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THE PHYSICO-CHEMICAL AND MICROBIOLOGICAL ANALYSIS OF BOREHOLE WATER SAMPLES IN OGUN STATE COLLEGE OF HEALTH TECHNOLOGY, ILESE-IJEBU

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ABSTRACT

In Ijebu-ode, borehole water is the most reliable and readily available source of water to the various households. Though, borehole water (groundwater) quality can be satisfactorily well but a poor siting and management of a borehole can pose potential risks to consumers. For instance, lack of observing maximum distances from source of contamination, poor sanitation and waste management will eventually directly or indirectly contaminate the water and the consumers' health is being jeopardised. The study was carried out to determine the physico–chemical and microbiological parameters of six (6) borehole water samples in Ogun State College of Health Technology campus, the sanitary status of these boreholes and any potential health hazard that consumption of the water can pose. The water samples from the boreholes were analysed for: pH, Colour, Turbidity, Total Dissolve Solid, Hardness, Iron, Manganese, Zinc, Sulphate (SO_4^{2}), Lead (Pb), Chloride, (cl^-) Nitrate NO_3^- and E-coli, Salmonella and Total viable count for microbiological parameters. Sanitary survey form was also used to determine the potential risks associated with the contamination of the boreholes. The data collected were summarized with descriptive statistics. The results showed that turbidity (13NTU), Iron (1.6mg/l), Manganese (3.03mg/l), hardness (245.5mg/l) and Zinc (23.8mg/l) exceeded the WHO standard but Nitrate and lead values were within WHO standard while E-coli and salmonella were not detected and the risk scores were between low and intermediate. The study concluded that the borehole water is fit for consumption except the parameters identified above that can make the consumer reject the water based on the palatability and aesthetic. Therefore, there is need for continuous monitoring of the borehole water in order to maintain and sustain the qualities of the borehole water sources.

INTRODUCTION

Water is one of the most demanded of all urban and rural amenities and it is indispensable for man's activities. Water occupies about 70% of the earth's surface and yet it is one of the scarcest commodities especially in the developing countries of the world (Anyanwu, 2012). Though, borehole water quality can be satisfactorily well but a poor siting and management of a borehole can pose potential risks to consumers. For instance, lack of observing maximum distances from source of contamination, poor sanitation and waste management will eventually directly or indirectly contaminate the water and the consumers health being are jeopardized. Furthermore, water of good drinking quality is of basic importance to human physiology and man's continued existence depends very much on its availability. An average man (of 53 kg – 63 kg body weight) requires about 3 litres of water in liquid and food daily to keep him or her healthy (Wardlow *et al*., 2004). This fact apparently accounts for why water is regarded as one of the most indispensable substances in life and like air it is most abundant. However, despite its abundance, good quality drinking water is not readily available to man. In a report by Sehar *et al*. (2011), water is extremely essential for survival of all living organisms and over one billion people worldwide have no access to safe drinking

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water. The quality of water is therefore of vital concern for mankind since it is directly linked with human welfare. Also, water quality is likely to change day by day and from source to source since it is a dynamic system, containing living as well as nonliving, organic, inorganic, soluble as well as insoluble substances. Any change in the natural quality may disturb the equilibrium system and render it unfit for designated uses. The availability of water through surface and groundwater resources has become critical day by day. Only 1% is available on land for drinking, agriculture, domestic power generation, industrial consummation, transportation and waste disposal. The problems of groundwater quality are much more acute in the areas which are densely populated, thickly industrialised and have shallow groundwater tables. The rapid growth of urban areas has further affected groundwater quality due to over exploitation of resources and improper waste disposal practices. Hence, there is always a need for and concern over the protection and management of groundwater quality (Sehar *et al*., 2011). Followed from the above, the quality of borehole water consumed in the Ogun State College of Health Technology, Ilese-Ijebu was assessed to determine physicochemical parameters and bacteriological characteristics so as to confirm its suitability for drinking purpose and other consumption.

MATERIALS AND METHODS

Description the Study Area

Ogun State College of Health Technology, Ilese-Ijebu is located at Ilese in Ijebu North East Local Government Area of the State. The College is occupying an area of about 100 hectares of land, it is bordered in the North by old Ijebu-Ode/Benin road, and in the South by the Lagos/Benin express way; in the East by Ijebu-Mushin and in the West by OREGUN and Oke-OWA Sawmill of Ijebu North East and ODOGBOLU Local Government Area respectively.

Sample Collection

Samples of borehole water were collected from the six (6) borehole water sources within the Ogun State College of Health Technology, Ilese-Ijebu Campus. The water samples were collected in sterile sampling bottle and well labeled. The samples were analysed in the central laboratory of Institute of Agricultural Research and Training, Moor Plantation, Ibadan.

Physicochemical Parameter Analysis

The physicochemical parameter determined include the following; pH, total dissolved solids, total hardness, total solids, nitrate, sulphate, manganese, sodium, calcium, lead, turbidity, iron, and zinc as described by APHA (1998). Also, bacteriological assay was used in the determination of Escherichia Coli, Salmonella Count and Total viable count. The inspection was carried out to spot any faults and deficiencies that could lead to the pollution of potable water. All the results were compared with the World Health Organization (WHO) Standard. The GPS instrument (Garmin 72 model) was also used to take the coordinates of the borehole locations.

RESULTS AND DISCUSSION

Table 1 shows the geographical location of the boreholes within the college campus. The results and comparison of the sample parameters with the World Health Organization (WHO) standards were presented in Tables 2, 3, 4 and 5. The pH value ranged from 6.85-7.20 which is within the neutral limit. The maximum pH was recorded at college mosque (7.21) and minimum at Girls hostel (6.85). The mean pH value for the six boreholes was 7.01+0.133 which is within the WHO standard of 6.5-8.9 and may not pose any health risk. The results of physic-chemical parameters are shown in Table 2. According to WHO (2006), though 7.0 is the neutral, up to 9.2 may be tolerated, provided that microbiological monitoring indicated no deterioration in bacteriological quality. In this case, all indicators showed no deterioration in bacteriological quality and may not need serious attention. The pH values obtained from this study agree with values obtained by Longe *et al*. (2010) and Ikem *et al*. (2002). The results however are not in agrement with the pH value of 5.68-5.72 reported by Akinbile and Yusuff (2011). The disparity is quite obvious as their work assessed groundwater quality near a municipal landfill in Akure, Nigeria. The maximum colour of 1.4 TCU was recorded at the Girls Hostel and the minimum colour variation of 1.0 TCU was recorded at the college mosque borehole. The mean colour variation of the six borehole water samples was 1.18+0.147 TCU.

Table 1. Coordinates of the borehole locations

Boreholes Locations	Longitudes N	Latitudes E	Elevation
College Gate	06^o 48.108	003^o 57.198	244.5
Boys Hostel	06^o 47.795	003^o 57.242	156.7
College Mosque	06^o 47.907	003^o 57.276	209.2
CHEW Block	06^o 48.037	003^o 57.108	249.5
Girls Hostel	06^o 48.037	003^o 57.108	90.3
Office Block	06^o 47.971	003^o 57.189	211.5

Comparison with WHO standards of 15TCU shows that the water is acceptable. The colour is a factor of appearance and presence of particles which does not necessarily infer contamination NERC (2005). The result disagrees with the findings of Akinbile (2006) who found presence of colour in groundwater as an indication of pollution and confirmed leachate infiltration into the wells. The turbidity readings of the samples were above the WHO standards with the maximum value of 13.4NTU recorded at the office block and the minimum of 12.8 NTU at the College gate. The mean turbidity was 13.0+0.290 NTU. Similar high turbidity values have earlier been reported by Sangodoyin (1991) during the assessment of groundwater and surface water pollution by open refuse dumps in Ibadan, indicating that the wells may be unlined. Very similar observation was made in a study conducted by Akinbile *et al*. (2013). The WHO (2006) recommended a value of 5 NTU as the maximum above which disinfection is inevitable. Extremely high values of turbidity assume the presence of fine particles. Turbidity adversely affects the efficiency of disinfection. However, there is no direct health impact of drinking water turbidity but it can affect the effectiveness of water treatment like filtration Adegbite *et al*. (2013).

The iron values obtained ranged from 1.3 to 1.9 $mgL^{-1}$and its mean value of 1.6+0.237 mgL^{-1} is above the 0.3mgL^{-1} WHO limit. The characteristics and constituents of iron may vary as a result of other consideration, or in relation to the type of distribution system and the prevalence of corrosion problems. The Iron constituent is not of health concern at concentrations normally observed in drinking water. Taste and appearance of

Table 2. The physio-chemical parameters of the water samples

Boreholes	pH	Colour (TCU)	Turbidity (NTU)	Iron (mg/l)	Manganese (mg/l)	Sulphate (mg/l)	Chloride (mg/l)	Hardness (mg/l)	Zinc (mg/l	TDS (mg/l)	Ca (mg/l)	Nitrate (mg/l)
College Gate	6.89	1.1	12.8	1.8	3.2	20.1	76.8	246.6	23.8	113.4	34.8	10.4
Boys Hostel	7.10	1.2	13.1	1.7	3.0	20.8	77.4	244.5	24.1	110.5	33.5	11.1
College Mosque	7.21	1.0	12.9	1.4	2.8	21.4	74.1	248.9	23.4	114.5	39.2	10.9
CHEW Block	6.99	1.3	13.2	1.9	2.9	20.5	76.5	239.9	24.6	105.2	33.8	10.7
Girls Hostel	6.85	1.4	12.6	1.3	3.6	21.6	77.9	247.1	23.3	220.1	36.5	11.5
Office Block	6.99	1.1	13.4	1.5	2.7	21.2	78.5	245.8	23.7	231.4	35.2	11.3
Mean ± SD	7.01± 0.133	1.18 ± 0.147	13.0 ± 0.290	1.6 ± 0.237	3.03 ± 0.327	20.9 ± 0.572	76.9 ± 1.537	245.5 ± 3.091	23.8 ± 0.4792	149.2 ± 59.50	35.5± 0.553	10.98± 0.271
WHO Standard	6.5-8.9	15	5	0.3	0.4	250	250	150	3.0	1000	300	50

Table 3. Bacteriological analyzes of the borehole water samples

Boreholes	E-coli Count (cfu/ml)	Salmonella Count (cfu/ml)	Total viable count (cfu/ml)
College Gate	0	0	1.0×10^3
Boys Hostel	0	0	1.1×10^3
College Mosque	0	0	1.2×10^3
CHEW Block	0	0	1.0×10^3
Girls Hostel	0	0	1.1×10^3
Office Block	0	0	1.2×10^3
Mean ± SD	0	0	$1.1 \times 10^3 \pm 0.0756$
WHO Standard	0	0	-

Table 4. Sanitary inspection and the risk scores for the borehole

Borehole	Risk Score	Remarks
College Gate	3	Intermediate
Boys Hostel	4	Intermediate
College Mosque	1	Low
CHEW Block	2	Low
Girls Hostel	3	Intermediate
Office Block	2	Low

water are affected at concentrations below the health-based value but it can cause staining and the exacerbation of discoloration of water. This metal is not however, considered hazardous to health but in fact considered essential for good health because of its role on the transportation of oxygen in the blood. Thus the recommended limit of 0.3 mg/dm^3 for iron in water is based on taste and appearance rather than on any detrimental health effect. Rather, this can be used as a tool for the evaluation of water quality.

For instance, when its level in water exceeds the 0.3 mg/dm^3 limit, red, brown, or yellow staining of laundry, glassware, dishes and household fixtures such as bathtubs and sinks occur. The water may also have a metallic taste and an offensive odour. Also, water system piping and fixtures can be clogged NERC (2005). For manganese, the values ranged from 2.7 to 3.6 mgL^{-1} with mean value of 3.03+0.327mgL^{-1} which is high above the WHO limit of 0.1mgL^{-1}. As noted by Akinbile (2006), above 0.5mg/L, manganese will impair portability. Longe *et al*. (2010) also reported that excessive concentration of manganese would result in taste and precipitation problems. The result disagrees with the findings of Ogedengbe *et al*. (2004). At levels exceeding 0.1mgL^{-1}, manganese in water caused an undesirable taste in beverages and stains sanitary ware and laundry. The presence of manganese in drinking water, like that of iron may lead to the accumulation of deposits in the distribution system. Calcium levels ranged from 33.8 to 39.2mgL^{-1} which is within the WHO standard limits of 300 mg/L. Though very low, it can cause danger of hardness in water. The implication is that forming lather with soap will be a major challenge for domestic users (Akinbile, 2006). Chloride values for the borehole water samples are within the WHO limit. The office complex sample had the highest chloride content of 78.5mgL^{-1} and the college mosque sample had the least of 74.1mgL^{-1}. Chloride, in the form of sodium (NaCl), potassium (KCl) or calcium ($CaCl_2$) is one of the major inorganic anions in fresh and waste-water but in potable water, the salty taste produced by it varies and depends upon the chemical composition of the water. High chloride content may harm metallic pipes and structures as well as growing plants, cause hypertension and increased concentration of other metals in water (WHO, 2003). The chloride content or limit recommended by EPA is 250 mg/L and none of the samples analysed in this study had higher values than this limit. Its presence connotes pollution hence requires treatment before use. The results obtained in this study agreed with the findings of Igbinosa *et al*. (2009). Hardness was detected in the water samples. The minimum hardness of 239.9mg/L was detected at CHEW block and the maximum value of 248.9mg/L at College gate.

The mean value is 245.5mg/L which is exceeded the 150mg/L WHO limits. This does not have any associated adverse health related effects on human but is an indication of deposits of Ca and /or Mg ions. Their presence will disallow water from forming lathe with soap thereby preventing economic management of water resources. Public acceptability of the degree of hardness of water may vary considerably from one community to another, depending on local conditions (Adegbite *et al*., 2013). The sulphate contents of all the water samples are within the WHO limits of 250mg/L, hence could be utilized in fisheries project and agricultural activities. According to Esry *et al*. (1991), the levels of sulphate above 600mg/L act as purgative in humans. The Zinc levels detected in the water samples ranged from 23.3 to 24.6mg/L. The mean value is 23.8+0.479mg/L, a value above the 3.0mg/L recommended WHO limit. Though, zinc is an essential element needed by the body and is commonly found in nutritional supplements and all foods. However, when taken in relatively large quantity over a period of time, zinc affects human health (NERC, 2005). A similar result was reported by Igbinosa and Okoh (2009). The result is in agreement with the findings of Ikem *et al*. (2002) and Shyamala *et al*. (2008).

Though the Total Dissolved Solids (TDS) which ranged from 105.2mg/L to 231.4mg/L was lower than the WHO limit, the value indicated pollution. This result is in consonance with the findings of Akinbile *et al*. (2013). Nitrate, the most highly oxidized form of nitrogen compound is commonly present in surface and groundwater because it is the end product of aerobic decomposition of organic nitrogenous matter.

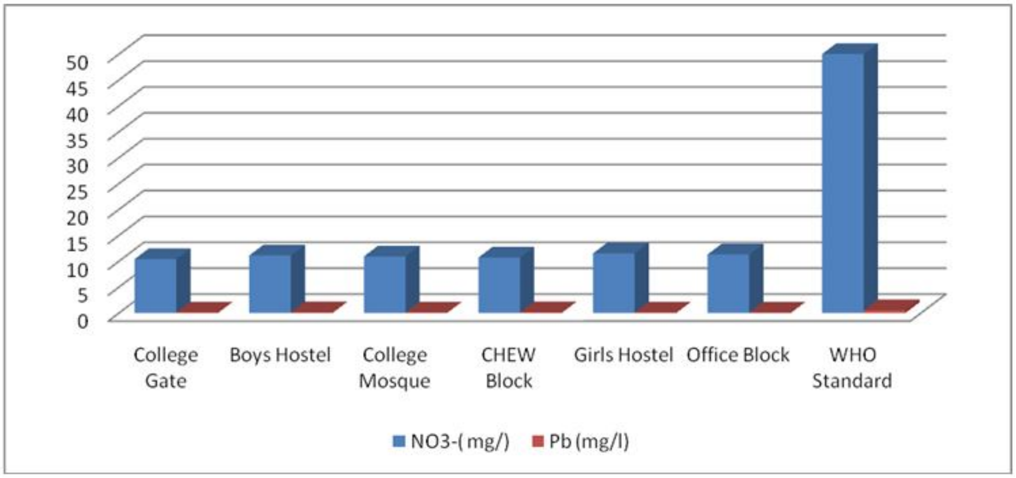

Figure 1. Lead and nitrate levels in the water samples

Unpolluted natural waters usually contain only minute quantities of nitrate. The nitrate values in the study ranged from 10.4 to 11.5mg/L which were below WHO recommended limit of 50mg/L (Figure 1). Nitrate concentration above the recommended value of 10mg/L is dangerous to pregnant women and poses a serious health threat to infants less than three to six months of age because of its ability to cause methaemoglobinaemia or blue baby syndrome in which blood loses its ability to carry sufficient oxygen Frecham *et al*. (1986). Malomo *et al*. (1990) reported nitrate concentrations up to 124mg/L and nitrite up to 1.2mg/L in shallow groundwater near pollution source in southwest Nigeria. These concentrations were unusually high. The common concentrations were a little above 10mg/L for NO_3 and 0.06 mg/L for NO_2 as reported by previous investigators (Adepelumi *et al*., 2001). The lead Pb level in the water samples analysed is within the WHO regulation. However, the high level of lead Pb in CHEW Block sample (Figure 1) could be attributed to the proximity of the location to the main road. The presence of the lead does not constitute any health risk or significance to cancer, and interference with vitamin D metabolism. The other impact of lead is that it affects mental development in infants, toxic to the central and peripheral nervous system.

Bacteriological Analysis

The bacteriological characteristics of the samples tested were indicated in the Table 3. The microbiological qualities of the boreholes water samples are satisfactory. *Escherichia coli* and Salmonella species that are major indicator of water pollution were not detected. Coliform populations are indicators for pathogenic organisms. They should not be found in drinking water but usually present in surface water, soil and feces of human and animals. Human waste contaminant in water causes water-borne diseases such as diarrhea, typhoid and hepatitis (Root *et al*., 1982). Absence of Coliform population in all the water samples is a clear indication of good sanitary conditions in the study area. High coliform counts appear to be characteristics of rural ground water quality in Nigeria. This result is in contrary with the works of other investigators who worked on bacteriological characteristics of rural water supplies in other parts of the country.

Sanitary Inspection of the Boreholes

The results of sanitary inspection and the risk scores for the borehole are shown in the Table 4. The Table indicates the risks ranges from low to intermediate risks. Sanitary surveying is an inspection technique that records such visible problems, enabling fieldworkers to assess the likely quality of the water, relative to other sources. The recorded risks in the case of the college boreholes showed the close distance of latrines or sources of contamination (poor site selection), or cracks in the pipe or poor protection of the boreholes against pollution and structural deteriorations of the borehole. However, the results and risk scores do not creates a situation of treating the water before consumption or abandoning of these water sources.

Conclusion

It is evident from this study that the physico-chemical and microbiological qualities of the water were satisfactory. Some of parameters that were above the WHO standards could only affect the palatability and acceptability of the water based on its aesthetic nature. It could not affect the microbiological qualities because there was no presence of pathogenic organisms that can cause diseases or pose any potential risks. Therefore, there were no potential public health risks or impacts on the consumers of these boreholes water. On long run the qualities might change when the population of the college and town increases. It is recommended that increased and continued combined environmental interventions, through public health education by community based health workers, awareness and sensitization campaigns should also be carried out for improved college community sanitation.

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