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Quality Characteristics of Groundwater Utilized by Resident Students of a Nigerian University

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Abstract: The resident student community of the Federal University of Technology Owerri, Nigeria is heavily dependent on ground water for various activities. In an attempt to solve a lingering water shortage problem at the student hostels, the university authority recently constructed and commissioned three new water boreholes at the student hostels. This study assesses the physico-chemical and bacteriological characteristics of such underground water being utilized by the resident students. Overall mean conductivity value (102 us/cm) and those for individual hostels were similar to the WHO recommended minimum ($p>0.05$). Other physical characteristic values such temperature, Total Dissolved Solids (TDS), Total Suspended Solid (TSS), turbidity, color, odor and appearance were equally significantly ($p<0.05$) lower than the WHO minimums. The overall mean values recorded for pH (4.93), sulphate (1.00 mg L^{-1}), nitrate (3.11 mg L^{-1}) and free chlorine (0.04 mg L^{-1}) were significantly ($p<0.05$) lower than the WHO minimums. Mean values of iron, copper and manganese (0.61, 3.11 and 0.24 mg L^{-1}, respectively) were on the other hand significantly ($p<0.05$) higher than the WHO recommended minimum values. Total coliform and total viable bacteria counts were too numerous and significantly higher than the WHO recommended standards. There is an urgent need for the proper treatment before distribution of borehole water being utilized at the student hostels of the Federal University of Technology Owerri. Such treatment should emphasize the disinfection against coliforms and removal of excess iron, copper and manganese.

Key words: Ground water, quality, Nigerian University, students

INTRODUCTION

Water is an essential resource required for human survival on earth since many activities of man require the use of water. Man uses water for domestic, agricultural, social and industrial purposes. The major issues associated with the use of water by humans are quantity and quality[1]. Although natural water is regarded as one of the most abundant commodities on earth, the usefulness of any water is determined by its quality. In traditional societies, water quality is usually assessed through its physical properties such as color, odor and taste. Modern science has however developed efficient methods of assessing water quality for the benefit of man.

Many anthropogenic activities of man have led to water pollution in our environment. This, in addition to irregular supply of pipe borne water has forced many to resort to exploration and exploitation of groundwater in Nigeria[2]. Ground water originates as infiltrations from precipitations, stream flows, lakes and reservoirs[3]. The quality of any ground water therefore depends on the types of materials on the passage routes, the dissolved salts and general human activities especially those bordering on waste disposal systems[4]. Ray[5] reported that where the water table is shallow and the soil porous, dissolved gases, nitrates, sulfates, soluble organic compounds and dissolved salts might be introduced into the ground water system. Thus, if solid wastes disposal sites are not chosen wisely, high concentrations of chemical and gaseous compounds or decayed organic matter may leach through the soil and contaminate ground water[6].

The acceptability of water is evaluated in terms of the quality requirements for a specific beneficial use. For example, water meant for human consumption should be palatable, free of disease causing organisms, minerals and other organic substances that could impair human health[7-9]. Water quality standards established by regulatory agencies to define the limiting levels of various constituents that can be tolerated have been published[10].

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When these standards are not fully met, the water may not be 100% fit for human consumption and may be the source of water borne ailments.

The resident community of the Federal University of Technology Owerri (FUTO) is predominated by on-campus students. Indeed, all the staff and faculty members of the university reside in the adjoining towns. This resident student community is heavily dependent on ground water for various purposes. The university has however had reoccurring water shortage problem among its resident students community that has led to improper human wastes disposal in recent times. Students have resorted to answering the call of nature in the adjoining bushes. In an attempt to solve this problem, the university authority recently constructed and commissioned three new water boreholes at the student hostels. While this action may have alleviated the problem of water shortage considerably, there is however, the need to assess the quality characteristics of water derived from these boreholes considering the history of human and other waste disposal methods in the area.

This study is designed to assess the physical, chemical and bacteriological characteristics of underground water utilized by resident students of the Federal University of Technology Owerri, Nigeria.

MATERIALS AND METHODS

Water samples collection: Underground water were collected from boreholes located at the student hostels B, C and D of the Federal University of Technology Owerri, during morning hours (9 to 10 am). Samples for physico-chemical analysis were collected in properly labelled 2 L plastic containers. Prior to collection, these plastic containers were thoroughly washed and filled with 5% HCl and left to dry for 24 h. Thereafter each container was again washed with the borehole water to be collected and then filled with the water sample and corked.

Water samples for bacteriological analysis were collected in plastic containers, which have been sterilized in an autoclave at 121°C for 30 min. After allowing for several liters of water to run to waste, samples were taken by allowing water to flow directly from the borehole pump into the sterilized plastic containers. The containers were thereafter corked and placed in a cooler to maintain temperature during transportation the laboratory for analysis. All the samples were analyzed at the Imo State Environmental Protection Agency (ISEPA) laboratory, within 4 h of their collection but where this was not possible, samples were refrigerated at 4°C.

Physico-chemical analysis: The methods described by the American Public Health Association[11] and Association of Official Analytical Chemists[12] were adopted in the analysis of physico-chemical characteristics of the water samples. The parameters determined included pH, temperature, conductivity/Total-Dissolved Solids (TDS), Total Suspended Solid (TSS), turbidity, color, odor and appearance.

Electrolytes concentrations were determined with the aid of an atomic absorption spectrophotometer (Hach, DR/2010). Overall, sulfate, iron, copper, manganese, nitrate and free chlorine concentrations were determined.

Bacteriological analysis: Water samples for bacteriological analysis were subjected to serial dilution and coliform and viable bacteria counts determined according to the method developed by WHO[10].

Data analysis: All data generated were subjected to simple descriptive statistics such as averages and percentages. The means of these were further compared with the standard minimums declared by WHO[10] using the Student t-test[13].

RESULTS

Physico-chemical characteristics: Mean conductivity value (102 us/cm) and those for individual hostels were similar to the WHO recommended minimum value ($p>0.05$). All the other physical characteristics values were equally significantly ($p<0.05$) lower than the WHO minimums (Table 1).

Table 1: Physical characteristics of borehole water samples from student hostels at the Federal University of Technology Owerri, Nigeria and their comparisons with WHO minimum standards

Physical parameters	Sample A hostel B	Sample B hostel C	Sample C hostel D	Mean	WHO*	p- value
Temperature (°C)	27.60	28.30	28.00	27.97	-	-
Conductivity (us/cm)	122.90	96.50	88.40	102.60	100.00	0.008
TDS (mg L^{-1})	63.40	26.60	34.80	41.60	250.00	0.395
TSS (mg L^{-1})	3.00	1.00	1.00	1.67	250.00	0.496
Color (PTCO)	6.00	9.00	4.00	6.33	15.00	0.246
Odor	Unobject.	Unobject.	Unobject	Unobject.	Unobject.	-
Appearance	Clear	Clear	Clear	Clear	Clear	-
Turbidity	5.24	4.86	3.96	4.69	50.00	0.441

*WHO[10], TDS = Total Dissolved Solids, TSS = Total Suspended Solids, UNOBJECT = Unobjectionable

Table 2: Chemical characteristics of borehole water samples from student hostels at the Federal University of Technology Owerri, Nigeria and their comparisons with WHO minimum standards

Physical parameters	Sample A hostel B	Sample B hostel C	Sample C hostel D	Mean	WHO*	p-value
pH	4.93	5.07	4.81	4.93	7.50	0.129
Sulphate (mg L^{-1})	1.00	2.00	0.00	1.00	250.00	0.498
Iron (mg L^{-1})	0.70	0.50	0.63	0.61	0.30	0.209
Copper (mg L^{-1})	2.45	3.24	3.65	3.11	1.00	0.302
Manganese (mg L^{-1})	0.02	0.30	0.24	0.24	0.10	0.249
Nitrate (mg L^{-1})	2.45	3.24	3.65	3.11	4.00	0.079
Free Chlorine (mg L^{-1})	0.04	0.03	0.04	0.04	0.30	0.416

* WHO[10]

Table 3: Bacteriological characteristics of borehole water samples from student hostels at the Federal University of Technology Owerri, Nigeria and their comparisons with WHO minimum standards

Bacteriological parameters	Sample A hostel B	Sample B hostel C	Sample C hostel D	WHO*
Total coliform (CFU)	TNC	360	TNC	2
Total viable bacteria (CFU)	>400	>400	>400	10

* WHO[10], TNC= Too Numerous to Count, CFU = Colony Forming Units

The overall mean values recorded for pH (4.93), sulphate (1.00 mg L^{-1}), nitrate (3.11 mgL^{-1}) and free chlorine (0.04 mg L^{-1}) were significantly ($p<0.05$) lower than the WHO minimums (Table 2). Mean values of iron, copper and manganese (0.61 mg, 3.11 and 0.24 mg L^{-1}, respectively) were on the other hand significantly ($p<0.05$) higher than the WHO recommended minimum values.

Bacteriological characteristics: Table 3 showed that total coliform and total viable bacteria counts in all the sampled borehole water were too numerous and significantly higher than the WHO recommended standards.

DISCUSSION

Domestic water use, which includes drinking, cooking, washing and toilet uses among others, represents a vital component of the abstractive use of water[14]. Water for human consumption should therefore be free of organisms, chemical and physical substances in amounts that may affect human health. Furthermore, such water should not posses objectionable odor, taste, color or turbidity.

The temperature, color and pH ranges in all the sampled borehole water at the Federal University of Technology Owerri, are within the WHO acceptable standards for potable water[10]. All the water samples were however slightly acidic. This could be attributed to the presence of dissolved carbon dioxide or other mineral acids in the water samples[15]. TDS and TSS concentrations in all the sampled borehole water will not constitute any health hazard since they fall below the WHO minimums. Odor and appearance of the water samples were equally found unobjectionable and clear. Odor in water is usually caused by volatile substances associated with organic and chemical materials such as algae and chlorine[16,17]. The normal free chlorine levels obtained in the present study support this. Conductivity level of sample A was visually higher than the WHO standard while the values for the other sites remained below and statistically lower.

The significantly higher values of iron, manganese and copper reported here, may impact metallic taste as well as poor aesthetic qualities like reddish or greenish brown stains on sinks and other water fittings. Such stains develop when on exposure to air, iron and manganese dissolved in ground water become oxidized to form precipitate compounds. High concentrations of manganese in drinking water may over time cause aching limbs, back pains, nervousness, drowsiness, nasal congestion and nose bleeding to consumers of such water[7]. Similarly, concentrations of copper in drinking water above 1.0 mg L^{-1} have been reported to trigger off certain cardiovascular diseases. Large doses of copper may cause gastro intestinal distress and vomiting within an hour of ingestion[7,18].

Total coliform and total viable bacteria in most of the samples were too numerous to count, indicating that they were heavily contaminated with fecal matter. This evidence alone points to the urgent need for the borehole water to be treated before use by the students. The sources of these fecal contaminations could be traced to the indiscriminate and deliberate littering of human and animal waste in adjoining bushes to the borehole sites. During the rainy season, the fecal contaminants infiltrate and follow the sub-surface hydrologic regime[4,6].

CONCLUSIONS

The data generated from the present study highlights the urgent need for the proper treatment before distribution of borehole water being utilized at the student hostels of the Federal University of Technology Owerri. Such treatment should emphasize the disinfection against coliforms and removal of excess iron, copper and manganese.

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