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Research Article

Assessment of Physico-Chemical Parameters and Bacteriological Quality of Drinking Water Obtained from Batang Stream in Bendeghe Ekiem, Etung- Cross River State-Nigeria

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Abstract

Aim: To assess the physico-chemical parameters and bacteriological quality of drinking water obtained from Batang stream in Bendeghe Ekiem, Etung- Cross River State-Nigeria.

Methods Standard physico-chemical and bacteriological techniques were used in the analysis to determine potability of the stream water. Membrane filtration (MF) and multiple tube dilution (MTD) were used in estimation of total coliforms and fecal coliforms present in the samples. A total of six (6) water samples (A-F) were obtained from three (3) different points within Batang stream and tap water (G) was used as positive control and distilled water (H) used as negative control. Biochemical tests were carried out for the identification and characterization of various microorganisms isolated from the water samples.

Results: The presence of Iron (Fe+) was 1.8mg/L as compared to WHO standard of 0,03mg/L. Also, biological oxygen demand (BOD) was 6.51mg/L, above WHO standard range of 1.0-5.0. There was a significant difference at $p>0.05$ for Nitrite content of 1.20mg/L when compared with WHO standard of 0.02mg/L. Similarly, ammonia gas content was 1.80mg/L when compared with WHO standard of 0.00mg/L. Turbidity was significant at $p>0.05$ with a value of 9.20NTU when compared with WHO standard of 5.00NTU. The different microorganisms isolated were *Klebsiella pneumoniae, Escherichia coli, Shigella perfringens, Enterobacter aerogenes, Clostridium perfringens, Salmonella paratyphi and Streptococcus faecalis, Enterococcus faecalis, Bacillus subtilis, Pseudomonas spp.* Total heterotrophic coliform count and total fecal coliform counts in the water samples were too numerous to count (TNTC) as compared with World Health Organization(WHO) standard for drinking water, which is MCLG=0/100mL of drinking water samples. The coliforms and fecal coliform levels of Batang stream drinking water was highly significant at $p<0.05$ when compared to WHO standard.

Conclusion: The results obtained from this study have revealed a significant bacterial load in the drinking water which made the water source unsafe for drinking. There is need for public health awareness on proper treatment of water before consumption due to the high risk its contamination poses, as the only source of drinking water in this community.

Keywords: Physico-Chemical; Bacteriological Quality; Potability; Batang Stream

Introduction

Water is the most essential requirements for living things [1]. Water gives life and is a necessity to our daily life, social organization, economic, ambition and function [2]. It is one of the most important natural resources on earth [3]. It is one of the most important natural resources on earth (ref). It isknown to support certain life-forms and fulfill basic life sufficiency demands though it contains no calories or organic nutrients, with chemical formula H2O, meaning two (2) atoms of hydrogen and one atom of oxygen connected by covalent bonds [4]. Water occupies about 70% of the earth surface and about 65% of the human body [5]. Pure water is transparent, tasteless, odourless and free from any fecal pollution [6]. A trusted source of clean potable water is essential to good health and continuous existence [7]. In Nigeria, safe and potable water supplies has been challenging and inadequate despite the country's endowment with abundant surface and sub-surface water resources, and spirited efforts by the government through its agencies to ensure safe drinking water, Nigeria is still faced with the challenge of poor or inadequate potable water supply for its residents [8]. The government have been committed to the different developmental programmes such as Millenium Development Goal (MDG) (2015) and Sustainable Development Goal (SDG) (2017), to alleviate these problems, among the rural poor, who are more vulnerable [9]. The effect of polluted water sources on the lives of the rural communities cannot be over emphasized. There is therefore need for adequate potable water to be provided to fulfill basic human needs, development, health and well-being of the citizenry, besides, it is an internationally accepted human right [10]. The availability of potable water is an indispensible feature of preventing disease such as diarrhea and related water borne diseases and to improve quality of life. The problem of providing portable drinking water is habitual in Nigeria [11]. The vast water resour-

ces in Nigeria is categorized into fresh and surface water which includes oceans, rivers, streams, lakes etc and groundwater which depends on rain fall and underground water storage in the ground [7]. Half of the population have access to safe drinking water in the urban city centers, while the rural population suffer to obtain water [12]. Most of the available water is polluted by contaminants, brought about by human activities such as oil and gas (petroleum product), fecal pollution, agricultural pollutants etc., sadly, these have brought about high negative impact on health and economy of the citizens [12]. Water has been described as vehicle for the transmission of microbial diseases, especially cause by coliforms [13]. High rate of infections and mortality have been reported in Nigeria as a result of water-related diseases, such as water-borne disease like cholera, dysentery, typhoid fever and diarrhea, water-contact disease such as trachoma, water- based diseases like: bilharziss, guinea worm, schistosomiasis etc. and malaria, cause by insect vector in polluted water [5]. Batang stream is an all purpose water body in Bendeghe-Ekiem community, a largely agrarian community, who depends on the stream for their drinking water, household, farm and other services, this water body may serve as a reservoir for water related diseases, if left unchecked. The situation is worsened by poor sanitary conditions coupled with poor terrain, which makes the land erosion prone. Also, the large human population of the village and its adjoining farm settlements have made the stream vulnerable to contamination.

This research is aimed at assessing the physico-chemical and bacteriological quality of Batang stream, the only source of drinking water for Bendeghe-Ekiem people, an agrarian community in Etung Local Government Area of Central Cross River State- Nigeria and high-lighting the water pollution problems inherent and proposing sustainable development solutions for potable water.

Materials and Methods

Collection of samples

The stream water (samples) was collected randomly at three different points at a distance of 5m apart, (A, B, C) at the depth of 20 – 30cm, in Batangstream. The water was collected into six (6) 100mLsterile sample bottles two times daily for 30 days. These samples were taken to the Cross River State Water Board laboratory for analysis. Samples were labeled A-F for convenience. Sample- G was municipal water and it served as positive control, while sample- H was distilled water which served as negative control.

- **Study Area:** Batang stream is an all-purpose water source located in Bendeghe Ekiem, anagrarian community in Etung Local Government Area in the central part of Cross River State - Nigeria.
- **Methods:** Standard aseptic**ally**physico**-**chemicalandbacteriologicalmethodswereusedintheanalyses**.**
- **Physico-chemical Analysis:** The presence or absence of the following physic-chemical parameters were assessed;
- **Colour:** A coloured test kit (Lovibon Comparator 2000 Visual) was used to determine the colour of the sample. Alovibon comparator matched tube was filled with 50ml of the sample water and the other tube filled with distilled water was used as control. This step was repeated for all the samples. The two tubes were placed on a comparator. NSA disc was inserted and on rotation, the nearest colour match was recorded as positive, and results reported in whole number as Hazen unit [6].
- **Temperature:** The temperature of the samples were taken at water sampling site, using mercury-in-glass thermometer, this was done by dipping the thermometer into water and allowing it to stand for one minute before direct reading was taken [2].
- **pH:** A standard pH meter (Toledo, MP 220) was used to determine the pH of the water samples. The pH was standardized in a pH solution (buffer solution) at 7.0 before inserting the pH meter probe into a beaker of 100cm^3 of water samples to determine the pH of the sample and readings taken. The process was repeated for each water sample and the probe was standardized after each reading.
- **Turbidity:** The turbidity of all the water samples was determined using turbidometer (HANA instrument H193703) and readings expressed in whole number as Nephelometric Turbidity Unit (NTU) as described by Sheshe and Magashi [5]**.**
- **Conductivity:** Digital conductivity meter model 4522 JENWAY, Serial number 01264 was used to determine electrical conductivity of water samples. This test was carried out as described by Sheshe and Magashi [5]. The probe was standardized with 0.01M KCl solution and rinsed in distilled water, after which, it was immersed into sample again and values recorded.
- **Nitrite and Nitrate:** A portable UV-visible spectrophotometer (HACH D 89) was used determine the nitrite and nitrate content of the water sample, according to the method described by AOAC (2006). The formation of amber colour after 5min, indicated the presence of nitrite. On addition of nitraver 3 reagent powder, colour formation was observed after 5min. The formation of pink colour, indicated presence of nitrite. Absorbance was measured in mg/L.
- **Total Hardness:** Spectrophotometry method was used to determine Total Hardness of each water sample. One milliliter of water sample was put in a reaction cell and 1ml of total hardness reagent (H-1K) added with pipette and allowed to stand for 3min, before recording the results at wavelength of 450m.
- **Heavy Metal:** Determination of the following heavy metals: Iron (Fe), Lead (Pb), Copper (Cu), Zinc (Zn), Arsenic (As) and Manganese (Mn) in the water sample was done using AAS (Buck Scientific, VPG 210) procedure as described by Sawere and Uwagwue [14] and Nwabor., *et al.* [1] and results obtained recorded.
- **Fluoride:** Fluoride in water sample was determined using the method described by AOAC (2006). Ten (10) milliliters of water sample was put in dry sample cells and 2cm^3 of SPADNS reagent added and shaken gently to mix for 1min. The absorbance of the sample was read from spectrophotometer.

- **Total Dissolved Solids (TDS):** The total dissolved solids TDS) for each sample was determined mathematically using the formula: TDS = Conductivity x 0.5. Where: 0.5 is a constant.
- **Total Suspend Solids (TSS):** The filter paper was used to determine the total suspended solids by weighing the filter paper and recording its initial weight. Then 100ml of the sample water filtered using the filter paper and oven dried at 50^0C for 1hr. Then the filter paper was re-weighed and final weight recorded. The TSS is the difference between the final and initial weight of the filter paper.

Biological Oxygen Demand (BOD)

This process was determined by titration method.

Bacteriological analysis

The membrane filtration (MF) method of water analysis was used, according to AWWA and APHA (1998) using Millipore HA, 0.45mn pore-size membrane filters (Millipore, Corporation, Bedford, MA). Water sample was filtered through the membrane. With the use of sterile forceps, the membrane was removed and placed on the surface of nutrient agar plate, and EMF and MacConkey Agar plates with Eosin methyl blue (EMB), and incubated upside for 24 hours at 44oC for optimum growth of fecal coli forms. After incubation, the colonies were observed and enumerated. The isolates were identified and characterized by using biochemical tests.

Antibiotic and susceptibility test

The antibiotic sensitivity profile of isolates obtained from samples was carried out using the paper disc diffusion technique of Kirby-Bauer. An 18h culture inoculated on Mueller-Hinton Agar plates was used. Discs impregnated with appropriate antibiotics were placed 5cm apart on the surface of the agar medium. Susceptibility or resistance were determined by presence or absence of zones of clearance or inhibition created by antibiotic used.

Results

The results of the mean physico-chemical properties of the Batang Stream water samples located in Bendeghe-Ekiem-Etung L. G. A. in Cross River State is presented in Table 1. The results showed mean turbidity as 9.00NTU as against World Health Organization (WHO) standard of 5.00NTU. Similarly, Iron (Fe) was 1.36mg/L when compared with WHO standard of 0.30mg/L. BOD was 6.51 as against the 1.0-5.0 WHO range. Total coliform and fecal coliform counts were too numerous to count (TNTC) per 100mL/cfu. Ammonia was 1. 80µg/L as compared to WHO standard of 0.00µg/L. Nitrite level was 1.20mg/L as against WHO standard of 0.00.

S/N	Parameter/unit	Sample	NSDWQ/ WHO
1	Temperature (oC)	28.5	Ambient
2	pH	5.64	6.5-8-5
3	Colour (H.U)	L5	30
4	Turbidity (NTU)	9.20	5.0
5	Conductivity (µs/cm)	46.7	1000
6	Total Hardness (mg/I)	68.0	100
7	Calcium Hardness (mg/I)		
8	Magnesium Hardness (mg/I)		
9	Alkalinity (mg/I)		
10	Total Chlorine (mg/I)	ND	0.5
11	Free Chlorine (mg/I)	ND	0.2
12	Iron (mg/I)	1.76	0.30
13	Manganese (mg/I)	0.16	0.1
14	BOD	6.51	1.0-5.0
15	Taste	Unobjectionable	Unobjectionable
16	Odour	Unobjectionable	Unobjectionable
17	Lead (mg/I)		
18	Ammonia (mg/I)	1.8	0.0
19	Nitrate (mg/I)		
20	Nitrite (mg/I)	1.20	0.02
21	Total Dissolved Solids (mg/I)	28.02	500
22	Total Suspended Solids (mg/I)	0.010	0.00
23	Total Coliform Count/100ml/CFU	TNTC	0
24	Feacal Coliform Count/100ml/CFU	TNTC	0
25	Bicarbonate (mg/I)	0	0

Table 1: Mean results of physico-chemical parameters of water samples obtained from Batang Stream in Bendeghe-Ekiem, Etung L.G.A of Cross River State- Nigeria.

Legend: NSDWQ- National Standard for Drinking Water Quality

WHO- World Health Organization

TNTC- Too Numerous to Count

Cfu-Colony for my units

The results of the biochemical identification and characterization of isolates from water samples obtained from Batang Stream in Bendeghe-Ekiem in Etung L. G. A. of Cross River State-Nigeria is presented in Table 2. The following organisms were isolated, *Escherichia coli, Enterococcus aerogenes, Enterobacterfaecalis, Salmonella paratyphi, Bacillus subtilis, Streptococcus faecalis, Shigellaspp, Klebsiellaspp, Staphylococcus aureus* and *Pseudomonas aeruginosa.*

Sample code	Cell morphology	Colonial pigmentation	Gram stain	Catalase	Coagulase	Oxidase	Citrate utilization	Sucrose	Glucose	Mannitol	Lactose	Spore formation	Voges proskeur	Methyl red	Starch hydrolysis	Motility	Nitrate reductase	Indole production	Protein hydrolysis	Gelatin hydrolysis	Most probable organism inference
01	Circular, tetrad convex, water insoluble pigment	White or yellow	+	+				+ A	-	+ A G			-	+	+						*Micrococcus roseus*
02	Short rods	Yellowish green	-	+		+	+	-	+ A		-	-	-	+	-	+	+	-	+		*Pseudomonas aeruginosa*
03	Cocci in clusters	Cream	+	+						-					+				-		*Staphylococcus epidermidis*
04	Long rods	White	+	+			+			+		+	+		+						*Bacillus subtilis*
05	Swarming ring	Dark					-	+ A	+	-	-							+		+	*Proteus vulgaris*
06	Short rods	Red colonies on MacConkey	-	+			-	-	+ G	+	+ G		-	+	-	+	+	+			*Escherichia coli*
07	Cocci in clusters	Yellow or white cream	+	+	+		+	+ A G	+ A G	+ A G	+ A G			+			+				*Staphylococcus aureus*
08	Cocci in chains	Cream	+	-									+	+							*Streptococcus pneumoniae*
09	Cocci in chains	Cream	+	-																	*Streptococcus pyogenes*
10	Regular rods	Cream	+	-				+ A	+ A G	+ A G	+ A	-		+							*Lactobacillus sp*
11	Short rods	White with black centres	-	-		-	+	-	+ A G		+ A			-	+		+	-			*Enterobactersp*
12	Rods		+	+			-	-	+ A G	+ A G	-										*Salmonella typhimurium*
13	Short rods	yellow	-					+	+	-		+									*Flavobacterium aquatile*
14	Rods		+	+												+					*Clostridium sp*
15	Regular rods	White																			*Shigellasp*
16	Regular rods	Mucoid and creamy	-	+										+				-			*Klebsiellapneumoniae*
17	Cocco-bacilli or short rods	Pink or red	-				+	+				-			+	+	-				*Serratia marcescens*
18	Short rods	Green	-	+		+	+	+A	+ A	+ A	+ A		-	+	-		-	+	+		*Pseudomonas cepacia*
19	Rods		+																		*Corynebacterium kutsceri*
20	Rods		+																		*Bacillus cereus*

Table 2: Biochemical characterization and identification of isolates from water samples from Batang stream in Etung L.G.A.

Legend: + = Positive; A = Acid production; - = Negative; G = Gas production

Microorganisms and no. of isolates tested	(50%)	(90%) Range	No. of isolates	percentage susceptibility at MIC (µg/ml) of:			
			Streptomycin (STM) 10µg	Chloramphenicol (CLM) 10µg	Ciprofloxacin (CPX) 5µg	Nalidixic Acid(NLD)10µg	Gentamycin (GNT) 10µg
Staphylococcus aureus	(10) ≤1	3 ≤1-10	15(75%)	0(0%)	18(90%)	0(0%)	12(60%)
Escherichia coli	(4) ≤2	3 ≤1-36	1(15%)	0(0%)	3(75%)	0(0%)	0(0%)
Pseudomonas aeruginosa	(25)10	>36 ≤0.27->36	15(50%)	20(80%)	20(80%)	0(0%)	10(40%)
Bacillus subtilis	(15)10	>36 ≤0.27->36	0(0%)	2(08%)	25(100%)	0(0%)	20(80%)
Salmonella typhimurium	(10)0.5	>36 ≤0.14->18	5(70%)	5(90%)	10(90%)	0(0%)	15(75%)

Table 3: Antibiotic susceptibility profile of some pathogenic bacterial isolates from Batang stream in Bendeghe-Ekiem, Etung Local Government Area, Cross River State-Nigeria.

Legend:

Zone of inhibition ≤ 2mm = Resistant

Zone of inhibition ≥ 7mm = Sensitive

Zone of inhibition ≤ 2mm ≥ 3mm = Intermediate

Discussion and Conclusion

The physico-chemical parameters and bacteriological quality of Batang stream as a drinking source has been investigated. The following parameters were within the World Health Organization (WHO) range: Temperature, pH, colour, conductivity, total hardness and calcium hardness. The results are in agreement with those reported by Okorafor., *et al*. [2] and Sheshe and Magashi [5]. The following parameters were significantly different at p>0.05 as shown in Table 1: Iron (Fe+) was higher than the WHO standard of 0.03mg/L with 1.80mg/L. Sawere and Uwagwue [14] reported that, most contaminated streams and surface water, may have high content of heavy metals. The turbidity of the stream water samples was significantly different at p> 0.05 when compared with WHO standard (9.20NTU as against 5.0NTU. This is in agreement with the results obtained by Okorafor., *et al*. [2], where it was reported that presence of impurities in surface water body may increase its turbidity. Also, elevated levels of ammonia were observed (1.80mg/L) as compared with the WHO standard. The bacteriological quality of Batang stream was compromised by the presence of certain microorganisms in the water samples, especially the presence of fecal coliforms which were too numerous to count (TNTC). This result agrees with that of Edema., *et al.* [11], where it was reported that the presence of fecal coliforms in drinking water, affected the quality of the water and, led to the contamination of the water which made it a potential reservoir for water- related diseases.

The stream being an active flowing water body, during its traverse, picks up impurities in varying amounts, gases from the atmosphere, inorganic and organic salts from topsoil and geological strata may cause contamination, sometimes beyond desirable limits. The presence or absence of organic and inorganic salts in water may determine its quality. Due to continuous human and animals/agricultural activities, there have been slow but steady eutrophication of the stream, these adverse effects of impurities may bring about aesthetically not acceptable coloration which may affect its potability. This contamination may also induce health related problems such as water-borne diseases, water contact diseases, and water –related diseases and probably death of humans and life-forms. The agro-chemicals (fertilizers and pesticides), used by farmers, may sometimes get washed-off into the stream and pollute it, thus affecting its quality. Also, the insanitary conditions of the surrounding areas, unhygienic practices by the natives and discharge/seepage of sewage, erosion and domestic wastewater disposal may affect the quality of water. Poor environmental sanitation of this agrarian community, maybe largely responsible for the contamination of Batang stream as a source of drinking water. Similarly, poor personal hygiene, low public health enlightenment programmes and improper storage of water have affected the portability of Batang stream as drinking water. Besides, these conditions are further compounded by absence of pipe- borne water, poor drainage systems, and lack of appropriate waste-disposal facilities. Lack of social amenities and municipal utilities has impacted negatively to poor personal and environmental hygiene in the locality. Like in most rural areas and villages in Nigeria, Batang Stream is an all-purpose water body that serves as the only source of drinking water, and also as water source for house chores and other life-forms in Bendeghe-Ekiem village, Etung Local Government area of Cross River State-Nigeria. There is therefore, an urgent need for the provision of hygienic and safe drinking water source in Bendeghe-Ekiem and in most rural areas in Nigeria, to prevent outbreak of any water-borne diseases of public health concern.

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