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Assessment of the Microbiological Quality of Borehole Water in Abia State College of Health Sciences and Management Technology, Aba

Onuoha-Elvis, C.N*., Oluoha, O.S., Onwuchekwa, O.V., Ezenwa, A.M. and Kanu, M. I
Department of Science and Laboratory Technology, Abia State College of Health Sciences and Management Technology, Aba, Abia State, Nigeria.
***Corresponding Author:** *cynthiaelvis017@gmail.com*

ABSTRACT

Water is critical for the proliferation of life and all known forms of life including man depend on water. Hence adequate supply of fresh and clean drinking water is a basic need for all human beings. This study investigated the microbiological quality sources of drinking water in Abia State College of Health Sciences and Management Technology, Aba, Abia State, Nigeria as to ascertain the potability of the water. Water samples were aseptically collected from five (5) boreholes located around the Pharmacy Laboratory, Hostel C, Male Hostel, Rotary Tap, and Bursary Unit. Samples were analyzed using standard pour plate method and the most probable number (MPN) technique. Mean values of total heterotrophic bacterial counts for the borehole water in Pharmacy Lab, Hostel C, Male hostel, Rotary Tap, and Bursary unit were 1.1 x 10^2CFU/ml, 1.2 x 10^2 CFU/ml, 2.1 x 10^2CFU/ml, 1.0 x 10^2CFU/ml and 2.5 x 10^2 CFU/ml respectively. While the MPN index for coliform counts in borehole water samples in Male Hostel, Bursary Unit and Hostel C was 50 cells/100ml, 26 cells/100ml and 2 cells/100ml respectively. However, Pharmacy Lab and Rotary Tap had 0 cells/100ml (zero count). The fungal counts from Pharmacy Lab was 2.2 x 10^2CFU/ml, while counts for Hostel C, Male hostel, Rotary Tap, was 1.0 x 10^2CFU/ml each, and Bursary unit was 1.1 x 10^2CFU/ml. The bacteria isolated and identified were; *Staphylococcus, Pseudomonas, Micrococcus*, *Enterobacter*, *Bacillus*, and *Serratia* sp, while the fungi were; *Penicillium*, *Fusarium, Aspergillus,* and *Rhizopus* sp. The bacteria and fungi isolated contain species which are potential pathogens capable of causing disease. Thus, there is urgent need for public awareness on the danger associated with the use and consumption of these borehole water without adequate treatment.

Keywords: Borehole water, microbiological quality, bacteria, fungi, potability, health institution.

Introduction

Water has many distinct properties that are critical for the proliferation of life and all known forms of life depend on water. Water is vital both as a solvent in which many of the body's solutes dissolve and as an essential part of many metabolic processes within the body. Water fit for human consumption is referred to as potable water or drinking water. Water that is not potable may be made potable by filtration or distillation, or by a range of other methods. More than 660 million people do not have access to safe drinking water (Jammi, 2018). In most developing countries as well as Nigeria, boreholes are dug by individuals, public and private entities in a bid to overcome the challenge of water shortage and supply. This has resulted in dependence on boreholes as readily available source of potable water for drinking and domestic uses. However, this has caused concerns among health professionals.

Safe water is important for human health and sustainable development (Sungsitthisawad and Pitaksanurat, 2013). Availability and adequate supplies of water are necessary for agriculture, human consumption, industry as well as recreation. It is a well-known fact that fresh water is an important necessity for our health. With the advancement of technology, increased population and industrialization, fresh water resources all over the world are threatened. The quality of ground water is the result of the processes and reactions that act on the water and varies from one place to another depending on the depth of the water table (Abong'o *et al*., 2017; Mohan *et al*., 2014). Groundwater can be contaminated by chemicals as well as microorganisms (Bharti *et al*., 2011).

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Generally, groundwater becomes purer with increase in depth (Ojo *et al*., 2012). The presence of local sanitation systems, human activity, urbanization, industrialization, and sewage makes groundwater vulnerable to contamination by microorganisms. Populations who have boreholes or wells often use groundwater as their main source of water. Many people assume water is safe to drink because it looks good and is crystal clear. However, this water may contain microorganisms or substances harmful to human health and be unsuitable for human consumption (Silva *et al*., 2023).

According to WHO (2003) recommended standard, the effective distance between septic tank and any drinking water source is estimated to be a minimum of 30m and above. However, because of space and knowledge about water drilling, most boreholes are dug close to septic tanks and pit latrines which may result in the contamination of underground water sources with faecal material. Most residents of Aba depend on borehole water for drinking and domestic activities. Regrettably, the underground water is not treated before use and there is no effort to ascertain its safety.

Microbiological assessment of water is considered very important because of acute risk to human health posed by microorganisms in drinking water. It is, therefore, a health-based activity which emphasizes the protection of public health through ensuring that the available source of water is of a good quality (Raji and Ibrahim, 2011). In view of the above fact, this study was conducted to assess the microbiological quality of borehole water used by students and residences of Abia State College of Health, Aba, as to ascertain the potability of the water.

Material and Methods

Collection of Borehole Water Samples

Borehole water samples were aseptically collected from five (5) locations **(**Pharmacy Laboratory, Hostel C, Male Hostel, Rotary Tap, and Bursary Unit) within the school premises and labelled A- E respectively. The water samples were immediately transported in cool box containing ice packs to the laboratory for bacteriological analysis. All analysis was carried out in duplicates.

Cultivation and Enumeration of Total Heterotrophic Bacteria and Fungi in the Borehole Water Samples

Standard microbiological methods for determination of total heterotrophic bacterial count, total coliform count and total faecal coliform count were employed. One milliliter (1 mL) each of the water samples was pipette into 9mL of sterile physiological saline and thoroughly mixed by swirling and was serially diluted. The spread plate method was used in inoculating aliquot (0.1 mL) of 10^2 dilution into a sterilized nutrient agar and potatoes dextrose agar (PDA) medium in Petri dishes for the cultivation of bacteria and fungi respectively. Cultured plates were incubated at 37℃ for 24 to 48 hours for heterotrophic bacteria and 27^{o}C for 2 to 5 days for fungi. The colonies obtained were counted and expressed as colony forming units per milliliter ($CFUmL^{-1}$) of borehole water sample.

Enumeration of Total and Faecal Coliforms

The multiple tube fermentation technique also called the Most Probable Number (MPN) was used to estimate the total coliforms and faecal coliform. Three sets of five test tubes containing lactose broth and the right sample volumes (10mL, 1.0mL and 0.1mL) were used. Tubes showing acid and gas production indicates positive for the organisms, the number of organisms present was determined statistically using the MPN table. This technique consists of three major steps, the presumptive, confirmatory and completed tests. The presence of faecal coliforms was further characterized by streaking positive tubes from the previous procedures, on Eosine methylene blue agar (EMB) plates. Colonies from these plates were Gram stained and their biochemical test carried out for identification.

Confirmed test

In order to confirm the presence of coliforms, an inoculum was taken from the positive presumptive tubes and was streaked on Eosin-methylene blue (EMB) agar plates and incubated at 35°C for 24 hours. The methylene blue in EMB agar inhibits Gram positive organisms and allows the Gram-negative coliforms to grow. Coliforms produce colonies with dark centers. *E. coli* and *E. aerogenes* can be distinguished from one another by the size and color of the colonies. *E. coli* colonies are small and have a green metallic sheen, whereas *E. aerogenes* forms large pinkish colonies.

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Completed test

The completed test was carried out by using the organisms which grew on the EMB, These organisms were used to inoculate a nutrient agar slant and a tube of single strength lactose broth using a sterile wire loop and incubated at 35°C for 24-48hours.

The lactose broth was checked for the production of gas, and a Gram stain was made from organisms on the nutrient agar slant and was viewed microscopically for Gram-negative, non spore-forming rod that produced gas in the lactose tubes which is positive that coliforms are present in the Water samples.

Identification of the Bacterial Isolates

The isolates were identified based on their microscopic characteristics, motility, colony morphology, Gram staining reactions and biochemical characteristics including sugar fermentation test.

Identification of the Fungal Isolates

Morphological characteristics such as shape, colour, arrangement of spores, structure of the mycelium, structure of hyphae and arrangement of sporangiophores was used to identify the fungi isolates. Isolates were further examined microscopically by staining with lactophenol cotton blue. A drop of lactophenol cotton blue was placed on a teased fungal isolate on a grease free clean glass slide. The teased sample was covered with clean cover slip avoiding air bubbles and the slide was examined under the microscope using ×10 and × 40 magnifications.

Results

The results of the Microbial counts including the Most probable number (MPN) of Coliform of borehole water samples in College of Health Sciences, Aba are presented in Table 1. While the Morphological and physiological (biochemical) characteristics of bacteria isolated from borehole water are presented in Table 3.

Table 1: Microbial Counts of Borehole Water Samples in College of Health Sciences, Aba

Location of water sample borehole	Microbial Counts (CFU/ml) of Borehole Water Samples			
	Total heterotrophic bacteria	Total coliform	MPN index/100ml	Total fungal count
Pharmacy Lab	1.1×10^2	-	0	2.2×10^2
Hostel C	1.2×10^2	-	2	1.0×10^2
Male hostel	2.1×10^2	1.1×10^2	50	1.0×10^2
Rotary Tap	1.0×10^2	-	0	1.0×10^2
Bursary unit	2.5×10^2	1.6×10^2	26	1.1×10^2
WHO	1.00×10^2		0	
USEPA	1.00×10^2			

Table 2: Morphological and Physiological Characteristics of Bacteria Isolated from Borehole Water

Morphology	Gram	Catalase	Coagulase	Citrate	Oxidase	Indole	Methyl Red	Vogue/proskauer	Lactose	Glucose	Sucrose	Most problem organism
Bright yellow on MSA	+ve Cocci	+	+	+	-	-	+	-	A/-	A/-	A/-	*Staphylococcus* sp.
Greenish on NA	-ve Rod	+	-	+	+	-	-	+	A/G	A/G	A/-	*Pseudomonas* sp.
Milky on NA	+ve Rod	+	-	-	-	-	-	+	-/-	A/-	A/-	*Micrococcus* sp.
Pink on Mc	-ve Rod	+	-	+	+	-	-	+	A/G	A/G	A/-	*Enterobacter* sp.
White on NA	+ve Rod.	+	_	+	+	-	+	-	A/-	A/-	A/-	*Bacillus* sp.
Red on NA	-ve Rod	-	-	-	+	+	-	+	A/-	-/-	A/-	*Serratia* sp.

Key: NA = Nutrient agar; MC = McConkey; + = Possitive; - = Negative; -/- = Negative acid and gas; A/- = positive acid and negative gas; A/G= positive acid and gas

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Table 3: Morphological and Microscopic Characteristics of Fungi Isolated from Borehole Water

S/N	Cultural Morphological	Microscopy	Probable fungal isolate
1	Large fluffy white colonies almost covering the whole surface	Non – septate branched hyphal enlarge at the apex to form cornidophorex they produce brownish black *ceridia* in chains.	*Penicillium* sp
2	Colonies growing rapidly growing, aerial mycelium white, becoming purple, with discrete orange sporodochia present with aerial mycelium,	Non-septate, microconidia, ellipsoidal to cylindrical, straight and curved, with terminal chlamydospores, hyaline, smooth – walled,	*Fusarium* sp
3	Black powdery conidiophores	Conidiophores arising from long branched foot calls, irregularly roughened.	*Aspergillus niger*
4	Fast growing colonies forming hyaline ariel hyphae, rhizoids are pigmented with brownish sporangiophores	Differentiated into stolons and nodes with rhizoids and sporangiophores, sporangiophores are short ellipsoidal with almost pointed ends	*Rhizopus* sp

Table 4: Prevalence of Bacteria Isolates in Borehole Water Samples in College of Health Sciences, Aba

Isolate	Location of borehole water sample					Prevalence
	Pharmacy lab	Hostel C	Male hostel	Rotary unit	Bursary unit	(%)
Staphylococcus sp.	+	+	+	+	+	100
Bacillus sp.	-	-	+	-	+	40
Pseudomonas sp.	-	+	+	-	+	60
Micrococcus sp.	+	+	-	+	+	80
Enterobacter sp.	-	-	+	-	+	20
Serratia sp.	-	+	-	+	-	20
Penicillium sp.	+	-	+	-	-	40
Aspergillus sp.	-	+	+	-	+	60
Fusarium sp.	+	+	-	+	-	60
Rhizopus sp.	-	-	+	-	-	20

Discussion

The present study investigated the microbial quality of ground water (Bore hole) used within the Abia state college of health Aba. Findings from the study revealed that some of the water samples analyzed had microbial contaminants beyond the world health organization (WHO) standard for potable water.

The bacterial count ranges from 1.1 x 10^2, 1.2 x 10^2, 2.1 x 10^2, 1.0 x 10^2 and 2.5 x 10^2 respectively for the different sample while the MPN index for coliform count per 100ml of the water was 50 for male hostel, 26 for bursary unit and 2 for hostel C.

The fungi count ranges from 2.2 x 10^2 for pharmacy lab, 1.0 x 10^2 for hostel C, male hostel and Rotary tap and 1.1 x 10^2 for bursary unit. The bacteria and fungi isolated in this study included *Staphylococcus, Pseudomonas, Micrococcus*, *Enterobacter, Bacillus, Serratia* Sp, *Penicillium, Fusarium, Aspergillus,* and *Rhizopus* sp. (Table 2 and 3).

The observed finding in the present study can be attested to that reported by several other researches Biiton, (1994), Okonko *et al*., (2008), Likambo (2014), and Okoro *et al*., (2017) who reported similar microorganisms in their study.

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The presence of these organisms signifies contamination of ground water from anthropogenic activities, dept of bore hole, closeness to potential source of contamination and others. The *Staphylococcus* species is known micro flora of the skin and have been reported to produce enterotoxin (Okonko *et al*., 2008). *Bacillus* and *Serratia* sp are widely distributed in soils and water and their presence in the water sample can be attributed to the environmental condition of the taps and/or closeness of the tap to the ground. *Pseudomonas* sp is an example of non-faecal coliforms, while *Enterobacter* species are a fecal coliform. Their presence in the borehole water samples can be attributed to the depth and distance of the bore hole to septic tank, domestic refuse dump site and other human activities that predisposed the water sources to microbial contamination. According to Likambo (2014) the greater the distance of the borehole from the potential source of pollution, the more difficult it will be to become contaminated.

The results of the study (Table 1 and 2) also showed that the male hostel and bursary unit had the highest microbial and coliform count compared to water samples from hostel C, pharmacy lab and Rotary tap as the least. The high microbial contamination seen in the male hostel and bursary unit can be attributed to its closeness to septic tank, hostel waste dump and nearness of the tap to the floor. However, water samples from the Rotary tap and pharmacy lab were of good microbial quality and within the accepted standard recommended by the WHO for portable water as no coliform counts were recorded. According to WHO (2017), total microbial counts should not be more than 1.0×10^2 cells/ ml, and zero MPN count per 100 ml of a water sample.

The presence of fungi species (*Penicillium*, *Fusarium*, *Aspergillus*, and *Rhizopus* sp) in the water (table 4) is not surprising as the spores are present in the atmosphere where they can settle in water tanks whose lid is not properly placed or from surrounding environments. Study by Biiton (1994) and Okoro *et al*. (2017) added that diverse unfriendly environmental human activities in the vicinity of underground water and poor borehole construction, contributed greatly to their pollutions and poor water qualities. In addition, it was observed that some of the boreholes are pumped into pipes for distribution and storage in plastic and metal tanks.

Rusty pipes and tanks affect the quality of water by allowing seepage of microbial contaminants into the borehole water (Ibe *et al*., 2002). Some of these tanks are equally long overdue for wash which may allow the growth and formation of microbial biofilm in the tank. The presence of these organisms in the borehole water samples is of great concern because they are mostly pathogenic and could cause serious health problems.

In conclusion, this study has revealed that borehole water (ground water) supplies for use in the College Of Health Sciences in Aba, is vulnerable to microbial pollution. Therefore, groundwater may not always be of pristine quality as is perceived. For this reason, adequate treatment of ground water is recommended before consumption. Detailed and continuous monitoring and assessment of the microbial status as well as other chemical parameters such as total phosphorus concentrations which are indicative of pollution from human and animal waste is highly recommended.

Public awareness and education on the need for personal and environmental hygiene is recommended to educate the students and staffs on the possible risks associated with the consumption of contamination water. Early detection of possible contamination can lead to faster implementation of corrective measures, preventing an imminent waterborne disease outbreak. In addition, borehole drillers should take into consideration factors that will affect the water quality such depth, distance to the potential pollutants, groundwater flow direction and soil structure.

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