Groundwater Quality Assessment Of Some Selected Boreholes In Calabar

[1]Agbor R.B., [1]Ekpo I.A., [1]Ekaluo U.B., [1]Okpako E.C., [1]Okigbo A.U., [2]Osang J.E., [1]Kalu S.E

[1]Department of Genetics & Biotechnology, University of Calabar, PMB 1115, Calabar, Nigeria
[2]Departmnet of Physics, Cross River State University of Technology, Calabar, Nigeria
E-mail: agborreagan@yahoo.com. Phone No: 08063430125

Abstract: Groundwater quality assessment of some selected boreholes was carried out. Nine boreholes water samples were collected from three different locations (Orok Orok, Okoro Agbor and Mount Zion). Water samples collected were taken to the laboratory and analyzed using standard laboratory procedures. The result obtained showed that significant difference ($p<0.05$) exist in the Physicochemical properties and heavy metal content of the borehole water samples in the three sample locations but the mean values were significantly lower than the WHO standard for drinking water. It can therefore be concluded that water samples from these boreholes are suitable for human consumption.

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INTRODUCTION

Groundwater is a major source of water supply in the developed and developing countries. Human activities have been known in recent times to affect the water quality through generation of hazardous wastes. Most of these wastes accumulate in the atmosphere forming atmospheric aerosol which sometime fall back as wet or dry particulate thus leaching into the underground water table and causing water impurity.

The provision of quality water for human consumption is essential for sustainable development program of society. The chemical composition of groundwater is a measure of its suitability as a source of water for human consumption or for other usages like agricultural and industrial purposes. Groundwater is water found below the soil surface in a zone of saturation (Isirimah, 2002). It becomes contaminated as a result of human activity that involves the introduction of unnatural dissolved, emulsified, immiscible or suspended materials into an aquifer. Contamination of ground water can be from household septic tanks, agriculture oil-field sources, refined petroleum product sources, centralized sewage treatment works, mining and milling sources and landfills (Dennis and Parker, 2000). The occurrence of groundwater contamination and the quality of ground water have become major issues since numerous hazardous waste sites were discovered in the seventies (Chows et al. 1988). Safe drinking water is a basic need for human development, health and well-being, it is an internationally accepted human right (WHO, 2002). Groundwater has been naturally very clean because of its filtering effect; however it can become polluted with nutrients and toxic chemicals when surface water carrying these substances drains into the groundwater environment (USEPA, 2001). Calabar and its environs is often faced with the issue of flooding during the rainy season, resulting in urban runoff of toxic chemicals that have high concentration of nitrate and phosphate derived from waste in the soil can filter through a dump and contaminate both ground and surface water. Insects, rodents, snakes and scavenger birds, dust, noise, and bad odor are some of the aesthetic problems associated with sanitary landfill. While at the set-in of the dry seasons the groundwater table decreases at this point as well as drying up of some the major streams and rivers. With these compounding issues it becomes difficult to ascertain the water quality of boreholes due to the increasing and decreasing levels of the water table. Adegbola, (2012) reported that the water sample obtained from shallow wells in Otte community, Kwara State, Nigeria did not meet WHO and NAFDAC standards. Ekpo *et al*., (2013) recommended that water from landfill areas is not suitable for human consumption since it can interfere with the normal state of health. It has been observed that bad quality water consumption leads to several health challenging issues such as typhoid, liver and kidney diseases. Adiudu *et al*., (2012) reported on groundwater mineralization of Osisioma Local Government area of Aba, Abia State, Nigeria, the result shows that the water is tasteless, odourless and colourless. The water sample was determined to be free from heavy metals contamination, like lead, arsenic, mercury and barium. Aluminum and manganese were also not detected.

MATERIALS AND METHODS

The study was carried out in the Department of Genetics and Biotechnology, University of Calabar, while the physicochemical analyses of the water samples was carried out in Cross River State Water Board Corporation (CRSWBC), Cross River State, Nigeria.

Groundwater samples were randomly collected from nine boreholes across the Calabar metropolis. Borehole water samples were collected from Okoro Agbor, Orok Orok and Mount Zion. The samples were collected according to WHO guidelines (WHO, 2002). The procedure for borehole water sample collection started with a reconnaissance survey to the areas. This was to help in identifying functional boreholes in the areas. Functional borehole was conceptualized as one that is frequently in use with high level of usage greater than 50 persons per day. Through this approach, nine functional boreholes were identified, and water samples randomly collected. Water samples were collected in 2.0 litre plastic bottles; before the collection of water samples, the borehole were allowed to pump for 15 minutes so that water with a constant temperature and pH, representing that from the aquifer was collected. Water samples were collected at the borehole heads. Prior to sample collection, all plastic bottles were rinsed thrice with the borehole water. Samples were collected in triplicates from each sample location. After sampling, the containers were tightly covered, labeled and taken to the laboratory for analysis. Data collected were analyzed using a Completely Randomized Design (CRD) and significant means were separated using Least Significant Difference (LSD) Test.

RESULTS AND DISCUSSION

The pH level in Orok Orok and Mount Zion water sample was significantly higher ($p<0.05$) than the pH of Okoro Agbor water sample. It was observed that the conductivity in Orok Orok water sample was higher than the EC of Mount Zion water sample while the water sample of Okoro Agbor had the lowest EC content but lower than the WHO standard for drinking water. The nitrates content in Mount Zion was significantly higher ($p<0.05$) than the nitrate content in Okoro Agbor and Orok Orok water samples that had no significant differences ($p>0.05$). But the nitrite content in water sample from OA was significantly higher than that of OO and MZ thus having significantly equal amount of nitrite. The result for the alkalinity of the water samples was significantly high in OO water sample followed by the alkaline content of MZ water sample which was then followed by the alkaline content of OA water sample. It was observed that the total hardness in OO water sample was significantly higher in OO water sample followed by the total hardness from OA and MZ that had no significant differences ($P>0.05$) in their total hardness content. Calcium hardness was high in OO water sample followed by the calcium hardness in OA which was also followed by the calcium hardness in mount zion. The result also shows that magnesium content was high in OO water sample while OA and MZ had similar amount of magnesium, the values obtained were significantly higher than the WHO standard. The TDS in OO water samples was significantly higher ($p<0.05$) than the TDS of MZ water sample that was followed by OA water sample. It was observed that the TSS of OA water sample was higher than the TSS of OO and MZ water samples that shows no significant differences ($p>0.05$). The result revealed that the chloride content of OA was significantly higher than the chloride content of OO and MZ water sample that had no significant difference ($p<0.05$). It was also observed that the potassium and sulphate content of OO and MZ water sample were significantly higher ($p<0.05$) than that of OA water sample (Table 1). However the values of the physical and chemical properties of the boreholes water samples were significantly lower than the WHO standard for drinking water except the magnesium content which shows high content above the WHO standard.

The results obtained shows that there were significant differences ($p<0.05$) in the iron content of the borehole water sample. The OA borehole water sample contain significantly high ($p<0.05$) amount of irons with means of 1.98 followed by the iron content present in OO and MZ that shows no significant difference ($p>0.05$), thus with means of 0.56 and 0.66 respectively. The manganese content in OA and OO water samples were the same followed by the manganese content in MZ water sample. It was observed that the fluoride content of MZ was significantly higher ($p<0.05$) than the fluoride content in OA and OO which had significantly equal amount of fluoride. The ammonia content in OA was significantly higher ($p<0.05$) than that of MZ while OO water sample had the lowest ammonia content. The result also revealed that the ammonium content in MZ, OO and OA water samples were significantly the same. The result shows that cyanides, chromates, zinc and aluminum were not present in all the water samples while copper was only detected in small amounts in OA water sample but not present in OO and MZ (Table 2). The values of the heavy metal content of the boreholes water samples were significantly lower than the WHO standard for drinking water. Potable drinking water is essential in maintaining quality health. Contamination of streams, rivers, wells and boreholes results in accumulation of several bacterial, heavy metals in the human system which leads to neprotoxicity, heptotoxicity, cancer and other nephorous diseases. Although pH usually has no direct impact on water consumers, it is one of the most important operational water-quality parameters. Careful attention to pH control is necessary at all stages of water treatment to ensure satisfactory water clarification and disinfection. For effective disinfection with chlorine, the pH should preferably be less than 8. The pH of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems. Failure to do so can result in the contamination of drinking-water and in adverse effects on its taste, odour, and appearance. The optimum pH will vary in different supplies according to the composition of the water and the nature of the construction materials used in the distribution system, but is often in the range 6.5–9.5. Exposure to extreme pH values results in irritation to the eyes, skin, and mucous membranes. Eye irritation and exacerbation of skin disorders have been associated with pH values greater than 11. Below pH 4, redness and irritation of the eyes have been reported, the severity of which increases with decreasing pH. Below pH 2.5, damage to the epithelium is irreversible and extensive (WHO, 1986). In addition, because pH can affect the degree of corrosion of metals as well as disinfection efficiency, it may have an indirect effect on health. High levels of nitrate in drinking water are a health concern primarily because of the potential for the nitrate to be converted to nitrite. Nitrite interferes with the ability of the blood to carry oxygen. It does this by converting blood hemoglobin into methemoglobin. Unlike hemoglobin, methemoglobin does not function as an oxygen carrier to the tissue. The resulting condition is known as methemoglobinemia and causes severe oxygen deficiency and can lead to death. The sensitive populations are infants, individuals with reduced gastric acidity, individuals with a hereditary lack of methemoglobin reductase, and women who are pregnant. Sodium ion is ubiquitous in water. Saline intrusion, mineral deposits, seawater spray, sewage effluents and salt used in road de-icing can contribute significant quantities of sodium to water. The treatment of water with chemicals, such as sodium fluoride, sodium bicarbonate, and sodium hypochloride, can together result in sodium levels as high as 30mg/litre. Excessive salt intake seriously aggravates chronic congestive heart failure, and ill effects due to high levels of sodium in drinking water. Excessive sodium in drinking water can produce an increase in blood pressure as a person ages. This can eventually lead to the development of hypertension in people with a family history of the disease. The amount of naturally occurring calcium and magnesium compounds dissolved by the water as it filters through the earth will determine its hardness. Hardness varies with location and the types of minerals and rocks in the earth. Hard water is not considered to be a health hazard. Moderate amounts of hardness are desirable because of the protective coating it produces on exposed metal surfaces. Excessively hard water, however, will cause a hard, chalky scale (boiler scale) to form when the water is heated. Water heaters are especially affected by hardness. The boiler scale will accumulate on the heating elements, reducing their heating capacity, and eventually causing them to burn-out. Hard water will form a white, powdery residue on plumbing fixtures, and will cause spots on dishes. Because calcium and magnesium compounds are not very soluble in cold water, ice made from hard water may contain white particles. Vegetables cooked in hard water may be tough. More soap must be added to a hard water to produce lather. With very hard water, soap will form a sticky "curd," which is difficult to remove from fabrics and containers. Laundry washed in hard water will be stiff and dingy. Hair becomes dull and limp when washed in hard water. Fluoride is a normal part of the human diet. Children exposed to excessive amounts of fluoride while their teeth are developing can develop dental fluorosis. Dental fluorosis appears as whitish or brown spots on the teeth. The occurrence of dental fluorosis increases as the fluoride concentration increases. Iron is an essential element in human nutrition. Estimates of the minimum daily requirement for iron depend on age, sex, physiological status, and iron bioavailability and range from 10 to 50mg/day (Fisch, 1975). Manganese will cause a coating to form inside the plumbing. This coating will periodically break free, causing black particles to appear in the water. Iron and manganese will give water a bitter, metallic taste. Coffee and tea prepared with the water may turn black. Deposits from these metals will cause stains on plumbing fixtures, appliances, and in laundry. Bleaches or scouring powders will not remove the stains and may make them worse. Special products designed to remove rust stains are available in most grocery stores. TDS in drinking water originate from natural sources, sewage, urban run-off, industrial wastewater, and chemical used in the water treatment process and the nature of the piping or hardware used to convey the water. Though, TDS produce no health hazard but significantly make the water corrosive, salty, thus resulting in scale formation which interfere and decrease efficiency of hot water heaters. Calcium and magnesium are important in the human body. Deficiency of this element could result in osteoporosis and osteomalacia. Chloride itself in drinking water is generally not harmful to human beings. At concentrations higher than 250 mg/L, the sodium associated with chloride may be a concern to people on sodium-restricted diets. Chloride may also contribute to the total dissolved solids (TDS) in drinking water. This may affect the rate of corrosion of steel and aluminum. Chloride may cause corrosion of some metals in pipes, pumps, fixtures, and hot water heaters. Lead is a cumulative general poison, with infants, children up to 6 years of age, the fetus and pregnant women being the most susceptible to adverse health effects. On the 21st April 2013 BBC report claims that 460 children in Zamfara State, Nigeria have so far died as a result of lead poisoning from gold mining activities in the area since 2009 with others suffering different forms of long term and serious medical condition such as paralysis, deafness and brain damage. Its effects on the central nervous system can be particularly serious. Lead in drinking-water arises from plumbing in buildings, and the remedy consists principally of removing plumbing and fittings containing lead, which requires much time and money. It is therefore emphasized that all other practical measures to reduce total exposure to lead, including corrosion control, should be implemented. Lead is toxic to the human body. It can cause damage to the brain, nervous system, kidneys, and red blood cells. Pregnant women, fetuses, infants, and young children are at the greatest risk of lead poisoning, even if exposed to lead for only a short time. Infants, who consume most of their food in liquid form (baby formula), can receive very large doses of lead through drinking water. Growing children absorb lead more rapidly than adults. Low levels of lead can have much larger impact on their small bodies than on an adult. Overexposure to lead during this stage of life can permanently stunt their growth. Individuals ingesting large doses of copper present with gastrointestinal bleeding, haematuria, intravascular haemolysis, methaemoglobinaemia, hepatocellular toxicity, acute renal failure and oliguria (Agarwal et al., 1993). At lower doses, copper ions can cause symptoms typical of food poisoning (headache, nausea, vomiting, diarrhoea). Staining of laundry and sanitary ware occurs at copper concentrations above 1 mg/litre. At levels above 2.5 mg/litre, copper imparts an undesirable bitter taste to water; at higher levels, the colour of water is also impacted. Zinc is a naturally occurring metallic element. The principal cause of zinc in drinking water is the corrosion of galvanized metal. Water having high concentrations of total dissolved solids or chlorides will also dissolves zinc from galvanized metal. Elevated levels of dissolved solids and chlorides increases the electrical conductivity of the water, making it easier for the chemical reactions involved in corrosion to occur. Dissolved zinc can cause the water to have a bitter, medicinal taste. Concentrations of 30 mg/L may give the water a milky appearance. When the water is heated, elevated levels of zinc may produce a greasy film on top of the water. Chromium and its salts are used in the leather tanning industry, the manufacture of catalysts, pigments and paints, fungicides, the ceramic and glass industry, and in photography, and for chrome alloy and chromium metal production, chrome plating, and corrosion control Ingestion of 1–5 g of "chromate" (not further specified) results in severe acute effects such as gastrointestinal disorders, haemorrhagic diathesis, and convulsions. Death may occur following cardiovascular shock (Janus and Krajnc, 1990).

Table 1: Physical and chemical characteristics of boreholes water samples

Parameters	Okoro Agbor (OA)	Orok Orok (OO)	Mount Zion (MZ)	WHO
Temperature	$24.45^{b}\pm0.04$	$27.98^{a}\pm0.50$	$27.25^{a}\pm0.08$	-
pH	$4.97^{b}\pm0.01$	$5.33^{a}\pm0.03$	$5.42^{a}\pm0.02$	6.5-8.5
Conductivity (µs/cm)	$46.5^{c}\pm0.45$	$97^{a}\pm0.24$	$53.23^{b}\pm0.16$	500
Nitrate (mg/l)	$4.28^{b}\pm0.07$	$5.08^{b}\pm0.02$	$8.03^{a}\pm0.02$	50
Nitrite (mg/l)	$0.15^{a}\pm0.01$	$0.02^{b}\pm0.01$	$0.03^{b}\pm0.01$	3
Alkalinity (mg/l)	$4.60^{c}\pm0.03$	$19.38^{a}\pm0.19$	$8.58^{b}\pm0.12$	500
Total hardness (mg/l)	$29.89^{b}\pm0.16$	$39.78^{a}\pm0.23$	$27.53^{b}\pm0.23$	200
Calcium hardness (mg/l)	$20.33^{b}\pm0.10$	$24.5^{a}\pm0.05$	$17.78^{c}\pm0.20$	75
Magnesium (mg/l)	$9.53^{b}\pm0.03$	$15.28^{a}\pm0.02$	$9.75^{b}\pm0.04$	0.02
TDS (mg/l)	$31.25^{c}\pm0.32$	$67.9^{a}\pm0.45$	$37.23^{b}\pm0.19$	1000
TSS (mg/l)	$0.07^{a}\pm0.01$	$0.001^{b}\pm0.00$	$0.01^{b}\pm0.00$	-
Chloride (mg/l)	$3.81^{a}\pm0.02$	$2.90^{b}\pm0.02$	$2.25^{b}\pm0.01$	250
Potassium (mg/l)	$1.13^{b}\pm0.01$	$1.62^{a}\pm0.20$	$1.79^{a}\pm0.02$	200
Sulphate	$1.20^{b}\pm0.01$	$3.10^{a}\pm0.03$	$3.00^{a}\pm0.03$	100

Means with the same case letter along the horizontal arrays indicate no significant difference ($p>0.05$)

Table 2: Heavy metal content of borehole water samples

Parameters	Okoro Agbor (OA)	Orok Orok (OO)	Mount Zion (MZ)	WHO
Iron	1.98[a]±0.06	0.56[b]±0.02	0.66[b]±0.02	0.5-50
Manganese	0.92[a]±0.01	0.93[a]±0.03	0.06[b]±0.01	0.1
Fluoride	0.49[b]±0.02	0.44[b]±0.01	0.69[a]±0.03	-
Ammonia	1.28[a]±0.04	0.78[c]±0.02	1.00[b]±0.05	-
Ammonium	0.39[a]±0.01	0.39[a]±0.01	0.46[a]±0.01	0.5
Lead	ND	0.002	ND	0.01
Cyanide	ND	ND	ND	-
Chromate	ND	ND	ND	0.05
Copper	0.001	ND	ND	1.0
Zinc	ND	ND	ND	3.0
Aluminum	ND	ND	ND	0.2

Means with the same case letter along the horizontal arrays indicate no significant difference (p>0.05). All units are in mg/l

CONCLUSION

Water is health and health is water. Humans rely on water for everything and thus water is one of the essential resources for human survival. Consumption of contaminated water brings about ill health. Majority of infectious diseases is contacted through water. However, as a means of ensuring the safety of humans and occupant of Okoro Agbor, Orok Orok and Mount Zion some boreholes were selected and assessed on the levels of heavy metal accumulation and physicochemical properties. The result shows that the selected boreholes provide portable water for human consumption as compared with the WHO standard for drinking water.

REFERENCE

1. Agarwal S.K, Tiwari S.C, Dash S.C (1993). Spectrum of poisoning requiring hemodialysis in a tertiary care hospital in India. *International Journal of Artificial Organs*, 16(1):20–22.
2. Adindu R.U., Igboekwe M.U., Lebe N. (2012). Groundwater mineralization analysis of Osisioma local government Area of Abia State, Nigeria., American Journal of Chemistry., 2(3): 121-125.
3. Adegbola, A.A. (2006). A review of safe water provision for residents of Ibadan City. Science focus: International Journal of Biological and Physical Sciences. 2(1): 139-146.
4. Ekpo I.A., Agbor R.B., Albert P.E., Okpako E.C and Inyang P.I (2013). Assessment of heavy metal status and bacteria population in municipal borehole water in landfill and non-landfill areas in calabar municipality, Cross River State, Nigeria. *International Journal of Engineering and Applied Sciences*. 2(4): 31- 41
5. Fisch R.O (1975). Potential toxicity of iron overload in successive generations of rats. *American Journal of Clinical Nutrition*, 28:136-139.
6. World Health Organization Working Group (1986). Health impact of acidic deposition. *Science of the total environment*, 52:157-187.
7. Janus J.A, Krajnc E.I. (1990). Integrated criteria document chromium: effects. Appendix. Bilthoven, Netherlands, National Institute of Public Health and Environmental Protection,
8. Isirimah N. O, *Understanding the Nature, properties and sources of Wastes for Quality Environment*. Tom and Harry Publications Port Harcourt Nigeria. 19 – 25. (2002).
9. Chow, V. T., Maidment, D. R., Mays, L. W., Applied Hydrology, McGraw-Hill International Editions, 1988 (GB 661.2 .C43 1988).
10. United States Environmental Protection Agency (USEPA) (2002). Current drinking water Standard Office of Groundwater and drinking water, Government Printing Office, Washington D.C.
11. WHO, (2002): Water for Health. World Water Day 2002, Washington.
12. Dennis M., and Parker, J. (2000) *Groundwater Contamination and Remediation.* New Mexico Environment Department Groundwater Quality Bureau.

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