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Selected Heavy Metals Levels (Cu, Cr, Cd, Pb, Fe) in Gwadabawa Lake, Sokoto State, Nigeria

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Abstract

The main aim of this work was to determine the concentrations of some heavy metals, specifically Cu, Cd, Pb, Cr and Fe in Gwadabawa lake, Gwadabawa Local Government, Sokoto State using standard methods (atomic absorption spectroscopy) and materials of analytical grade. The results were analyzed. The range of Fe concentration was 0.01 ± 0.001 to 1.37 ± 0.3(ppm), and range of Cu concentration determined was 0.00 to 0.02±0.008(ppm). The range of Cr was 0.02± 0.007 to 6.00± 0.32(ppm), the range of Cd was 0.03±0.10 to 1.68±0.3, and the range of Pb was 0.01± 0.001 to 0.02± 0.04(ppm). Cu CDI calculated in adults and children shows values higher than 1 in water collected from point B, and point A. This implies that consumption at these concentrations is likely to pose risk to adults and children. Likewise, only water in point A and B shows Pb value of more than 1, therewith, possibility of instigating risk due to consumption in children is likely. One point shows a HI of more than 1 (5.7/3805). Likewise, the water at point A and B shows HI at more than 1 (1.1/03451 and 6.96280084 respectively). Effective measures should be put in place to avoid lake water pollution to safeguard users.

Keywords: Lead, heavy metals, water, lake, environmental pollution

INTRODUCTION

Every element that exists on Earth is categorized as a metal, non-metal, or metalloid. Non-metals are not ductile, malleable, or good electrical conductors. In the interim condition between metals and non-metals, metalloids are found [1,2]. The characteristics of the metals, however, disagreed with those of the non-metals. Elements classified as metals have unique characteristics such strong light reflection, malleability, ductility, opaqueness, brilliance, and high rate of heat and electricity conductivity [3, 4]. Metals are among the most prevalent elements on Earth because they make up about 2, 3 of the already recognized elements. Fe, Na, K, Ca, Mg, and their connections in particular [4, 5, 6]. Certain metals are categorized into distinct classes according to certain standards that consider specific differentiating characteristics. When metals are advantageous to nutrition, as they are in the cases of Cu, Mg, Ca, Na, K, and similar elements, they can be considered necessary. In order for the body to correctly carry out biological metabolic activities, these metals must typically be consumed through diet at specific optimal levels [7, 8]. As a result, even a slight deviation in the concentration of these individual or combination of metals could have detrimental effects on the biological system, depending on consumption levels [9]. Similarly, certain classes of metals are designated as heavy metals in technical terms. Similarly, certain classes of metals are designated as heavy metals in technical terms. A class of metals or metalloids known as heavy metals have relatively large densities (over 5g/cm^3) as well as other harmful characteristics include the capacity to bioaccumulate, be highly toxic, and cause toxicity at extremely low concentrations [10].

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Additionally, there are two categories for heavy metals: necessary and non-essential. Elements such as copper and specific forms of chromium take on biological roles that the human body needs. Nevertheless, several metallic elements are thought of as non-essential heavy metals as their exact biological role in humans is unknown. This group includes elements including Cd, Pb, and certain types of chromium metal [11-14]. Undoubtedly, the Earth's crust contains naturally occurring heavy metals and other metallic forms. However, the world's anthropogenic activities—such as careless waste disposal, the use of agrochemicals, crude oil spills, inappropriate effluent disposal, livestock production, fishing, aquatic transportation, aquatic farming, mining, and so forth—have revealed an adequate amount of excess heavy metals into biological systems [8]. As a result of pollution, these metals end up in the food chain and water supply, where they are eventually consumed by humans and other living things [2,10]. Because heavy metals play such a large role in the lives of local communities, it is crucial to continuously monitor their levels in environmental components like freshwater lakes. Elevated concentrations of heavy metals in water may have negative impacts on aquatic life, including plants and animals, which are vital parts of the biosphere. Furthermore, plants and animals that are consumed by people or other animals may absorb the high concentrations of metals in the lake. Similarly, drinking water contaminated with heavy metals may have negative effects on people or other animals [1, 15, 16]. There are concerns in Nigeria regarding the growing amount of environmental contamination or pollution, which is brought on by a wide range of activities such as household, industrial, agricultural, medical, and technological use, which eventually results in food poisoning in both humans and animals [15]. In addition, pollution affects all living things, such as drinking water, meadows, plants, and fodder [10]. Proteins, phospholipids, DNA, enzymes, hormones, and other biomolecules are among the biomolecules that heavy metals are good at forming complexes with. Consequently, the complex modifies the biochemistry, transport, and host signaling of biomolecules, so changing their nature. The impacted body components may alter, become incapable of performing certain tasks, or become less active [9,17]. For example, it has been observed that Pb, Cr, and Cd are carcinogens that affect the neurological system, liver, and kidney [17, 18]. Pb harms the neurological system, causes aberrant bone development, interferes with pregnancy, affects hemoglobin synthesis, impairs GTT, and so on [14]. At low concentrations, cadmium is hazardous. Renal failure, lung illness, bone deformity, hypertension, reproductive abnormalities, and other pulmonary consequences can result from it [14]. In addition to being poisonous, hexavalent chromium causes cancer [14]. Liver damage, nausea, vomiting, diarrhea, cramps, and abdominal pain can all result from an excess of copper [3, 5]. As a result, it is critical to keep an eye on the concentrations of heavy metals in the water in our surroundings. According to an investigation of a well water sample from Kebbi state, there may not be any risks associated with the state's content of Pb, Zn, Fe, and Cr. Nonetheless, the amount of Cd in the water is dangerous [16]. [19] evaluated the Kware Lake water's characteristics and discovered that while Fe was in excess, Pb and Zn were below the WHO-recommended level [21]. [22] discovered that Na, K, Ca, and Mg were within the limits in their water investigation conducted in Sokoto. As a result, heavy metals weren't looked at. According to research, Pb, Cr, and Cd levels in well water taken from Almajiri schools in Sokoto East—the location of Gwadabawa—are higher than WHO guidelines [20]. investigated the presence of heavy metals in well water from a chosen secondary school in Sokoto East and found that K, Ca, Mg, Zn, Cu, and Fe are present. As a result, nothing is known about the presence of heavy metals in the water of Gwadabawa Lake, a vital resource for both home and agricultural use. Given that Gwadabawa Lake's fresh water is used for both household and agricultural uses and must be of a high caliber to protect the public's health, the study of heavy metals in this water is crucial. The public will be made aware of the potential risks associated with drinking the local water and disposing of waste there thanks to the information gathered throughout this project. Similarly, the baseline data will be briefed to policy makers so they may promptly take action to maintain water quality and reduce pollution. Scholars and students would discover baseline data for additional research on the Gwadabawa Lake. This work's primary goal is to measure the levels of Cu, Cd, Cr, Pb, and Fe in the water of Gwadabawa Lake and estimate the risk of non-carcinogenic health effects from heavy metal poisoning.

Yahaya et al (2023) found that heavy metals are posing health risk in the surrounding areas of a cement company in Sokoto, Nigeria. The metals determined include lead, zinc, copper, and cadmium as a result of the industrial pollution around [27].

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MATERIALS AND METHODS

Materials

The study was conducted in Gwadabawa Local Government Area of Sokoto State, Nigeria. Gwadabawa shares border with Kware, Illela, Tangaza, Gada, and Wurno Local Government Areas with a total land area of about 991 km^2 and a total population of 231,358 based on 2006 census report. Moreover, Gwadabawa town lies on 13.36° N latitude, 5.24° East Longitude and 256 meters above sea level [23].

Sample Collection and Preparation

One-liter sterile containers containing sodium thiosulphate (5mg/liter) were used to collect lake water samples from different points of the Gwadabawa lake. Every water sample was wrapped appropriately, labeled with care, and delivered to the lab in an ice-packed cooler for additional examination. First, water samples were acidified in preparation for elemental analysis. Next, 2 milliliters of perchloric acid (70% of $HClO_4$) and 5 milliliters of sulfuric acid were added. Heat the mixture until it becomes completely dry. After filtering the water with filter paper, 15 milliliters was added to the volumetric flask. After being cleaned with water, filter paper was diluted with deionized water. The AAS machine received the prepared for analysis [4].

AAS analysis

An Atomic Absorption Spectrophotometer (AAS) from Perkins-Elmer 500 was used to assess the final processed samples. First, the instrument was calibrated using MerCk's stock solution. The cathode lamp for the metal to be studied was put in the apparatus, and the desired wavelength was set. The lamp current was adjusted, then left to warm up. Burner was then installed. Thus, the machine inhaled standard and sample solutions, turning them into gas. Subsequently, the device displays the metal's real concentration [4]. Chemical elements in samples can be quantitatively determined using the AAS, a spectro-analytical technique, down to parts per million (ppm). determines the elements' concentrations in a liquid sample quantitatively. An Atomic Absorption Spectrophotometer (AAS) from Perkins-Elmer 500 was used to assess the final processed samples. First, the instrument was calibrated using MerCk's stock solution. The cathode lamp for the metal to be studied was put in the apparatus, and the desired wavelength was set. The lamp current was adjusted, then left to warm up. Burner was then installed. Thus, the machine inhaled standard and sample solutions, turning them into gas. Subsequently, the device displays the metal's real concentration [4]. Chemical elements in samples can be quantitatively determined using the AAS, a spectro-analytical technique, down to parts per million (ppm). determines the elements' concentrations in a liquid sample quantitatively [4].

Estimation of Human Health Risk Assessment

Human Health risk was calculated using three different equations shown in this section. $CDI=CP \times IR \times EF \times ED/Bw \times AT$ (mg/kg/day)

Where, CDI= Chronic Daily Intake, CP= concentration of metal in water, IR=Ingestion Rate=1, EF= Frequency of Exposure=90 days, ED=Exposure Duration=30 days, Bw=weight=60 kg, AT= 2700 days.

Hazard Quotient= CDI/RfD

Where, RfD= Chronic Oral Reference Dose, lead=3.5, chromium=3.0, cadmium=5.0. [8,18].

Hazard Index (HI)= Summation of hazard quotient of Pb, Cd, and Cr= $HQ_{cd} + HQ_{Cr} + HQ_{Pb}$

EDI= C×QMC/bw

EDI= Estimated daily intake, C= concentration of metal, QMC= quantity of water taken by a given person, quantity of water taken every day approximately from was 1 liter with the belief that there are other water sources that the people used besides the lake water, bw= weight, for children is 30kg and 60kg for adult.

Statistical analysis

Standard deviation (SD) ± mean was used to express the data. To compare data between different groups, one-way analysis of variance (ANOVA) with posthoc analyses was employed. P less than 0.05 was regarded as statistically significant. The Statistical Package for Social Sciences Software (version 22, Chicago, Il) application was used to do statistical analysis.

RESULTS

Results of concentration of Cu and Fe essential heavy metals in Gwadabawa Lake

Concentration of Cu and Fe essential heavy metals in Gwadabawa Lake are shown in Tables 1-2.

Table 1. Concentration of Fe and Cu detected in water collected from Gwadabawa lake

Different points where the Water Samples were collected	Cu (ppm)	Fe (ppm)
Point A	0.00	1.25±0.7
Point B	0.01±0.001	1.37±0.3
Point C	0.01±0.001	0.11±0.005
Point D	0.02±0.008	0.01±0.001

Table 2. Showing the concentrating Cr, Cd, and Pb heavy metals determined in water collected from Gwadabawa Lake.

Different points where the Water Samples were collected	Cr (ppm)	Cd (ppm)	Pb (ppm)
Point A	6.00±0.32	0.03±0010	0.01±0.001
Point B	0.03±0.001	0.03±0.001	0.01±0.001
Point C	0.03±0.001	1.68±0.3	0.02±0.001
Point D	0.02±0.007	1.59±0.5	0.02±0.04

Showing estimated health risk due to consumption of heavy metals in water of Gwadabawa Lake

Showing estimated health risk due to consumption of heavy metals in water of Gwadabawa Lake in Tables 3-7.

Table 3. Showing results of the estimated chronic intake to consumption of Fe and Cu heavy metals in water of Gwadabawa Lake.

	CDF for Adult (mg/kg/dm)		CDI for Children (mg/kg/dm)	
	Fe	***Cu***	***Fe***	***Cu***
A	0.00	0.020833	0.00	0.041666
B	0.001666	0.022853	0.000333	0.045666
C	0.001666	0.001833	0.000333	0.003666
D	0.000333	0.001666	0.006666	0.000333

Table 4. Showing estimated Chronic Daily intake of Pb, Cr, and Cd heavy metals in water of Gwadabawa Lake.

	Adult			Children		
	Cr	***Cd***	***Pb***	***Cr***	***Cd***	***Pb***
A	0.1	0.005062	0.001666	0.2	0.001	0.000333
B	0.005062	0.005062	0.001666	0.001	0.001	0.000333
C	0.005062	0.028	0.00333	0.001	0.056	0.006666
D	0.003333	0.0265	0.00333	0.006666	0.053	0.006666

Table 5. Showing the estimate Hazard Quotient of Fe and Cu of heavy metals detected in water collected from Gwadabawa Lake.

	Adult		Children	
	Fe	***Cu***	***Fe***	***Cu***
Point A	0.00	0.520825	0.00	1.04165
Point B	0.00238	5.70825	0.0004757	1.14165
Point C	0.00238	0.004582	0.0004757	0.09165
Point D	0.0004757	0.04165	0.009514	0.008325

Table 6. Showing HQ for Cr, Cd and Pb detected in water of Gwadabawa Lake.

	Adult			Children		
Different points of the Lake	***Cr***	***Cd***	***Pb***	***Cr***	***Cd***	***Pb***
A	0.02857	0.001012	0.000476	0.06666	0.0002	9.514208571428ES
B	0.001687	0.001012	0.000476	0.000333	0.0002	9.514208571428ES
C	0.001687	0.0056	0.000951	0.00333	0.0112	0.001904
D	0.00111	0.00.222	0.000951	0.00222	0.0106	0.001904

Table 7. Estimated H I for heavy metals detected in Gwadabawa Lake

Different points where the Water Samples were collected	Adult	Children
A	0.558308	1.1103451
B	5.713805	6.96280054
C	0.0152	0.110147
D	0.04365157	0.032563

DISCUSSION, CONCLUSION, AND RECOMMENDATION

Discussion

Concentration of Metals Determined in Water Collected from Gwadabawa lake

Table 1 shows the Fe and Cu concentration detected in different points of Gwadabawa lake water. The range of Fe was 0.01 ± 0.001 to 1.37 ± 0.3(ppm), and range of Cu determined was 0.00 to 0.02 ± 0.008 (ppm). Table 2 Shows Cr, Cd, and Pb detected in water obtained from Gwadabawa lake. The range of Cr was 0.02 ± 0.007 to 6.00 ± 0.32(ppm), the range of Cd was 0.03 ± 0.10 to 1.68 ± 0.3, and the range of Pb was 0.01 ± 0.001 to 0.02 ± 0.04(ppm).

Estimated Chronic Daily Intake (CDI) of Cu, Fe, Cr, Cd, Pb for Water Collected from Gwadabawa lake

Tables 3 and 4 Shows the CDI for Fe and Cu in Gwadabawa lake. With the assumption that a person around the lake could take at least a liter of water daily (less than the daily requirement of water for adults) because there are evidently other water sources such as well water, sachet water, bore hole water, and bottle water, the CDI Values for Fe, Cu, Cr, Cd, and Pb.

Values in Tables 1 and 2 are less than the oral reference doses of the respective metals. Therefore, it is possible that the concentration of metals (Fe, Cr, Cd, Cu, and Pb) could not elicit appreciable risk over life time consumption [18]. However, when people relied solely on the lake water, or a concentration of more than or 1 liter is consumed, the water (due to the heavy metals) could posed an appreciable risk to human biological system [5, 9, 18].

Tables 5 and 6 show the results for estimation of HQ for the metals observed in water of Gwadabawa lake. The entire values for Fe Cr, Cd, Pb in both children and adults are less and are therefore more likely not to elicit appreciable risk to the consumers at the respected concentration. Noteworthy, taking concentration above the values in tables 1 and 2 may elicit effects in children or adults [18].

Nevertheless, Cu CDI calculated in adults and children shows values higher than 1 in water collected from point B, and point A. This implies that consumption at this concentration is likely to pose risk to adults and children. Likewise, only water in point A and B shows Pb value of more than 1, here possibility of instigating risk due to consumption in children is likely [12,18].

H I is the ultimate value used to characterize the possibility of risk due to consumption of metal (or likes) embedded in an environmental matrix like water and food. In this work, Table 7 shows the results of HI for the metals (Fe, Cu, Cr, Cd, and Pb) detected in water collected from Gwadabawa lake. For adults, all the 3 water samples collected from 3 points were likely to be safe due to combination of the metals, except at point B that shows a HI of more than 1 (5.7/3805). Therefore, water at point B could elicit a non-cancer risk upon the adult consumers [10]. Likewise, the water at point A and B shows HI at more than 1 (1.1/03451 and 6.96280084 respectively). Therefore, the children consuming the water are likely having non-cancer effect over time due to combination of the metals. The intrinsic nature of metal in our environment has been appreciated for over a long period of time [22].

However, these metals are being discharged unusually (in excess amount) into various matrixes of environment due to an increasing trend of anthropogenic process that instigate pollution [10]. The metals (heavy ones) are in various human endeavors, and some of them are specifically essential in various biochemical process in plants, animals or microorganisms [20]. For example, Cu and Fe are essential micronutrients vital for the human body. Therefore, they need to be consumed in food, water and relations for proper functioning of the human body. Failure to provide optimum amount of these metals poses detrimental Effects to the body [23,24,25]. In other hand, when these metals are consumed in surplus cases, effects resurfaced. High chronic copper damages liver, kidney, blood vessels and causes anemia [26]. In this study, there was revealed possibility of risk due to copper (Table 5). In many circumstances copper is considered as carcinogen [22]. Fe consumption in excess is a common poisoning reported [18].

Nevertheless, other forms of heavy metals (Cd, Cr and Pb) determine in this work are virtually non-essential to humans, because they have no known function reported. In this work, the Pb is found to be possibly toxic due to its higher CDI of more than 1(in some points). Pb causes cancer of stomach, increased cancer risk of the kidney, liver bladder, colon, rectum and brain as well [18]. Cadmium excess causes effects on kidney, impaired iron metabolism, skeletal damage and is a carcinogenic metal [18]. Specifically, the relevant chromium form is toxic and elicits cancer [8].

Generally, heavy metals at excess level are toxic, are obtained from the environmental matrixes including water, and causes lactation problems, reproductive issues, immune effects, low infant weights, nervous problem, DNA damage, oxidative stress, type 2 diabetes etc. [10, 14,26,]. Therefore, the level of heavy metals in water (especially the one for consumption) should be determined to help in avocation for policy changes, and to help in creating awareness among the public for behavior change. The high level of metals (especially Cu and Pb) found in Gwadabawa lake water is pollution processes (such as indiscriminate dumping of refuse, and plastic waste) [5].

CONCLUSION

Heavy metals are potentially harmful, and pollution has been contaminating our water sources especially in the rural settings where people mostly relied on water of questionable quality. Therefore, it is pertinent for students and scholars to monitor the levels of heavy metals in water sources like Gwadabawa lake to safeguard public health. The aim of this work is to determine the level of Cu, Cr, Fe, Cd, and Pb in Gwadabawa lake, and the possible risk therewith. Thus, this work found that on many occasions the levels of metals are possibly harmful to humans.

Recommendations

Based on the findings revealed in this work the following are recommended:

1. The public should be enlightened on the dangers of pollution especially indiscriminate waste disposal.
2. The public should be enlightened to use safe water sources.
3. The policy makers should provide other safe portable water sources, and use phytoremediation plants to save the lake.

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