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Physicochemical and microbiological assessment of borehole waters in Umudike, Ikwuano L. G. A., Abia State, Nigeria

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ABSTRACT

Physicochemical and microbial analyses were carried out on the borehole waters in Umudike to examine the quality of the water. Parameters like Taste, Odour, pH, Temperature, Electrical conductivity, Total dissolved oxygen, Biochemical oxygen demand, Hardness, Mg^{2+}, Ca^{2+}, Cl^-, Cd^{2+}, Fe^{2+} as well as microbial analysis were analyzed using their various standard methods. The results showed the values in the range; pH (4.46-5.55mg/l), conductivity (0.33-5.28 us/cm), TDS (0.00-0.008), DO (3.94-4.80), BOD (4.81-6.54), Cl^- (1.73– 2.81), Ca^{2+}(0.62-2.88), Mg^{2+}(0.28-1.44), Cd^{2+}(0.009-0.052). These results were compared with the WHO standards for drinking water and found to be within the tolerable limits, with the exception of Cd^{2+} that was above the tolerable limits of WHO. Microbial analysis carried out indicated the presence of coliforms though there was no cause for concern as they fell within the standards for coliform in water.

Keywords: Borehole, physicochemical, microbial, analysis

INTRODUCTION

Water as one of the earth's most precious resources is essential for human survival and undoubtedly one of the core components of primary health care, a basic component of human development as well as a precondition for man's success to deal with hunger, poverty and death [1].

Despite the invaluable need for water, many are denied access to sufficient potable water supply and sufficient water to maintain basic hygiene. Globally, 1.1 billion people rely on unsafe drinking water sources from lakes, rivers, streams and open wells. The majority of these are in Asia (20%) and sub-Saharan Africa (42%). Furthermore, 2.4 billion people lack adequate sanitation worldwide (WHO/UNICEF, 2000) [2]. In Nigeria, a lot of people in the rural areas depend on unsafe water from rivers, lakes streams and wells for their daily water supply. Access to adequate safe drinking water is of prime importance to many individuals, governments and International Organizations. There is a growing concern everywhere that in the coming century, cities will suffer imbalances in quality water supply, consumption and population. Many regions of the world are already limited by the amount and quality of available water. According to World Health Organization (WHO) [3], in the next thirty years alone, accessible water is unlikely to increase more than ten percent (10%) but the earth's population is projected to rise by approximately one third. Unless the efficiency of water use rises, this imbalance will reduce quality water services, the conditions of health of people and deteriorate the environment and the world at large. Although many international conferences as well as researches have been going on, little by way of success has been chalked so far. Report from WHO [3] indicates that over 2.6 billion people are still suffering from the effect of poor water around the world. It is based on this that Heads of States and Governments met and signed the Millennium Declaration at the 2000 UN Millennium Summit to end the sufferings from the effects of poor water quality across the globe, as a matter of urgency [3]. The growing demands for adequate quality water resources create an urgent need to link research with improved water management, better monitoring and assessment. Since then adequate water quality has improved greatly in some regions and countries, especially in the developed world but for poor nations, it is still a major issue of concern [4] Water related health problems are a growing human tragedy, and according to WHO [5] kills more than 5 million people a year with infants being at most risk. This figure is high as compared to wars and disasters [6]. The problem prevents millions of people from living healthy lives, and undermines developmental efforts by burdening them with substantial socio-economic costs for treatment of water-borne diseases. To meet the 2015 target of the United Nations Millennium Development Goals (MDGs) on access to safe drinking water it requires that countries should create political will and resources to manage water especially in growing urban cities [7].

Getting safe water for human consumption is a prerogative and essential for good health and a basic human right. Quality of water especially boreholes, therefore needs to be checked periodically to ascertain their fitness for human consumption and other domestic uses as many people resort to borehole water for their water needs. Umudike community, the study area, houses a lot of people ranging from University students and staff, Research Institute staff and Government College, has a lot of boreholes. Within these communities are various improperly managed sanitation systems which can predispose the water system to infection by bacteria and other microorganisms. It is therefore of great importance to investigate the possibility or otherwise of pollution of these water sources from the boreholes.

MATERIALS AND METHODS

Sample collection: Ten functional boreholes were selected in Umudike and water samples collected from each of them using a 2 litre plastic container thoroughly washed and rinsed with 1:1 HCl and deionized water. The selected areas were as follows: (A1) Ogbonye, (A2) Okpontus, (A3) Obinetiti, (A4) Umudodo, (A5) Okorie Abukwu, (A6) Chukwueke, (A7) MOUAU female hostel, (A8) NRCRI Umudike, (A9) MOUAU male hostel and (A10) MOUAU new hostel. Environmental assessment of the sampling locations was carried out. The sample containers were further rinsed with the water from the boreholes at the point of collection. Five samples were collected from each site at the interval of 2 hours and mixed together to make a composite sample. Water from each of the boreholes were pumped out for about ten minutes using existing infrastructure before samples were collected from the point of casing and immediately carried to the laboratory.

Analytical Treatment

The samples were analyzed for physicochemical and microbial contents, the following physicochemical parameters were analyzed, general appearance, odour, taste, pH, conductivity, temperature using the methods described by Gaines and Greenberg *et al* [8, 9]. pH was determined using microprocessor pH meter and conductivity using Hanna electrical conductivity meter.

Standard methods by Ademoroti [10] were used for Total solids and Total Hardness and Phosphorus. Chloride was determined by direct reading titrator [11]. Dissolved oxygen was determined using Winkler's method and Biochemical Oxygen Demand using Dilution method. Magnesium and calcium were determined by EDTA titrimetric methods, while heavy metals were determined using Atomic Absorption Spectrophotometric methods.

Constituents of the water sample that deteriorate very rapidly with time such as dissolved oxygen, pH, and temperature were determined immediately after collection. For microbial analysis, the following microorganisms were isolated *Vibiro Cholera, Salmonella, Shigella, E. coli, Staphylococcus aureus, yeast* and mould using their various standard methods.

RESULTS AND DISCUSSION

Table 1 revealed the environmental assessment of the sampling locations, locations A1, A3, A6, A8 and A10 were clean while A2, A4 and A5 were fairly clean whereas A7 and A9 were dirty. All the sampling points except A1, A7 ad A9were far from sewage tanks, whereas all the sampling points except A5 and A6were far from poultry farms. Almost all the boreholes were located far from refuse dump sites, except A2 and A7. Serious efforts should be made to make the entire environment clean especially location A7 as dirty environments can pollute the water and also lead to high prevalence of diseases like malaria, cholera, typhoid, tuberculosis which lead to high mortality rates in the country [12].

Table 1: Environmental assessment of the sampling locations

Sample Source	Physical Appearance	Proximity to Sewage Tank	Proximity to Poultry Farm	Proximity to Refuse Dump Sites
A1	Clean	Close	Far	Far
A2	Fairly Clean	Far	Far	Close
A3	Clean	Far	Far	Far
A4	Fairly Clean	Far	Far	Close
A5	Fairly Clean	Far	Close	Far
A6	Clean	Far	Close	Far
A7	Dirty	Close	Far	Close
A8	Clean	Far	Far	Far
A9	Dirty	Close	Far	Far
A10	Clean	Far	Far	Far

Table 2: Mean values of the physicochemical characteristics of the different boreholes in Umudike

S/N	Appearance	Odour	Taste	Temp °c	pH	Conductivity us/cm	TDS Mgl	DO mg/l	BOD mg/l	Total Hardness mg/l	Cl^- mg/l	P mg/l	Mg mg/l	Ca mg/l	Fe mg/l	Cd mg/l
A1	Clear	Odourless	Tasteless	29.50	5.5	0.71	N.D	4.51	6.45	1.21	1.73	2.44	0.59	0.62	0.093	0.009
A2	Clear	”	”	28.50	4.98	0.64	N.D	.30	5.28	1.71	2.03	2.17	0.48	1.22	0.075	0.013
A3	Clear	”	”	28.50	4.46	0.48	N.D	4.16	5.76	2.87	2.81	2.74	0.34	2.53	0.033	0.036
A4	Clear	”	”	28.50	4.62	0.82	N.D	3.94	4.81	3.63	2.75	3.17	0.75	2.88	0.055	0.028
A5	Clear	”	”	29.50	4.80	5.28	0.008	4.24	5.96	4.02	2.47	1.57	1.24	2.78	0.047	0.027
A6	Clear	”	”	28.50	4.82	0.38	N.D	3.95	6.12	2.65	2.56	1.54	1.04	1.61	0.055	0.017
A7	Clear	”	”	29.50	4.74	0.52	N.D	3.94	5.74	1.69	2.06	1.31	0.28	1.41	0.072	0.014
A8	Clear	”	”	28.50	4.36	0.55	0.002	6.16	6.52	1.49	1.94	1.24	0.38	1.11	0.063	0.020
A9	Clear	”	”	29.50	4.70	0.41	0.003	4.80	6.54	2.06	2.44	1.35	0.63	1.43	0.044	0.052
A10	Clear	”	“	29.00	4.89	0.47	N.D	4.26	5.46	2.65	2.41	1.85	1.00	1.65	0.061	0.029
Total				289.5	48.92	10.26	0.013	44.26	58.64	23.97	23.20	19.38	6.73	17.24	0.60	0.25
Mean				28.95	4.89	1.03	0.0013	4.43	5.86	2.40	2.32	1.94	0.67	1.72	0.060	0.025
Range				28.50-29.50	4.46-5.50	0.33 -5.28	0.002-0.008	3.94-4.80	4.81-6.54	1.21-4.22	1.736-2.81	1.24-3.17	0.28-1.24	0.062-2.88	0.033-0.093	0.009-0.052
WHO (2011 Limit)				29.50	6.5-8.5	500	259-500	7.5	9	200	250	0-5	30	3.75	1-3	0.003

From the results in Table 2, the appearance of all the borehole waters were clear showing absence of dead organic matter or other particles. They were all tasteless and odourless and their values fell within the permissible WHO limits for drinking water, while their pH values ranged from 4.46 to 5.50. The pH values were however lower than the WHO recommended value of 6.5 to 8.5 [13], making the borehole waters acidic for human consumption and thus may cause health problems like acidosis [14]. It has been reported that potable water that is acidic can have adverse effects on the digestive and lymphatic systems in humans [15]. Temperature values ranged from 28.50 – 29.50° (with the mean (29.00) falling below the recommended value of 29.50°. The temperature range is in agreement with temperature levels in studies carried out in various locations in the Niger Delta [16, 17]. Conductivity varied from 0.38 – 5.28µs/cm with A5 recording the highest and A6 the lowest. The level of conductivity was far lower than the WHO limit indicative of the absence of dissolved minerals and hence suitable for domestic use and human consumption. The results of conductivity agreed with the work of Egereonu *et al* [18]. Total Dissolved Solids (TDS) levels ranged from 0.002 – 0.008 with mean value of 0.013. TDS was either lower or completely absent in most of the borehole waters. Total hardness ranged from 1.21 in A1 to 4.02 in A5. These values were far lower than the permissible levels of WHO indicating the water as soft. Soft waters are associated with rickets in children and have been found to be statistically related to high mortality from cardiovascular diseases [19]. DO ranged from 3.94 – 4.80. Potable water should contain at least 5mg/dm^3 of dissolved oxygen [20]. This means that Umudike borehole waters have moderately low Dissolved Oxygen. Dissolved oxygen is an important measure of the extent of pollution, the lower its value, the higher the pollution concentration and vice versa. The level of BOD ranged from4.81-6.54 and 4.81-6.95 and fell within the permissible level of WHO Chloride and Phosphate ions ranged from 1.73 – 2.81 and 1.24 – 3.17 respectively and fell within the tolerable limit of the WHO. High concentrations of phosphate could indicate pollution and are largely responsible for eutrophic conditions [13].
Calcium, magnesium and iron had their ranges from 0.0.62–2.88, 0.28-1.24 and 0.033-0.093 respectively which fell within the WHO standards for drinking water. Therefore, Umudike borehole waters are suitable for drinking and other domestic purposes. The result for iron is in agreement with the work of Mgbemena *et al* [21]. The concentration of Cd ranged from 0.009 to 0.052 with a mean value of 0.025. Cd contents in all the borehole waters were far above the permissible level of WHO. Cd is released as a by-product of zinc refining and zinc is used as an additive in lubricant and oil production. The high Cd may be due to used lubricants and engine oils scattered around

which may have leached down into the deeper aquifer. Cd is toxic at extremely low levels. In humans, long term exposure results in renal dysfunction. Cd is also associated with bone defects [22].

Table 3: Results of Microbial Analysis

sample No	Total Bacteria Count (cfux10^3)	total Coliform Count (MPN/100)	Feacal Coliform Count (cfu/ml)
A1	1.8	5	0
A2	2.7	2	0
A3	3.2	0	0
A4	1.6	1	0
A5	1.4	0	0
A6	2.8	3	0
A7	2.1	2	0
A8	3.4	0	0
A9	1.6	0	0
A10	1.3	0	0

All the borehole water samples the presence of some bacterial organisms which include *Staphylococcus*, *Klebsiella* Sp., *Salmonella, Micrococcus* Sp., *Pseduomonus* Sp. and *E. coli* (Table 3). The total bacterial count in the samples ranged from 1.3 to 3.4 x 10^{10} cfu/ml which were within the limit of 100 cfu/ml allowed for potable water [23]. Similarly the total coliform count of the waters ranged from 0.5MPN/100ml. All the borehole water samples had zero count of feacal coliform. Erah *et al* [24] conducted a study on the quality of ground water in Benin City, Nigeria and found acceptable levels of aerobic bacteria and fungi in Tebog District of Benin City. All the borehole waters were not free of total coliforms which probably might have resulted from the environment. They were however non-feacal in origin because the samples were devoid of feacal coliforms. Potable water should totally be devoid of coliforms [3]. Sample A1 had the highest total coliform count whereas sample A8 had the highest total bacterial count. It is noteworthy to mention that 50% of the borehole water samples had zero total coliform count. The result of total coliforms obtained in this study was not in agreement to that of Rogbesan *et al* [24] who reported the presence of total coliform outside the range allowed by WHO in over 60% of their samples [24].

CONCLUSION

Underground water is believed to be one of the purest waters because of the purification properties of the soil. However, some of them get contaminated probably due to the improper design, shallowness and environmental sources like proximity to sewage tank, refuse dump sites and other various anthropogenic activities. Proper borehole location, good sanitation and control of human activities are essential in siting boreholes.

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