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Physico-chemical and bacteriological characteristics of selected streams and boreholes in Akamkpa and Calabar Municipality, Nigeria

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ABSTRACT

Physico-chemical and bacteriological characteristics of some streams and boreholes which supply drinking water to the inhabitants of Akamkpa and Calabar municipality were examined. The water samples collected from five streams and six boreholes (eleven sampling locations) were subjected to physico-chemical test and membrane filtration techniques. The physico-chemical parameters examined include pH, temperature, turbidity, electrical conductivity, total hardness, calcium, magnesium, zinc, lead, dissolved solids, ammonium, nitrate, manganese and iron. Results from physico-chemical test showed that parameters such as pH, electrical conductivity, odour, calcium, magnesium, nitrate and ammonium, for all the samples were lower than the WHO standard. Only two of the water supply sources (B1 and B4) met the WHO standard (for coliform count) for drinking water, as coliforms were isolated from other sources except the two. Water samples from streams had a significantly higher coliform (E. coli) counts (P<0.05) compared to those collected from boreholes. The potential impacts of unsafe drinking water are discussed and recommendations to salvage the situation offered.

Keywords: physico-chemical, Bacteriological, stream, boreholes, drinking water.

INTRODUCTION

Water is essential to sustain life; therefore a satisfactory (adequate, safe and accessible) supply of drinking water should be available to all. Every effort should be made to achieve a good quality of drinking water [20]. Quality water is of basic importance to human physiology and man's continued existence depends very much on water availability [1] [5].

The provision of portable water to rural and urban population is necessary to prevent health hazards [6] [12]. Drinking water is one of the oldest public health issues and is associated with a multitude of health related concerns. Access to safe drinking water is a prerequisite to poverty reduction and prevention of the spread of water-borne and sanitation related diseases [7] [16] [17].

Water quality assessment has become a big issue today because of the potential hazards associated with the use of contaminated water supply. Consequent to the realization of the potential health hazards that may result from contaminated drinking water, contamination of drinking water from any source is therefore of primary importance because of the danger and risk of water borne diseases [11]. Various researchers have reported on the serious and severe illness likes typhoid, cholera, dysentery etc. resulting from the use of contaminated water supply [2] [4] [14].

In general, certain requirements must be met for water to be fit for human consumption. These requirements are freedom from organisms and chemicals substances which might be injurious to health. Drinking water should be of such composition that consumers do not question the safety of the water. This implies that turbidity, colour, taste and odour should be low, and macro organisms (e.g. Worms, Asellus, aquatic and fly nymphs) should be absent [10].

The World Health Organization has recommended continuous surveillance of water supplies, which should involve keeping a careful watch at all times, from public health point of view, over safety and sustainability of water supplies. This is to be achieved through sanitary inspection and water quality analysis. While sanitary inspection identifies potential risk factors of contamination and source of pollution, water quality analysis confirms whether the water supply is faecally contaminated [8] [22].

Water is an integral part of achieving all of the UN Millennium Development Goals [15]. The Millennium Development Goals (MDG) target for water is to halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation. The WHO (2004) [19] estimates that if these improvements were to be made in sub-Saharan Africa alone, 434,000 child deaths due to diarrhoea would be averted annually.

Majority of the inhabitants of Akamkpa and Calabar municipality have access to Boreholes and Streams as their major sources of water supply. They use the water supplied from these sources for drinking and other domestic activities such as cooking, washing, bathing, poultry, etc. Therefore the determination of the portability and sustainability of such supplies is of serious concern.

On this note, this research is aimed at examining the suitability of the surface water sources (streams) and subsurface sources (boreholes) for both drinking and other domestic purposes. This will be achieved through evaluating the physico-chemical and bacteriological parameters of the supplies.

MATERIALS AND METHODS

Description of Study Area

The study took place in Akamkpa and Calabar municipality, Cross River State, Nigeria, between October 2011 and February 2012. Calabar Municipality lies geographically on Latitude 4˚57'North and Longitude 8˚ 19' East. The area has both urban features as well as rural settings in the environs of the metropolis. Akamkpa lies between latitude 05^0 34'East and longitude 08^0 47'North. Temperature of both areas ranges from 21.0 5˚C to 33.15℃ while rainfall ranges from 42.0 to 1401.0(mm/month). Akamkpa shares a boarder with republic of Cameroon.

Methods

The environments of the water sources were surveyed to examine the sanitary condition of the environments. Factors considered were: cleanliness of the area, proximity to toilet, proximity to abattoir, proximity to poultry house, proximity to refuse dump, proximity to industrial discharges (effluents) and presence of leaking pipes.

For the purpose of this study, the water supply sources (boreholes and streams) were randomly selected. Samples used for the bacteriological analysis and physico-chemical test were collected from six boreholes and five streams. The boreholes were labelled B1 to B6 while the streams were labelled S1 to S5.

Before collecting water samples from the boreholes, the opening of the taps were flamed and sterilised by cleaning with spirit/alcohol to avoid contamination and the tap was allowed to run for two to three minutes for the initial water to rush out before final collection for analysis. The taps were also adjusted to prevent splashing while collecting the water with the sample bottles. The bottles were closed in a manner to avoid contamination from fingers and by using a new pair of rubber gloves for each sample [10]. Water from streams was collected at the depth of 20 to 30cm into sterile sample bottles. Water samples were collected twice a month for the period of five months (October, 2011 to February, 2012) from the eleven (11) different points of supply. Water samples were collected in sterile 250ml bottles with glass stoppers. The samples were packed in cooler containing ice bags to avoid unpredictable changes. Samples were transported to Cross River State Water board laboratory for analysis. All samples were analysed within three hours of collection.

Physico-chemical Analysis

The conventional parameters used in assessing the quality and portability of water for drinking are level of suspended solids, total dissolved solids, appearance, hardness, conductivity, pH, colour and odour.

The temperature of the water samples were taken at all sampling sites, using a thermometer. The bulb was dipped into the water and allowed to stand for one minute before the reading was taken directly.

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 samples. The pH level was read off above the temperature level displayed on the screen.

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

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

Colour was determined with Lavibond comparator. A 50ml cylinder was filled with the sample and placed on the left-hand side of the comparator. The disc NSA was inserted and on rotation, the nearest colour match was taken.

Total hardness was determined by spectrophotometric procedure. The procedure involved the addition of 1ml of the samples which was placed in a reaction cell and 1ml of total hardness reagent (H-1K) added with a pipette. Three minutes reaction time 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 repeated in all the samples.

For the determination of total suspended solids (TSS), filter paper was weighed using an electronic digital balance and the initial reading noted. 100ml of the sample was then filtered through and the filter oven-dried at 50^0C for 1hr. 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 TSS.

Bacteriological Analysis

The membrane filtration method of water analysis was used. Sterilization of materials throughout this work was done by the use of the autoclave. The autoclave was designed to use steam under pressure over time to kill spore forming bacteria and other microbial forms. Sterilization was achieved at a temperature of 121^0C pressure of 1 bar and for 15 minutes.

Membrane filter of 47mm and pore size of 0.45µm were used according to recommendations by APHA – AWWA (1998) [3]. 100mls each of water samples from six boreholes and five streams were filtered and the bacteria isolated and identified using the methods described by Cheesbrough, (2000) [8]. MacConkey agar was used for the isolation of coliforms.

Incubation was done at 44^oC for 24 hours in an incubator. This temperature was recommended by manufacturers of the EMB and MacConkey agar for optimum growth of faecal coliforms and mesophilic bacteria.

Colonies that have appeared on the plate were counted by marking the bottom of the plate, those that produce a plate count of between 30 and 300 colonies per plate.

Biochemical Tests

The test organisms were inoculated on a MacConkey agar plates and incubated at 40^0C for 24 hours. Positive lactose fermentation was indicated by pink colonies.

Results from the different water supply sources were subjected to student t-test to test if there is any significant difference between the *E. coli* count from the borehole water samples and that of the stream water samples at 0.05% probability level.

RESULTS

Environmental assessment of the sampling locations revealed that most of the environments were dirty and some muddy. Most of the streams were close to toilets. All the sampling points were far from poultry house and abattoir. Although the boreholes were located far from refuse dump, few of the streams were close to the refuse dump (Table 1).

Table 1: Environmental Assessment of the sampling locations before collection of samples in Akamkpa and Calabar Municipality, Nigeria

Water sources	Physical appearance	Proximity to toilet	Proximity to abattoir	Proximity to poultry house	Proximity to refuse dump	Proximity to industrial discharges (effluent)
B_1	Clean	Far	far	Far	far	far
B_2	Fairly clean	Far	"	"	far	"
B_3	Fairly clean	Close	"	"	far	"
B_4	Clean	Far	"	"	far	"
B_5	Fairly clean	Far	"	"	far	"
B_6	Dirty	Close	"	"	far	"
S_1	Bushy/ muddy	Close	"	"	far	"
S_2	Dirty/ muddy	Close	"	"	close	"
S_3	Bushy/dirty	Close	"	"	close	"
S_4	Dirty	Far	"	"	Far	"
S_5	Bushy/dirty	Close	"	"	Far	"

Table 2 shows the physico-chemical characteristics of the examined water samples. Results obtained for most of the physico-chemical parameters conformed to the WHO standards for drinking water quality [21]. All the supply sources were odourless and colourless except S1 and S2 which were slightly creamy in colour. All the boreholes and streams however recorded high level of manganese and iron. Two of the streams (S1 and S2) recorded lead concentrations (0.06 and 0.07) slightly above the WHO recommended standards. High turbidity was also recorded in B5, S1 and S2.

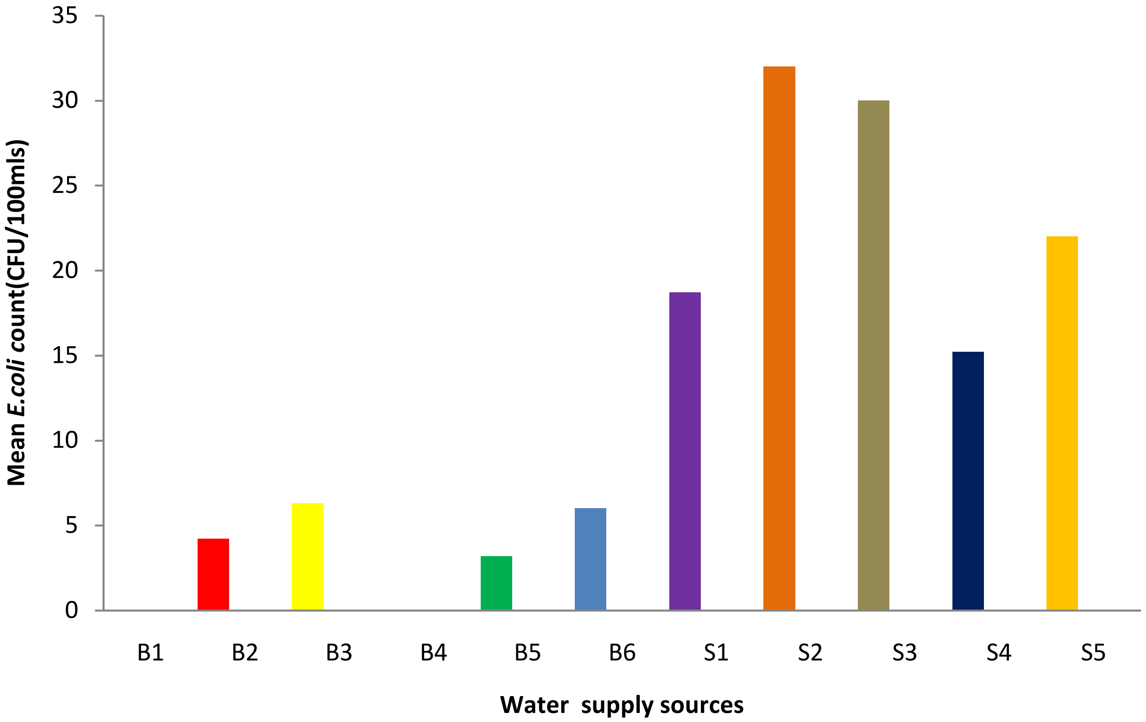

FIGURE 1: Means values of faecal coliform *(E.coli*) count from selected boreholes and streams in Akpamkpa and Calabar Municipality, Cross River State, Nigeria.

Figure 1 shows the mean values of faecal coliforms (*E. coli*) counts during the periods of study. The values range from 0 to 6.30Cfu/100ml in borehole waters and 15.20 to 32.00 in streams. Two boreholes (B1 and B4) recorded zero (0) coliform count while B3 recorded the highest coliform count (6.30Cfu/100ml). Results from coliform counts from samples collected from the streams showed that S4 recorded the least coliform count (15.20Cfu/100ml) while S2 recorded the highest (32.00Cfu/100ml). Water samples from streams had a significantly higher coliform (*E. coli*) counts ($P<0.05$) compared to those collected from boreholes. However, the mean coliform counts for the various water supply sources examined were higher than WHO standard (≤ zero Cfu/100ml) [21] for drinking water, except B1 and B4.

TABLE 2: The mean values of physico-chemical analysis and *E. coli* count of water samples from selected boreholes and streams in Akamkpa and Calabar Municipality, Nigeria

Parameters	Water Sources											WHO Standard
	B1	B2	B3	B4	B5	B6	S1	S2	S3	S4	S5	
Temp. (^{0}c)	28.50	27.70	28.30	27.30	27.1	27.1	28.00	28.20	27.1	27.1	27.1	25^{O}C
pH	7.33	7.67	7.33	5.25	5.44	5.79	7.63	7.70	5.30	5.30	5.80	6.50-8.50
Turbidity (NTU)	0.20	0.35	0.26	1.24	6.98	1.51	4.08	4.14	2.43	2.77	2.09	≤ 1 NTU
E. C. (10^3µ ohms/cm)	0.07	0.07	0.06	0.07	0.05	0.07	0.06	0.05	0.05	0.07	0.09	1.40
TDS	0.09	25.00	36.20	16.50	25.20	86.34	30.31	25.60	15.50	10.26	46.50	600
T. H. (Mg/L)	18.00	18.00	18.00	14.36	11.20	19.70	6.50	6.86	16.99	15.16	10.19	No guideline
Mag. (Mg/L)	3.01	3.40	4.11	4.35	3.10	4.65	4.20	3.56	2.94	3.66	4.39	30
Zinc (Mg/L)	0.85	0.66	0.81	0.78	0.09	0.44	0.91	0.99	1.80	1.72	0.18	5.0
Calcium (Mg/L)	9.66	10.00	9.56	9.66	8.10	15.6	11.50	12.00	8.04	11.50	12.60	75
Lead (Mg/L)	0.02	0.04	0.01	ND	0.03	ND	0.06	0.07	0.005	0.006	ND	0.05
Nitrate (mg/L)	0.51	0.42	0.32	0.41	0.44	0.39	0.60	0.52	0.41	0.41	0.43	10
Amm.. (Mg/L)	0.02	0.01	0.02	ND	ND	ND	0.01	0.01	ND	ND	ND	10
Mang. (Mg/L)	3.00	4.11	3.87	4.35	4.71	4.65	4.12	4.34	4.29	4.4	4.39	0.05
Iron(mg/L)	1.30	0.95	1.24	1.58	5.0	1.53	2.90	2.85	2.07	1.93	1.55	0.3
Mean E.coli count (Cfu/100ml)	0	4.20	6.30	0	3.20	6.00	18.70	32.00	30.00	15.20	22.00	≤ 0

Key: *Temp=Temperature; E.C=Electrical Conductivity; TDS=Total Dissolved Solid; T.H=Total Hardness; Mag. =Magnesium; Amm. =Ammonium; Mang. =Manganese; ND=Not Dictated; B=Borehole; S=Stream.*

DISCUSSION

Most of the physico-chemical parameters had values which conform to the WHO standard for drinking water. However, the high concentration of some parameters such as manganese, iron, lead and turbidity depict possible pollution.

The condition of our physical environment is one of the factors that can contribute to the state of our drinking water supplies. The environments of the sampling locations (especially the streams surroundings) were dirty and bushy. Some were close to toilets and dump sites which may have contributed to the high number of coliforms recorded in the water samples. According to Ali *et al*. (2007) [9], the untidy nature of our physical environment along with close proximity of some wells to toilet, rubbish dump and poultry house may be responsible for the presence and somewhat high density of *E. coli* in the drinking water sources.

The zero (0) *E. coli* count from B1 and B4 may be due to routine treatment of such sources of drinking water. The presence and high number of faecal coliforms in most of the water samples analysed showed that there were focally contaminated. The result showed that only two (B1 and B4) of the drinking water sources met the WHO standard for drinking water (≤ zero Cfu/100ml). Nevertheless, the water from streams has higher potential risk than those from boreholes. According to Apantaku *et al*. (1998) [13] cited by Ali *et al.* (2007) [9], the greatest risk to humans from water sanitary point of view is from faecal contamination of water supplies. The sanitary quality of water therefore is based on the presence and density of faecal coliform or *E. coli* [18].

CONCLUSION

Consuming unsafe drinking water may lead to several water borne diseases, and other long and chronic health problems. Therefore, provision of safe drinking water to each and every individual living in this planet is required. On this note, a routine water treatment should be employed to avoid any health hazard that could erupt through drinking of contaminated water.

The inhabitants of Akamkpa and Calabar Municipality who use boreholes and streams as their drinking water supply sources should properly boil the water or use any other good treatment measures before drinking such water. Toilets, poultry house, abattoir and refuse dump should be sited far from drinking water supply sources as they are sources through which coliforms can enter into our drinking water sources.

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