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Assessment of Microbial and Physicochemical Contaminations of Water for Domestic Use in Calabar Metropolis, Nigeria

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ABSTRACT
An assessment of domestic water quality using microbial andphysicochemical parameters was conducted on both domestic water supply sources and storage containers viz: borehole, upper and lower overhead tanks and stream water in Calabarmetropolis. Water samples meant for physicochemical and microbial studies were collected in 1.5L plastic containers and stored in safe condition prior to laboratory analysis of their Physicochemical and microbial parameters in line with APHA recommended standard and WHO permissible limits to ascertain if the mean values of the water parameters were or not within the acceptable limits for human consumption. The results of the descriptive statical analysis of the physicochemical and microbial components of the different domestic water sources revealed mean pH of 6,4±0.6 for the stream water, 6.33±0.57 for the borehole, 5.9±0.9 for the upper overhead tank and 5.79±0.59 for the lower overhead tank. Mean DO concentration of the stream was 7.25±0.25mg/l, with 8.66±0.54mg/l for the borehole, 6.8±0.2mg/l for the upper overhead tank and 1.79±0.39mg/l for the lower overhead tank (Table 1). Mean water temperature recorded for the stream was 27.5±0.5^{0}C, with 27.40±0.6^{0}C for the borehole, 27.45±0.55^{0}C for the upper overhead tank and 27.71±0.31^{0}C for the lower overhead tank. Fe had mean concentration of 1.035±0.001mg/l in the stream water, with 0.040±0.560mg/l in the borehole, 0.664±0.014mg/l in upper overhead tank. Hg mean concentration was <0.001±0.00mg in all the water samples. Bicarbonate had mean concentration of 30.75±0.25mg/l in the stream water, with 36.85±0.256mg/l in the borehole, 24.69±0.31mg/l in the upper overhead tank and 30.75±0.25mg/l in the lower overhead tank. Mean total coliform components were 84.75±0.5 cfu/100ml in the stream water, with 127±2.5 cfu/100ml in the borehole water, 44±2.0 cfu/100ml in the upper overhead tank and 34.5±0.5 cfu/100ml in the lower overhead tank. Total plate count (TPC) had mean values of 127±1,0 cfu/100ml in the stream water, with 164.5±1.5 cfu/100ml in the borehole, 42±8.0 cfu/100ml in the lower overhead tank. Yeast/mould had mean concentration of 0.005±0.005 cfu/100ml in the stream water, with 1.5±0.5 cfu/100ml in the borehole water, 3.5±0.5 cfu/100ml in the upper overhead tank and 2.4±0.4 cfu/100ml in the lower overhead tank. To reduce the risk of human infection that may arise from the continuous use of the water sources and the tank-stored water, it is strongly recommended that tanks be washed at regular intervals and the treatment of water with recommended doses of chemicals meant for such purposes.

Key words: Microbial and physicochemical contaminations, storage containers, water quality, water sources

1. INTRODUCTION

Water is connected to every form of life on earth to the extent that without it the earth will be incompatible and uninhabitable by humanand to any life form. At a basic level, everyone needs access to safe water in adequate quantities for drinking, cooking, personal hygiene and sanitation facilities that do not compromise the dignity ofdrinking water[9]. Therefore, access to safe and dependable water is a fundamental human right[17]. The United Nations and other countries declared that access to clean and safe drinking water is not only a basic human right, but constitute a very important step toward improving living standards worldwide.

Unsafe drinking water is a leading cause of preventable diseases particularly in developing countries[12]. Waterborne pathogens, including a variety of viral, bacterial, algal and protozoan account for much of the deaths each year worldwide[10,16,17,8,9].Wright *et al.*, (2004)[8] and Chia *et* *al*., (2013)[9] attributed the prevalence of water related diseases to storage site and facility couple with management practices.

In tropical developing countries, the predominance of unsafe water sources for drinking and other purposes is alarming the situation is complicated by attempts by different households to source for veritable means of constant water supply in order to avert associated problem of infrequent availability[9].Imoke*et al* (2021) Also stressed of water availability due to climate change within the zone. Unfortunately, many do it in an unsafe manner thus, creating an ambiance for bacterial and other microscopic organisms to thrive. Olanrewaju and Ogunyemi (2014)[13] attributed the presence of bacteriological and physicochemical indicators in domestic water supply to storage containers and source of supply. Majesty *etal*,(2013)[5] also corroborated and said that these indicators in water including their storage containers have profound influence on domestic water supply. The type of container and time was also examined (Adebeli & Nwaiwu, 2018)[7]. In Nigeria,Calabar in particular the situation is not different as most households depend on wells, boreholes,streams and pipe borne waters as veritable sources of domestic water supply. However, consequent upon the intermittent and unreliable supply frequencies of the later it has become inevitable to store water for drinking and other domestic purposes using available storage facilities such as tanks, plastic containers, basins, wells and others (Ziadat, 2005)[1] to guard against inconsistencies associated with timely supplies (Ukata*et al*., 2011)[15]. From literatures it could be said that a lot has been done in respect of water contamination due to physicochemical and bacteriological effects on borehole water but more is yet to be accomplished on other water sources example, surrounding streams). This work focuseson the assessment of microbial and physicochemical contamination ofwater supply sources and the storage containers in Calabar Metropolis.

2.MATERIALS AND METHODS

This study area is Calabar Metropolis located between Longitude $08^{0}14^{1}\ 40^{11}$ and $08^{0}\ 17^{1}\ 30^{11}$ of the Greenwich Meridian and Latitude $05^{0}\ 08^{1}\ 30^{11}$ and $04^{0}\ 56^{1}\ 20^{11}$N of the Equator. After a well-articulated survey, it was necessary to create four study locations purposively, they included; ikotene-obong, Ekorinim, Satellite town and Anatigha all in Calabar Metropolis, information were elicited through personal observation and interviews on their experiences in the use of plastic storage facility and water usage.Four months duration was used for this study (April – July 2020) each site was allotted different month beginning from Anatigha to Ikotene-obong during raining season when the water table was supposedly high and the environmental condition tend to favour the prevalence of physicochemical indicators and the fecundity of bacterial organism which drain into the soil usually found their way into adjacent water body[14]. Streams and borehole water constitute major water sources that are used to feed storage facilities in the study area

Effort was made to purposively select residential household base on certain characteristics.Consequently, two bed room residential building with a family size of 2–4 household members with water storage capacity of two (2) plastic containers measuring 3000Litres each were considered appropriate for the study. The reason is that it takes a longer time to exhaust 6000litres of water by a family of 2-4 persons. Two plastic containers mounted on a 6m platform made of galvanized poles were strategically positioned (upper and lower overhead tanks). While the water in upper plastic container can be exhausted between 4-7 days the lower plastic container takes a longer time depending on household size and water usage. Water samples were collected from the lower overhead tank within the first three (1-3) days after pumping water into the overhead tankwhile samples were collected within4-7 days from the upper overhead tank by this time water in the lower overhead tankis supposedly used up leaving the one in upper overhead tank.

Water samples meant for physicochemical and microbial studies were collected in 1.5Litres plastic container. Prior to samples collection, samples containers were washed with neutral liquid and rinsed with distilled and deionized water according to APHA (1985)[2] recommended standard.

2.1 Physicochemical analysis

Fast changing parameters such as DO, pH and temperature were taken *insitu* according to the APHA (1985, 2012)[2]method. HCO^{-}_{3} was measured in the laboratory using HACH 2000 spectrophometer following APHA (1985, 2012)[2] recommendation. All physicochemical parameters were measured in duplicates for authenticity of result. Mean values were compared with WHO permissible limits (Table 1).

2.2 Microbial analysis

Quantitative, qualitative and biochemical tests were conducted on the water samples following APHA (1985, 2012) recommended method.

3. RESULT AND DISCUSSION

Table 1: Physico-chemical andmicrobial parameters of the different water sources (range and mean)

Parameters	**Stream** **Anat Sat Ekorilkot**	**Borehole** **Anat Sat Ekorilkot**	**Upper tank** **Anat Sat Ekorilkot**	**Lower tank** **Anat Sat Ekorilkot**	**WHO**
PH	5.80 5.90 6.1 7.00 Range: 5.8 – 7.0 Mean 6.4 ± 0.6	5.76 5.80 6.9 6.20 Range: 5.76 – 6.90 Mean = 6.33 ± 0.57	5.88 6.80 5.1 5.0 Range: 5.0 – 6.80 Mean = 5.9 ± 0.9	5.74 5.64 5.20 6.38 Range: 5.20 – 6.38 Mean = 5.79 ± 0.59	6.5 – 8.5
Do mgl	8.4 8.12 9.2 8.3 Range: 8.12 - 9.2 Mean: 8.66_+ 0.54	7.1 7.1 7.3 7.0 Range: 7.0 – 7.5 Mean = 7.25 ± 0.25	1.4 1.5 1.7 2.18 Range: 1.4 – 2.18 =1.79 Mean: 1.7 ± 0.39	6.8 6.6 6.9 7.10 Range: 6.6 – 7.0 = 6.8 Mean = 6.8 ± 0.2	6.5 – 8. 0
Temp.	27.5 26.9 28.0 27.0 Range: 27 – 28.0 = 27.5 Mean = 27.50 ± 0.5	26.8 27.20 28.00 27.00 Range: 28 – 26.8 = 26.8 Mean = 26.8 – 28 =27.4 27.40 ± 0.6	28.0 27.20 26.90 27 Range: 26.90 – 28.0 Mean = 27.45 ± 0.55	27.4 28.0 28.02 27.67 Range: 27.40 – 28.02 Mean = 27. 71 ± 6.31	25.0 – 27.0
Fe	1.025 1.045 1.027 1.062 Range: 1.025 – 1,045 Mean = 1.035 ± 0.01	0.562 0.571 0.6 0.52 Range: 0.520 – 0.600 Mean = 26.8 – 28 = 27.4 27.40 ± 0.6	0.673 0.650 0.670 0.679 Range: 0.650 – 0.679 Mean = 0.664 ± 0.014	0.366 0.370 0.325 0.335 Range: 0.325 – 0.366 Mean = 0.345± 0.020	0.3
Hg	<0.001 0.001 0.001 1.062 Range: 0.001 – 0.001 Mean = 0.001 ± 0.000	<0.001 0.001 0.001 0.001 Range: 0.001 – 0.001 Mean = 0.001 ± 0.000	<0.001 0.0001 0.002 0.001 Range: 0.001- 0.002 Mean = 0.0115 ± 0.0005	<0.000 0.001 0.000 0.001 Range: 0.000 – 0.001 Mean = 0.005 ± 0.0005	<0.001
Bicarbonate	30.50 30.67 31.00 31.00 Range: 30.50 – 31.00 Mean = 30.75 ± 0.25	36.60 36.79 37.00 37.10 Range: 36.60 – 37.10 Mean = 36.85 ± 0.25	24.40 24.38 24.60 25 Range: 25.00 – 24.38 Mean 24.66 ± 0.31	30.50 30.60 31.00 30.70 Range: 30.50 – 31.00 Mean = 30.75 ± 0.25	200
Plate count	42444650 Range: 42 – 50 Mean = 46± 4.0	34 40 45 50 Range 34 – 50 Mean = 42 ± 8.0	163 165 166 164 Range: 163 – 166 Mean = 164.5 ± 1.5	126 127 128 127 Range: 126—128 Mean:127-$^{+}$ 1.0	0
Yeast	0.0 0.1 0.0 0.0 Range: 0.0 – 0.1 Mean = 0.005 ± 0.005	1.0 2.0 2.0 1.0 Range: 1.0 – 2.0 Mean = 1.5 ± 0.5	3.0 3.0 4.0 3.0 Range: 3.0-.4.0 Mean:=3.5++0.5	2.0 2.7 2.8 2.2 Range: 2.0 – 2.8 Mean = 2.4 ± 0.4	0
Coli form	84.01 85.00 85.50 84 Range: 84.0 – 85.5 Mean = 84.75 ± 0.5	125 127 130 125 Range: 125 – 130 Mean = 127.5 ± 2.5	42 46 43 43.4 Range: 42 – 46 Mean = 44 ± 2.0	34 35 35 34 Range: 34 – 35 Mean = 34.5 ± 0.5	10

3.1 Results

Physicochemical and microbial components

The results of the analysis of the physicochemical and microbial components of the different domestic water sources revealed mean pH of 6,4±0.6 for the stream water, 6.33±0.57 for the borehole, 5.9±0.9 for the upper overhead tank and 5.79±0.59 for the lower overhead tank. Mean DO concentration of the stream was 7.25±0.25mg/l, with 8.66±0.54mg/l for the borehole, 6.8±0.2mg/l for the upper overhead tank and 1.79±0.39mg/l for the lower overhead tank (Table 1). Mean water temperature recorded for the stream was 27.5±0.5^{0}C, with 27.40±0.6^{0}C for the borehole, 27.45±0.55^{0}C for the upper overhead tank and 27.71±0.31^{0}C for the lower overhead tank.

Fe had mean concentration of 1.035±0.001mg/l in the stream water, with 0.040±0.560mg/l in the borehole, 0.664±0.014mg/l in upper overhead tank. Hg mean concentration was <0.001±0.00mg in all the water samples. Bicarbonate had mean concentration of 30.75±0.25mg/l in the stream water, with 36.85±0.256mg/l in the borehole, 24.69±0.31mg/l in the upper overhead tank and 30.75±0.25mg/l in the lower overhead tank. Mean total coliform components were 84.75±0.5cfu/100ml in the stream water, with 127±2.5cfu/100ml in the borehole water, 44±2.0cfu/100ml in the upper overhead tank and 34.5±0.5cfu/100ml in the lower overhead tank. Total plate count (TPC) had mean values of 127±1,0cfu/100ml in the stream water, with 164.5±1.5 cfu/100ml in the borehole, 42±8.0cfu/100ml in the lower overhead tank. Yeast/mould had mean concentration of 0.005±0.005cfu/100ml in the stream water, with 1.5±0.5cfu/100ml in the borehole water, 3.5±0.5cfu/100ml in the upper overhead tank and 2.4±0.4cfu/100ml in the lower overhead tank. As shown in Table 1, apart from bicarbonate and Hg, every other physicochemical component exceeded the WHO permissible limits for drinking water. Similar observation was recorded in the mean concentrations of the microbial components (Total plate counts, Total coliform and Yeast/mouldcfu/100ml).

3.2 Discussion

Water quality for domestic use is better assessed by determining the levels of physicochemical and microbial components and comparing the observed data with acceptable and recommended limits[6,19]. The results of the present study indicate that the mean levels of the physico-chemical and microbial load of the water sources and stored water were above the WHO permissible limits for drinking water,. The pH ranges of 5.74±0.59 – 6.4±0.6 indicate high acidity of the water from the various sources and those in the storage containers. Demineralization of buried organic matter in the soils releases CO_2 as a by-product, therefore, underground and stream waters draining through such substrates leach the trapped CO_2, thereby contributing to increased acidity of the aquifers[6,8].

Free CO_2 may also be present as a result of erosion of $CaCO_3$ deposits by underground water. The low pH in all the water sources may not be unconnected with the presence of humicacids. The consumption of acidic (low pH waters) is potentially dangerous, bearing in mind that this can cause an increase in acidic content of the stomach leading to peptic-ulcer in some cases ([6]; Agbogu*et al.*, 2006;[9]).

DO levels above 5.0mg/l are known to be an indication of an oxidized state[6,16,18]. The lowest mean value of 1.79mg/l recorded in the upper overhead tank showed that the water might have stayed relatively longer in the tank than expected. Such can support the growth of anaerobic microbes, which are detrimental to human health.

Fe level exceeding the permissible limit of 0.3mg/l for drinking water is dangerous to biological systems and could lead to iron intoxication and suffocation especially when it is found in the reduced form (Fe^{2+}) [6,9]. Patients who receive iron treatment gain weight. Iron therapy increases serum ferritin levels accompanying with body weight. Consumption of iron laden water can lead to associated danger of weight gain

The microbial numerical estimates of the isolate showed that the microbial components (Total plate count, Total coliform, Yeast/mouldcfu/100ml) each exceeded the international drinking water standard set by WHO[19]. Potable water should not contain more than 10 total coliforms per 100ml. The high numbers of total coliform (34.5±0.5 – 127.5±2.5cfu/100ml) and total plate count (42±8.0 cfu/100ml – 164.5±1.5cfu/100ml) are strong indications of the microbial contamination of the water sources and those in the storage containers. Water from diverse sources such as discharge and seepage of domestic sewage into underground water addition of non-flushing and washing of reservoir water tanks for several months[6,9]. The absence of yeast/mould in the stream water may not be unconnected with constant flow of the stream water and the high mean iron concentration in the stream water, a result which collaborates with those of Asuquo&Asuquo, 1999)[6]Chigor*et al.*, (2013)[18] during their respective studies on assessment of domestic water quality in Calabar and Zaria, Nigeria.

4. CONCLUSION AND RECOMMENDATIONS

From the results it is evident that, both the water in the storage containers andfrom stream and borehole sources used for the domestic purposes are contaminated and potentially unsafe for human consumption. The stream water was however not contaminated with yeast/mould, possibly due to the high mean iron concentration and its constant flow.

To reduce the risk of human infection that may arise from the continuous use of the water sources and the tank-stored water, it is strongly recommended that tanks be washed at regular intervals and the treatment of water with recommended and appropriate doses of chemicals meant for such purposes. Water engineers are to be strictly involved in borehole and domestic water management from point of release to point of use by consumers. The results of the physicochemical and microbial data of the different water sources and storage containers (mean ± SD) were compared with WHO permissible limits for ascertaining the usability of the domestic water sources.

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