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Assessment of Levels of Selected Heavy Metals in Borehole Water in Zuru Metropolis, Kebbi State Nigeria

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A B S T R A C T

This paper assesses the concentrations of specific heavy metals in borehole water within Zuru Metropolis, Kebbi State. Utilizing rigorous sampling and analytical methods, the study aims to provide insights into the potential health risks associated with heavy metal exposure in the local water supply. Twenty different borehole water samples were assessed for Zn, Pb, Hg, Mn, Cr and Cd levels (mg/l). The results revealed that only few boreholes water samples had concentration levels of heavy metals that are not within WHO recommended levels. While chromium and cadmium levels are below detection limits .The findings contribute to the understanding of water quality in the region, offering valuable information for public health interventions and water management strategies.

INTRODUCTION

Groundwater pollution (also referred to as groundwater contamination) happens when impurities are emitted on to the ground and percolate to the groundwater, this may also happen in nature, according to Momodu and Anyakora (2010), and when the pollutant is small, undesirable element, or impurity in the groundwater, is alluded to as a contamination rather than pollution (Momodu and Anyakora 2010).

Several trace metals are constituents of certain rock formations and make their way into the environment by weathering of the rocks. Industrial activities like mining, metallurgy, disposal of solid waste, paint and enamel works contribute to increased levels of poisonous metals like lead, cadmium, and chromium. These impurities possess the ability to reach groundwater (Iqbal and Gupta, 2009). The movement of metals and their metalloids into groundwater is dependent on several factors, for instance, chemical reactions that determine the separation of impurities into various phases and species. Therefore, the movement of these metals are dependent on the pH and redox state of groundwater (Kallis, 2006).

LITERATURE REVIEW

Water is one of the essentials that supports all forms of plant and animal life (Vanloon and Duffy, 2005) and it is generally obtained from two principal natural sources; Surface water such as fresh water lakes, rivers, streams, etc. and Ground water such as borehole water and well water (Mendie, 2005). Water has unique chemical properties due to its polarity and hydrogen bonds which means it is able to dissolve, absorb, adsorb or suspend many different compounds (WHO, 2007), thus, in nature, water is not pure as it acquires contaminants from its surrounding and those arising from humans and animals as well as other biological activities (Mendie, 2005). One of the most important environmental issues today is ground water contamination (Vodela et al., 1997) and between the wide diversity of contaminants affecting water resources, heavy metals receive particular concern considering their strong toxicity even at low concentrations (Marcovecchio et al., 2007).

Groundwater pollution is grouped based on three factors which include: municipal, industrial and agricultural sources Other sources of groundwater pollution could be categorized as oint and non-point origin. Point sources are particular identifiable sources for instance pipe discharges while non-point sources are diffuse and no specific source can be identified for instance runoff. The concern of heavy metals and metalloid pollution in the surrounding is a growing concern globally. This is due to their persistence in the environment. The metal ions bio accumulate in biota and are removed byexcretion into the environment, leading to their toxic nature among other abundant sources, (Mason *et al*, 1999) and as such, there is need to assess the concentrations of heavy metal regularly. As indicated by Oves *et al*, 2016, heavy metals occur in our environment as particulates, dissolved and colloidal phases.

Sawere and Ojeba (2016) described heavymetals as a metalelementthatha sarelatively high density and are hazardous at little concentrations. However, Gautam *et al* (2014) were more specific and described heavy metals as "Groups or metals or metalloids with an atomic density larger than 4 g/cm3 or are 5 times denser than water". Idoko (2010) emphasized that the "Density of heavy metal is of minimal concern but the emphasis should be placed on their chemical properties instead" (Momodu *et al*, 2010).

Mercury, lead, cadmium, and arsenic have been known to cause detrime ntal healthproblems Idoko (2010). These metals naturally occur in the surrounding but are also released into the environment due to anthropogenic activities that largely contribute to their existence in the environment. Some of the anthropogenic activities that could lead to their release into the environment include mining, industrial waste disposal, transport sector, agricultural activities, and the domestic effluent disposal systems.

HEAVY METAL POLLUTION

Motivations for controlling heavy metal concentrations in gas streams are diverse. Some of them are dangerous to health or to the environment (e.g. Hg, Cd, Pb, Cr) , some may cause corrosion (e.g. Zn, Pb), some are harmful in other ways(e.g. As may pollute catalysts). Within the European community the 13 elements of highest concern are As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Tn, Th, the emissions of which are regulated in waste incinerators. Some of these elements are actually necessary for humans in minute amounts (Co, Cu, Cr, Mn, Ni) while others are carcinogenic or toxic, affecting, among other, the central nervous system(Mn, Hg, Pb, As) (Adepoju-Bello *et al.*, 2009).

Heavy metals can cause serious health effects with varied symptoms depending on the nature and quantity of the metal ingested (Lapworth et al., 2017). They roduce their toxicity by forming complexes with proteins, in which carboxylicacidCOOH), amine (NH2), and thiol (SH) groups are involved. The se modified biological molecules lose their ability to function properly and result in the malfunction or death of the cells. When metals bind to these groups, they inactivate important enzyme systems or affect protein structure, which is linked to the catalytic properties of enzymes. This type of toxin may also cause the formation of radicals which are dangerous chemicals that cause the oxidation of biological molecules.

There is thus the need to assess the quality of ground water sources. TheorldHealthOrganisation has specified Maximum Contaminant Level for th e presence of heavy metals in water. The aim of this research is to assess the quality of ground water in selected boreholes within Zuru metropoly.

Materials And Methods

Sample Collection And Location:

The borehole water samples for the study were collected from different localities in Zuru Metropoly. About 20 samples of borehole water were used for the study. Four (4) samples from each kindred and the containers were coded as follows: Zango Area as village A, has sub-samples (A1, A2, A3 and A4), Zuru Centre as B with sub-samples (B1, B2, B3 and B4), Roadblock Area as C with (C1, C2, C3 and C4), then Tudun wada Areaas D with the sub-samples (D1, D2, D3 and D4). Finally Jarkasa Area as E with sub-samples (E1, E2, E3 and E4). During this collection, the tap was opened and allowed to runoff for few minutes before
collection so as to obtain a uniform flow rate (Ambrose**,** *et al.*, 1989). The sample s were collected during the month of July 2022.

Acid Digestion For The Analysis Of Heavy Metals

To each 100 ml triplicate water sample in a pre-cleaned 250 ml beaker, 25 ml of 10 % hydrochloric (2.5 ml concentrated hydrochloric acid + 22.5 ml distilled deionized water) was added to the beaker and heated on a hot plate. The solution was boiled until 10 -15 ml was left. 10 ml of perchloric acid was added and the solution was heated until perchloric fumes evolved. The remaining sample was put in a 100 ml volumetric flask and topped to the mark. The solution was then shook well, transferred into a clean sampling bottle and awaited analysis by Flame Atomic Absorption Spectroscopy. The samples were prepared in triplicates from every site.

Preparation of heavy metal standard stock solutions

The following standard stock solutions were prepared in readiness for the heavy metal analysis.

Zinc (Zn) stock solution

A thousand (1000) mgl-1 of zinc ion standard stock solution was prepared by heating 1.0g of zinc II Chloride (ZnCl2) (99.9%) and dissolving it in 30 ml (1:1 v/v) of water: nitric acid solution then transferring the solution to 1000 ml volumetric flask and diluting to the mark.

Cadmium (Cd) stock solution

A thousand (1000) mgl-1of Cd ion standard stock solution was prepared by heating 1.0 g of cadmium Oxide (CdO) (99.9%) and dissolving it in 30ml (1:1 v/v) of water: nitric acid solution cooled then transferring the solution to 1000 ml volumetric flask and diluting to the mark.

Chromium (Cr) stock solution

A thousand (1000) mgl-1 of Cr ion standard stock solution was prepared by heating 1.0g of chromium trioxide (CrO_3) (99.9%) and dissolving it in 20ml of aqua regia and then cooled and then diluted to 1 litre.

Lead (Pb) stock solution

A thousand (1000) mgl-1 of lead (Pb) ion standard stock solution was prepared by heating 1.0g of lead nitrate $Pb(NO_3)_2$ (99.9%) and dissolving it in 30ml (1:1 v/v) of water:nitric acid solution then transferring the solution to 1000 ml volumetric flask and diluting to the mark.

Mercury (Hg) stock solution

A thousand (1000) mgl-1 of mercury (Hg) standard stock solution was prepared by dissolving 1.354g of analytical grade salt of mercuric chloride ($HgCl_2$) (99.9%) in distilled deionized water and diluting to the mark,

Manganese (Mn) stock solution

A thousand (1000) mgl-1 of Mn ion standard stock solution was prepared by heating 1.0g of manganese sulphate (Mn_2SO_4) (99.9%) and dissolved in 20ml of aqua regia and diluted to 1 litre.

Quality Assurance

Quality assurance was ascertained by analysis of blank solutions. Quality control was carried out as recommended by USEPA method, (2002); analysis of laboratory reagent and fortified blanks, as well as samples as an ongoing measurement of performance. Rinsed blanks and calibration of six standard solutions of all monitored analytes were prepared at parts per million (ppm) or parts per billion (ppb) concentration ranges for the various analytes.

Analysis of the heavy metals with Atomic Absorption Spectrometry (AAS)

Samples were analyzed by direct absorption, except for mercury which was done by cold vapor generation in a special accessory. The samples were analyzed in triplicates to minimize errors. The Flame Atomic Absorption Spectroscopy (FAAS) was warmed up and the recommended wavelengths and flame/gas types set for the various heavy metals as shown in Table 1.

Table 1 Atomic Absorption Spectrometry wavelengths and flame gas used forheavy metals analysis

Element	Wavelength (nm)	Flame/ gases
Zinc	213.9	air/acetylene
Cadmium	228.8	air/acetylene
Chromium	357.9	air/acetylene
Lead	217.0/ 283.3	air/acetylene
Mercury	253.7	Cold vapour generation
Manganese	279.5	air/acetylene

Heavy metals analysis

The heavy metals: zinc (Zn), cadmium (Cd), chromium (Cr), lead (Pb); mercury (Hg) and manganese (Mn); were determined by Perkin Elmer 2380 Flame Atomic Absorption Spectrophotometer. APHA method, (1992) was followed during preparation of samples to be analyzed. The operating manual was used to give guidance setting up and optimization of the instrument and air- acetylene mixture was used as source of flame. However, for the determination of Hg, hydride generation method was used. The wavelengths for the determination of each metal were as indicated in Table 1. Every analysis was done in triplicate and the average of the three readings was recorded, to calculate the standard deviation for each element analyzed.

RESULTS

Table 2. Observed values of level of heavy metals from twenty boreholes water samples and WHO recommended level of drinking water.

Location	**Heavy metal level (mgl^{-1})**					
	Zn	**Pb**	**Hg**	**Mn**	**Cd**	**Cr**
A_1 Zango	0.70	0.03	0.004	0.07	BDL	BDL
A_2	0.8	0.	0.002	0.02	BDL	BDL

	8	03				
A_3	0.70	0.02	0.003	0.09	BDL	BDL
A_4	0.75	0.01	0.001	0.02	BDL	BDL
B_1 Zuru Centre	0.16	0.02	0.002	0.08	BDL	BDL
B_2	0.18	0.02	0.003	0.03	BDL	BDL
B_3	0.23	0.02	0.001	0.03	BDL	BDL
B_4	0.18	0.02	0.001	0.09	BDL	BDL
C_1 Road Block	0.50	0.04	0.002	0.04	BDL	BDL
C_2	0.54	0.02	0.003	0.18	BDL	BDL
C_3	0.20	0.01	0.001	0.17	BDL	BDL
C_4	0.17	0.04	0.002	0.03	BDL	BDL
D_1T/ Wada E_1	BDL	0.01	0.003	0.04	BDL	BDL

D_2	BDL	0.01	0.002	0.18	BDL	BDL
D_3	BDL	0.02	0.001	0.14	BDL	BDL
D_4	BDL	0.02	0.002	0.09	BDL	BDL
E_1Jar kasa	BDL	0.02	0.00.3	0.05	BDL	BDL
E_2	0.17	0.02	0.004	0.06	BDL	BDL
E_3	0.23	0.03	0.002	0.08	BDL	BDL
E_4	0.34	0.02	0.003	0.17	BDL	BDL

WHO Reccomended Values Of Drinking Water

Zn	Pb	Hg	Mn	Cd	Cr
3.0	**0.01**	**0.006**	**0.01**	**0.003**	**0.05**

DISCUSSION

The study shows that zinc was not detected in all four boreholes under study in Area D, and one borehole in Area E. The ranges for other heavy metals are as follows: Pb 0.01 (lowest) to 0.04 (highest), Hg 0.001 (lowest) to 0.004 (highest), Mn 0.02 (lowest) to 0.18 (highest), while cadmium and chromium were all not detected. The lowest values of Zinc were obtained in B1, B2, B4, and C4 AND E2. These areas are less densely populated compared to other fifteen sample areas, they are mostly institutional areas.

Elevated zinc concentration in site A2, A3 and A4 could be attributed to the population and landscape of the area, the area is on slope as such surface run offs down the slope could contribute to the elevated concentration. According to (WHO 2000, 2007 and 2008) zinc poisoning causes fever, vomiting, stomach cramps and diarrhea.

The Pb concentration in the water sample is low in areas such as A4, C3, D1, and D2. The cconcentration of lead in these sample boreholes are all within WHO acceptable limits. The high concentration of lead in other area````s could be attributed to human activities sucha as vulcanizing and waste water discharge in areas such as C4 and E3. High concentration of lead in drinking water can cause hypertension, brain damage, fatigue, anaemia and even death (Lapworth 2017).

The mercury concentration in all the samples are within the standard level of WHO 0.006mg/l. Mercury has been found to be carcinogenic and poisonous and in some cases causes impared growth in babies (Kalis, 2006).

The manganese levels recorded in the study has shown that areas such as A2, A4 And C4 has low concentration level of Mn. Whereas the highest values recorded are in C2, C3, D2 and E4. The values are generally higher than the recommended level 0.01mg/l set by WHO. Most of the areas with high level of Manganese are rocky, manganese in rocks and sand can elevate the manganese concentration in these areas. Other contributing factors may include waste disposal at these sites. Manganese poisoning can cause hallucinations, forgetfulness, nerve damage, bronchitis and Parkinson disease (Iqbal, 2009).

Cadmiun and Chromium concentration were below the detection level of 0.001mg/l and 0.005 mg/l respectively. Cadmium poisoning causes kidney damage, bronchitis, and anemia, while chromium has been found to cause nephritis, as well as irritaation of gastro intestinal lining(Iqbal, 2009)

CONCLUSION

The concentration levels of the heavy metals under study are mostly elevated by population density and human activities in most areas. However the majority of the sample boreholes have the concentration of these metals within standard set by WHO. Whereas cadmium and chromium concentration levels are at the level below detection.

REFFERENCES

Adepoju-Bello, A.A., Ojomolade, O.O. Ayoola, G.A. and Coker, H.A.B. (2009). Quantitative analysis of some toxic metals in domestic water obtained from Lagos metropolis. The Nig. J. Pharm. 42(1): 57-60.

Gautam K. R., Sharma K. Sanjay, Mahiya S, and Chattopadhyaya (2014): Contamination of Heavy metals in aquatic media-Metals in Aquatic Media:Transport, Toxicity and Technologies for Remediation.

Iqbal M. A. and Gupta S. G. (2009): Studies on Heavy Metal Ion Pollution of Ground

Water Sources as an Effect of Municipal Solid Waste Dumping, *African Journal of Basic & Applied Sciences*, **1:** 117-122.

Idoko, O.M.(2010): Seasonal variation in iron in rural groundwater of Benue State, middle belt

Nigeria. *Pakistan Journal of Nutrition*, **9**:9 892-895.

Kalis E. J. J. (2006): Chemical speciation and bioavailability of heavy metals in soil and surface waters. Doctoral thesis, Wageningen University. The Netherlands. p.6.

Lapworth, D.J., Nkhuwa, D.C.W., Okotto-Okotto, J., Pedley S., Stuart M.E., Tijani M.N, and Wright J.(2017): Urban groundwater quality in sub-Saharan Africa: current status and implications

For water security and public health. *Hydrogeol Journal*,**25**:1093 1116. https://doi.org/10.1007/s10040-016-1516-6

Marcovecchio, J.E., Botte S.E. and Freije, R.H. (2007). Heavy Metals, Major Metals, Trace Elements. Handbook of Water Analysis. L.M. Nollet, (Ed.). 2nd Edn. London: CRC Press, pp: 275-311

Mason Y, Amman A, Ulrich A,and Sigg L. (1999): Behavior of heavy metals nutrients and major components during roof runoff infiltration. *Environ*

Sci Technol **33:**1588 –1597.

Momodu M.A and. Anyakora C.A (2010) **Heavy Metal Contamination of Ground Water: The Surulere Case Study** Research Journal Environmental and Earth Sciences 2(1): 39-43, 2010 ISSN: 2041-0492

Mendie, U. (2005) The Nature of Water In: The Theory and Practice of Clean Water Production for Domestic and Industrial Use. Lagos: Lacto-Medals Publishers pp: 1-21

Oves M., Saghir K. M., Huda Q. A., Nadeen F. M, and Almeelbi T.(2016):

Heavy Metals: Biological Importance and Detoxification Strategies. Jeddah: King

Abdulaziz University. *Journal of Bioremediation & Biodegradation*, **7:2** 1-15.

Sawere B. T.,and Ojeba C.K., (2016): Assessment of Heavy Metal Concentrations in Borehole-Hole Water in Ozoro Town, Delta State, *International Research Journal of Advanced Engineering and Science*, **1**:3 61-65.

Vanloon, G.W. and Duffy, S.J. (2005) The Hydrosphere In: Environmental Chemistry: A Global Perspective. 2^{nd} Edn. NewYork: Oxford University Press, pp: 197-211

Vodela, J.K., Renden, J.A., Lenz S.D., Mchel W.H. Henney and Kemppainen, B. W. (1997). Drinking water contaminants. Poult. Sci., 76: 1474-1492

WHO (2000). Hazardous Chemicals in Human and Environmental Health: A Resource Book for School College and University Students. World Health Organisation, Geneva.

WHO (2007). Water for Pharmaceutical Use In Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials. 2nd Updated Edn. World Health Organisation, Geneva, 2: 170-187

WHO (2008). World Health Organization. Guidelines for drinking-water quality. Geneva, 1(3)306-492.