Water Quality Assessment Using Heavy Metal Indicators in Aghoro Community, Bayelsa State, Nigeria

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Abstract

In this study, Chemical analysis for Fe, Cu, Pb, Ni, Cd, Zn was carried out on water samples collected from various location points in Aghoro Community in Southern Ijaw Local Government Area of Bayelsa State. The analyses were done to determine the environmental status and portability of the water in the area for drinking and domestic uses, with reference to WHO standard. Eight (8) water samples were collected from stream channels, hand dug wells and boreholes located across Aghoro Community and analyzed for heavy metals. The analytical results indicate the following ranges of concentrations for the heavy metals; Fe (1.17±0.07–3.37±0.12mg/l), Cu (0.02±0.00 - 0.05±0.01mg/l) Ni (0.06±0.01-0.17±0.01mg/l), Pb (0.02± 0.00-0.06± 0.00mg/l) and Zn (0.12±0.01-0.16±0.07mg/l). When compared with standards recommended by the various regulatory bodies most of the values, particularly the water samples from the hand/manual operated boreholes showed very high levels of heavy metals as most values were above WHO permissible limits. Hence there is a need for holistic and sustainable monitoring and treatment of water before drinking in the area.

Keywords: Portability, Water Samples, Wells, Heavy Metals, Nigeria

INTRODUCTION

Groundwater is of major importance and is intensively exploited for private, domestic and industrial uses. According to Ajibade *et al*., (2011), 90% of the population depends largely on hand-dug wells. Majuru *et al*., (2011) estimated that about 65 million Nigerians had no access to safe water, and WHO (2011) reported that about 884 million people in the world still do not get their drinking water from approved sources, and almost all of these people are in developing regions.

Though water is continuously recycled in the environment by evaporation and rain, more water becomes polluted from pesticides, chemicals, oil spills, and sewage which results in less water being suitable for human consumption and agricultural use. Heavy metals are transported by runoff from industries, municipalities and urban areas, while most of these metals end up accumulating in the soil and sediments of water bodies (Musilova, 2016). Heavy metals can be found in traces in water sources and still be very toxic and impose serious health problems to humans and other ecosystems. This is because the toxicity level of a metal depends on factors such as the organisms which are exposed to it, its nature, its biological role and the period at which the organisms are exposed to the metal. Food chains and food webs symbolize the relationships amongst organisms. Therefore, the contamination of water by heavy metals actually affects all organisms. Humans, an example of organisms feeding at the highest level, are more prone to serious health problems because the concentrations of heavy metals increase in the food chain (Lee *et al*., 2002). The physical and chemical parameters of an aquatic body not only reflect the type and diversity of aquatic animals but also the water quality and pollution, which may lead to severe poisoning if they pollute the groundwater used for drinking or irrigation purposes (Osibanjo *et al*., 2011; Lou *et al*., 2017).

Heavy metal contaminants such as chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), cadmium (Cd), and lead (Pb) are generally more persistent than organic contaminants as they can be mobile in soils and leach into aquifers. In small quantities, certain heavy metals are nutritionally essential for a healthy life e.g., iron, copper, manganese, and zinc, referred to as the trace elements, commonly found naturally in foodstuffs, in fruits and vegetables, and in commercially available multivitamin products (Herawati *et al*., 2000). Under normal circumstances; the body is able to control some of these amounts but Ogbonna *et al*. (2017) showed that continuous exposure to elevated levels of metals could cause serious illness or death and increased exposure may occur through inhalation of airborne particles or through ingestion of contaminated soil by children or by absorption through the skin as they can also cross the placenta and harm an unborn child in pregnant women.

Children are the most susceptible to health problems caused by heavy metals, because their bodies are smaller and still developing and the health hazards presented by heavy metals depend on the level and the length of exposure. In some cases, the health effects are immediately apparent; in others, the effects are delayed. High levels of toxic metals deposited in body tissues and subsequently in the brain, may cause vital developmental and neurological damage, including depression, increased irritability, anxiety, insomnia, hallucination, memory loss, aggression and many other disorder (Ogbonna *et al*., 2017).

Over the years, groundwater has served as a potential source of water supply especially through springs, hand dug wells and boreholes. Due to their increasing popularity as a veritable source of water supply, it becomes necessary to access critically their quality and portability for human consumption. It is in view of this, that the present study was carried out in order to examine to what extent heavy metals in these deposits have polluted groundwater within and around the study area.

MATERIALS AND METHOD

The study area is Aghoro community, a rural settlement of Izon-speaking people situated in the South of Ramos River and North of Dodo River Longitude 5^o 28' 00''E and Latitude 5^o 07' 00''N in Ekeremor Local government area of Bayelsa State, Nigeria (figure 1). Fishing is the main occupation of the people, using line and hooks as well as nets of various sizes to catch fishes which are mostly sold in the market on a 12 days interval. They cultivate small area of arable land in the vicinity of their villages, crops such as sweet potatoes, cassava, plantain, banana, maize and sugar cane are grown in small quantities for personal consumption.

The depths of hand dug wells in this region vary from 3.81 to 30.37m above the mean sea level (MSL), boreholes are generally between 21 and 58.86 m deep and the stream channels are mostly surface water. Most of the hand dug wells are shallow and are neither lined nor have properly constructed base or covers. Some are simply demarcated by large tree trunks and are left bare (uncovered). In this investigation chemical analysis for Fe, Cu, Pb, Ni, Cd, Zn was carried out on water samples collected from selected locations in Aghoro of Southern Ijaw Local Government area of Bayelsa State.

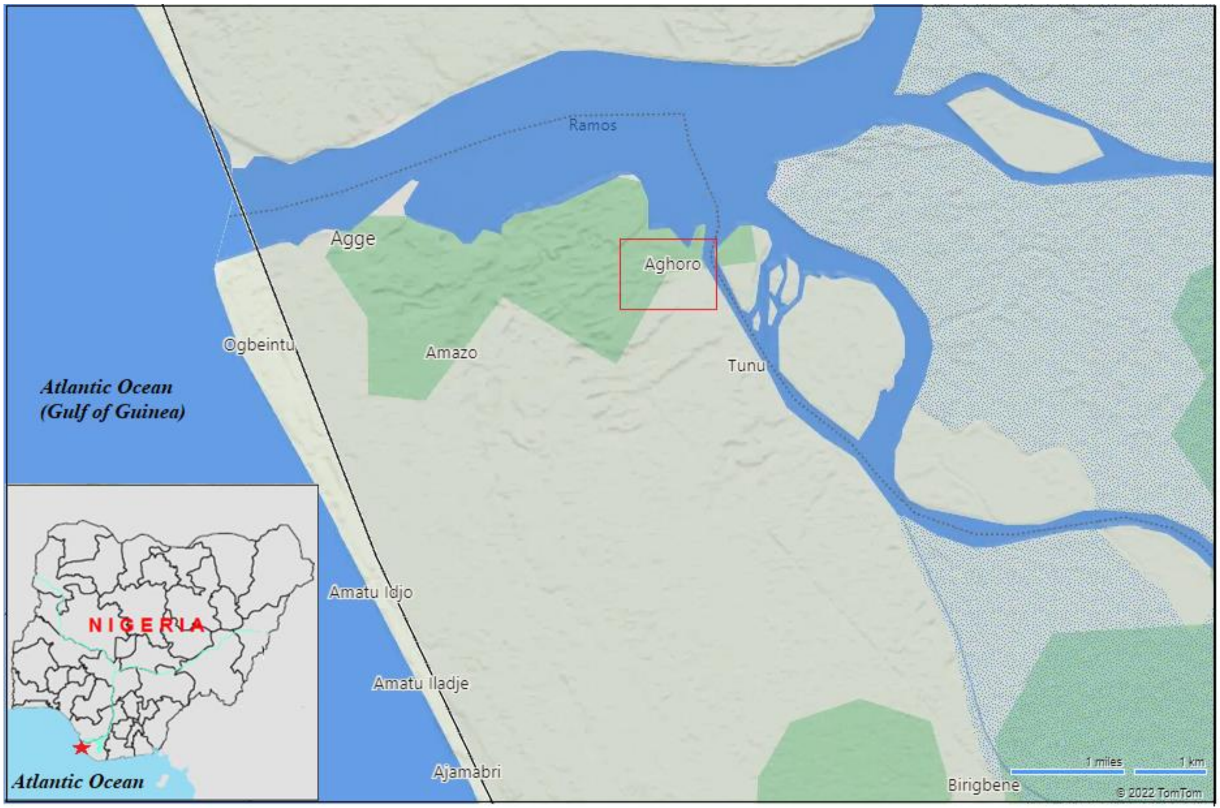

Figure 1: Map of the Study area showing Aghoro and River Ramos flowing into the Atlantic Ocean at the Gulf of Guinea. Inset is map of Nigeria with start showing the location of study area.

Water samples were randomly collected from eight locations within the study area. The choice of the sampling stations considered location, accessibility, proximity to residential areas and the topography of the study area. Two sample stations were collected from electric boreholes within residential areas (within 2 km radius), two government built manual pumped boreholes in the commercial area (market), two hand dug shallow wells and two stream channels around the commercial section of the study area. Water samples collected were stored in polyethylene containers which had been previously sterilized, thoroughly cleaned with 1:1 HNO3, rinsed several times with distilled water, and dried in an electric oven, the containers were completely filled with water before they were corked to avoid trapping of air bubbles. The samples were stored in a cooler with ice cubes and taken to the laboratory for analysis.

Water sample preparation and processing

The water samples collected had particles with unclear appearance or discolouration, which necessitated digestion of the samples before analysis. Concentrated nitric acid (5 ml) was added to each water sample (50 ml) into a beaker and then covered with a watch glass. The samples were heated gently and evaporated on a hot plate to about 10 ml. The heating process continued with the addition of concentrated nitric acid until digestion was complete (generally indicated when the solution became clear in colour and its appearance remained unchanged with continued heating).

The sample was filtered using Whatman No. 4 filter paper to remove insoluble materials that could clog the atomizer. The filtrate was then transferred to a 50-ml volumetric flask and diluted to the mark with distilled water for Atomic Absorption Spectrophotometer, (AAS, Buck Scientific VGP 210) analysis (FEPA 1991).

About 2ml of each water sample was measured into a boiling tube and 10ml concentrated Nitric acid was added and heated slowly over a hot plate until the dense white fume disappeared. The solution was cooled and diluted with distilled water and then filtered into a 100ml volumetric flask and made up to mark. The resulting solution was then taken to the AAS for analysis.
The heavy metals concentrations in the samples were determined by Atomic Absorption Spectrophotometer, (AAS, Buck Scientific VGP 210) using air acetylene flame with digital read out system. The samples were aspirated through nebulizer and the Absorbance measured with a blank as reference.

The water samples were analyzed for electrical conductivity (EC), potential hydrogen (pH), heavy metals which include; Lead (Pb), iron (Fe), zinc (Zn), copper (Cu), cadmium (Cd) and Nickel (Ni). pH and EC were determined using pH/conductivity meters (Jenway model) while Cu, Fe, P,b, Zn, Cd and Ni were determined with the aid of the Atomic Absorption Spectrophotometer (AAS), respectively at 327.4; 248.3; 283.3; 213.9; 228.9 and 341.5 nm wavelengths (APHA *et al*., 1992). Mettler Toledo MC 2006 conductivity meter was used to measure electrical conductivity and pH was determined using Lovibond instruments and electronic meters.

RESULTS AND DISCUSSION

Results of the analysis of the heavy metals in the water samples presented in Table 1, was viewed against the standards as recommended limits by the World Health Organisation (WHO) (2011). Results showed Cadmium (Cd) to be below detection level (BDL) indicating that Cd level in the study area is not of any health concern as the WHO detection limit is 0.003mg/L. Copper (Cu) ranged between 0.02 and 0.05 mg/L which showed a significant difference between locations at wavelength of 327.4nm, and is within the permissible limit of 1mg/l as recommended by SON (2002) and 2mg/l as recommended by WHO (2011).

Although Cu is an essential trace element that is required to maintain good health, high concentrations may result in poisoning, giving the water a metallic and an unpleasant bitter taste and can aggravate gastrointestinal disorder in man. The low concentration of Cu recorded in this study, indicates that the area is free of copper poisoning. Iron (Fe) showed a range value of 1.17 - 3.37mg/L, showing a significant difference ($p=0.05$) in concentration from different locations, which is relatively high as compared to studies by (Imasuen and Egai, 2013) where the range for Fe level was 0.01 – 0.68mg/l. The highest value of Fe was in the hand operated borehole (1) 3.37 ± 0.12mg/, which may be attributed to the rusting pipes used in constructing the borehole and also resulting in the pale brown colouration of the water samples used.

The 2011 WHO guidelines however, stated that Iron (Fe) metals found in water is not of health concerns. Iron is an essential element to the human body; hence higher iron concentration does not pose a threat to the human health. However, it stains laundry and induces incrustation, brownish and rusty colouration. The iron may have been derived from a marshy environment and also from acidic soils.

From Table1, the concentration of Ni showed a significant difference (p= 0.05) from the different locations under study. The primary source of Nickel in drinking water is leaching from metals in contact with the water, such pipes and fittings, which may be attributed to a higher Ni value in the residential bore hole (1) at a concentration of 0.17 mg/L. This result is higher than the WHO (2011) guidelines for drinking water ,whereas the maximum allowable limit of Ni, recommended for any dirking water is 0.07mg/l, but report from WHO, 2011 shows that concentration in drinking-water is normally less than 0.02 mg/l, although nickel released from taps and fittings may contribute up to 1 mg/l; in special cases of release from natural or industrial nickel deposits in the ground, concentrations in drinking-water may be higher, this allowed for a maximum of 0.07mg/l for drinking water (WHO,2011).

Table 1: Concentration of heavy metals from water samples in Aghoro community of Bayelsa State, Nigeria.

Location	*pH	Ec (µS/cm)	Cd (mg/L)	Cu (mg/L)	Fe (mg/L)	Ni (mg/L)	Pb (mg/L)	Zn (mg/L)
Residential electric borehole (l)	6.93±0.02	161.83±0.94	BDL	0.02± 0.01	1.17± 0.07	0.17± 0.01	0.02± 0.00	0.15± 0.01
Residential electric borehole (2)	6.77±0.01	644.67±1.20	BDL	0.04± 0.01	2.27± 0.09	0.12± 0.01	0.02± 0.01	0.13± 0.03
Hand dug well (1)	6.27±0.02	150.60±0.81	BDL	0.03± 0.01	1.23± 0.09	0.14± 0.01	0.06± 0.00	0.17± 0.01
Hand dug well (2)	6.36±0.01	46.63± 0.18	BDL	0.04± 0.00	1.50± 0.06	0.15± 0.00	0.03± 0.00	0.12± 0.00
Shallow well (1)	6.35±0.07	39.17± 0.18	BDL	0.02± 0.00	1.20± 0.06	0.06± 0.01	0.03± 0.00	0.13± 0.00
Shallow well (2)	6.32±0.01	87.40± 0.21	BDL	0.03± 0.00	1.43± 0.03	0.12± 0.01	0.04± 0.00	0.12± 0.01
Hand operated borehole (1)	6.37±0.02	254.67±1.20	BDL	0.03± 0.00	3.37± 0.12	0.11± 0.01	0.04± 0.01	0.16± 0.07
Hand operated borehole (2)	6.40±0.01	263.33±1.20	BDL	0.05± 0.01	2.43± 0.09	0.15± 0.01	0.02± 0.00	0.12± 0.01
Significance (p=0.05)	S	S		S	S	S	S	NS
Wavelength (nm)			228.9	327.4	248.3	341.5	283.3	213.9
WHO detection limit(mg/L)	6.5- 8.5	400µS/cm	0.003	2.00	**	0.07	0.01	**

** = mean of 3 replicates ± standard error*
*** = Not of health concern as levels found in drinking water (WHO, 2011)*
BDL = Below detection level

In the area of investigation, Lead (Pb) concentration was as high as 0.06±0.00mg/l found in the hand dug well (Table 1). All the water samples, indicated the presence of Pb above the stipulated WHO limit of 0.01mg/l. This is a case for concern as Lead is a very toxic element, which accumulates in the skeletal structure of man and animals. In addition, toxic concentration of lead (≥ 0.01mg/L) in human beings has been implicated for causing anaemia, kidney damage and cerebral oedema (Townsend, 1991; Egborge, 1991).

The aggravated lead concentration in the study area maybe traceable to the total hydrocarbon content (THC) resulting from waste products from illegal refineries, occasional oil spills, possible leashing from polluted underground water as a result of incessant use of fertilizers and the indiscriminate dumping of waste into the rivers. The result for zinc shows that the values obtained for the samples range from 0.12±0.01mg/l to 0.17±0.01mg/l. Though WHO (2011) stated that Zinc (Zn) metal found in water is not also of health concern, as levels found in drinking water. As in the case of Iron, Zinc is also an essential element for human development especially for child bearing women (Gupta and Gupta 1998). Zinc is an essential trace element found in virtually all food and potable water in the form of salts or organic complexes. The diet is normally the principal source of zinc. Although, levels of zinc in surface water and groundwater normally do not exceed 0.01 and 0.05 mg/l, respectively, concentrations in tap water can be much higher as a result of dissolution of zinc from pipes (WHO, 2011).

Metals in drinking-water can cause taste and staining problems. Staining problems are usually associated with iron, copper and manganese. Taste problems are usually due to iron, copper, manganese or zinc. The metals that usually appear at the highest concentrations are iron, copper and zinc. Iron and zinc may arise from iron pipes or galvanized or brass fittings in the distribution system. Copper is more likely to arise from the corrosion of the consumer's own plumbing, although both iron and zinc may also appear in water from the dissolution of materials on the consumer's property.

The result of this study showed a pH range between 6.25- 6.95 which is within the WHO range of 6.5- 8.5. The pH of pure water is 7 at 25^{o}C. A low pH (< 6.5) could be acidic, soft and corrosive, as this could leach metal ions such as iron, manganese, copper, lead and zinc from aquifiers, plumbing fixtures and piping. Therefore, water with a low pH could contain high levels of toxic metals causing metallic or sour taste, staining of laundry and the characteristic blue-green staining of sinks and drains. However, the human body – the stomach and the kidneys are able to maintain a pH equilibrium, so is not affected by water consumption. There are many claims of health promoting effects of alkaline water which are not scientifically substantiated. A study by Wolf *et al*. (2014), showed that neutral water pH7 compared to acidic water pH3 increased the incidence of diabetes in non-obese diabetic mice. In a study of male volunteers, they did not show any differential effect of alkaline versus neutral drinking water on gut micro biota composition or glucose regulation (Hansen *et al*., 2018).

Pure water is not a good conductor of electric current but acts as an insulator. Increase in ions concentration enhances the electrical conductivity of water (EC). EC is the measures the ionic process of a solution that enables it to transmit current. When the EC of water is higher, electricity will be more attracted to water, which is why it can be dangerous to take a bath or go for swim during thunderstorms According to WHO standard, the EC should not exceed 400µS/cm. Electrical conductivity of the areas under study, showed that the residential bore hole (2) had a value of 644.67 µS/cm, which was the highest, as against shallow well (2) at 39.17 µS/cm which showed significance at p=0.05 in different locations. Residential bore hole (2) with EC value of 644.67 µS/cm is above the WHO limits which is an indication that the water is considerably ionozed with high ionic concentration activity due to large dissolved solids (Soylak *et al*., 2002). A high EC levels lead to stunted growth, leaf damage and plant death, which is a high threat to the agrarian community. However, high electrical conductivity of water (EC) can be reversed by boiling the water before use.

CONCLUSION

This is a as a serious matter of concern for consumption of drinking water in this community, as the presence of heavy metals signify the deterioration of the quality of the water. The high concentration of the heavy metals content in most of the rivers and ponds in Aghoro community is an indication that the surface water is not suitable for drinking and domestic purpose. The water is a threat to public health in the area and is not potable, as it is not safe for drinking and other domestic uses. It is evident from the present study that direct drinking of water from these water sources, which is done in Aghoro community in Bayelsa State, can be deleterious to consumers. However, there is an urgent need for proper monitoring and treatment of water before drinking. The presence of oil spills and oil thieves may be the likely sources of the contaminants and they should be checked by the appropriate government agencies.

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