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Qualitative analysis of water samples from various boreholes in Uyo, Nigeria

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ABSTRACT

Fifteen different water samples sourced from various boreholes in Uyo Akwa Ibom State Nigeria were subjected to physicochemical and microbiological analyses using WHO standard methods. None of the samples met the World Health Organization (WHO) pH value standard. Apart from samples C, F, J and N which failed in content of calcium and or calcium carbonate, all the other eleven samples met the WHO standards for chemical content. Microbiological tests revealed one or more of the following organisms, Staphylococcus aureus, Staphylococcus albus, Escherichia coli, Bacillus species, Micrococcus species., Microsporum canis, Aspergillus terreus, Aspergillus niger and Geotrichum candidum in thirteen of the samples. From the results obtained, only samples I, and L were devoid of microorganisms and had acceptable ionic contents, but with unsatisfactory taste, odour and pH which rendered them unfit for drinking without intervention to improve the water quality. This should be of interest to regulatory agencies and public health officials in designing programmes to reduce water-borne diseases.

Key words: Qualitative, physicochemical, microbiological, borehole, water.

INTRODUCTION

Water is essential to life [1]. It is a liquid which combines the elements hydrogen and oxygen in a 2:1 ratio [2]. About 60-70% of body weight in men and 55-60% in women are made of water [3,4]. Water occupies seventy percent (70%) of the earth's surface out of which 97% is salt water, leaving 3% as fresh water. Only about 1% of the fresh water is suitable for drinking [5-7].

Unsafe water poses a global public health threat, exposing users to a host of water borne diseases such as worm infestations, water blindness, dysentery, diarrhoea, typhoid fever, cholera, gastroenteritis, amoebasis, hepatitis, schistosomiasis and other diseases [8] as well as chemical intoxication (heavy metal poisoning).

It is estimated that 2.5 billion people lack access to improved sanitation and about 1.1 billion still defecate in the open [9, 10]. Diarrhoea is the second leading cause of death among children under five in the world. It kills more children than malaria, AIDS, and measles combined [11]. Interventions to improve water quality have been found to be generally effective for preventing diarrhoea in all ages and in under 5s [12].

Due to lack of adequate provision of public clean drinking water by the government, erections of boreholes have become the order of the day. Many families patronise boreholes located in their area to source water for drinking, cooking and other household chores. Considering the gravity of the danger which unhygienic and untreated water poses to human lives, it becomes pertinent and justifiable to assess the quality of water from various boreholes being patronized by the populace with a view to providing information that will be useful to all stakeholders.

EXPERIMENTAL SECTION

Materials

Water samples were sourced from fifteen (15) boreholes within Uyo metropolis. The samples were collected aseptically using sterile bottles and were stored in the refrigerator, pending analysis. Each of the samples was tagged with the address of street of collection, as well as the date and time of collection.

Test for colour

Nesslerizer with Disc NSA for Hazen (Briswin Senior Comparator-Lovibond 2000) was used for the test. A matched Nessler tube (glass) was filled with the water sample to be analyzed to the 50ml mark. By rotating the disc, the colour of the water was compared with the standard on the disc until similarity was observed. The value was read out of the Hazen unit and the reading recorded.

Test for odour

The water sample was poured into clean, odour-free glass bottles and warmed to room temperature. The stopper of the glass bottle was removed and the odour sniffed at the mouth of the bottle. The intensity of the odour sniffed was graded in the range of 0-5.

Test for taste

Each water sample was tasted on both tip and back of the tongue after being warmed to room temperature. The intensity of the taste was graded as with the odour.

Turbidity testing

A 2100P Portable Turbidimeter by Hach USA, was used for the analysis. The prescribed procedure for using the instrument was duly followed for all the samples.

Determination of pH

pH meter (pH-3D Sanxin) was used for the analysis. The two electrodes of the instrument were thoroughly rinsed first with distilled water and then with the sample of water to be measured. The instrument was allowed to stabilize after dipping the electrode into the beaker containing the test solution before the reading was taken.

Determination of total dissolved solids, electrical conductivity and salinity

The apparatus used for these tests was HACH Sension 5 by Hach USA. The electrode was thoroughly rinsed with both distilled water and sample water respectively before being dipped into the water sample for analysis.

Determination of calcium carbonate (total hardness)

The determination of calcium carbonate ($CaCO_3$) followed the same procedure as that of calcium except that ammonium chloride (NH_4Cl) was used as buffer instead of sodium hydroxide (NaOH).

Determination of heavy metals, trace elements, cations and anions

These tests were carried out using portable, datalogging spectrophotometer (HACH DR 2010). The water sample to be analyzed was poured into a glass bottle (previously rinsed with distilled water) in a jacket in the machine. The wavelength associated with the element or radical of interest to be monitored was dialled on the machine to reveal the concentration of that element or radical in the sample of water.

Test for the presence of coliforms

The multiple–tube method was used [13]. This entailed presumptive coliform count [5] and confirmed tests coliform count [5]. For the presumptive tests, all inoculated lactose broths were incubated at 37^oC for 24 hours. Similarly, for the confirmation test, the inoculated eosin methylene blue agar (differential medium for the isolation and enumeration of coliform organisms) plates were incubated at 37^oC for 24 hours.

Pour plate technique

The pour plate technique enabled the determination of number of colony-forming units in the samples per ml (cfu/ml). Two culture media were used: nutrient agar (general purpose medium) and Sabourand dextrose agar (selective medium for isolation of yeast and fungi). 1 ml of each water sample was transferred aseptically into assigned sterile Petri-dishes for nutrient agar (NA) and Sabourand (SDA) dextrose agar respectively. 20 ml nutrient agar was aseptically transferred into each of the designated NA plates while 20 ml Sabourand dextrose agar was transferred into plates assigned for SDA. The Petri-dishes were covered and thoroughly mixed by gentle tilting and swirling. Positive and negative control Petri-dishes were also done for both NA and SDA. The Petri-dishes were left

on the desk for 15 minutes to allow the mixtures to solidify. The NA dishes were inverted and incubated for 24-48 hours while those containing SDA were observed at room temperature after 96 hours.

Biochemical test

Various biochemical tests were carried out to aid the identification and classification of the microbial contents of the nutrient agar plates. The tests included: Gram stain, motility tests, coagulase test, catalase production, oxide test, sugar fermentation, nitrate reduction, in hole production, urease test and citrate utilization.

Identification of the organisms on the Sabourand dextrose agar (SDA) plates

Microscopical viewing of the developed inoculated SDA plates helped to identify the fungal organisms present.

RESULTS AND DISCUSSION

The results of physical tests are recorded in table 1. The results of chemical tests are in table 2. Tables 3 and 4 contain the results of presumptive test and confirmatory tests respectively. The Pour Plate technique results are in table 5 while table 6 contain fungi identified. Table 7 has the results of the biochemical tests of organisms on nutrient agar.

Table 1. Result of physical tests on the water from different boreholes

Sample	Odour	Taste	Colour (Hazens)	pH	Temperature ^{0}C	Turbidity (NTU)*	Salinity %	Conductivity (µS/cm)	Total dissolved Solids (mg/L)
A	2	2	5	4.20	27.2	0.32	0.0	93.1	41.2
B	3	3	5	5.41	28.3	0.67	0.0	49.0	21.4
C	1	1	5	6.05	28.3	0.53	0.0	145.2	65.1
D	0	0	5	5.51	28.4	0.58	0.0	50.4	21.9
E	5	5	5	5.00	28.4	3.98	0.0	83.3	36.7
F	2	2	5	5.28	28.4	1.50	0.0	37.9	16.4
G	4	3	5	4.59	28.5	1.32	0.0	106.3	46.9
H	5	4	5	4.35	28.6	1.32	0.0	122.4	54.2
I	2	2	5	3.77	28.9	0.93	0.1	218.0	96.1
J	5	5	5	4.30	28.8	1.65	0.0	83.4	36.5
K	3	3	5	5.64	27.9	1.42	0.0	98.2	41.6
L	1	1	5	6.12	28.3	0.63	0.0	204.9	88.1
M	2	3	5	4.83	29.3	0.48	0.1	232.0	93.2
N	3	3	5	5.26	29.3	0.72	0.0	63.4	27.2
0	5	4	5	6.18	29.4	1.98	0.1	219.0	97.0

**NTU= nephelometric turbidity unit.*

Table 2. Result of chemical tests of the various borehole water in mg/L

Water Sample	Arsenic	Barium	Cadmium	Calcium	Calcium carbonate	Chloride	Chromium	Copper	Cyanide	Fluoride	Iron	Lead	Magnesium	Manganese	Mercury	Nitrate	Phenols	Sulphate	Selenium	Zinc
A	0.01	0.00	0.000	30.0	34.0	0.0	0.00	0.000	0.00	0.02	0.000	0.000	0.08	0.000	0.0000	0.00	0.000	0	0.0000	0.000
B	0.00	0.00	0.000	44.0	98.0	0.0	0.00	0.000	0.00	0.02	0.000	0.000	0.17	0.000	0.0000	0.00	0.000	1	0.0000	0.000
C	0.00	0.00	0.000	**90.0**	**114.0**	0.0	0.00	0.000	0.00	0.03	0.002	0.000	0.05	0.000	0.0005	0.00	0.000	0	0.0000	0.000
D	0.00	0.00	0.000	68.0	32.0	0.0	0.00	0.000	0.00	0.04	0.000	0.000	0.07	0.000	0.0010	0.00	0.000	0	0.0000	0.000
E	0.00	0.00	0.000	40.0	40.0	0.0	0.00	0.000	0.00	0.00	0.000	0.000	0.11	0.000	0.0000	0.00	0.000	0	0.0000	0.000
F	0.00	0.00	0.000	66.0	**132.0**	0.1	0.02	0.000	0.00	0.02	0.000	0.004	0.18	0.012	0.0005	0.00	0.000	3	0.0000	0.002
G	0.00	0.00	0.000	32.0	28.0	0.1	0.00	0.004	0.00	0.00	0.001	0.001	0.06	0.001	0.0003	0.00	0.000	2	0.0001	0.000
H	0.00	0.05	0.000	36.0	64.0	0.2	0.01	0.001	0.00	0.00	0.000	0.000	0.04	0.000	0.0000	0.01	0.001	5	0.0000	0.004
I	0.00	0.00	0.004	52.0	64.0	0.0	0.00	0.010	0.00	0.00	0.000	0.003	0.09	0.006	0.0001	0.00	0.000	2	0.0000	0.000
J	0.00	0.03	0.000	**88.0**	60.0	0.3	0.00	0.000	0.00	0.00	0.000	0.000	0.12	0.001	0.0000	0.00	0.000	6	0.0000	0.000
K	0.00	0.01	0.000	44.0	100.0	0.2	0.03	0.001	0.00	0.02	0.001	0.000	0.11	0.000	0.0008	0.03	0.000	1	0.0000	0.001
L	0.01	0.01	0.001	30.0	58.0	0.0	0.00	0.000	0.00	0.00	0.000	0.001	0.14	0.015	0.0000	0.00	0.000	1	0.0000	0.000
M	0.00	0.00	0.000	38.0	72.0	0.1	0.00	0.000	0.00	0.00	0.006	0.002	0.08	0.000	0.0000	0.01	0.000	8	0.0001	0.001
N	0.01	0.00	0.000	**90.0**	56.0	0.2	0.01	0.003	0.00	0.01	0.002	0.004	0.13	0.003	0.0002	0.02	0.000	12	0.0000	0.000
O	0.00	0.04	0.000	72.0	26.0	0.0	0.00	0.001	0.00	0.00	0.000	0.000	0.16	0.011	0.0000	0.00	0.000	1	0.0000	0.003
Max. Tolerated Conc. (mg/ml)	**0.01**	**1.00**	**0.010**	**75.0**	**100.0**	**100**	**0.05**	**0.050**	**Nil**	**0.05**	**0.030**	**0.050**	**0.20**	**0.050**	**0.0010**	**10.00**	**Nil**	**100**	**0.0100**	**5.000**

Table 3. Result of presumptive test for chloroforms

Sample	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
10ml Double Strength	3	1	4	2	5	5	1	2	0	0	5	0	3	5	3
1ml Single Strength	2	1	3	1	5	5	1	1	0	0	3	0	2	5	1
0.1ml Single Strength	0	1	1	1	4	5	1	0	0	0	1	0	1	2	1
MPN	0.14	0.06	0.33	0.09	16	>24	0.06	0.07	<0.01	<0.01	0.94	<0.01	0.17	5.40	0.14

Table 4. Result of confirmatory test for the presence of coliforms

Sample	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Coliform	-ve	+ve	-ve	-ve	+ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve

Table 5. Result of pour plate technique experiment

	Nutrient agar plate				Sabourand dextrose agar plate	
	At 24 hours		At 48 hours		At 96 hours	
Sample	Growth	No of colonies	Growth	No of colonies	Growth	No of colonies
A	+ve	22	+ve	59	+ve	3
B	+ve	98	+ve	178	+ve	1
C	+ve	163	+ve	264	-ve	—
D	+ve	2	+ve	3	+ve	2
E	+ve	8	+ve	13	-ve	—
F	+ve	128	+ve	398	+ve	46
G	+ve	2	+ve	5	+ve	4
H	+ve	6	+ve	9	-ve	—
I	-ve	—	-ve	—	-ve	—
J	-ve	—	-ve	—	+ve	2
K	+ve	3	+ve	4	-ve	—
L	-ve	—	-ve	—	-ve	—
M	+ve	9	+ve	18	-ve	—
N	+ve	7	+ve	11	-ve	—
O	+ve	1	+ve	3	-ve	—

Table 6. Result of microscopical examination of SDA plates

Sample	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Type of fungus present	Microsporum Canis	Aspergillus terreus	|	Microsporum canis	|	Aspergillus Niger	Geotrichum candidum	|	|	Aspergillus terreus	|	|	|	|	|

Table 7. Result of biochemical test of organisms on nutrient agar

Sample	Gram Staining	Motility	Catalase	Coagulase	Oxidase	Lactose	Maltose	Urease	Indole	Organism
A	G+ve	-ve	+ve	+ve	-ve	+ve	+ve	-ve	-ve	*Staph. aureus*
B	G+ve G-ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	*Staph. aureus* *E. coli*
C	G+ve	-ve	+ve	+ve	-ve	+ve	+ve	-ve	-ve	*Staph. aureus*
D	G+ve	-ve	+ve	-ve	-ve	+ve	-ve	-ve	-ve	*Staph. albus*
E	G-ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	*E. coli*
F	G+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	*Bacillus spps.*
G	G-ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	*E. coli*
H	G+ve	-ve	+ve	-ve	+ve	+ve	-ve	-ve	-ve	*Micrococcus spps.*
I	-	-	-	-	-	-	-	-	-	-
J	-	-	-	-	-	-	-	-	-	-
K	G+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	*Bacillus subtilis*
L	-	-	-	-	-	-	-	-	-	-
M	G+ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve	*Bacillus subtilis*
N	G+ve G-ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	*Staph. aureus* *E. coli*
O	G+ve	-ve	+ve	-ve	+ve	+ve	-ve	-ve	-ve	*Staph. albus*

All the water samples analyzed were clear and colourless. All the samples, with the exception of sample D, had odour and taste. Portable water must be aesthetically attractive and organoleptically acceptable. The normal pH range of drinking water is 6.5 – 8.5 [14]. All the samples had pH below this range. Water with a low pH can be acidic and corrosive. Acidic water could have high metallic content with sour taste. Cyanide was not found in any of the samples. WHO recommends that phenol should not be found in drinking water but samples D and H had phenol in very low concentrations. However, phenol can have nemotoxic, carcinogenic, mutagenic and teratogenic effects on the consumers. The acceptable concentrations of Calcium and Calcium carbonate in drinking water are 75mg/L and 100mg/L respectively but samples C, J and N have higher Calcium content while sample C and F have higher Calcium carbonate content (table 2). Samples I and L were devoid of microbial organisms. The rest of the water samples had one or more organisms as indicated in tables 5 and 6. The organisms revealed included *Staphylococcus aureus, Staphylococcus albus, Escherichia coli, Bacillus species, Bacillus subtilis, Micrococcus species, Microsporum canis, Aspergillus terreus, Aspergillus niger and Geotrichum candidum.* These organisms are disease–causing [15, 16, 17, 18] and therefore the water samples containing them could not be fit for drinking without further purification. Samples I and L could have been recommended for having satisfied all parameters measured

except pH . Considering the findings as indicated above, none of these borehole water analyzed is fit for drinking without proper treatment. Clasen *et al* 2007b [19] and Clasen *et al*, 2008 [20] had discussed interventions to improve water quality, including borehole water.

CONCLUSION

This work expended effort to ascertain the safety profile of water from various boreholes being patronized and consumed by the populace in targeted areas within Uyo metropolis. None of the water samples examined from fifteen boreholes, met the WHO standard for quality and therefore not fit for drinking without intervention to improve the water quality. This revelation should and is expected to be of grave concern to regulatory bodies and public health officials as they map out strategies in the effort to reduce water-borne diseases to the barest minimum

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