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RESEARCH ARTICLE

PHYSICO-CHEMICAL AND MICROBIAL ASSESSMENT OF DIFFERENT WATER SOURCES IN OTA, OGUN STATE, NIGERIA

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ABSTRACT

Pollution of water bodies is one of the areas of major concern to environmentalists and requires continuous assessment. This necessitated the evaluation of the physical, chemical and microbiological quality of water from the primary sources of supply in different locations of Ota using standard methods. Results of the values of the surface and potable water in the study area showed that turbidity(0.19 to 11.6 NTU), conductivity (36.5 to 396 µs/cm), salinity (10 to 80 mg/L), alkalinity (0 to 64 mg/L), nitrate (0.20 to 4.60 mg/L), total hardness (5.0 to 80.0 mg/L), total solid (4000 to 7000 mg/L) total suspended solids (3967 to 6978 mg/L) total dissolved solids (17.9 to 198 mg/L), dissolved oxygen (4.50 to 9.60 mg/L), biochemical oxygen demand (ND to 4.67 mg/L), MPN count (2 to 1600 MPN/100 ml) and the faecal coliform counts ranged between ND to 2.5×10^4. The Physico chemical parameters of most of the samples analysed were within the limits set by both National and International standard regulatory bodies for drinking and domestic waters (SON, 2007; WHO, 2011). Overall, the potable water sources are suitable for drinking, but the faecal contamination in Iju River makes it unfit for drinking.

INTRODUCTION

Water is a basic nutrient of the human body and is critical to human life. It is essential to living organisms, agricultural production, industrial processes and domestic use for humans (Hvitved–Jacobson and Yousef, 1991). Older adults require at least 1.6 liters of drinking water daily to replace lost fluid. However, contaminated water can serve as a medium of transmitting dangerous pathogens and toxic chemicals into the body (Hodgkinson *et al.,* 2003). Water quality is defined in terms of the chemical, physical, and biological characteristics of water, usually in respect to its suitability for an intended purpose (Meybeck *et al.,* 1996). No single measure constitutes good water quality; this is because the quality of water appropriate for recreational purposes differs from that used for industrial processes. Also water suitable for drinking can be used for irrigation, but water used for irrigation may not meet drinking water guidelines (USDA-CSREES, 2001).

Water quality is an important determinant of availability because water which is not fit for use is in effect unavailable. The quality and quantity of available water have implication on the health status of a community. Polluted water is the major reason for the spread of many endemic diseases like skin and eye infections, cholera, tuberculosis, typhoid, diarrhea, viral hepatitis A and even death (Harrison, 1958; Lenat and Crawford, 1994; Biggs, 1995; Gergel *et al*., 1999; Caraco *et al*., 2003; Donohue *et al*., 2006, and Khan *et al*., 2012). Over 50,000 people die daily due to water borne diseases (Herschy, 1999), also mortality in children less than five years due to water related diseases annually is estimated to be about 4 million in under-developed countries. In addition, the World Health Organization estimates that 3.4 million people, mostly children, die every year from water-related disease (WHO, 2004). Ota is the capital of Ado-Odo/ Ota local government area in Ogun state, with an estimated 163,783 residents living in or around there. The primary influence on groundwater and surface water quality in Ota is the contamination brought about by human activity. These contaminations include fertilizers and pesticides in agricultural runoff, domestic wastewater, industrial wastewater, septic tank leachate, and hydrologic modifications. In Nigeria, availability of quality water has become a significant and imperative challenge posing a great concern to families, communities and the Government (Okonko *et al*., 2008). Statistics survey from Ota State Hospital from March, 2011 to February, 2012 revealed over 415 cases of water borne diseases and few death cases due to faecal contamination of water. It is therefore important that the quality (physical, chemical and microbial) of the water in Ota be monitored so as to prevent more health hazards in the environment.

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MATERIAL AND METHODS

Samples

A total of thirteen water samples were collected in February, 2012 during the late harmattan from the primary sources of water supply in different locations of Ota, Ogun State. These water samples are tap water, river water, underground well water, bottled water, sachet water, water from swimming pool and borehole water. The samples were all collected in Ota and coded as follows:

Table 1. Water samples available for study and their sources

Samples	Code	Samples	Code
Iyana borehole	B.I.	C4 Well	W.C
State hospital borehole	B.H	Iyana well	W.I
NNPC bore-hole	B.N	Kesh table water	K.W
Bells Swimming pool	B.P	Hebron table water	H.T
Covenant Swimming pool	C.P	Hebron sachet water	H.S
Postgraduate Quarters Tap water	T.W	Iju River	I.R

Samples for physico-chemical and microbial analysis were collected in 2 (two) litre pre-washed polyethylene containers. The containers were pre-rinsed three times with the sample water before final collection. Water samples for micro-bacterial analyses were collected aseptically in sterile bottles. All samples were stored in an icebox at 4°C and transported to the laboratory for further analyses.

Physico-Chemical Analysis

Water samples were collected, preserved and analyzed in accordance with Standards Methods (APHA, 1998 and ASTM, 1982). Temperature and pH were measured in situ, using a thermometer and portable Hanna microprocessor pH meter respectively. Routine laboratory analysis such as alkalinity, biochemical oxygen demand (BOD), total hardness and salinity were done by the methods of American Society for Testing and Materials (ASTM, 1982). The amount of chloride was determined according to Mohr's method (APHA, 1998). The total solid (TS), total dissolved solids (TDS), suspended solid (SS) were determined gravimetrically using APHA method (APHA, 2008, Beychok *et al.*, 1967, Ademoroti, 1996, and Shalom *et al.*, 2011). The Dissolved Oxygen (DO) was determined by using the winkler's method of analysis (Ademoroti, 1996), turbidity was determined using a standardized Hanna H198703 turbidimeter and conductivity was done using a Jenway conductivity meter (4510 model).

Microbial Analysis

The media used for the bacteriological analysis of water include Eosin Methylene blue agar (EMB), Lactose broth (LB), and Nutrient agar (NA). All the media used were prepared according to the specified instructions and directions by the manufacturers. The Most Probable Number (MPN) technique which is an important method of estimating microbial populations in waters, were done via three stages, namely, Presumptive Test, Confirmative Test and Completed Test (APHA, 1998). The total coliform and total *E. coli* count were also done and compared with standards (WHO, 2010),

RESULTS AND DISCUSSION

Results

The results shown in Tables 2 and 3 for the physic-chemical analysis of the water samples are the means of triplicate measurements.

Discussion

pH

pH is one of the most common analyses in soil and water testing. It is the standard measure of how acidic or alkaline a solution is. It is measured on a scale from 0 – 14. pH of 7 is neutral, pH less than 7 is acidic, and pH greater than 7 is basic. The pH values of the surface and potable water in the study area ranged from 4.1 to 7.1 and 4.4 to 6.7, respectively. Most of the results showed a marked deviation from the Standard Organization of Nigeria (SON, 2007) drinking water permissible limit of 6.5 to 8.5, with exception of Hebron sachet water, NNPC borehole water and Hebron table water. The pH of drinking water generally is not a health concern. However, acidic water can leach metals from plumbing systems which can cause health problems. The reason for the slight acidity found in these samples could be due to the presence of excess CO_2 and SO_2 caused by microbial activities. Generally low pH values obtained in the water might be due to the high levels of free CO_2 which may consequently affect the bacterial counts (Pavendan *et al.*, 2011).

Table 2. Results of Physico- chemical analysis of water samples collected from different sources in Ota

Water Sources	Temp °C	pH	Turbidity (NTU)	Conductivity (μs/cm)	Salinity (mg/l)	Alkalinity (mg/l)	Nitrate (mg/l)
B.I	28.6	4.4	0.64	45.7	10	0.00	2.10
B.H	28.7	5.3	0.39	51.9	20	5.00	4.40
B.N	31.1	6.1	1.79	93.7	20	45.00	0.20
C.P	28.4	4.1	0.62	124	30	0.00	3.40
W.C	29.1	5.7	1.11	62.7	20	12.00	4.60
W.I	27.6	5.6	0.43	67.9	20	11.00	3.70
T.W	27.2	4.6	0.62	44.6	10	0.00	2.00
K.W	28.7	5.1	0.52	36.5	10	3.00	2.80
E.W	27.5	5.6	0.34	53.1	20	3.00	4.30
H.T	28.8	6.5	0.48	98.2	20	33.00	2.90
I.R	25.6	5.9	11.6	116.1	30	23.00	3.50
H.S	24.3	6.6	0.19	71.2	20	64.00	2.40
B.P	28.6	7.1	0.92	396	80	38.00	2.40
WHO			5		<200	120	50
SON		6.5- 8.5	0-5	1000			50

Table 3. More Results of the Physico- chemical analysis of water samples collected from different sources in Ota

Samples	Free chlorine (mg/l)	Total chlorine (mg/l)	TS (mg/l)	TDS (mg/l)	TSS (mg/l)	DO (mg/l)	BOD (mg/l)	Total hardness as $CaCO_3$ (mg/l)
B.I	0.53	0.12	4000	22.4	3978	4.50	1.50	5.0
B.H	0.34	0.12	4000	25.6	3974	6.20	4.67	80
B.N	0.77	0.13	5000	45.7	4954	7.30	N.D	16.0
C.P	0.70	0.17	5000	60.5	4940	8.00	1.17	17.0
W.C	0.41	0.20	4000	31.0	3969	7.70	2.00	15.0
W.I	0.05	0.16	4000	33.5	3967	8.50	1.67	15.0
T.W	0.20	0.21	7000	22.0	6978	7.60	3.33	10.0
K.W	0.16	0.12	5000	17.9	4982	8.10	0.83	9.0
E.W	0.35	0.12	4000	26.1	3974	6.20	4.50	9.0
H.T	0.41	0.29	5000	48.2	4952	8.20	0.67	6.0
I.R	0.30	0.28	5000	57.0	4943	4.90	2.33	14.0
H.S	0.25	0.11	5000	35.4	4965	7.50	0.50	8.0
B.P	0.53	0.18	7000	198	6802	9.60	N.D	40.0
WHO				<600				
SON	0.2-0.25			500				150

Turbidity

Turbidity is a measure of water clarity. Turbidity in water is caused by suspended particles or colloidal matter that obstructs light transmission through the water (WHO 2011). From Table 1, the WHO acceptable limit for potable water is 5 NTU. All the samples had turbidity values within the WHO permissible value except that of the surface water sample from Iju River (11.6 NTU). This result agrees with a previous reported work on Iju River with a turbidity value of 10.25 ± 0.55 (Shalom *et al.,* 2011). This high turbidity in Iju River may be due to human activities around the river like discharge of effluents into the river, construction and farming, which in turn leads to high sediments levels entering the water bodies through water runoff. High turbidity values can block sunlight required for photosynthesis by aquatic vegetation and subsequently reduce aquatic life and diversity.

Conductivity

Conductivity is an indirect measure of the ion concentration in water. It is often used as a surrogate for total dissolved solids (a conductivity of 1400 µS/cm is equivalent to 1000 µg/l of dissolved solids) and is, therefore, an indicator of the taste and salinity of the water (Ince et al., 2010). Electrical conductivity of the samples had values varying from 116 to 396 µs/cm for the surface water and 36.5 to 98.2 µs/cm for potable water. All the conductivity values were below the SON permissible limits for unpolluted water of 1000 µs/cm.

Salinity

Salinity is the saltiness or dissolved salt content of a body of water. Salinity of the samples ranged between (10 to 20 mg/l and 30 to 80 mg/l) for portable and surface water respectively. These values are less than 200 mg/l set by the World Health Organization.

Alkalinity

Alkalinity of water is its capacity to neutralize acids. Alkalinity of many surface waters is primarily a function of carbonate, bicarbonate, and hydroxide content. Waters with a high alkalinity may not fit certain applications because of the high cost of acid neutralization of large amount of water, but the advantage is the resistance to acidic precipitation. A change in alkalinity may be an indication of pollution problems. The alkalinity of the potable water and surface water ranged between (0 to 64 mg/L). Alkalinity values for all sites are relatively lower than the 120mg/L value prescribed by WHO.

Nitrate

Nitrate is an essential plant nutrient and its levels in natural waterways are typically low (less than 1 mg/L). Excessive amounts of nitrate can cause water quality problems, accelerate eutrophication, as well as contribute to the illness known as methemoglobinemia in infants (Zhang, 2007). The nitrate results are presented in table 2 as follows, potable water (0.20 to 4.60 mg/L) and surface water (2.40 to 3.50 mg/L). Our results showed nitrate content to be relatively lower than the WHO permissible limit of 50 mg/L (WHO, 2011).

Total hardness

Total hardness is defined as the sum of calcium and magnesium concentrations in water, expressed as calcium carbonate equivalents in milligrams per litre (APHA, 1998). The total hardness values in the studied samples for potable water and surface water ranged from 5.0 to 15.0 mg/L and 14.0 to 40.0 mg/L, respectively. Results were found to be far below the 150 mg/L maximum permitted limit of Standard Organization of Nigeria (SON, 2007). These results are similar to the ones reported by Shalom, 2011 with total hardness value in the range of 17.0 ± 1.0 to 51.0 ± 3.0. These results show that the water samples are suitable for domestic uses.

Solids

Solids refer to matter suspended or dissolved in water or wastewater. They have different forms depending on their operation principles. A total solid (TS) refers to the material residue left in the vessel after evaporation of a sample and its subsequent drying in an oven at a defined temperature. They include total suspended solids (TSS) and total dissolved solids (TDS). TSS is the portion of total solids retained by a filter, whereas TDS is the portion that passes through the filter (Zhang, 2006). The TS, TSS and TDS recorded in this work falls within the following range 4000 to 7000, 3974 to 6978 and 17.9 to 198 mg/L, respectively. The results were relatively higher when compared with previous work done in Ota - TS (5 to 3005 mg/l), TSS(5 to 2910 mg/l) TDS(0 to 100 mg/l)) by Shalom *et al.* (2011) and at Ife–North Local Government of Osun State - TS (90.00 to 1175.00 mg/L), TSS (34.50 to 794.00 mg/l) and TDS(37.80–622.50mg/l), by Oluyemi *et al.,* 2010. However, the TDS values in the studied area were within the permissible limit of SON and WHO as shown on Table 2. High levels of TDS may cause excessive scaling in water pipes, industrial and household appliances. Also, it can be toxic to aquatic life and can reduce habitat.

Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD)

Dissolved oxygen analysis measures the amount of gaseous oxygen (O_2) dissolved in an aqueous solution. The amount of dissolved oxygen in water is largely dependent upon the raw water temperature (colder water carries more dissolved oxygen than warmer water). Very high levels of dissolved oxygen may exacerbate corrosion of metal pipes (WHO, 2011). BOD refers to the amount of oxygen that would be consumed if all the organics in one liter of water were oxidized by bacteria and protozoa (ReVelle and ReVelle, 1988). The DO and BOD_5 for potable and surface water were found within the range of (4.50 to 8.50 mg/L and 4.90 to 9.60 mg/L) and (ND to 4.67 mg/L and ND to 2.33 mg/L), respectively. According to Oluyemi *et al.,* 2010, BOD values less than 6 mg/L suggests that the water is less polluted by organic matter and they could support aquatic life. The highest DO value (9.60 mg/l) obtained for the Bells swimming pool may be due to aeration process during water treatment.

Free Chlorine

Free chlorine refers to chlorine gas dissolved in water. It is toxic to fish and aquatic organisms, even in very small amounts. Total chlorine test measures both free and combined forms of chlorine. Large decaying materials or organic matter present in water can combine with free chlorine to form compounds called trihalomethanes (THMs). Chlorine is the most commonly used disinfecting agent for drinking water, swimming pools and wastewater. Chlorine application must be monitored even at low concentrations because the gas can irritate the eyes, nasal passages and lungs. Also it can results in the formation of toxic and carcinogenic by-products, such as chloroforms which are persistent. Our results for the Free chlorine and Total chlorine in the potable and surface water were found within the range of (0.05 to 0.77 mg/L) and (0.11 to 0.29 mg/L), respectively. Two of the samples tested had a free chlorine value < 0.2 mg/L (0.05 mg/L and 0.16mg/L). These drinking water sources are a cause for concern, since very low chlorine residuals implies a reduced protection against microbial contamination (Ince *et al.*, 2010). Also, one drinking water sample had a free chlorine value > 0.6 mg/L (0.77 mg/L). There is an increasing tendency that some consumers may object to the taste of water with a residual free chlorine concentration of between 0.6 and 1.0 mg/L (WHO, 2011).

Microbial analysis

The microbiological analysis of some selected water samples are shown in Tables 4.

Table 4. The microbial properties of the samples

Samples	Coliform count on E.M.B (cfu/ml)	Coliform count on M.A (cfu/ml)	Coliform count on N.A (cfu/ml)	Total coliform count MPN/100ml
T.W	N.D	2.8×10^5	4.0×10^5	4
C.P	N.D	4.0×10^4	2.9×10^6	22
I.R	2.5×10^4	4.8×10^4	1.2×10^7	1600
B.I	N.D	1.7×10^5	1.3×10^7	10
W.C	N.D	3.2×10^5	1.1×10^6	2
E.W	N.D	2.7×10^5	8.0×10^5	2
WHO STANDARD				0 per 100ml
EPA STANDARD				0

ND-Not Detected

Microbiological analysis indicated the presence of coliforms, non-coliforms, pathogenic, heterotrophic bacteria which also include opportunistic pathogens such as Aeromonas sp., Proteus and Pseudomonas sp. All the samples were positive for coliform groups which include Shigella sp., Streptococcus sp., and Salmonella sp., which are capable of causing serious diseases. The most probable number (MPN) for the presumptive total coliform count of the water samples ranges from 2 to1600 MPN per 100 ml (Table 4). It indicates that water from Iju river had the highest load of total coliform counts of 1600 MPN per 100 ml while the lowest load of total coliform count in the water sample were present in the well and table water. None of the water samples met the EPA maximum contamination level in drinking water of zero total coliform per 100ml (EPA, 2003, Shittu, *et al.,* 2008). The sources of bacterial contamination for the Iju River may be attributed to surface runoff, animal wastes, seepage or discharge from septic tanks, discharge from sewage treatment facilities and natural soil/plant bacteria (EPA, 2002). The highest number of total and faecal coliform in river sample was not in agreement with WHO and EPA water standard for agricultural use (EPA, 2003). It was observed that there were growth of coliform and other organisms in all the potable and surface water samples analyzed. This buttress the fact that the coliform bacteria are found in nature (Binnie et al., 2002). However, the bacteria load was low and the isolated coliforms were not of feacal origin because when same were inoculated on EMB Agar, there was no significant growth after 48 hours of incubation at 37^0C. Since coliform of faecal origin was not detected, it implies that the water treatment process was adequate enough to kill possible organisms that were of faecal origin.

EMB Agar yielded growth of Gram-negative short rods, the cultural characteristic showed a mucoid colony with the characteristic blue-green/ purple pigmentation after 24 hours at 37^0C, for only the Iju river sample (2.5×10^4 cfu/ml), and were identified as *Escherichia coli (E. coli).* The results infer that the general sanitary quality of the river is unacceptable. For water to be considered safe to human health, the faecal coliforms counts/100 ml should be zero (WHO, 2011). The organism isolated from the river sample was *E.coli* and since *E.coli* is an indicator of faecal pollution, it implies that the Iju River is polluted with faeces (Talaro, 2002, Banwo, 2006; Okonko, 2008). This renders the water source unfit for domestic use without treatment. Also for agricultural purposes, there may be a possibility of contamination on vegetables and other crops eaten in their raw state. However, results from other samples revealed that there were no significant growths of *E. coli* on EMB Agar. Furthermore, there were growth of bacteria on Mac Conkey Agar and Nutrient Agar in all the water samples, but the highest bacteria growths were present in the river sample ($4.8x10^4$). Mac ConkeyAgar, is a media that supports the growth of members of other coliform groups and other bacteria. Growth on Mac Conkey Agar, yielded mixed culture of both gram-positive cocci and gram -negative rods, for the Iju river sample.

Conclusion and Recommendation

Present investigation revealed that the potable water sources are fit for human consumption. However, Iju river water was found to be grossly polluted as a result of microbial contamination due to feacal E. *coli*. In the foregoing, regulatory agencies should ensure that companies and households surrounding the Iju River desist from channelling sewage, effluent, refuse, and human feaces into the water body without prior treatment. Also, an environmental awareness campaign should be organized to educate members of the community on the proper disposal of waste, management and protection of their water resources. These would drastically reduce acute problem of water related diseases, which are endemic to the health of man.

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