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Microbiological and Physico-Chemical Evaluation of Borehole Water in Owerri, Imo State

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Abstract
Microbiological and physico-chemical evaluation of borehole water in Owerri Imo State was investigated. Samples of borehole water were collected from ten different sampling sites in Owerri Municipal. Standard microbiological methods like membrane filter methods, biochemical test, culture, wet mount and wet mount using iodine were used to determine the presence of microorganism. Standard sampling and physico-chemical analysis of the borehole water was done using the standard methods for the examination of water, the American public health association to determine different parameters of the borehole water. The result of the analysis showed that bacteria, fungi and parasites were identified. Bacteria isolated and identified were *Staphylococcus aureus, Escherichia coli, Vibrio cholerae, Salmonella* spp, *Proteus* spp, *Pseudomonas* spp, *Bacillus* spp *and Klebsiella* spp. *Fungi identified were Aspergillus flavus, Aspergillus tamarii, Aspergillus niger, Rhizopus* spp. *Fusarium* spp. and *Candida* spp. Parasites identified were *Ascaris lumbricoides, Entamoeba histolytica, Trichuris trichura, and Taenia saginata.* The result of the analysis showed that pH values were slightly acidic and ranged from 6.1 to 6.8 while total dissolved solids values were from 81 and 97 mg/l. Total alkalinity ranged between 62 and 86 mg/l. Some Physico-chemical parameters were not within permissible limits for drinking water. Treatments of borehole water, boiling and filtering of drinking water as well as improved sanitary conditions and personal hygiene are recommended. This will ensure better health for the people of Owerri Municipal.

Keywords: Borehole Water, Media, Microorganisms, Physico-Chemical Test

Introduction

Water is a chemical substance that is characterized to be transparent, inorganic, colourless, tasteless and odorless. Water is the main constituent of Earth's hydrosphere where it covers 71% of the Earth's surface, mostly in seas and oceans, as well as the liquid composition of all known living organisms. Water is one of the most essential natural resources needed by every living organism to grow and survive [1]. Whether it is used for drinking, bathing, food production or recreational purposes; portable and accessible water supplies are crucial for good personal health as well as public health. It also acts as a solvent which is used in a wide variety of substances both mineral and organic [2]. Water is used at home for cooking and washing. Water is used in many sports activities and entertainment like swimming, boat racing, sport fishing, surfing, diving, and ice skating. Borehole as a water source should have at least a depth of 150 feet (45.72m) is drilled to reach ground water and serve as a source for drinking water [3]. Ground water (borehole) occurs in the interstices (pores and crevices) of rock below the earth's surface, the aquifers (where ground water occurs) which are not directly exposed to man, animals, and the atmosphere, which makes borehole water somewhat protected from contamination. Ground water that is free from microbial contamination is a function of natural processes as well as anthropogenic activities. Ground water is rich in dissolved solids like carbonates sulfates of calcium and magnesium as well as chloride and bicarbonates. This depends on the strata through which ground water flow [4]. There should be additional treatment in order to provide uncontaminated water for drinking and household use [5]. Water is essential to life. An adequate, safe and accessible supply must be available to all and sundry. Improving access to safe drinking-water can result in significant benefits to good health. Enormous effort should be made to achieve a drinking water that is safe as possible to avoid water borne diseases like cholera, typhoid, salmonellosis, shigellosis [6]. The aim and objectives of this study is to determine the microorganisms found in borehole water and to evaluate the physico-chemical

parameters of borehole water.

Materials and methods

Study Area

Owerri Municipal is the study area. Owerri is the capital of Imo State Nigeria. Owerri consists of three local Government areas including Owerri Municipal, Owerri North and Owerri West. Owerri is located at Latitude: 5° 29' 1.07" N and Longitude: 7° 01' 59.70" E. Owerri has a population of about 1.1 million as at 2024 while Owerri municipal has an estimated population of 174,200 as at 2022. Owerri is approximately 100 square kilometres (40 sq mi) in area [7].

Collection of water Sample

Water samples were collected from different boreholes in owerri municipal. The samples for Bacteriological analysis, Mycological analysis and parasitical analysis were collected aseptically in sterile tubes. The samples for physiochemical analysis were also collected in clean bottles with screw caps and all the samples were sent for analysis at microbiology laboratory, Imo State University, Owerri.

Determination of physiochemical parameter of borehole water

Borehole water temperature was measured using a standard mercury thermometer. The pH was measured using model 291 MK pH mete. Turbidity was determined using attenuated radiation method. Colour, taste and odour were also determined. Colour was measured by APHA. Total hardness and alkalinity were investigated using EDTA titrimetric method and methyl orange method respectively as described by [8] and [9]. Nitrate, sulphur and phosphate contents were estimated using brucine, gravimetric and abscorbic acids methods respectively, and all tests were performed according to [8] record results recorded in mg/l and mg/kg.

Media Preparations

The powder components of the media, Nutrient agar, MacConkey, *Salmonella and Shigella* agar, Thiosulfate citrate bile salt agar, Simmon's citrate agar, sabouraud dextrose agar and Peptone water was dissolved in a conical flask according to the manufacturer's instruction, The conical flask was closed with cotton plug and covered with Aluminium foil, placed into an autoclave and sterilized at 121^0C for 15mins. The medium was cooled to 45^0C after sterilization, the cotton plug was removed and the mouth of the flask flamed over a Bunsen burner in other to ensure sterility, and the medium was poured into sterile, empty petri dishes (15-20ml into each petri dish).The petri dishes were kept horizontally until the medium were completely solidified, then they were turned upside down and stacked for storage.

The plates were labeled according to the medium and also a sterility test was performed on them by incubating some plates at 37^0C for 24hrs and after which they were examined [10].

Sterilization

All glass wares used were washed with detergent and hot air oven, they were then sterilized. Media were also sterilized by autoclaving at 121^0 C, 15Psi. All wire loops were flamed to red hot using Bunsen burner. Laboratory benches were cleaned before and after work with 75% alcohol [10].

Bacteriological Evaluation

The membrane filter method was used to analyze bacterial contamination. Water samples were collected and necessary dilutions were made. Forceps were sterilized and used to aseptically remove membrane filters from their packets. The membrane filter was placed into the funnel assembly, then the pouring lip of the sample containers were sterilized by flaming and the samples poured into the funnel, the vacuum was turned on and the sample was allowed draw completely through the filter, the funnel was rinsed with sterile buffered water, the vacuum was turned on and the liquid was allowed to draw completely through the filter, the forceps were flamed and the membrane filter removed from the funnel and then placed in the prepared petri dish and incubated at appropriate temperature for the appropriate period of time, after which colonies was counted after incubation [10].

Subculturing of the cultures

After the Culturing and incubation period, the plates were observed and colonies were counted, and the discrete colonies were sub-cultured into a freshly prepared Nutrient agar and other media plate to get a pure culture. The sub-cultured plates were incubated for 24hrs, and examined for pure culture. The pure culture growth was used for gram staining, motility test and biochemical characterization of the organisms like Catalase, Oxidase tests, Coagulase, Citrate utilization test, Indole test, Methyl-red test, Voges proskaeur test and Sugar fermentation. A stock culture was prepared using a bijou bottle: This stock culture was used in storing the organisms for further biochemical characterization [10].

Identification of isolates

The bacterial isolates were identified using colonial, cellular characteristics; Colony's shape, colour, consistency, surface appearances and size of the colony (diameter in mm), Gram Staining, Motility test and biochemical properties; Catalase, Oxidase tests, Coagulase, Citrate utilization test, Indole test, Methyl-red test, Voges proskaeur test and Sugar fermentation [10].

Colonial, cellular characteristics

Shape or form of the colony (circular, irregular, filamentous, punctiform, rhizoid, spindle), elevation of the colony (flat, convex, pulvinate, umbonate, crateriform), margin of the colony (entire, undulate, lobate, filamentous), pigmentation of the colony (diffusible water soluble or water-insoluble pigments), surface of the colony (smooth, glistening, rough, dull, wrinkled), density of colony (transparent-clear, opaque, translucent-almost clear, but distorted vision-like looking through frosted glass, iridescent-changes colour in reflected light) were examined [10].

This technique is used to differentiate microorganisms into Gram-positive and Gram-negative as a result of their gram reaction [11]. Gram staining method described by [11] was adopted. With the aid of a sterile inoculating wire loop; smears of the isolates was made on clean, grease-free microscope glass slides, air-dried and heat-fixed by passing the slides 2-3 times over a Bunsen burner flame. Afterwards, each smear was covered with a Crystal violet (primary stain) for 60 seconds, after which it was quickly washed off with clean water. The smear was flooded with lugol's iodine (Mordant) for 30 seconds. After, they were decolorized with 75% alcohol for 30seconds, which was washed off quickly with clean water and counter stained with safranin for 30 seconds. The safranin stain was washed off quickly with

clean water. Back of the slides were then wiped and placed in a draining rack to air-dry. The smear was then examined microscopically using the oil immersion objective (X100). Gram positive cells showed purple while gram negative cells showed red colour [11].

Motility test

The method also described by [11] was adopted. It is used to differentiate between motile and non-motile organisms due to the presence of locomotory structures like flagella and cilia. This test was carried out using the stab method. Test tubes of semi-solid motility medium were inoculated by stabbing a sterile straight wire loop charged with inoculums from the isolated pure culture vertically into the media and it was incubated at 37^0C for 24hours. Non-motile bacteria produced growths that were un-diffused from the line of stab while motile bacteria produced diffused growth away from the line of stab into the medium and rendered it opaque (Cheesbrough 2011) [11].

Biochemical tests

Catalase test

A drop of 3% hydrogen peroxide was placed on each end of a microscope slide, with the aid of a sterile wire loop, colonies of the test organisms were transferred on to one end of the microscope slide, and the other end was not inoculated but served as a control. The presence of gas bubbles indicates a positive catalase test, while absence of bubbles indicates a negative catalase test [11].

Citrate utilization test

The test is carried out to-demonstrate the use of citrate as a sole source of carbon by alkalinisation of the medium and ammonia as the only source of nitrogen by the bacteria, *Enterobacteriaceae* family. The Method as described as by [10] was adopted. The test was carried out by inoculating sterilized Simmon's citrate agar with the test organisms using a sterile wire loop and incubating at 37^0C for 48 hours and observing for changes in colour. Positive result shows a change of the medium colour from green colour to royal blue colour, indicating the presence of citrate utilizing bacteria [10].

Coagulase test

A drop of distilled water was placed on each end of the microscope slide. A colony of test organism was emulsified in each of the drops of distilled water that was placed on the ends of the microscopic slide, to make thick suspensions. A 100cfu/l of plasma was added to one of the suspension and mixed gently. No plasma was added to the same suspension serving as control. Clumping of the mixture within 10 seconds will indicate positive coagulase test, while absence of clumps within 10seconds indicates a negative result [11].

Indole test

The test organism is cultured in a medium which contains tryptophan. Indole production is detected by Kovac's reagent which, contain 4-p-dimethylaminobenzaldehyde; it reacts with the indole to produce a red coloured compound. The test organisms were inoculated in a bijou bottle containing 3ml of sterile tryptone water, which was incubated at 37^0C for 48hrs, after incubation, 0.5ml of kovac's reagent was added, the tubes were gently shaken, and the appearance of a red surface layer within 10mins indicates a positive indole test [11].

Oxidase test

A piece of filter paper was soaked with a few drops of oxidase reagent (tetra-ethyl-p-phenylendeamine dihydrochloride). A colony of the test organism was picked with a sterile glass rod and smeared on the filter paper. A blue purple colour develops within a few seconds if the organism is an oxidase producer as a result of the oxidation of the phenylendeamine, while the absence of a blue purple colour indicates a negative result [11].

Methyl red/ voges-proskauer (mr/vp)

The bacteria isolates were inoculated into 2mls of glucose phosphate (peptone water) and was incubated at 37^0C for 48hours. After the period of incubation, 4 drops of methyl red indicator was added to the tube. The solution was homogenized and observed immediately for colour change. The appearance of a red colour indicates a positive result while the appearance of a yellow colour indicates a negative result [10], For Voges proskauer test, the method described by [10] was adopted, the bacteria isolates were added to 2ml of glucose phosphate (peptone water) and it was incubated at 37^0C for 48hrs, after incubation, 40% KOH and 3ml of 5% alcoholic alpha-naphthol were added, the appearance of a pink colour after 2-5 minutes indicates a positive result.

Sugar fermentation test

This test was employed to check for the ability of an organism to ferment sugar. The agar used in this test is called Triple Sugar Iron (TSI). This test engines the ability of the organism to produce gas, Hydrogen sulphide, to ferment Glucose, maltose and fructose to also ascertain if its Slant and Base are acidic or basic. The agar was sterilized at 121^0C at 15mins. The test organism was inoculated at a slanted test tube. A colour change from purple to yellow indicates the utilization of several sugars. A black duct at the slanted area indicates the presences of H_2S. Also a gaseous bubble at the bottom or slant of the test tube indicates the presence of gases while displacement in the durham's tube indicates gas production [10].

Mycological analysis of borehole water

The borehole water samples were cultured on sabouraud dextrose agar (SDA), the samples were inoculated on molten SDA and allowed to solidify after which it was incubated at 28^0C for 3-7 days at room temperatures, the fungal isolates were identified using a combination of macroscopic and microscopic method.

Macroscopic analysis

The isolated fungal isolates from the SDA were identified based on colonial morphology; Colony growth pattern, Conidial morphology, Pigmentation and Surface Colour, Margins, Elevation, Reverse side Pigmentation [12].

Microscopic examination

Tease mount

A drop of the lactophenol cotton blue stain was made on a clean slide with the aid of a mounting needle, a small portion of the aerial mycelia from the fungi representative of pure cultures were removed and teased on the drop of the lactophenol cotton blue on the slide. The mycelia were well spread on the slide with the needle and a cover slip was gently placed with little pressure to eliminate air bubbles. The slide was then mounted and viewed under the light microscope with ×10 and ×40 objective lenses [12].

Wet mount

This method is used to examine yeast cells for the presence of ascopores, hyphae and pseudo-hyphae.

Procedure

Sabouraud's dextrose agar was prepared appropriately and

the media was aseptically dispensed into a sterile test tube and inoculated with the test organisms. The tube was examined for growth and pellicle formation. The mount was prepared on a clean grease free slide and was examined under high and low objective.

Analyses of borehole water samples for parasite

The borehole water samples were analyzed for parasites using a combination of the macroscopic and microscopic method (wet preparation).

The borehole water were centrifuged and the deposits dropped on a clean grease free slide, covered with cover slip and viewed under the microscope using X10 objective lens. The sediments were examined under the microscope using unstained and stained deposits [11].

Wet preparation (using iodine)

The borehole water deposits were dropped on clean grease free slides and a drop of iodine was placed on it, it was covered with cover slip and was viewed under the microscope using X10 and X40 objective [11].

Concentration method

Concentration of the sample for eggs, cysts and adult parasites were performed. 5mls of the deposit was dispensed into a test tube followed up by the addition of formal ether to the brim of the test tube. Cover slip was placed on it and allowed for 10mins, then gently removed and placed on a clean grease free slide viewed under the microscope using X10 and X40 objective lens [11].

Results and Discussion

The various borehole water samples were analyzed scientifically and the results are as follows: The colour, taste, and odour were clear, tasteless and odourless. Bacterial isolates identified were *Staphylococcus aureus, Escherichia coli, Vibrio cholerae, Salmonella* spp, *Proteus* spp, *Pseudomonas* spp, *Bacillus* spp *and Klebsiella* spp. Fungal isolates identified were *Aspergillus flavus, Aspergillus tamarii, Aspergillus niger, Rhizopus* spp. *Fusarium* spp. and *Candida* spp. Parasites identified were *Ascaris lumbricoides, Entamoeba histolytica, Trichuris trichura, and Taenia saginata.*

Table 1 shows the mean bacterial load of borehole water samples from Owerri municipal local government area. Table 2 shows the identification of the different bacterial strains isolated from borehole water samples in owerri municipal local government area and the analysis showed that the eight pathogenic bacterial contaminants were *Staphylococcus aureus, Escherichia coli, Vibrio cholerae, Salmonella* spp, *Proteus* spp, *Pseudomonas* spp, *Bacillus* spp *and Klebsiella* spp. Table 3 shows the Prevalence of the bacterial isolates among borehole water samples from owerri municipal local government area of Imo state. The eight isolates were *Staphylococcus aureus, Escherichia coli, Vibrio cholerae, Salmonella* spp, *Proteus* spp*, Pseudomonas* spp*, Bacillus* spp *and Klebsiella* spp. The highest prevalence of bacterial isolates was seen in, Douglas road, Tetlow road and Bishopscut, Ikenegbu layout and MCC road while the lowest prevalence was found at Prefab, Shoprite road and wetheral road.

Table 4 shows the cultural and microscopic characteristics of fungal isolates identified using culture method.

Table 5 shows the Prevalence of the fungal isolates among borehole water samples from owerri municipal local government area of Imo state. The six fungal isolates were *Aspergillus flavus, Aspergillus tamarii, Aspergillus niger, Rhizopus* spp. *Fusarium* spp. and *Candida* spp. The highest prevalence of fungal isolates was seen in MCC Road, Okigwe road, Ikenegbu layout, Tetlow road, Douglas road and Bishopscut road while the lowest prevalence was found at Prefab, Imsu, Shoprite road and wethedral road.

Table 6 shows the distribution of four parasitic isolates from borehole water in owerri municipal local government area of Imo state. The parasitic isolates were *Ascaris lumbricoides, Entamoeba histolytica, Trichuris trichura, and Taenia saginata.* The highest prevalence was at MCC Road, Okigwe road, Ikenegbu layout, Tetlow road, Douglas road and Bishopscut road while the lowest prevalence was found at Prefab and wetheral r.

Table 1: Bacterial Load (mean value) of Borehole Water Samples from Owerri Municipal Local Government Area.

Borehole water samples	Total Heterotrophic plate count cfu/ml	Faecal Coliform Count cfu/ml
Imsu	3.1×10^3	3.2×10^3
Wethedral Road	3.2×10^3	3.0×10^3
Mcc Road	3.7×10^3	2.7×10^3
Okigwe Road	3.4×10^3	2.4×10^3
Prefab	2.8×10^3	2.4×10^3
Shoprite road	3.4×10^3	2.7×10^3
Ikenegbu layout	4.5×10^3	3.8×10^3
Tetlow road	4.8×10^3	3.5×10^3
Douglas Road	5.6×10^3	4.7×10^3
Bishopscut road	3.8×10^3	3.5×10^3

Table 2: Identification of Bacterial Isolates from Owerri municipal local Government Area

Isolates	Bacteriological tests			Biochemical tests										Probable organism
	Gram reaction test	Cellular shape	Motility test	Catalase test	Coagulase test	Oxidase test	Indole test	Citrate test	Voges Proskuer test	Methyl red test	Glucose test	Lactose test	Sucrose test	
1	+	Cocci	-	+	+	-	+	+	+	+	A/G	A/G	A/G	*Staphylococcus aureus*
2	-	Rod	+	+	-	-	+	-	-	+	A/G	A/G	-	*Escherichia coli*
3	-	Curve	+	+	-	+	-	+	-	-	A/G	A	A/G	*Vibrio cholerae*
4	-	Rod	+	+	-	+	+	+	-	-	A/G	-	-	*Salmonella typhi*
5	-	Rod	+	+	-	-	-	+	+	-	-	-	-	*Protus spp.*
6	-	Rods	+	+	-	+	-	+	-	-	-	-	-	*Pseudomonas spp.*
7	+	Rod	-	+	-	+	+	+	-	-	**A**	-	-	*Bacillus spp*
8	-	Rod	+	+	-	-	-	+	+	-	**A**	**A**	**A**	*Klebsiella spp.*

Keys

+ Positive A =Acid

-Negative A/G =Acid and Gas.

Table 3: Prevalence of Borehole Water Bacterial Isolates in Owerri Municipal LGA

Organisms	Imsu	Wetheral road	Mcc Road	Okigwe road	Prefab	Shoprite road	Ikenegbu layout	Tetlow Road	Douglas road	Bishopscut road
Staphylococcus aureus	+	+	+	+	+	+	+	+	+	+
Escherichia coli	+	+	+	+	+	+	+	+	+	+
Vibro Cholerae	+	+	+	+	+	+	+	+	+	+
Salmonella spp	+	-	+	+	+	+	+	+	+	+
Protus spp.	+	+	+	+	-	-	+	+	+	+
Pseudomonas spp.	+	-	+	+	+	+	+	+	+	+
Bacillus spp	+	+	+	+	-	+	+	+	+	+
Klebsiella spp	-	+	+	-	-	-	+	+	+	+

Keys
+ Positive
-Negative

Table 4: Cultural and microscopic characteristics of fungal isolates identified using culture method

Cultural	Microscopic	Isolates
Colonies are green in colour	Hyphae are septate	*Aspergillus flavus*
Rusty brown in colour	Conidia head with long chain of conida,	*Aspergillus tamarii*
Black colonies are usually seen.	Black spores, septate hyphae	*Aspergillus niger*
White colonies becoming gray-brown	Rhizoids and stolons present	*Rhizopus* spp.
Pale or bright colour conidia	Septate hyphae	*Fusarium* spp.
White smooth colour	Single budding of cells	*Candida* spp.

Table 5: Prevalence of Borehole Water Fungal Isolates in Owerri Municipal

Organisms	Imsu	Wetheral road	Mcc Road	Okigwe road	Prefab	Shoprite road	Ikenegbu layout	Tetlow Road	Douglas road	Bishopscut road
Aspergillus flavus	+	+	+	+	+	+	+	+	+	+
Aspergillus tamarii	+	+	+	+	-	+	+	+	+	+
Aspergillus niger	+	+	+	+	+	+	+	+	+	+
Rhizopus spp.	+	+	+	+	+	+	+	+	+	+
Fusarium spp.	-	-	+	+	-	-	+	+	+	+
Candida spp.	+	+	+	+	+	+	+	+	+	+

Keys
+ Positive
-Negative

Table 6: Prevalence of Borehole Water Parasitic Isolates in Owerri Municipal LGA

Organisms	Imsu	Wetheral road	Mcc road	Okigwe road	Prefab	Shoprite road	Ikenegbu layout	Tetlow road	Douglas road	Bishopscut road
Ascaris lumbricoides	+	+	+	+	+	+	+	+	+	+
Entamoeba histolytica	+	-	+	+	-	+	+	+	+	+
Trichuris trichura	-	-	+	+	-	-	+	+	+	+
Taenia saginata	+	+	+	+	+	+	+	+	+	+

Keys
+ Positive
-Negative

Table 7 shows the physico-chemical properties of surface water in Owerri Municipal Local Government area of Imo state.
The physico-chemical properties of surface water in Owerri Municipal Local Government area of Imo state as shown in Table 7 reveals the followings:
The highest temperature value was found in Douglas road and Tetlow Road 27.3 while the lowest was found in Prefab 25.5.
The highest pH value was found in Douglas road 6.8 while the lowest was found in Prefab 6.1
The highest Total Dissolved solids were found in Douglas road 97 (Mg/l) while the lowest was found in Prefab 81 (Mg/l).
The highest turbidity was found in Douglas road 5.5 while the least was found in Prefab and Wethedral road being 3.6 (Mg/l).
Total Alkalinity had the highest value in Douglas road and Tetlow 86 (Mg/l) and the lowest value was found in Prefab 62 (Mg/l).
The highest Total Hardness was found in Douglas road 100 (Mg/l) while the lowest was found in Prefab 66 (Mg/l).
The highest total solids were found in Douglas road and Bishopscut road being 0.28 and lowest in Ikenegbu layout and Prefab 0.15.
The highest Chloride value was found in Douglas road 70 while the lowest was found in Prefab and Shoprite road 52.
The highest Sulphate value was found in Douglas road and Tetlow 98 (Mg/l) road while the lowest was found in Prefab and Imsu 70 (Mg/l).
The highest Nitrate value was found in Douglas road and tetlow road being 55 (Mg/l) while the lowest was found in Prefab and Wetheral road 38 (Mg/l).
The highest Nitrite value was found in Douglas road and Tetlow Road 3.8 while the lowest was found in Prefab and IMSU road 2.8.

Table 7: Physico-chemical Analysis of Borehole Water from Owerri municipal L.G.A

Parameters	WHO Standard	Imsu	Wethedral road	Mcc Road	Okigwe road	Prefab	Shoprite road	Ikenegbu layout	Tetlow Road	Douglas road	Bishopscut road
Temperature (^{0}C)	30	25.6	24.8	26.7	25.4	25.5	23.5	25.1	27.3	27.3	26.2
pH (Meter)	6.5-8.5	6.4	6.3	6.2	6.6	6.1	6.3	6.2	6.7	6.8	6.0
Total dissolved solids.(Mg/l)	500	82	83	91	85	81	82	84	83	97	87
Turbidity (NTU)	5	3.7	3.6	5.1	4.7	3.6	3.9	4.1	5.3	5.5	5.1.
Total Alkalinity (Mg/l)	200ppm	65	64	72	71	62	65	71	86	86	81
Total hardness (Mg/l)	300	70	71	80	82	66	81	90	92	100	93
Total solids (Mg/l)	1000	0.25	0.18	0.25	0.23	0.15	0.20	0.15	0.25	0.28	0.28
Chloride (Mg/l)	200	53	55	60	62	52	52	60	64	70	64
Sulfate (Mg/l)	100	70	84	83	80	70	85	91	98	98	91
Nitrate (Mg/l)	50	40	38	43	42	38	44	50	55	55	52
Nitrite (Mg/l)	3.5	2.8	3.4	3.6	3.2	2.8	3.1	3.3	3.8	3.8	3.5

Most of the borehole waters analysed showed high load of bacterial, fungal and parasitic contamination and as such most did not fall within the acceptable level set by [13].The physicochemical analysis showed that some borehole waters parameters were not within the acceptable limit set by World Health Organisation. The presence of coliform group in water samples suggests that the borehole waters may have been contaminated with faeces which may be of human or animal origin. The study of [14] revealed that water sources harbors' microorganisms such as *Salmonella* sp., *Staphylococcus* sp., *Pseudomonas* sp., *Bacillus* sp., *Shigella* sp., *Klebsiella* sp. and *Escherichia coli*, which could pose a possible environmental hazard or health effect. [15] found out that the bacterial load recovered from the studied borehole water samples were above the WHO standard for bacterial loads, and coliform content and concluded that borehole waters were not safe for drinking.
The work of [16] concluded some of the borehole waters were not free from contamination and as such are not fit for human consumption, but needed to be treated before consumption, as the presence of coliforms and basically *E. coli* was seen in them.

Conclusion

The analysis showed that the borehole waters were contaminated with microorganism. Therefore the borehole waters did not fall within acceptable standard limits. The physicochemical analysis also showed that some of borehole waters were not within the acceptable limit set by World Health Organisation, and were considered not physic-chemically fit for consumption.

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