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Research Article

THE QUALITY AND COMPOSITION OF BOREHOLE WATER IN EBONYI STATE, NIGERIA

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ABSTRACT

The quality and composition of borehole water in Ebonyi State Nigeria was conducted in Ebonyi State between June and August, 2011. A total of twenty borehole water samples were assessed for the presence of coliform bacteria using Most Probable Number techniques. The study revealed that *E. coli, Bacillus sp* and *Bacillus subtilis* were isolated from the water samples assessed. *Bacillus subtilis* was recorded highest among others from samples collected at Ogbaga road and Udensi. However, the physico-chemical study showed that the borehole water examined were salty which is contrary to the WHO 2009 standard which ought to be tasteless, water conductivity ranged between 14-16 mg/l far less than WHO 2009 standard of 250 mg/l. Water parameter such as calcium and magnesium were found to be higher (68 mg/l and 89 mg/l) instead of (60 mg/l and 80 mg/l) respectively than WHO 2009 standard. Parameter like iron, sulphate, zinc, phosphate recorded lesser value of 4.5-6.5, 0.50-0.69,2.0-4.2 mg/l other than the standard of 9.0, 400, 8.0, 60 mg/l respectively. The pH of various samples ranged from 7.0-9.0 almost equivalent to the standard 8.0. The statistical analysis done using chi-square ($p<0.05$) method showed that Udensi and Ogbaga road boreholes have high bacteria load with normal levels of chemical constituents when compared to others. The study and evaluation show that the quality and composition of borehole water in Ebonyi State fall below the World Health Organization Standards therefore, water treatment measures such as filtration and boiling will be appropriate before used.

Keywords: Abakaliki, Coliform, Physico-parameters, Borehole, Water, Ebonyi.

INTRODUCTION

Water is of fundamental importance to human life, animals and plants, it is of equal importance with the air we breathe in maintaining the vital processes to life and it makes up about 60% of body weight in human body. Among the various sources of water, borehole water is known to be more appropriate and often meets the criteria of quality water, the most widely used source of water in most African countries, Nigeria inclusive. The quality of borehole water is the resultant of all the processes and reactions that act on the water from the moment it condensed in the atmosphere to the time it is discharged by a well or spring and varies from place to place and with the depth of the water table (Vijendra, 2004). Borehole waters have unique features, which render them suitable for public water supply (Benjelloun, 1997; Offodile, 1983). They have excellent natural quality, usually free from pathogens, color and turbidity and can be consumed directly without treatment (Birmingham, 1997). Borehole water is particularly important as it accounts for about 88% safe drinking water in rural areas, where population is widely dispersed and the infrastructure needed for treatment and transportation of used surface water does not exist. Nevertheless, there are various ways borehole water may suffer pollution e.g. Land disposal of solid wastes, sewage disposal on land, agricultural activities, urban runoff and polluted surface water (Birmingham, 1997). The WHO recommends that boreholes should be located at least 30m away from latrines and 17m from septic tanks (Bonjoch *et al.,* 2004).

Microorganisms of concern in contaminated water include the following bacterial agents of diarrhea and gastroenteritis namely *Salmonella spp*, *Klebsiella spp*, *Escherichia coli* and *vibrio cholerae* (Birmingham *et al,* 1997). Protozoa agents of diarrhea include *Entamoeba histolytica*, *Giardia lamblia, Balantidium coli* (Dawets *et al*, 1991) and C*ryptococcus pervum* (Kelly *et al.,* 1997). Enteroviruses causing various clinical ailments, not necessarily diarrhea, but are transmitted by water include poliovirus, Rotavirus, Hepatitis A virus (Hejkal *et al.,* 1982) and Hepatitis E virus (Benjelloun *et al.,* 1987).

Presence of feacal coliforms or *Escherichia coli* is used as an indicator for the presence of any of these water borne pathogens (Chukwurah, 2001; Okafor, 1985; Okpokwasili and Akujobi, 1996). WHO recommends that no faecal coliform should be present in 100ml of drinking water. Good quality water is odourless, colourless, tasteless and free of faecal contamination and chemicals in harmful amounts. The chemistry of rocks and soils and the rock geological conditions in any borehole has a great influence on the quality of water which determines the concentration of introduced cations and anions such as Na^{+}, K^{+}, Mg^{2+}, NO_3^{-}, CO_3^{2-}, SO_4^{2-}, Cl^{-} e.t.c.

The comparison of the hydro geochemistry of the borehole water will help to ascertain the water quality in those terrains; however, the assessment of borehole water quality will be based on the physical and chemical characteristics while the physical characteristics of borehole water include the temperature, total dissolved oxygen, pH value, colour, turbidity and hardness. This study was therefore carried out to determine the bacteriological and chemical analysis or quality of water from boreholes located in the vicinity of the Ebonyi state University Abakaliki metropolis. Students and other members of the community do buy the water and it was important to find out if the water was safe for drinking and domestic use and to recommend treatment if necessary or suggest measures to be taken to eliminate the source of pollution.

METHODOLOGY

Collection of Samples: Cotton wool soaked in 70% (v/v) ethanol was used to sterilize the nozzle of the borehole from which samples were collected. The tap was allowed to run for two minutes before sterile 250ml screw capped glass bottles were carefully uncapped and filled with the water and recapped. Water samples were transported to the laboratory in a cooler with ice for bacteriological analysis within two hours of collection.

Media Preparation: All the media used were prepared in applied microbiology laboratory of Ebonyi State University Abakaliki. Sterilization was done by the use of an autoclave, which provided moist heat to kill the organisms present. Sterilizations of most glassware's and media were done at a temperature of 121^{0}C for 15 minutes. Workbenches were also cleaned using ethanol to ensure adequate sterility.

Preparation of macconkey broth, single and double strength: For each sample of water, 15 test tubes of MacConkey broth were needed. 5 test tubes contained 10ml double strength of broth, 5 test tubes contained 10ml single strength of broth and 5 test tubes contained 5ml single strength broth; all the tubes were fitted in with Durham vials. To prepare 100ml of double strength broth 70kg of the MacConkey broth powder was weighed out and dissolved in 100ml of distilled water. The broth was dispensed at 10ml into each fermentation tubes, fitted with Durham vials and autoclaved at 121^{0}C for 15miuntes. To prepare 100ml of single strength, 35g of MacConkey was dissolved in 100ml of distilled water. The broth was dispensed into fermentation tubes fitted with Durham vials, autoclaved at 121^{0}C for 15minutes.

RESULTS

Presumptive coliform tests result: Positive tubes turned from purple to yellow with gas produced at the Durham vials. The numbers of tubes showing acid and gas were noted and recorded.

Table 1 Presumptive Coliform Tests Result

		No of tubes inoculated				
Zone	No of samples collected	10ml SS	10ml DS	5ml SS	No of tubes positive	MPN of Coliforms in 100ml of Water (CFU/ml).
A	10	50	50	50	2 1 1	9
B	5	25	25	25	5 0 0	25
C	6	30	30	30	3 2 1	17

Key: 10ml DS = 10ml double strength MacConkey broth**,** 5ml SS = 5ml single strength MacConkey broth. CFU = Colony forming units.

Table 2 Confirmatory Tests Result

Water sources	Colony colours	Organism(s) present
A	Whitish mucoidally ranised with smooth surface	*Bacillus spp.*
B	Dirty white creamy, ranised smooth surface and rough edge colonies	*Bacillus subtilis, E.coli*
C	Yellow creamy colour with smooth surface and edge and greenish metallic sheen on Eosine methylene blue Agar.	*E.coli*

The colonies formed were examined under the electron microscope and some were found to contain greenish metallic sheen colour, while some had white mucoid colours and some colonies were yellow creamy in colour. Since colonies were formed, completed test was carried out.

Table 3 Characterizations and Possible Identification of Isolates from Abakaliki Borehole Water.

Isolates	Morphology	Gram Stain	Catalase	Oxidase	Citrate	Methyl Red	Indole	Voges Proskauer	Probable Identification
1	Short rods	+	+	-	+	-	-	+	*Bacillus spp*
2	Short rods	+	+	-	+	+	+	-	*Bacillus subtilis*
3	Short rods	-	+	-	+	+	+	-	*E. coli*
4	Short rods	+	+	-	+	-	-	-	*Bacillus spp*

Table 4 Comparison of Results on Physico-Chemical Parameters of Abakaliki Bore Hole Water with WHO Standard

Parameter(mg/l)	Sample A	Sample B	Sample C	WHO (2009)
Magnesium	65	68	62	60
Iron	6.0	6.5	4.5	9.0
Lead	0.32	0.35	0.32	0.3
Nickel	0.30	0.35	0.25	0.4
Zinc	2.0	4.20	3.10	8.0
Calcium	85	89	81	80
Phosphate	3.20	4.2	3.5	60
Sulphate	0.50	0.69	0.65	400
Total hardness	50	70	45	No guideline
Colour	Colourless	Colourless	Colourless	Colourless
Taste	Salty	Salty	Salty	Tasteless
Odour	Odourless	Odourless	Odourless	Odourless
DO	4.00	4.00	4.00	N0 guideline
PH	7.0	8.0	8.0	6.5-9.0
Turbidity (JTU)	0.0	40	40.00	N0 guideline
Conductivity (US/cm)	14	16	15	250
Temperature(^{0}C)	28	28	28	28

Statistical analysis of physico - chemical parameters of Abakaliki borehole water:

Table 5 Statistical Analysis of Sample A

Parameter	Sample A	WHO(2009)	P
Magnesium	65	60	125
Iron	6	9	15
Lead	0.32	0.3	0.62
Nickel	0.3	0.4	0.7
Zinc	2.0	8	10
Calcium	85	80	165
DO	4	-	4
PH	7	7.8	14.8
Turbidity	0	-	0
Temperature	28	28	56
Total $\sum P^2j$	**197.62**	**193.5**	**391.12**

Table 6 Statistical Analysis of Sample B

Parameter	Sample B	WHO (2009)	P
Magnesium	68	60	128
Iron	6.5	9	15.5
Lead	0.35	0.3	0.65
Nickel	0.35	0.4	0.75
Zinc	4.2	8	12.2
Calcium	89	80	169
DO	4	-	4
PH	8	7.8	15.8
Turbidity	40	-	40
Temperature	28	28	56
Total $\sum P^2 j$	**248.4**	**193.5**	**441.9**

Table 7 Statistical Analysis of Sample C

Parameter	Sample C	WHO (2009)	P
Magnesium	62	60	122
Iron	4.5	9	13.5
Lead	0.32	0.3	0.62
Nickel	0.25	0.4	0.65
Zinc	3.1	8	11.1
Calcium	81	80	161
DO	4	-	4
PH	8	7.8	15.8
Turbidity	40	-	40
Temperature	28	28	56
Total $\sum P^2 j$	**231.17**	**193.5**	**424.67**

DISCUSSION/RECOMMENDATIONS

Water suitable for human consumption (potable water) should be free from disease producing organisms or large numbers of non- pathogenic organisms, table 4. The borehole water from (Presco campus, Nkaliki, Udensi, and Cas campus) has considerably lower faecal bacteria counts, table 1 and could be concluded to be of better quality for domestic use than the Udensi and Ogbaga road waters which had much higher counts of bacteriological coliforms.

Regarding the faecal coliform counts, even though the Udensi and Ogbaga road waters had much higher values of 23MPN and 17MPN per 100ml respectively compared to counts of 7 to 11MPN per 100ml for the other four boreholes, table 1, it can be concluded that all the boreholes are not fit for drinking without processing (WHO, 1971; WHO 1986).

World Health Organization standard for faecal colifom in drinking water is zero faecal coliform per 100ml. Therefore water from the boreholes should be boiled and filtered for clarity before drinking. The observations in this study support the fact that higher bacterial counts in water reflect high coliform counts and the presence of faecal coliforms, table 2. The presence of high faecal coliform counts in sample B and D could be attributed to the proximity of the boreholes to a pit latrine located near the boreholes at a distance less than the 30m recommended by WHO and the general unhygienic environment surrounding the boreholes. It could be that the pipes used for water distribution were rusty thus allowing seepage of microbial contaminants into the boreholes. In addition, the bacterial isolates from the water belong to the genera of potential pathogenic bacteria, hence the recommendation that water from all the boreholes need to be boiled before use.

Results of the chemical analysis of the borehole water, table 5,6,7 show that the borehole water had the least dissolved oxygen (DO) concentration, which is expected due to its enclosed nature. Sources of oxygen in water include the atmosphere, as by–product of photosynthesis and through hydro mechanical input i.e. surface agitation. According to WHO (1992), DO is of much more limited use as an indicator of pollution in borehole water and is not useful for evaluating the use of borehole water for normal purposes.

Conductivity values of borehole waters were far lower than WHO limit, making the waters suitable for domestic uses, including human consumption. In addition, pH values recorded (table 4) show borehole waters to be highly alkaline and within the WHO's limit for drinking water. We presume that the high pH of the borehole waters is likely caused by organic contamination. Total hardness indicates that the borehole waters had the high values and will produce lather with soap easily. The direct effect of hardness on human health is yet to be proven scientifically (Whitlock *et al.,* 2002).

The physical examination of borehole waters for taste, colour and odour, table 5, 6, 7 showed that all water samples tasted salty and therefore contrary to the WHO standard. The metal components of borehole waters showed that magnesium, calcium and lead for all the water samples were significantly above WHO standard. The levels of the phosphate and sulphate recorded are also very low compared to WHO limits of 60mg/L and 400mg/L respectively. This means that the sulphate and phosphate levels of the borehole waters are not injurious to health. High sulphate concentration causes gastrointestinal irritation. Excess phosphate in drinking water causes infantile methaemoglobinaemia, which acts on hemoglobin in children, leading to poor oxygen uptake at the cellular level. The statistical analysis done using chi-square ($p<0.05$) method showed that Udensi and Ogbaga road boreholes have high bacteria load with normal levels of chemical constituents compare to others hence the quality of the borehole waters for drinking are in the order: Udensi > Ogbaga road > Presco > Nkaliki> Udemezie > Cas borehole. There is need to increase awareness of the community towards the dangers associated with the use of contaminated water, the danger in constructing pit latrines and septic tanks near a water source and vice versa; the use of rust – free polyvinyl chloride (PVC) pipes for water distribution and treatment of water by boiling and filtering before use for drinking and cooking purposes.

CONCLUSION

On the basis of the chemical parameters examined, Abakaliki borehole waters contain magnesium, calcium and lead in high amount, which falls outside WHO permissible limit and raises serious health concern.

The traces of faecal coliforms in all the water samples assessed imply that consumers of borehole waters are vulnerable to the risk of infection. The risk of infection is further enhanced by the presence of *E. coli* in the sample B and C. from the standpoint of both chemical and bacteriological parameters examined; the quality of the borehole waters for drinking has to be ascertained by boiling and filtering the water for clarity before drinking.

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