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Surface Water Quality Profile of Flood-Prone Waterfronts in Calabar South Local Government Area of Cross River State

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ABSTRACT

Surface water quality profile of flood-prone waterfronts in three location in Calabar South was investigated using bacteriological and physicochemical parameters. Bacteriologically, Idang had the highest mean total viable counts of $9.0x10^5$cfu/ml as compared to other samples from Jebs (8.2×10^4 CFU/ml) and Anantigha (6.5×10^4cfu/ml). These values far exceed World Health Organization (WHO) and Nigerian standard of 1.0×10^2cfu/ml. Total coliforms count was Too Numerous to Count (TNTC), indicating the high level of fecal contamination. Physicochemical parameters showed that total dissolved solid exceeded WHO standard with 984 mg/l, 911.4 mg/l and 1860 mg/l for Jebs, Idang and Anantigha respectively. Total hardness was also higher in the three locations compared to WHO standard. Iron and manganese contents were also higher. This study has revealed that water sources from the three flood-prone water fronts in Calabar South are unsafe and unfit for human consumption and other domestic uses. It is hereby recommended that these sources should be adequately treated before use.

INTRODUCTION

Water is the most known and most abundant of all known chemical substance which occurs naturally on the surface of the earth (Nwidu *et al.,* 2008). It is fundamentally important to all plants, animals, and man Ajewole (2005), it is a prime solvent and its properties determine many natural phenomena. Water could be found in three states, solid as ice, liquid as water and gas as water vapour (Kuppers, *et al*., 2004) and it can be obtained from a number of sources, among which are streams, lakes, river ponds, rain, springs, ocean and wells (Nguendo, 2011; Orji *et al.,* 2006). Water is a resource that has many uses, including recreation, transportation and hydroelectric power, domestic, industrial and commercial uses (Hemant *et al.,* 2012), it supports all forms of life but can also affect our health, life style and economic well-being (Hemant *et al.,* 2012). Generally, water resource problems are of three main types; too little water, too much water and polluted water (Adebola, 2001), with an urban-rural run off identified as the major pollution problems for most water bodies (River, Lakes, stream etc) today in Nigeria (Adebola, 2001). Flood can bring more rain and can also carry an immense dose of pollutants such as municipal, domestic, industrial and pharmaceutical wastes from the house, industries, hospital dispensaries, community pharmacies and clinics into water ways (Edema *et al.,* 2001). In the investigations of Kuyeli (2007), Adie and Orji *et al.,* (2006); Iskandar (2010), they reported that even with gentle rains, urban and rural runoff is the biggest source of water pollution remaining today, and this may be the primary reason why many sections of rivers in Nigeria remain polluted and fail to meet national and world health quality standards. Approximately one-third of Nigerians live with moderate to high water stress (Adebola, 2001), as the areas where rivers are situated have experienced quick economy development and urbanization and have become economy centers for the populace. This rapid development and corresponding human activities have had severe influences on water environments (Adebola, 2001). Rivers play a major role in assimilation and carrying off of industrial and municipal waste water, runoff from agricultural land, and these constitute the source of pollution and seasonal phenomenon respectively (Akoto and Adiyah, 2007).

Kahara (2002) stated that the rivers themselves are now considered an environmental health hazard due to the high concentrations of chemical and bacteriological pollution and despite this, nearly half of the urban population are at one time or the other, dependent on them as a source of water for domestic use and in worst cases for drinking. Apart from the already well known problems of pathogens and viruses, some emerging causes for concern were highlight

which include endocrine disrupters such as vestrogens, steroids, dioxins, phthalates and alkyl phenol exylates, which would all pose a threat to the food chain if they get into rivers or the sea (Muduli and Panda, 2010; Issaias, 2000; Karikari *et al.*, 2006).

MATERIALS AND METHODS:

Study area

The study was carried out in Calabar South Local Government Area of Cross River State, Nigeria. It lies geographically on latitude $4^0$57'N and longitude $8^0$19'E. The area has both urban features as well as rural settings in the environs of the metropolis.

Collection of samples:

Water samples were collected from flood-prone areas mainly before collection of water samples, the environments were surveyed to examine the sanitary condition of the environment, the factor considered was cleanliness of the area, proximity to refuse dumps, proximity to industrial discharges (effluents), and the physical appearance of the water. Anantigha, Jeb's and Idang stream at a depth of 20 to 30cm into sterile 250ml hottles with glass stoppers. The samples were packed in the cooler containing ice bags to avoid unpredictable changes and were then transported to the laboratory for analysis.

Materials:

a. **Glass ware**: Petri dishes, test tubes, pipette, burette, measuring cylinder, beaker, conical flask, L- shape glass spreader, slides, sample bottles.

b. **Equipment**: Autoclave, incubator, microscope, weighing balance wire loop, spatula, pressure pot, Bunsen burner, (clamp) gas cooker, membrane filtration machine spectrophotometer, hardness total test kit, turbidity meter, mettler teledo, pH meter.

c. **Miscellaneous (other materials used):** Disposable hand gloves, nose mask, cotton wool, foil paper, Whatman filter paper, syringes (2ml and 10ml) hand towel, detergent, methylated spirit, masking tape, matches, test tubes rags.

d. **Reagent**: Ethanol, crystal violet, sofranin, 70% alcohol/ acetone, hydrogen peroxide and Dettol.

Media:

The media used for this study were nutrient agar and MacConkey agar. They were both products of hardy diagnostic ltd, USA and were prepared in accordance with manufacturer's instruction.

Chemical:

Chemicals used for the study were of analytical grade. They include absolute alcohol, methanol (Sigma, USA), P-iodonitrotetrazilium violet (Research organics, USA), neutral red, methyl red indicators, phenol red indicator urea (Titan Biotech, India). Reagents used were oxidase strips, Indole Kovacs and were products of hardy diagnostics, USA.

Bacteriological analysis of samples:

Sample preparation

The membrane filtration method of water analysis was used. Membrane filters of 47mm and pore size of 0.45µm were used according to recommendations by APHA-AWWA (1998). 100mls each of water samples from the streams were then filtered using the afore-mentioned filter papers.

Plating procedures:

The filtered papers were then inoculated on already prepared nutrient agar and MacConkey agar in Petri dishes. The plates were incubated at 44^0C for 24 hours and both total bacteria counts (Nutrient agar plates), and total coliform counts (MacConkey agar plates) were noted.

Purification of isolates:

Following the enumeration of total bacteria and Coliform counts, representatives of observed colonies were selected and sub-cultured repeatedly on nutrient agar for purification. Purified isolates were then stocked in nutrient agar slants for further studies.

Identification and characterization of isolates:

Purified isolates were characterized by gram staining and biochemical tests using the scheme in Bergey's manual of determinative bacteriology (Holt *et al.*, 1994; Cheesbrough, 2000).

Physicochemical analysis of water samples:

The conventional parameters used for assessing the quality of the water samples were;

pH

The pH meter was calibrated by inserting its probe in a standard pH solution at 7.0, then rinsed with distilled water and inserted in the water samples. The pH level was read off above the temperature level displayed on the screen.

Turbidity

The turbidity of the water samples was determined with the use of turbidity meter. The samples were placed in the turbidity bottle and the bottle was wiped clean to erase any fingerprint that may affect the reading. The bottle was then placed on turbidity meter and reading was taken.

Electronic conductivity

Conductivity meter was to determine electrical conductivity. The conductivity probe was rinsed and immersed into the sample and the reading noted.

Total hardness

Total hardness was determined by the spectrophotometric procedure. The procedure involved the addition of 1ml of sample into a reaction cell and 1ml of total hardness reagent (H-1K) was then added with a pipette. Three minutes reaction was allowed before the total hardness was read out in the spectrophotometer at a wavelength of 450m. This method was used for manganese and sulphate and was repeated for all samples.

Total Suspended Solid (TSS)

For the determination of Total Suspended Solid (TSS), the filter paper was weighed using an electronic digital balance and the initial reading noted 100 mls of the sample was then filtered through and the filter oven dried at 50^0C for 1 hour.

The filter paper was then re-weighed and the final weight noted. The difference between the initial and the final weight of the filter paper gives the value of total suspended solids (TSS).

RESULTS

Bacterial load of collected water samples

Table 1 presents total viable counts (CFU/ml) of the collected water samples. It showed that water samples collected from Idang had the highest mean total viable count ($9.0x10^5$cfu/ml) compared to others collected from Jebs (8.2×10^5cfu/ml) and Anantigha (6.5×10^5cfu/ml). However, the mean total viable counts of the collected water samples exceeded the WHO and USEPA standards of 1.0×10^2cfu/ml.

Table 2 presents the result of the total coliform count in the collected water samples. It showed that the coliform count from the water samples collected was too numerous to count (TNTC) compared to the WHO standards of 0/100cfu/ml for drinking water quality.

Morphological and biochemical characterization of bacterial isolates

Table 3 presents the result of the biochemical characterization of bacteria isolated from the collected water samples. It showed that bacteria genera isolated from the samples were identified as; *Escherichia coli*, *Bacillus spp*, *Klebsiella spp, Shigella spp, Salmonella spp, Staphylococcus spp, Pseudomonas spp, Micrococcus spp* and *Proteus spp*.

Physicochemical analysis of the collected water samples

Table 4 presents the result of the physicochemical analysis of the collected water samples. It showed that among the physicochemical parameters determined, total dissolved solids (TDS) temperature, and total hardness zinc of the water sample exceeded that of the WHO and USEPA standards, while other parameters such as calcium and copper were below WHO and USEPA standards.

Table 1: Total viable bacteria counts (CFU/ml) of the collected water samples

Sample	Sample location	Mean total viable counts (CFU/ml)
Water	Jebs	$8.2x10^4$
	Anantigha	$6.5x10^4$
	Idang	$9.0x10^5$
	WHO standard	$1.0x10^2$
	USEPA standards	$1.0x10^2$

Table 2: Total Coliform counts (cfu/ml) of the collected water samples

Sample	Coliform	World Health standard (WHO)
Sample	Counts	0/100cfu/ml
Jebs	TNTC	0/100cfu/ml
Anantigha	TNTC	0/100cfu/ml
Idang	TNTC	0/100cfu/ml

TNTC: Too numerous to count

TABLE 3: Morphological and biochemical characterization of bacteria isolated from the collected water samples

Isolate code	Cell shape	Gram Rxn	Catalase	Oxidase	Coagulase	Citrate	indole	Urease	Methyl	Motility	Starch hydrolysis	Slope	Butt	Hydrogen sulphide production	Gas	Probable organism
I_1	Short Rods	-	+	-	-	+	+	+	-	+	-	R	Y	-	AG	*Escherichia coli*
I_2	Short Rods	+	+	+	-	-	-	-	+	+	-	Y	Y	-	-	*Bacillus spp*
I_3	Short rods	-	+	-	-	-	-	-	+	-	-	Y	Y	-	-	*Klebsiella spp*
I_4	Short rods	-	-	+	-	+	-	-	+	+	-	R	Y	-	AG	*Shigella spp*
T_{I5}	Short rods	-	+	+	-	+	+	-	+	+	-	R	Y	-	AG	*Salmonella spp*
J_1	Cocci	+	+	+	+	+	+	-	+	+	-	R	Y	-	AG	*Staphylococcus aureus*
J_2	Short rods	-	+	-	-	+	+	+	-	+	-	R	Y	-	AG	*Escherichia coli*
J_3	Short rods	-	+	-	-	+	-	+	-	-	-	R	Y	-	AG	*Proteus spp*
J_4	Short rods	-	-	+	-	+	-	-	+	-	-	Y	Y	-	A	*Shigella spp*
J_5	Short rods	-	+	+	-	+	+	-	-	+	-	R	Y	-	A	*Pseudomonas spp*
A_1	Cocci	+	+	-	-	-	+	+	-	-	-	Y	Y	-	AG	*Micrococcus spp*
A_2	Short rods	+	+	+	-	-	-	-	-	-	+	Y	Y	-	A	*Bacillus spp*
A_3	Short rods	-	+	-	-	+	+	+	-	+	-	R	Y	-	AG	*Escherichia coli*
A_4	Short rods	-	+	-	-	-	-	-	+	-	-	Y	Y	-	A	*Klebsiella spp*
A_5	Short rods	-	+	-	-	+	-	+	-	-	-	R	Y	-	AG	*Proteus spp*

Legend: **- =** Negative, + = Positive, R=Red, Y=Yellow, AG=Acid and Gas, A=Acid

Table 4: Physicochemical analysis of the collected water samples

Physiochemical parameters	Jebs	Idang	Anatigha	WHO standard	USEPA
Temperature (°C)	29.6	29.1	28.6	<25	<25
Ph	6.38	6.62	6.53	6.5-8.2	6.5-8.5
Conductivity (µs/cm)	1640	1519	3160	Unobjectionable	Unobjectionable
TDS(mg/L)	984	911.4	1860	<600	No limit
Total hardness (mg/L)	188.1	136.8	234.1	100	-
Turbidity (NTU)	4.61	44.5	1.48	-	-
Calcium (mg/L)	1.87	BDL	BDL	75	75-100
Magnesium (mg/L)	0.49	2.08	1.73	-	-
Copper (mg/L)	0.74	1.15	0.02	0.05-1.5	No limit
Zinc(mg/L)	0.26	0.58	0.13	0.5	0.51
Iron (mg/L)	1.31	4.23	1.19	0.3	0.3
Manganese (mg/L)	1.40	4.1	0.2	-	-

BDL = Below Detection Limit

DISCUSSION

In rural and some urban areas, surface and underground water are generally supplied as drinking water either directly as in the previously mentioned areas or as bore-hole and individual or community wells in urban areas (Biger, *et al.*, 2004). The total viable bacterial and Coliform count in any water body is used to estimate the total amount of bacteria in water and indicates the overall microbial status of the water (Aksu and Vural, 2004). The total viable counts obtained in the collected water samples analyzed in this study indicates that the microbial counts in the water samples, Idang ($9.0x10^2$cfu/ml), Jebs ($8.2x10^4$cfu/ml), and Anantigha ($6.5x10^4$cfu/ml) were higher than WHO and USEPA standards ($1.0x10^2$cfu/ml). Also, the total coliform count from the 1water samples was too numerous to count (TNTC) compared to WHO standards of 01/100cfu/ml, and this was an indication of fecal pollution of the flood-prone water bodies. This observation was not surprising as the similar study by Sunday *et al.*, (2012), also reported a high bacterial load in stream samples collected in Uturu, Abia state. Also the similar study by Amr *et al.*, (2013) reported having recorded a high total viable bacteria counts in underground and surface water samples in Egypt. Michael *et al.*, (2015) also reported a high bacterial load in water samples collected from Imabolo stream water in Ankpa urban area of Kogi State, Nigeria. However this observation was not surprising, as the high total viable count observed in the water samples could have been as a result of human

activities around the water bodies such as dumping of sewages and deposition of human excretas into the water bodies, run-off of fertilizers or manures from farmlands close to the shore of the water bodies, and excreta from grazing animals along the shores of the water bodies. The highest mean total viable count observed in Idang water was also not surprising as it was a clear reflection of the turbidity and brackish color of the water.

Bacteria genera identified from the water samples were species *of Escherichia coli, Bacillus, Klebsiella, Shigella, Salmonella, Staphylococcus aureus, Proteus, Pseudomonas,* and *Micrococcus.* This observation corroborates with that of Chan *et al.,* (2007), who reported having identified *Escherichia coli*, *Streptococcus faccalis* and *Pseudomonas aeruginosa* from collected surface water samples in Malaysia. Also the similar study by Oluwayemisis *et al.,* (2015) reported having isolated *Campylobacter, Escherichia coli, Pseudomonas, Salmonella, Proteus, Shigella, Enterococcus* and *Vibrio* from some river waters in Port-Harcourt.

The presence of the pathogenic organisms isolated from the collected water samples was worrisome as they present a health risk factor to people who ingest them either directly or indirectly. *Staphylococcus aureus* could cause gastroenteritis in individuals who ingest them directly or indirectly (Krapac *et al.,* 2002). The presence of *Klebsiella, Escherichia coli, Salmonella* and *Shigella* in the water samples is a clear indication of faecal contamination of the water bodies. When ingested, these organisms can cause diarrhea, cramps, nausea, headaches and other symptoms (USEPA, 2004).

The physicochemical analysis of the water samples showed that the pH of the water samples was low and in line with the WHO and USEPA standards, and this may be due to the level of CO_2 in water which may consequently affect the bacterial count (Edema *et al.,* 2001). The total dissolved solids in the water samples were higher than the WHO and USEPA standards. This was a clear reflection of the non-appealing aesthetic quality of the water samples which could have probably been as a result of high level of pollution with solid waste. The high TDS in the water samples means that they are hard water and are not good for drinking domestic work, and are not also typically recommended for potable water supplies (WHO, 2006).

The level of calcium in the water sample was very low, although calcium has no effect on human health but it can cause serious hardness. The level of iron in the water samples was higher compared with WHO and USEPA standards. This may be due to the deposition of metal wastes in the water bodies, as they are strongly absorbed by soil and more easily dissolved in

minutely-negligible amounts. Iron when presence in high detectable amounts can affect the color of water and promote the growth of iron bacteria in water and also make water distasteful (Yagoub and Ahmed, 2009). The level of copper in the water samples was below WHO standard, this indicates that the samples are free from copper contaminants.

CONCLUSION

This study has shown that water samples from Jebs, Idang, and Anantigha are highly polluted and thereby needs a serious effort in limiting the number of microorganisms release into the water systems. The microbial level observed in the water samples render them unfit for either human consumption or domestic uses. However, the water quality of Jebs, Idang, and Anantigha should be controlled inorder to minimize the acute problem of water-related disease which is endemic to the health of human. Therefore it is recommended that an effective hygienic and sanitary practices be implemented along these water bodies.

RECOMMENDATIONS

The government should enact the punishable law that will prohibit the dumping of refuse and also defecate into water bodies and also create awareness in the rural and urban areas concerning the hazardous effects of this habit. Therefore it is also recommended that an effective hygienic and sanitary practice should be implemented along this water bodies in order to reduce contamination.

The government should also provide treatment plant for this environment so as to provide the residence with safe drinking water.

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