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

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ABSTRACT

This paper assesses certain heavy metal concentrations 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

According to Momodu and Anyakora (2010), contaminants can also occur naturally and cause groundwater pollution, also known as contamination. When a When an unwanted substance or impurity is discovered in groundwater, it is referred to as contamination rather than pollution because the pollutant is small (Momodu and Anyakora 2010).

A number of Certain rock formations contain trace metals, which are released into the environment when the rocks weather. Hazardous metal concentrations, including those of lead, cadmium, and chromium, are raised as a result of industrial processes such as mining, metallurgy, paint and enamel manufacturing, and solid waste disposal. These contaminants are able to get into groundwater (Iqbal and Gupta, 2009). One of the chemical processes that determines how contaminants are separated into various phases and species factors that determine the movement of metals and their metalloids into groundwater. As a result, the pH and redox condition of groundwater affect how these metals migrate (Kallis, 2006).

LITERATURE REVIEW

All forms of plant and animal life depend on water (Vanloon and Duffy, 2005). There are two main natural sources of water: surface water, which includes freshwater lakes, rivers, streams, etc., and ground water, which includes well and borehole water (Mendie, 2005). Water's polarity and hydrogen bonding give it special chemical properties that allow it to dissolve, absorb, adsorb, or suspend a wide range of compounds (WHO, 2007). As a result, water in nature is not pure because it picks up contaminants from its surroundings as well as those that come from people, animals, and other biological activity (Mendie, 2005). Contamination of ground water One of the most important environmental issues is the separation of pollutants into different phases, which is determined by chemical reactions. of our time (Vodela et al., 1997). Of the many different types of pollutants that affect water resources, heavy metals are of particular concern because of their strong toxicity, even at low concentrations (Marcovecchio et al., 2007).

Three categories are used to categorize groundwater pollution: agricultural, industrial, and municipal sources. It is possible to classify additional groundwater pollution sources as non-point and oint. Point sources, such as pipe discharges, are specific, identifiable sources, whereas non-point sources, such as runoff, are diffuse and cannot be specifically identified. The world is becoming increasingly concerned about the pollution caused by heavy metals and metalloids in the environment. Their tenacity in the environment is the reason for this. As a result of the the buildup of metal ions in the biota and their release into the surroundings, which makes them hazardous among other abundant sources (Mason et al., 1999), it is necessary to routinely monitor the concentrations of heavy metals. Heavy metals can be found in the form of particles, dissolved phases, or colloidal phases, as stated by Oves et al. (2016).

Sawere and Ojeba (2016) characterized As a metal element with a comparatively high density, heavy metals that can be dangerous in small amounts. Heavy metals are defined according to "Groups of metals or metalloids with an atomic density larger than 4 g/cm3 or are 5 times denser than water" according to Gautam et al. (2014), who were more precise. According to Idoko (2010), " Instead, focus should be on their chemical characteristics. of their density, which is of minimal concern" (Momodu et al, 2010).

It is known that exposure to mercury, lead, cadmium, and arsenic can result in harmful health issues. (2010) Idoko. These metals are present in the environment naturally, but they are also released into it as a result of human activity, which plays a major role in their persistence. A few examples of human-caused activities that may result in their discharge into the environment are mining, the removal of industrial waste, the transportation industry, farming, and home wastewater disposal systems.

Heavy Metal Pollution

There are various reasons to regulate the levels of heavy metals in gas streams. Some of them, like Hg, Cd, Pb, and Cr, are hazardous to human health or the environment; others, like Zn and Pb, may cause corrosion; still others, like As may pollute catalysts, are harmful in other ways. The 13 elements that the European community is most concerned about are As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Tn, and Th. The emissions of these elements are controlled in waste incinerators. While certain elements—like Co, Cu, Cr, Mn, and Ni—are genuinely required in trace amounts for human health, others—like Mn, Hg, Pb, and As—are poisonous or carcinogenic and can harm the central nervous system among other organs. (Adepoju-Bello et al., 2009).

Depending on the type and concentration of the metal consumed, heavy metals can have a serious negative impact on health and cause a variety of symptoms. (Lapworth et al., 2017). They produce their toxicity by forming complexes with proteins, in which carboxylic acid (–COOH), amine (NH2), and thiol (SH) groups are involved. These 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 must evaluate the sources of ground water's quality. The Maximum Contaminant Level set by the World Health Organization for the 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.

METHODOLOGY

Sample Collection and Location

The borehole water Samples were gathered for the study from various locations within the Zuru Metropoly. For the study, about twenty borehole water samples were used. Each kindred had four (4) samples, 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 a few minutes prior to collection in order to achieve a consistent flow rate. (Ambrose, et al., 1989). The samples were collected during the month of July 2022.

Acid Digestion for The Analysis of Heavy Metals

25 ml of 10% hydrochloric acid In a 250 ml beaker that had been previously cleaned, (2.5 ml concentrated hydrochloric acid + 22.5 ml distilled deionized water) was added to each 100 ml triplicate water sample. The beaker was then heated on a hot plate. After boiling the solution, 10 to 15 milliliters were left. After adding 10 milliliters of perchloric acid, the mixture was heated to a point where perchloric fumes emerged. The remaining specimen was filled to the brim with a 100 ml volumetric flask. After giving the solution a good shake, it was put in a sanitized sampling bottle and left to be analyzed using flame atomic absorption spectroscopy. Three duplicates of each sample were prepared from each site.

Heavy Metal Standard Stock Solutions Preparation

The following standard stock solutions were prepared before the heavy metal analysis.

Zinc (Zn) Stock Solution

After heating 1.0g of zinc II chloride (ZnCl2) (99.9%) and putting it into a 30 ml water:nitric acid solution (1:1 v/v) solution, the solution was transferred to a 1000 milliliter volumetric flask and diluted to the proper concentration to produce a zinc ion standard stock solution of one thousand (1000 mgl-1).

Cadmium (Cd) Stock Solution

One kilogram (one thousand) mgl-1 of cadmium oxide (CdO) (99.9%) was prepared by heating 1.0 g of CdO and dissolving it in 30 milliliters (1:1 v/v) of water. created. Following cooling, the mixture was moved to a 1000 ml volumetric flask and diluted to the appropriate amount.

Chromium (Cr) Stock Solution

A thousand (1000) mgl-1 of Cr ion standard stock solution was made by heating 1.0g of chromium trioxide (CrO3) (99.9%), dissolving it in 20ml of aqua regia, cooling, and then diluting to one litre.

Lead (Pb) stock solution

Lead A 1:1 v/v solution of water and citric acid was used to dissolve 1.0g of lead nitrate Pb(NO3)2 (99.9%) in order to create the ion standard stock solution (1000 mgl-1). Once in a 1000 ml volumetric flask, the solution was diluted to the appropriate level.

Mercury (Hg) Stock Solution

Mercury (Hg) standard stock solution (1,000 mgl-1) was made by combining distilled deionized water with 1.354g of 99.9% analytical grade salt of mercuric chloride (HgCl2), and then diluting to the appropriate level.

Manganese (Mn) Stock Solution

After After 1.0g of 99.9% manganese sulphate (Mn2SO4) was heated and dissolved in 20ml of aqua regia, 1000 mgl-1 of Mn ion standard stock solution was produced diluted to 1 litre.

Quality Assurance

Analyzing blank solutions allowed for the determination of quality assurance. As advised by the USEPA method (2002), quality control was performed by analyzing laboratory reagents, fortified blanks, samples, and continuously measuring performance. Six standard solutions were prepared at concentration ranges of parts per million (ppm) or along with rinsed blanks.

The Use of Atomic Absorption Spectrometry (AAS) for Heavy Metal Analysis

All samples underwent direct absorption analysis. with the exception of mercury, which was examined using a specialized accessory that generated cold vapor. To reduce errors, the samples were analyzed three times. Warming up Atomic Absorption Spectroscopy (FAAS) in flame setting the flame/gas type and recommended wavelengths for each heavy metal as indicated in Table 1 was done. Below

Table 1. Absorption of Atoms Flame Gas and Spectrometry Wavelengths are Utilized in the Analysis of Heavy Metals

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 The Perkin Elmer 2380 Flame Atomic Absorption Spectrophotometer was used to measure the following heavy metals: manganese (Mn), mercury (Hg), Manganese (Cd), lead (Pb), zinc (Zn), cadmium (Cd), and chromium (Cr). The 1992 APHA method was adhered to when preparing the samples for analysis. The air-acetylene mixture was utilized as the flame source, and the instrument's setup and optimization were guided by the operating manual. On the other hand, the hydride generation method was employed to determine Hg. Table 1 shows the wavelengths that were used to determine each metal. To determine the standard deviation for each element analyzed, each Three readings were taken during the analysis process, and the average of them was noted.

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	0.88	0.03	0.002	0.02	BDL	BDL
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 RoadBlock	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_1Jarkasa	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

Table 3. 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 following are the ranges for additional heavy metals: Pb 0.01, the minimum 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 runoffs that descend the incline may contribute to the increased focus. 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 areas could be attributed to human activities sucha as vulcanizing and waste water discharge in areas such as C4 and E3. High levels of lead in drinking water can harm the brain, raise blood pressure, and fatigue, anaemia and even death (Lapworth 2017).

The mercury concentration in all the samples are within the standard level of WHO 0.006mg/l. It has been discovered that mercury is toxic and carcinogenic. 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).

CONCLUSIONS

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)

FURTHER STUDY

This research still has limitations so further research on the topic still needs to be done “Assessment of Levels of Selected Heavy Metals in Borehole Water in Zuru Metropolis, Kebbi State Nigeria.”

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