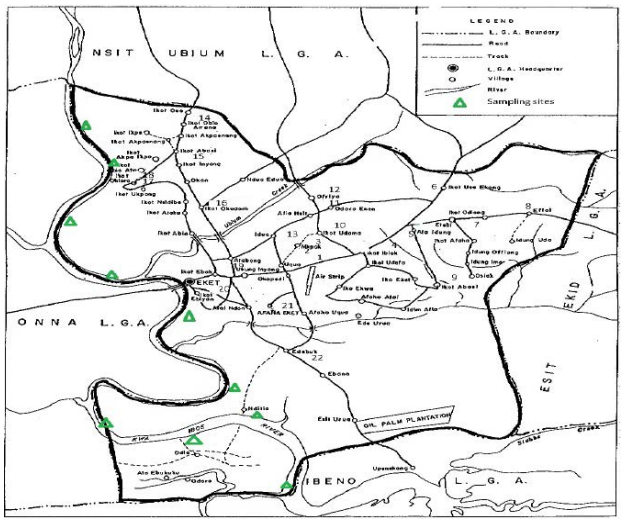

Fig. 1 Map of Eket local government area, Akwa Ibom State.

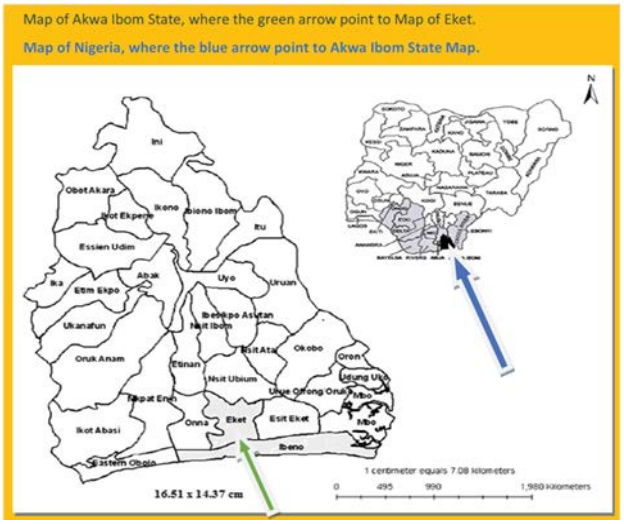

Fig. 2 Geography of the project location showing the map of Nigeria and Akwa Ibom State.

ethnic group of the region and their language. Eket Local Government area (LGA) occupies the South central portion of Akaw Ibom State. It lies entirely in the tropics with territorial expense, spanning Northwards between Latitude 4°33″ and 4 45″ and Eastward between Longitude 7°52″ and 5°02″. Eket is bounded on the north by Nsit Ubium LGA, on the east by Esit Eket LGA, on the west by Onna LGA and on the south by Ibeno LGA/Bright of Bonny.

Eket has a population of 172,557, where the males are 88,563 and 83,994 (NPC, 2006). Recently, in April 2014, the government of Akaw Ibom State directed the ministry of economic development Uyo, to release a projected population growth beginning from 2007 to 2015 by adopting the 2006 population census figures. The document contained 2013 to 2015 population and approximated area (km^2) and population density of inhabitants per km^2. Eket LGA only, have a projected population of 218438 in 2013 and it was estimated that by 2015, the population will increase to 233,544 where the females will be 113,289 and males 120,255 dominant in 176000km^2. Eket is an industrial city that houses various infrastructures of importance.

MATERIALS AND METHODS

Sampling Locations

Four sampling locations were marked out to collect twelve sample points. The sampling locations were established based on ecological settings and human activities. They are approximately 1 kilometre apart from each other. A total of 3 km was covered from one to location four.

Location 1: This sampling point forms the upstream. It is located along Ikot Ikpe and Ikot Akpoenang at latitude 4°55.8'' and longitude 7°40.8'' see Fig 1. Activities are mainly fishing and boat making at the River bank. The water is relatively clean by human eye-sight evaluation see Fig 3 for illustration.

Location 2: Location 2 receives effluents from slaughter houses along Ikot Aroku and Ikot Naidiba Village Road. Household from residential houses are discharged into the River. The main activities are mining and loading of sand for commercial purposes. It is about 1 km away from station 1 and located at latitude 4°22.9'' and longitude 7°13.8''.

Location 3: This is found along Eket-Etinan Road, within Ebiyan and Ndon directly opposite Onna Local Government Area. Activities include Cars washing, Clothes and bathing. The vegetation is dominated with bamboo trees. It is about 1km away from location 2 and located at latitude 4°23.2''and longitude 7°40.2''.

Location 4: This is located at Ndilla, the opposite villages across the River are Odio and Ale Ebukuku. This descended into Ibeno local government area, see Fig 1. The human activities include fishing and mining. Vegetation is mainly mangrove. This area is turbid due to the discharge of much wastes, it is deep due to mining activities. It is about 1km from location 3 at latitude 4°43.5'' and longitude 7°53.3''.

Collection of River Water samples

River water samples were collected using 12 syringes, each 2mL at twelve different points on the 2nd May, 2015 between 10 a.m to 3 p.m along the coast. The samples collected were serially diluted before inoculation within 30 minutes.

Reagents and Chemicals

All reagents and chemicals used for this study are of analytical grades and are obtained from University

Fig. 3 The Qua Ibeo river, showing the human activities and the growing City.

of Nigeria, Nsukka laboratories. Such reagents include: Water sample, nutrient agar, nutrient broth, saubourad dextrose agar (SDA), macconky agar, sterilized normal saline, distilled water, and gram staining reagents (crystal violet, 75% ethanol, lugus iodine, safranin, malachite green), citrate, and glucose, sodium chloride and urease reagent.

Sample Collection and Storage for BOD_5 analysis

A thoroughly cleaned non-biodegradable plastic container was used to fetch out River water samples from twelve different locations of Eket community. A 5 Litre of each sample was empty into 12 amber bottles. The bottles were capped (to prevent further oxygen dissolution by aeration) and later stored in the dark (to prevent increase dissolved oxygen via photosynthesis by planktons) under a constant temperature range of 1°C to 4°C since the sample was not to be analysed within 2 hours (APHA *et al.*, 1995).

Total viable count (TVC) and mould count

A quantity 0.5% W/V glucose enriched over-dried nutrient agar plates were prepared. The dilution factor was determined via 10 fold serial dilution technique by diluting 1mL of water sample into 9 mL of the sterile water to obtain 10^{-2} dilution. The over-dried glucose enriched nutrient agar plate was divided with permanent marker into 8 equal parts. Using a precision pipette, 0.02 mL volume of 10^{-2} dilution was made on each of the eight segments. The plates were allowed to stand for 15mins to ensure proper absorption before incubation at 37 °C for 24 hours. TVC, coliform count at 25 °C for 48 hours for mould count. After the due period of incubation, the colonies were counted and the mean colony count per drop (MCC/d) was calculated using equation 1 below.

$$\frac{\frac{MCC}{drop}\times\frac{1}{dilution}factor}{0.02mL} \quad (1)$$

Where MCC = mean colony count.

The original cell population (OCP) was calculated and recorded in Cells/mL using equation 2 below.

$$OCP=\frac{MCC}{drop}\times\frac{1}{dilution}factors/0.02mL \quad (2)$$

Determination of Bio-load via surface viable count method

Biochemical oxygen demand test

Biochemical oxygen demand (BOD_5) is the traditional test used to establish the concentration of organic matter in water sample.

Procedure for BOD_5 Test

A 300 mL of dechlorinated water samples (using sodium sulphite) and pH adjusted to 6.5-7.5 was added to specially design well-labelled BOD bottles. The water inside the bottles was aerated in then 1mL each of the potassium phosphate, magnesium sulphate, calcium chloride, and ferric chloride solutions per 1 L of water sample was added. The bottles were shake for about one minute to dissolve the slurry and saturate the water with oxygen. The temperature of the sample using thermometer and ensure it stabilizes at 20 °C ± 1°C was determine. The initial dissolved oxygen (DO) of each sample was measured with DO meter. The sealed BOD sample bottles were placed in the air incubator and incubated at 20 °C ± 1°C for 5 days. At the end of the five days incubation ± 4 hours, the dissolve oxygen DO was determine in each sample using a DO meter and data were computed using equation 3.

Calculation

$$BOD5=\frac{DO1-DO5}{p-value} \qquad equation \quad (3)$$

Where:

DO1= initial DO of the samples before incubation

DO5= final DO of the samples after 5 days incubation.

P-value= decimal volumetric fraction of sample used.

Statistical analysis

Data obtained was inputted into Statistical Package for Social Sciences (SPSS) software version 16 and analysed using analysis of variance (ANOVA). The results is presented as mean ± standard deviation for three determination. To support data analysis the result is presented in tables, following descriptive interpretation.

RESULTS

Bacteriological assessment and Physiological Characteristics.

The cultural characteristics of bacteria present in water samples from Qua-Iboe River are shown in Table 1.

Key: += detected; - = not detected

Total mould counts, Total viable bacterial counts and total coliform counts of water samples from Qua-Iboe River.

The results of the total mould count, total viable

count and total coliform count of water samples from Qua-Iboe River are shown in Table 2.

Key: TMC = Total mould count; TVC = total viable count; TCC = total coliform count

Biochemical and Physical Characteristics

Table 3 shows the results of cell biochemical characteristics of bacteria from water samples obtained from Qua-Iboe River.

Key: Characterization of samples with the inscription * and ** above was done using fungal atlas because of the fungal characters exhibited on the culture medium and presented in Table 4 below.

Results of fungal atlas assay of samples 2 and 3

Table 4 showed the results of samples 2 and 3. Cultures of samples 2 and 3 have rapid growth with rough texture. Culture of sample 2 gave dark-green colour on the third day with scattered sporangiophore while sample 3 gave yellow, non-septate hypha.

Key: + = detected; - = not detected

Microbial/ biochemical tests on water samples from Qua-Iboe River

Results of microbial/ biochemical tests was carried out to confirm the microbes identified in water samples as shown in Table 5. The result identified *Serratia liquefaciens* a representation of the samples 3 and 4, and *Proteus vulgaris* was identified in samples 1, 2 and 5 respectively.
Key: -ve= Negative test result; +ve= Positive tests result

Results of the physicochemical properties of water samples from Qua-Iboe River

The results of the physicochemical properties of water samples is shown in Table 6.

All results are mean ± SD for 3 determinations

Table 1. Characterisation of organisms in water samples from Qua-Iboe river

Samples (SP)	Temperature (°C)	Turbidity (NTU)	pH (mol/L)	Conductivity (µS/cm)	Colour	Odor
SP1	23 ± 0.30	2.35 ± 0.10	6.48 ± 0.3	158 ± 0.3	Colourless	Unobjectionable
SP2	25 ± 0.10	2.24 ± 0.10	6.52 ± 0.2	178 ± 0.1	Colourless	Unobjectionable
SP3	25 ± 0.10	2.11 ± 0.20	5.84 ± 0.3	162 ± 0.1	Colourless	Unobjectionable
SP4	23 ± 0.30	2.30 ± 0.10	6.61 ± 0.1	155 ± 0.3	Colourless	Unobjectionable
SP5	26 ± 0.11	2.25 ± 0.20	6.83 ± 0.1	189 ± 0.1	Colourless	Unobjectionable
SP6	26 ± 0.11	1.56 ± 0.30	5.88 ± 0.3	221 ± 0.1	Colourless	Unobjectionable
SP7	23 ± 0.30	2.13 ± 0.20	6.12 ± 0.2	168 ± 0.2	Colourless	Unobjectionable
SP8	27 ± 0.20	1.42 ± 0.10	5.70 ± 0.3	231 ± 0.2	Colourless	Unobjectionable
SP9	25 ± 0.10	2.14 ± 0.10	6.20 ± 0.2	129 ± 0.3	Colourless	Unobjectionable
SP10	24 ± 0.30	1.11 ± 0.20	5.66 ± 0.3	90 ± 0.3	Colourless	Unobjectionable
SP11	25 ± 0.20	1.00 ± 0.20	4.98 ± 0.4	123 ± 0.3	Colourless	Unobjectionable
SP12	26 ± 0.10	2.30 ± 0.10	6.40 ± 0.2	145 ± 0.3	Colourless	Unobjectionable
WHO Specification	25-32	1.0-5.0	6.5-7.2	100-300	Colourless	Unobjectionable
All results are mean ± SD for 3 determinations						

Table 2. Total mould count, total viable count and total coliform count of water samples from Qua-Iboe river

Sample (SP)	(DO_1) (mg/L)	(DO_5) (mg/L)	P-Value (100 ÷ 300)	ΔDO (mg/L) (DO_1–DO_5)	BOD_5 (mg/L) [(DO_1 –DO_5) ÷ 0.3]
SP1	4.2	3.6	0.33	0.6	1.820 ± 0.110
SP2	5.1	4.7	0.33	0.4	1.210 ± 0.100
SP3	4.0	3.4	0.33	0.6	1.820 ± 0.111
SP4	4.1	3.8	0.33	0.3	0.910 ± 0.210
SP5	4.0	3.5	0.33	0.5	1.520 ± 0.120
SP6	3.5	3.1	0.33	0.3	0.910 ± 0.220
SP7	3.8	3.6	0.33	0.2	0.610 ± 0.300
SP8	3.6	3.1	0.33	0.5	1.520 ± 0.200
SP9	5.2	4.9	0.33	0.3	0.910 ± 0.190
SP10	3.1	2.6	0.33	0.5	1.520 ± 0.200
SP11	3.3	2.9	0.33	0.4	1.210 ± 0.113
SP12	4.2	4.0	0.33	0.2	0.610 ± 0.213
WHO		≤ 1.0		1-8.00	
All results are mean ± SD for 3 determinations					

Table 3. Results of cell characteristics of bacteria from the Qua-Iboe River water sample

Sample S/N	Shape	Arrangement	Colour	Gram character	Spore character
SP1	Rod	Single	Pink	Negative	Negative
SP2	*	*	*	*	*
SP3	**	**	**	**	**
SP4	Rod	Single	Pink	Negative	Negative
SP5	Rod	Single	Pink	Negative	Negative
SP6	Cocci	Pairs, tetrad	Purple	Positive	Negative
SP7	Rod	Single	Pink	Negative	Negative
SP8	Rod	Single	Pink	Negative	Negative
SP9	Rod	Single	Pink	Negative	Negative
SP10	Rod	Single	Pink	Negative	Negative
SP11	Rod	Single	Pink	Negative	Negative
SP12	Rod	Single	Pink	Negative	Negative

Table 4. Results of fungal atlas assay of samples 2 and 3

Sample	Cultural Characteristics	Colour	Microscopic Characteristics	Fungal atlas	Organisms
SP2	Rapid growth with rough texture	Dark-green colony observed on the third day	Non-septate hypha. Scattered sporangiosphore	+	*Aspergilus flavus*
SP3	Rapid growth with rough texture	Yellow colour on the third day	Non-septate hypha.	+	*Aspergilus niger*

Table 5. Bacterial biochemical tests on the Qua-Iboe River water sample

Samples Lactose	Oxidase		Indole Organism		Urease	Motility	H_2S
SP1	-ve	-ve	-ve	-ve	Motile	-ve with no pigment	*Serratia liquefaciens*
SP2	-ve	-ve	-ve	-ve	Motile	-ve with no red pigment	*Seratia liquifaciens*
SP3	-ve	-ve	+ve	+ve	Non-motile	+ve	*Proteus vulgaris*
SP4	-ve	-ve	+ve	+ve	Non-motile	+ve	*Proteus vulgaris*
SP5	-ve	-ve	-ve	-ve	Motile	-ve with no pigment	*Seratia liquifaciens*

Table 6. Physicochemical properties of water samples from Kwa-Iboe River

Samples (SP)	Temperature (°C)	Turbidity (NTU)	pH (mol/L)	Conductivity (µS/cm)	Colour	Odour
SP1	23 ± 0.30	2.35 ± 0.10	6.48 ± 0.3	158 ± 0.3	Colourless	Unobjectionable
SP2	25 ± 0.10	2.24 ± 0.10	6.52 ± 0.2	178 ± 0.1	Colourless	Unobjectionable
SP3	25 ± 0.10	2.11 ± 0.20	5.84 ± 0.3	162 ± 0.1	Colourless	Unobjectionable
SP4	23 ± 0.30	2.30 ± 0.10	6.61 ± 0.1	155 ± 0.3	Colourless	Unobjectionable
SP5	26 ± 0.11	2.25 ± 0.20	6.83 ± 0.1	189 ± 0.1	Colourless	Unobjectionable
SP6	26 ± 0.11	1.56 ± 0.30	5.88 ± 0.3	221 ± 0.1	Colourless	Unobjectionable
SP7	23 ± 0.30	2.13 ± 0.20	6.12 ± 0.2	168 ± 0.2	Colourless	Unobjectionable
SP8	27 ± 0.20	1.42 ± 0.10	5.70 ± 0.3	231 ± 0.2	Colourless	Unobjectionable
SP9	25 ± 0.10	2.14 ± 0.10	6.20 ± 0.2	129 ± 0.3	Colourless	Unobjectionable
SP10	24 ± 0.30	1.11 ± 0.20	5.66 ± 0.3	090 ± 0.3	Colourless	Unobjectionable
SP11	25 ± 0.20	1.00 ± 0.20	4.98 ± 0.4	123 ± 0.3	Colourless	Unobjectionable
SP12	26 ± 0.10	2.30 ± 0.10	6.40 ± 0.2	145 ± 0.3	Colourless	Unobjectionable
WHO Standard	25-32	1.0-5.0	6.5-7.2	100-300	Colourless	Unobjectionable

Results of biochemical oxygen demand of water samples from Qua-Iboe River

Table 7 showed the result of biochemical oxygen demand of water samples. Sample 11 have the highest BOD_5 while sample 5 have the lowest BOD_5.

All results are mean ± SD for 3 determinations; ΔDO is change in dissolve oxygen.

Table 7. Results of biochemical oxygen demand of water samples from Qua-Iboe River

Sample (SP)	(DO1) mg/L)	(DO5)(mg/L)	P-Value = (100 ÷ 300)	ΔDO (mg/L) (DO1–DO5)	BOD5 (mg/L) [(DO1 –DO5) ÷ 0.3]
SP1	5.2	3.8	0.33	1.4	4.220 ± 0.110
SP2	5.1	3.6	0.33	1.5	4.210 ± 0.100
SP3	4.8	3.6	0.33	1.2	3.720 ± 0.111
SP4	4.4	3.7	0.33	0.7	2.610 ± 0.210
SP5	4.0	3.3	0.33	0.7	1.920 ± 0.120
SP6	3.9	3.3	0.33	0.6	4.210 ± 0.220
SP7	5.3	3.9	0.33	0.4	3.610 ± 0.300
SP8	3.9	2.6	0.33	0.3	4.100 ± 0.200
SP9	5.4	3.9	0.33	0.5	2.910 ± 0.190
SP10	4.6	3.9	0.33	0.7	5.120 ± 0.200
SP11	5.3	2.9	0.33	0.9	3.410 ± 0.113
SP12	4.6	3.4	0.33	0.2	3.310 ± 0.213
WHO Standard	≤ 1.0		1-8.00		4.0

DISCUSSION

The increase in human population and economic activities especially around rivers has grown; the demands for large-scale suppliers of fresh water from various competing end users have increased tremendously (Gholikandi *et al*. 2012). The decline in the quality and quantity of surface water resources can be attributed to water pollution and the improper management of the resource (Mustapha and Nabegu, 2011). (Meinhardt, 2006) has highlighted susceptible population to waterborne diseases to include pregnant women, children, immune-suppressed individuals, geriatric patients and patients with pre-existing clinical disorders and chronic diseases. Nearly 40,000 cases cholera epidemic were reported in 11 states in Nigeria from January–October 2010, out of which 1,500 people were confirmed dead (Ali, *et al*., 2012). Diarrhoea is the second largest cause of children's mortalities in Nigeria according to (Water Initiative, 2010). Nigerian children of age less than 5 years make up 17% of the total annual deaths of 1.8 million recorded globally due to poor sanitation (Water Initiative, 2010). Results obtained in this study show that locations with high human activities (industrial, agricultural and mining) showed higher temperature, low pH, higher conductivity and high biochemical oxygen demand (BOD). The BOD_5 of some samples is higher compare the WHO permissible 4.0 mg/dl (Shittu, *et al*., 2008). The total viable counts (TVC) was generally high exceeding the WHO limit of 1.0 × 102 Cell/mL, a standard limit of TVC for drinking water (EU, 1998; Fakayode, 2005). TVC is indicative of the presence of high organic and dissolved salts in the water. The primary sources of these bacteria in water are animal and human activities. Sample 1 showed the highest TVC value which is collected from location 2 with heavy human and animal activity. The results showed reflects the activities around the water. All samples were found to have TVC higher than the WHO standard (1.0 x 106 Cell/mL) (Shittu, *et al*., 2008). The TVC was lower in samples 2, 3, and 6 compared to samples 1, 4 and 5; a similar result was reported by (Olayemi, 1994). The total coliform counts (TCC) for all samples was exceedingly higher than the WHO standard for coliform bacteria in water, where zero total coliform per 100mL of water is advocated. Result also revealed total coliform counts (TCC) for various samples corresponding to source nomination were high. The high coliform counts obtained may be an indication that the water received faecal contamination. (Martin, *et al*., 1982) have similarly reported contaminations in the coliform counts. None of the samples corresponding to the various sampling points of the water sources complied with WHO standard for coliform in water and this could be supported with evidence advanced by (Shittu, *et al*., 2008). According to WHO standard, every water sample that has coliform must be analysed further to ascertain contamination with human or animal waste and possibly pathogenic bacteria. WHO guideline (WHO, 1993) also stated that the total bacterial counts of a given drinking water should not be above 100 cfu/100mL. The presence of both gram-positive and gram-negative bacteria, including the presence of fungal species was indicated. Two genera bacteria (*Proteus and Serratia*) and one genus fungus (*Aspergillus*) were isolated and characterized using Biochemical tests and fungal atlas assay techniques, see Tables 4 and 6. Further characterization confirmed *Proteus vulgaris* and *Seratia liquifaciens* as major contaminants. *Seratia liquifaciens* has been implicated to induce acute liquefactive necrosis on the cornea and the specie

is resistant to antibiotics (Singleton, *et al*., 1992). *P. vulgaris* is an opportunistic pathogen with numerous factors including *fimbriae*, flagella, outer membrane proteins, lipopolysaccharide, capsule antigen, urease, immunoglobulin A proteases, hemolysins, amino acid deaminases. Finally, the most characteristic attribute of *Proteus*, swarming growth, enable them to colonize and survive in higher organisms. *Proteus vulgaris* is commonly responsible for urinary and septic infections. *Proteus vulagris* has a number of putative virulence factors, including the secreted hemolytic, which has been suggested to contribute to host cell invasion and cytotoxicity, an inducible urease, by generating ammonia; causes precipitation of bladder and kidney stones; fimbriae which promote bacterial adherence to the uroepithelium, a secreted protease able to digest immunoglobulins (Cabral, 2010). Also detected in the samples were *Aspergillus species*, the most ubiquitous fungi seen in soil, water and decaying vegetation. It affects the lungs, central nervous system, naso-orbital area, skin and sometimes, it may be disseminated. Cutaneous aspergillosis is mostly caused by *A. flavus, A. fumigatus,* and rarely, by *A. niger*. Clinically, the lesion is characterized by macules, papules, plaques or haemorrhagic bullae, which may progress into necrotic ulcers that are covered with heavy black eschar (Gangil, *et al*., 2013). In the light of this investigation, it is suggested that application of Qua-Iboe River should be subjected to treatment.

CONCLUSION

The implication of this finding is that Qua-Iboe River is not a safe source of drinking water; however, such water source can be used for agricultural purposes like irrigation farming. Alternatively, it is strongly suggested that water obtained from this source may be used for domestic purposes should be purified using suitable purifying agents, installation of water filters and use of boiled water for drinking purposes.

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