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Physico-Chemical and Microbiological Evaluation of Borehole Water Samples in Enugu, South-Eastern, Nigeria.

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Abstract: *The physical, chemical and microbiological qualities of borehole water samples in Enugu, south-East, Nigeria were studied. Water samples were collected from ten boreholes sited in different locations and analyzed. The result of the physical analysis of samples revealed that all the samples met the recommended WHO standards for appearance, colour, taste and odour. The chemical analysis of the samples also showed that nine of the samples had the pH values that were within the range of 6.5-8.5 set by WHO. The lead levels of four out of the ten borehole water samples were much higher than the WHO recommended value of 0.05mg/l. In addition, the concentration of iron in all the test samples was higher than the value of 0.3mg/l recommended by WHO. However, the levels of zinc, chloride, nitrate, sodium and potassium were generally lower than the recommended WHO standards in all the samples. The mean microbial count of the samples revealed that the total aerobic bacterial count ranged between* $0.24 \pm 1.8 \times 10^5$ *cfu/ml and* $1.34 \pm 0.52 \times 10^5$ *cfu/ml whereas the coliform count of the samples ranged between* $0.62 \pm 0.08 \times 10^4$ *cfu/ml and* $1.23 \pm 1.8 \times 10^4$ *cfu/ml, respectively. The fungal count of the samples also had a range of* $0.86 \pm 2.04 \times 10^4$ *cfu/ml to* $1.82 \pm 1.6 \times 10^4$ *cfu/ml. The physical, chemical and microbiological qualities observed indicate that the borehole water samples did not meet the overall acceptable WHO standards and hence, are not safe for drinking.*

Keywords: *Borehole water, qualities, physical, chemical, microbial, standards.*

I. Introduction

Water is universally acceptable as one of the principle elements of life and may also pass the test of renewable resource (Ajewole, 2005). It is a very essential and basic need of humans and the most abundant molecule in living things. Water is used in daily routines. It is used in agriculture for irrigation, a component for production of food. In food processing, water plays major critical roles. Man in order to ensure his well being, must therefore has good supply of water. There are two sources of water, namely surface and ground water. Fifty percent of the world's population depends daily on ground water for their drinking (Nweke *et al.*, 2004[a]). Water that is fit for human consumption is called drinking or potable water. Before water can be described as potable, it has to be free from harmful bacteria and chemical impurities. It must be clear and bright, colourless, odourless and contain no suspended matter or turbidity. In addition, it should have an attractive appearance and be presant to drink (Okoli *et al.*, 2005). Such water must comply with certain physical, chemical and microbiological standards which are designed to ensure that the water is palatable and safe for drinking (Ojiegbe, 2005). The problem of potable water for the teeming rural and urban population of the third world countries has been of great concern to the well meaning bodies all over the world and lack of this water has been causing untimely death especially of children (Nwosu and Ogueke, 2004). In most developing countries including Nigeria, statistics have shown that about 80% of all the diseases and over 30% of death are water related (Rekabi *et al.*, 2007). With the ever expanding population of Enugu, South-East, Nigeria, there is an increasing demand for the supply of good quality water. The only source of treated water is the Enugu Urban water supply which is not regular and does not serve the entire population. This has resulted in a greater number of people living in Enugu to be dependent on borehole water as their source of drinking water. Some of these boreholes have even been sited in locations which have detrimentally affected the quality of the water (Anyanwu, 2001). Based on the importance of potable water to human health, there is a great need to evaluate the quality of the water obtained from some boreholes in Enugu. The objective of this study is to evaluate the physical, chemical and microbial qualities of borehole water samples in Enugu so as to ascertain their conformity with standards set by World Health Organization (WHO) for drinking water.

II. Materials And Methods

Collection of Borehole Water Samples

Water samples were collected from ten boreholes sited in different locations in the commercial city of Enugu. The locations of the boreholes were New Heaven, Ugwuaji, Uwani, Obiagu, Gariki, Abakpa, Onu-asata, Emene, Top Land and Coal Camp. Samples were collected in cleaned sterile glass bottles from borehole taps. The bottles were aseptically corked and transported immediately to the laboratory for analysis.

Physical Analysis

The water samples were individually transferred into one litre glass bottles and their colour taste, odour and appearance were physically and organoleptically assessed according to the method of Abara *et al*. (2005).

Chemical Analysis

The pH, total alkalinity, total hardness, chloride, nitrate, potassium, sodium, lead, iron and zinc levels of the water samples were determined according to the method of Obasi *et al*. (2004).

Microbiological Analysis

The total aerobic bacterial, fungal and coliform counts of the water samples were determined in duplicate using the pour plate technique according to the method of (James, 2003). One milliliter of each sample of water was plated individually on nutrient ager plate and incubated at 35^0C for 48h. After incubation, the colony counts were taken in each case with the aid of Gallenkamp electronic colony counter (Model HCD 826G) and the mean values obtained were individually recorded. The above procedure was repeated for coli form and fungal counts expect that MacConkey ager was used in place of nutrient agar at 37^0C whereas potato dextrose agar was used for fungal count at 28^0C for 96h. All the results obtained after analyses were individually compared to the standards set by Word Health Organization (WHO) for drinking water.

III. Results And Discussion

The physical properties of the water samples are shown in Table 1. The result showed that all the samples met the recommended WHO standards for potable water for colour, appearance, odour and taste. This observation is good as it reduces the cost required to render the water suitable for use as drinking water. Table 2 shows the chemical properties of the water samples. It was also observed that all the samples met the WHO acceptable standards for total alkalinity, chloride, nitrate, sodium, zinc and potassium for potable water (WHO, 1996). The pH of the water samples ranged from 7.6 to 8.4. These pH values are within the standard range (6.5 – 8.5) set by WHO for potable water. The total hardness of the water samples from six out of the ten boreholes investigated was higher than the WHO recommended value of 100mg/l. Enugu soil is known to be rich in limestone. It has been also reported that water dissolves minerals in the rocks when it passes through the ground (Nwaogazie, 1990). This report therefore suggests that the presence of limestone in the soil could make significant contribution to the hardness of water obtained from boreholes located in such limestone rich areas. However, hardness of water can be simply reduced by boiling treatment. More sophisticated methods of treating hard water include lime-soda softening, distillation, membrane filtration, reverse osmosis and zeolite process (Obiekezie *et al*., 2005). The iron levels of the ten borehole water samples investigated were higher than the WHO value of 0.3mg/l. Since all the water samples studied were clear and colourless, it suggests that the type of iron present in the water is soluble iron. Soluble iron is also called "clear water iron". However, when water containing soluble iron is exposed to air, the iron in it oxidizes or "rusts" forming reddish brown particles. This problem could be controlled by treating the water with a water conditioner or a combination of a water softener and filtration treatment (Oladapo *et al*., 2009). The concentration of lead (pb) from four out of the ten samples investigated were above the WHO acceptable specification of 0.05mg/l. The high levels of lead recorded by some of the water samples could be as a result of the environmental constituents of the sites where the boreholes were located. Report has shown that the ground water obtained from lead mining environment is likely to have high concentration of lead (Dada, 2009) The presence of high concentration of lead in drinking water has serious health implication. Excess lead in the human body has been reported to cause serious and irreversible damage to brain, kidney, nervous system and red blood cells (Nweke *et al*., 2004[b]). Table 3 shows the microbiological qualities of the water samples. The total aerobic bacterial count of the samples ranged from $0.24\pm1.8 \times 10^5$ cfu/ml to $1.34\pm0.52 \times 10^5$ cfu/ml. These values are not within the WHO acceptable standards of zero aerobic bacteria for drinking water. The presence of aerobic bacteria is an indication of poor sanitary condition and exposure of the samples to air and other atmospheric conditions which are responsible for their contamination (Osibanjo, 1996). The coliform count of the samples showed that all the water samples investigated did not meet the WHO recommended standard of zero coliform for potable water. The presence of coliform bacteria indicates faecal contamination of the samples. This could be attributed to improper personnel hygiene and use of unsterilized equipment for pumping, distribution and storage of water in the reservoir (Agwung *et al*., 2006). The fungal count of the samples which ranged from $0.86\pm2.04 \times 10^4$ cfu/ml to $1.82\pm1.6 \times 10^4$ cfu/ml were above the WHO acceptable standard for drinking water. The presence of fungi in the samples could be due to improper sanitary condition and the resistance of their spores to heat and other environmental conditions (Oyedeji *et al*., 2009). Fungi spores have been known to be more resistance to heat and high temperature than the bacteria spores.

IV. Conclusion

The study has provided genuine and reliable information about the physical, chemical and microbial qualities of water samples from some boreholes in Enugu, South-East, Nigeria. The observation from the present study also revealed that virtually all the samples did not conform to the standards set by WHO for potable or drinking water for the levels of aerobic bacteria, coliform and fungi. In addition, it was also observed that the levels of iron, lead and total hardness of most of the samples were generally higher than the recommended WHO standards for drinking water. The presence of iron and lead in drinking water is commonly known to be dangerous to health. This emphasizes the need for regulatory agencies such as the National Agency for Food and Drug Administration and Control (NAFDAC) and Standard Organization of Nigeria (SON) to monitor the locations for the sitting of the boreholes as proximity to mining areas poses a greater danger to the consumers.

Table 1: Physical Properties of Borehole Water Samples

Samples											
Parameters	**WHO Stds**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Appearance	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Colour	Co	Co	Co	Co	Co	Co	Co	Co	Co	Co	Co
Taste	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS	TS
Odour	OS	OS	OS	OS	OS	OS	OS	OS	OS	OS	OS

CL – Clear, Co-Colourless, TS – Tasteless, OS – Odourless.
A – Borehole water sample from New Heaven, B – Borehole water sample from Onu-asata, C – Borehole water sample from Uwani, D – Borehole water sample from Obiagu, E – Borehole water sample from Top Land, F – Borehole water sample from Gariki, G – Borehole water sample from Ugwuaji, H – Borehole water sample from Abakpa, I – Borehole water sample from Emene, J – Borehole water sample from Coal Camp.

Table 2: Chemical Properties of Borehole Water Samples

Samples											
Parameters	**WHO Stds**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
pH	6.5-8.5	7.6	8.2	8.4	8.0	7.8	8.3	8.4	8.2	8.3	8.4
Total Alkalinity (mg/L)	100	18	15	10	20	17	22	28	14	36	32
Total hardness (mg/L)	100	108	42	90	168	152	80	86	182	202	196
Chloride (mg/L)	600	128.00	142.00	86.00	40.00	60.50	27.00	102.00	43.00	84.00	76.4
Nitrate (mg/L)	1	0.75	0.06	0.27	0.14	0.18	0.19	0.16	0.08	0.14	0.16
Potassium (mg/L)	<5	0.145	0.050	0.110	0.045	0.044	0.048	0.022	0.108	0.028	0.022
Sodim (mg/L)	<20	0.28	0.32	0.38	0.12	0.14	0.06	0.13	0.45	0.26	0.44
Lead (pb) (mg/L)	0.05	2.250	0.062	0.028	0.092	0.041	0.044	0.032	0.026	0.038	2.210
Iron (Fe^{2+}) (mg/L)	0.3	1.750	1.285	1.262	1.314	1.304	1.524	1.286	1.424	1.322	1.408
Zinc (Zn^{2+}) (mg/L)	5.0	0.620	0.628	0.018	0.148	0.032	0.650	0.136	0.036	0.124	0.018

A – Borehole water sample from New Heaven, B – Borehole water sample from Onu-asata, C – Borehole water sample from Uwani, D – Borehole water sample from Obiagu, E – Borehole water sample from Top Land, F – Borehole water sample from Gariki, G – Borehole water sample from Ugwuaji, H – Borehole water sample from Abakpa, I – Borehole water sample from Emene, J – Borehole water sample from Coal Camp.

Table 3: Microbial Qualities of Borehole Water Samples

Samples											
Parameters	**WHO Stds**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Total aerobic bacterial count (cfu/ml)	Nil	0.24± $1.8x10^5$	0.64± $1.2x10^5$	0.82± $2.2x10^5$	0.96± $2.6x10^5$	1.02± $1.56x10^5$	1.16± $1.7x10^5$	1.34± $0.52x10^5$	0.86± $1.2x10^5$	1.24± $0.64x10^5$	1.32± $0.56x10^5$
Coliform count (cfu/ml)	Nil	0.62± $0.08x10^4$	0.72± $0.12x10^4$	0.68± $0.16x10^4$	1.01± $0.18x10^4$	1.23± $1.8x10^4$	0.78± $0.14x10^4$	0.92± $0.11x10^4$	1.20± $1.6x10^4$	1.12± $1.3x10^4$	1.16± $1.5x10^4$
Fungal count (cfu/ml)	Nil	0.86± $2.04x10^4$	0.96± $2.02x10^4$	1.14± $1.08x10^4$	1.82± $1.6x10^4$	1.62± $2.2x10^4$	1.78± $1.4x10^4$	0.98± $2.02x10^4$	1.24± $1.5x10^4$	1.56± $1.7x10^4$	1.66± $1.4x10^4$

A – Borehole water sample from New Heaven, B – Borehole water sample from Onu-asata, C – Borehole water sample from Uwani, D – Borehole water sample from Obiagu, E – Borehole water sample from Top Land, F – Borehole water sample from Gariki, G – Borehole water sample from Ugwuaji, H – Borehole water sample from Abakpa, I – Borehole water sample from Emene, J – Borehole water sample from Coal Camp.

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