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Assessment of Heavy Metals Concentrations in River Totowu: Implication for Environmental Health and Management

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Introduction: Heavy metals are metallic elements that have high densities, atomic weights or atomic numbers. The rapid growth of industrialization and population is a leading cause of heavy metal pollution.
Aims: This study determined the concentration of Cu, Cr, Cd, Co and Pb in water, sediment and fish from Totowu River located at Ado-Odo, Otta in Ogun State
Materials and Methods: Atomic Absorption spectroscopy (AAS) was used for the analysis of heavy metals in sediment, water and fish from River Totowu in Ado-Odo Area of Ogun State.
Results: 0.016-0.030 mg/L, 0.00-0.123 mg/L and 0.078-0.269 mg/L for Cu, Cr and Pb were obtained respectively for water. Sediments gave concentrations of 0.057-0.137 mg/L, 0.00-0.191 mg/L and 0.102-0.578 mg/L for Cu, Cr and Pb respectively. The result for heavy metals analysis of fish gave concentrations of 0.025-0.103 mg/L, 0.00-0.189 mg/L and 0.111-0.602 mg/L for Cu, Cr and Pb respectively. Cadmium and Cobalt were not detected in all the samples.
Conclusion: The average value of Pb was high in sequence from Fish > sediment > water in the study area and was higher than the allowed permissible concentration of WHO. The result confirms that Totowu River is contaminated and could harm human health. Regular monitoring and effective clean-up are therefore recommended.

To Keywords: Heavy metals, Pollution, Environment, Atomic Absorption spectroscopy, Totowu River.

1. INTRODUCTION

In recent years, water pollution has been considered one of the most dangerous hazards to humans and is now a worldwide problem [1]. With the increasing industrialization and human activities, concerns about heavy metal contamination in our environment are growing. Heavy metals are naturally occurring elements with high atomic weights and can be toxic to living organisms, including humans at certain concentrations [2]. Anthropogenic activities such as mining and smelting operations, industrial production, and domestic and agricultural use of metals have been reported to significantly contribute to heavy metal pollution [3]. However, heavy metals are naturally present in

the environment and are considered the essential component for life due to their physiological and biochemical functions in biological systems according to research [4]. Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments, and biota [5]. According to studies, heavy metals including both essential (such as nickel, iron and zinc) and non-essential (e.g cadmium and lead) elements have a particular significance in ecotoxicology, since they are highly persistent, and all have the potential to be toxic to living organism [6]. The assessment of heavy metals in aquatic habitats such as sediment, benthic organisms and fish has been truly explored as a major environmental concern [7]. Metals in minerals and rocks are not usually harmful but will be more toxic when they are dissolved in water.

The rapid acceleration of industrial growth all over the world has a negative impact on the environment. Such implications arise from the discharge of contaminated effluents into the aquatic environment without adequate treatment [8]. The most common source of heavy metal pollution is industrial wastewater from automobile manufacturing, metal purification, electroplating, galvanizing, coating, paint, electronics, pharmaceutical, chemicals, and battery manufacturing [9]. Heavy metal-contaminated wastewater typically contains arsenic, cadmium, copper, chromium, lead, mercury, nickel, and zinc.

Heavy metals have toxic and persistent properties, and they can enter the food chain and the ecosystem, where they have an adverse impact on the biotic and abiotic components of the ecosystem. Because water serves as a medium of transport for pollutants, heavy metals have been found to have negative effects on the organs of living organisms [10]. Once pollutants enter the biological system, they can bio-accumulate and bio-magnify in aqueous medium, eventually reaching high concentrations [11]. When heavy metal toxicity becomes significant in the tropics, the health of humans as the final consumer in the food web is jeopardised.

In aquatic systems, sediments serve as an important sink for trace metals [12]. Heavy metal concentrations in sediment can be higher than in the surrounding water. In aquatic systems, more than 90% of the heavy metal load is bound to suspended particulate matter and sediment [13, 14]. Fine-grained sediments are a major repository for trace metals and a record of the temporal changes in contamination due to their high adsorption capacity [15]. As a result, sediments can be used to reconstruct history. Over the last few decades, sediment core studies have been used as pollution records. The core studies have proven to be an excellent resource for determining the effects of anthropogenic and natural processes on depositional environments [16].

Metal contents in sediments are frequently used to describe metal contamination in various environments. For example, Heavy metals were investigated in coastal wetland sediments from the Pearl River Estuary in China. The total concentrations of heavy metals like Zn, Ni, Cr, Cu, Pb, and Cd, as well as their chemical speciation, were studied. The results revealed that the sediments were heavily contaminated with Cd, Zn, and Ni. Pb, Cd, and Zn were strongly linked to exchangeable fractions, whereas Cu, Ni, and Cr were mostly linked to organic fractions. According to the findings, Cd and Zn are the main potential risks, and sediment quality is no longer meeting the demands of current wetland utilization strategies [17].

Human exposure to 35 different metals has raised serious concerns, 23 of these metals are heavy metals, including antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc. These heavy metals are common in the environment and our diet. In small amounts, they are necessary for good health, but in large quantities, they can be toxic or dangerous. Human exposure to these metals can lead to cardiovascular disorders, neuronal damage, renal injuries, reduce energy levels and impair the functioning of our body's vital organs [18]. Therefore, this study assessed heavy metal concentration in water, sediment, and fish of Totowu River in Ado-Odo/Ado of Ogun state, Nigeria. The results obtained from this study could be used to provide information for background levels of metals in the water, sediment, and fish species of the river. This may further contribute to the effective monitoring of the community in terms of environmental quality and the health of the organisms inhabiting the aquatic ecosystem.

2. MATERIAL AND METHODS

2.1 **Study Area:** The Totowu River, situated within the Ado-Odo/Otta, Igbesa Local Community Development Area (LCDA) in Ogun State, lies between longitudes 3.08 East and latitudes 6.62 North, at an altitude of 26.00m/85.30ft. Serving as a vital artery for the Totowu village community and its residents, the river faces heightened susceptibility to pollution from various sources, including the indiscriminate dumping of waste by passers-by, mechanical effluents, and household waste.

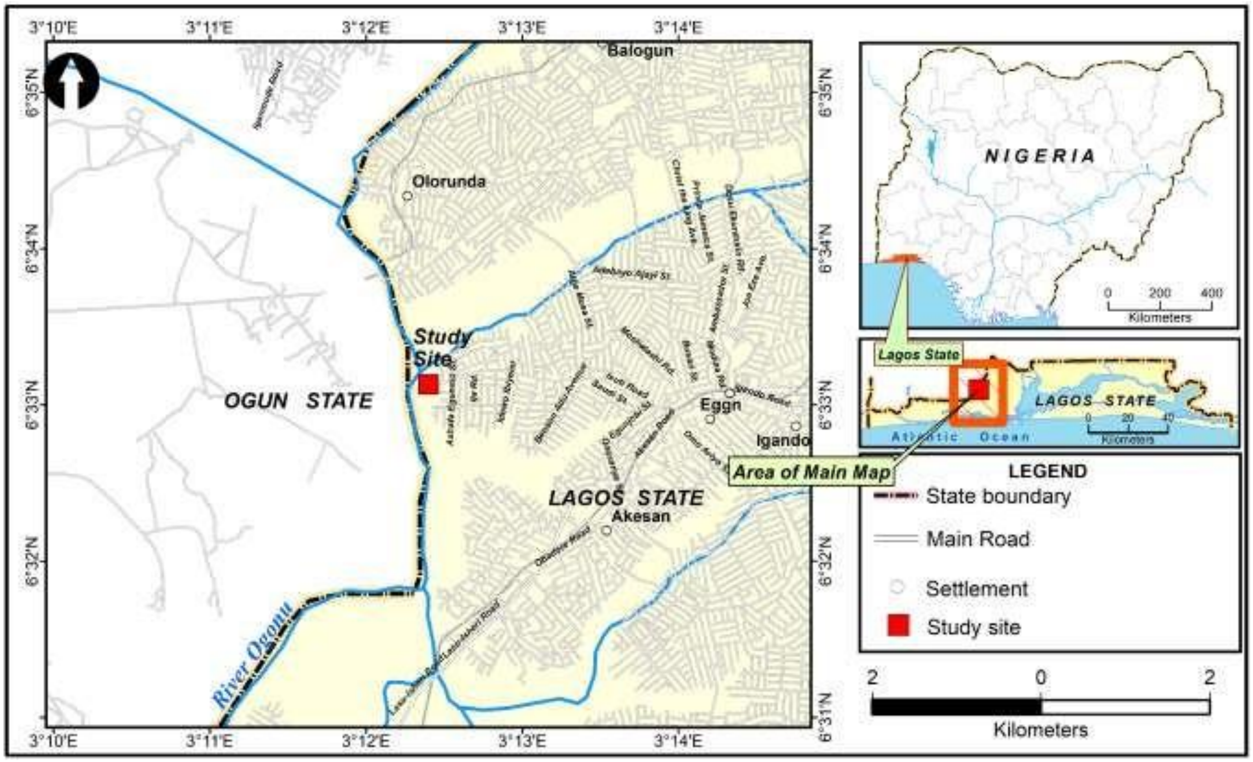

Figure 1: Map of Ogun State, South-West, Nigeria, showing the coordinate and location of the study site

2.2 **Sample and Sampling Techniques**

Water, sediment and fish samples were collected from July 2021 to April 2022 from two sites along the river. The sampling bottles underwent pre-conditioning with 5% nitric acid followed by thorough rinsing with distilled de-ionized water. Before sampling at each site, the polyethene bottles were rinsed a minimum of three times. A total of 25 tilapia fish (Oreochromis aureus) were captured using nets by local fishermen. The fish samples were promptly transported to the laboratory on the same day in a thermos flask with ice to maintain freshness. All fish samples were carefully stored at -30°C until analysis. Sample preparation and analysis followed the earlier outlined procedure. Before analysis, various organs including gill, stomach-intestine, and tissue were dissected from the tilapia fish specimens. Water samples were collected from 10 cm below the water surface, into plastic bottles that were precleaned with distilled water and then stored at 40C within twenty-four hours of collection. Sediment: The upper 10 cm of the bottom layer sediment was taken from the riverbank. Each sediment sample was packed separately in polythene packets and stored at 40C within twenty-four hours of collection.

2.3 **Laboratory Analysis:**

2.3.1 Determination of heavy metals in water

50 mL of the water sample was taken into a digesting glass tube. 12 mL of combined mixture of Aqua Regia (HNO3/HCl) in a ratio 1:3 was added to the water samples and the mixture was heated on a hot plate inside a fume cupboard. The temperature increased gradually, starting from 50^{0}C and increasing up to 200-3000C. The digestion was completed in about 40 mins as indicated by the white fumes. The mixture was left to cool down and was transferred to 50 mL volumetric flasks and the volumes of the contents were made to 50 mL with distilled water. The wet digested solution was transferred to plastic bottles labelled accurately. The digest was used for metal determination. Determination of heavy metals in sediment: Digestion same as described above. The digest was used for metal determination of the level of heavy metals in the sediment collected from River Totowu.

2.3.2 Determination of heavy metals in the flesh and gill part of the fish

The flesh and the gill parts of the fish were used for the analysis. 5g of the fish (flesh) sample was taken into a digesting glass tube. Digestion procedure same as described above. The digest was used to determine the level of heavy metals in the flesh and the gills of the fish. Levels of heavy metals in all the samples were measured by Buck scientific atomic absorption spectroscopy (Buck 210VGP) at SMO Laboratory, Ibadan. The minimum concentration of metals that could be detected was 0.00mg/L for each metal.

3. RESULTS AND DISCUSSION

Cobalt and Cadmium were not detected in the river water, sediment and fish (Figures 2,3,4,5, and 6). The Chromium concentrations in river water and sediment ranged from 0.000 to 0.123 mg/L and to 0.191 mg/L, respectively. The copper concentrations in water ranged from 0.000 to 0.269 mg/L, while copper concentrations in the sediment ranged from 0.000 to 0.578 mg/L. Figure 6 shows that the copper concentration in fish ranged from 0.04 – 0.08 mg/kg. The WHO guidelines for maximum permissible limit of copper in water is 0.05 mg/L, the range obtained was higher than the WHO value. Figures 2-6 show the lead concentration in water, sediment and fish. The concentrations of lead in the water ranged from 0.078 to 0.269 mg/L, while those in the sediment ranged from 0.102 to 0.578 mg/L. The concentration of Pb in fish ranged from 0.18 to 0.52 mg/L (Figure 6). The range found in this study is higher than WHO limit of 0.05 mg/L.

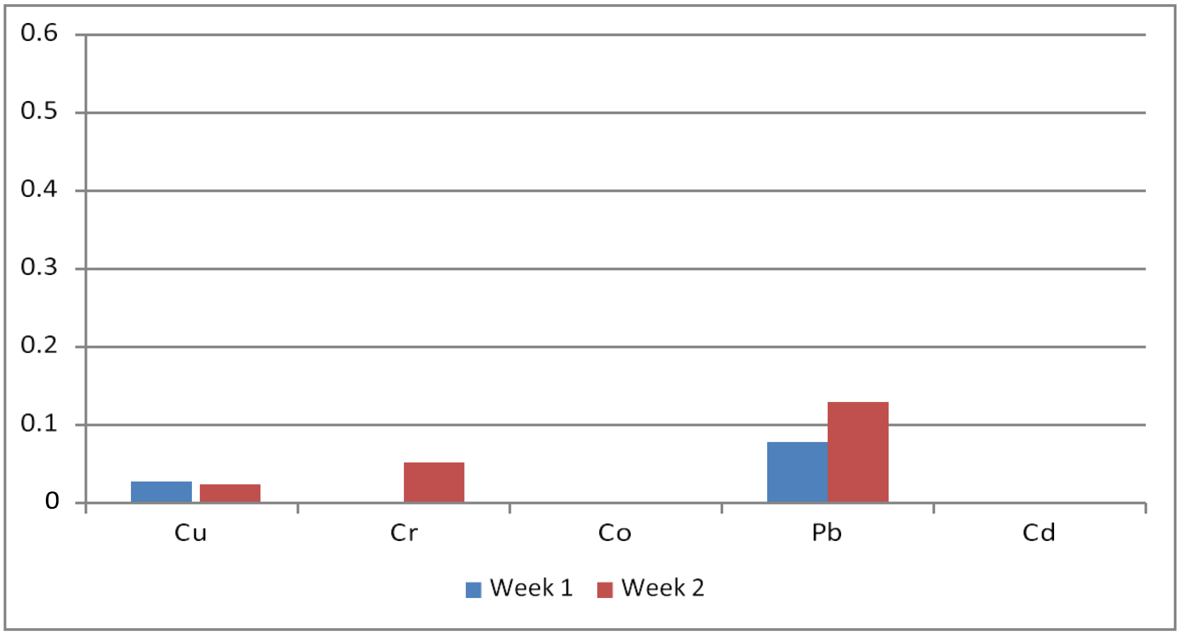

Figure 2: Average concentration of metals in water samples of river Totowu at point A

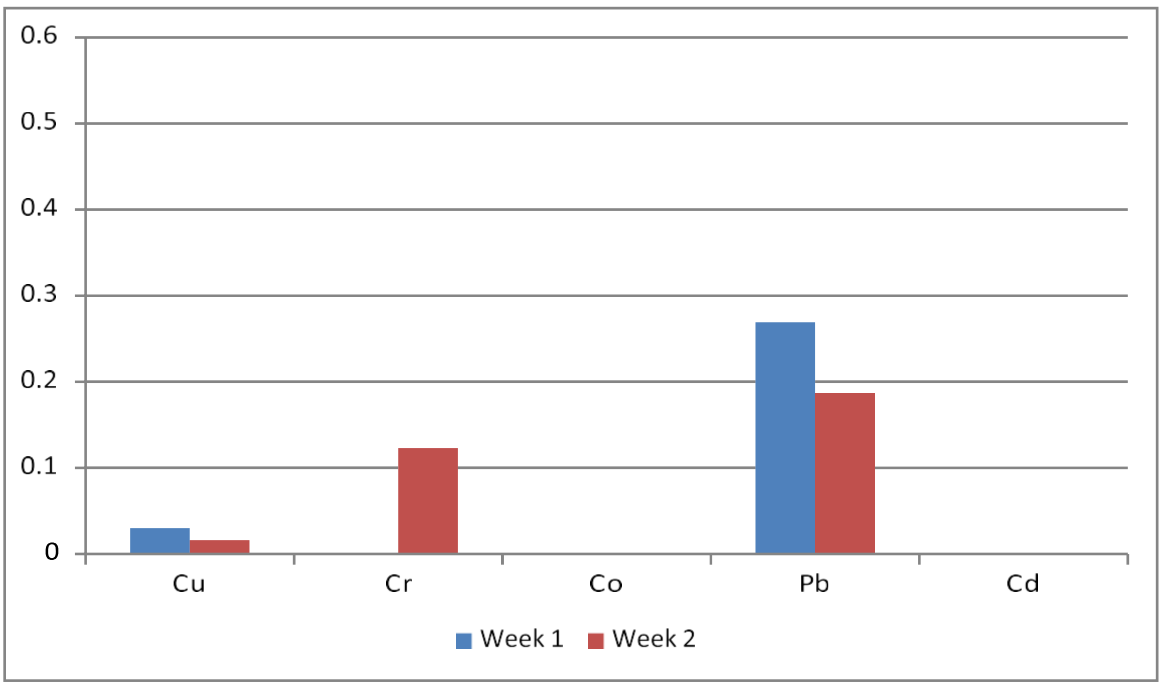

Figure 3: Average concentration of metals in water samples of river Totowu at point B

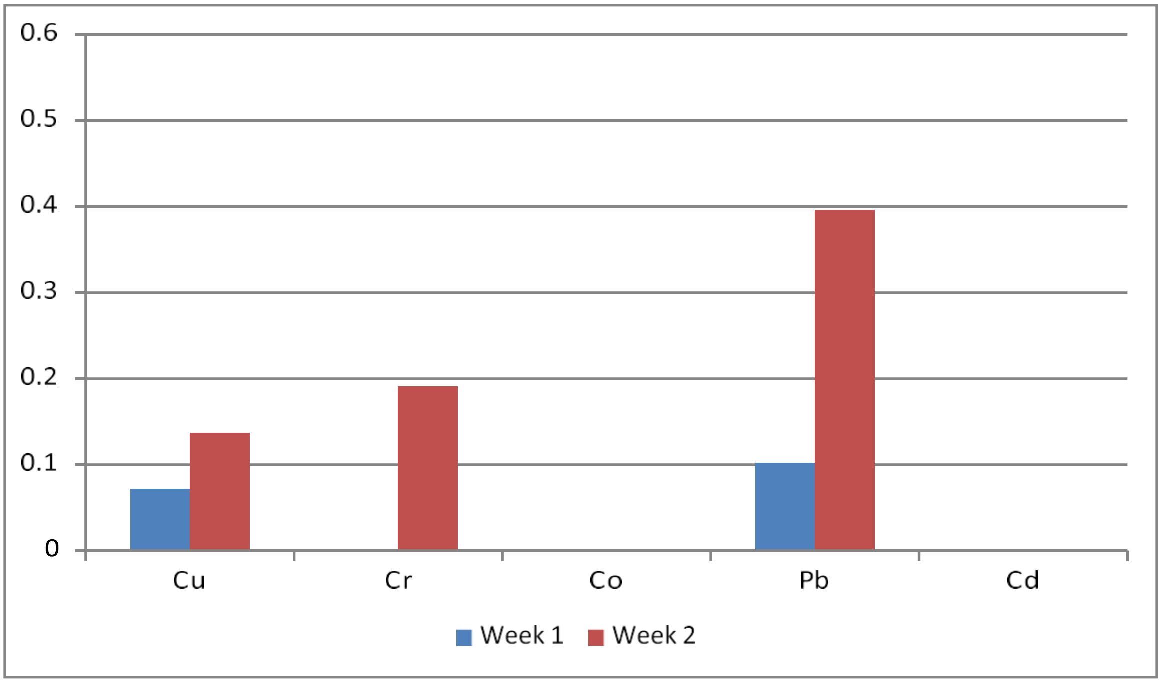

Figure 4: Average Concentration of metals in water sediment of river Totowu at point A

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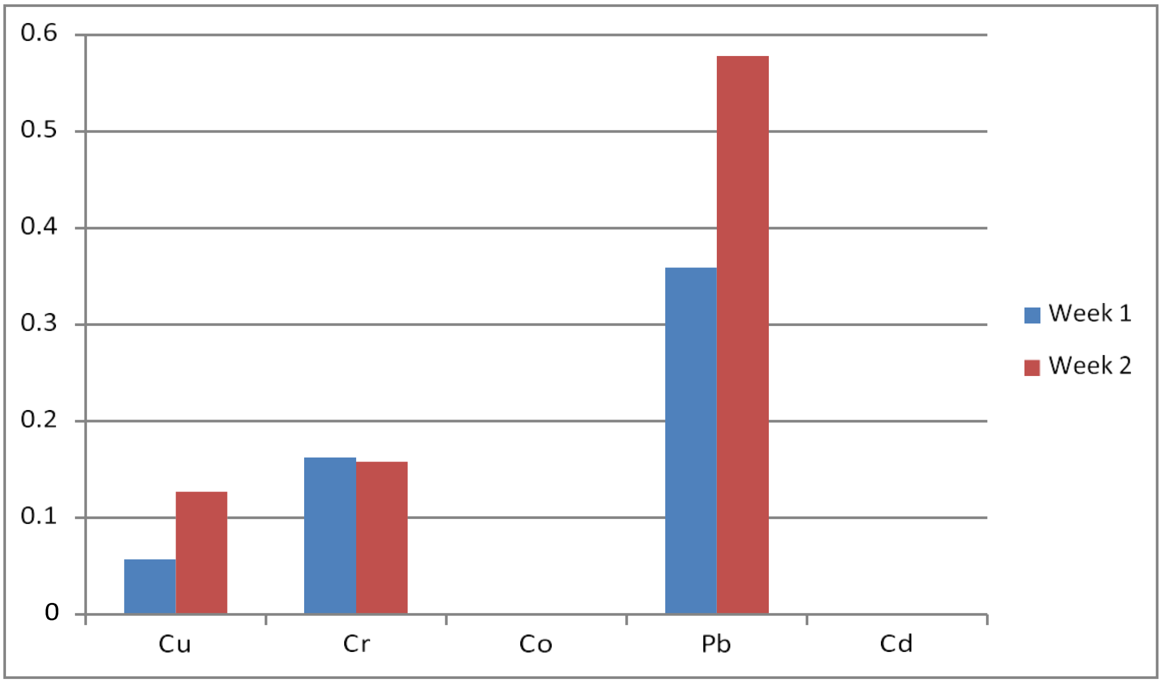

Figure 5: Average Concentration of metals in water sediment of river Totowu at point B

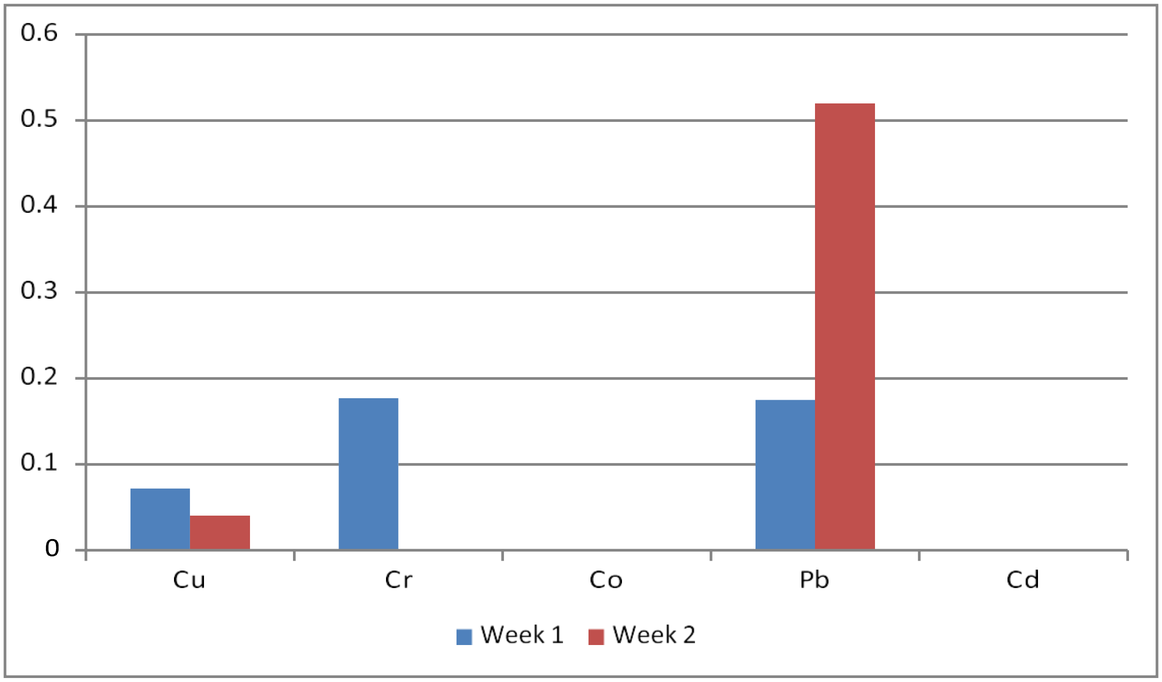

Figure 6: Average concentration of metals in Fish samples from river Totowu

4. Discussion

Fish is high in omega-3 fatty acids and protein, which the human body requires to stay healthy. However, potentially hazardous heavy metals are absorbed into the body tissues of fish and are transferred to humans when this affected fish is consumed. Food of high quality for human consumption can only be produced in an uncontaminated and polluted environment. Fish are very important economically, but they are greatly impacted by various chemicals, including heavy metals, in various ways, either directly or indirectly. Long-term exposure to heavy metals causes high mortality in juvenile fish and reduces adult breeding potential. River Totowu is highly populated with heavy metal as found in this study. The level of pollution of this water body may be due to the waste dumped around the riverbank as rivers sometimes serve as sinks for municipal waste [19]. The presence of heavy metals like Pb in the fish from River Totowu may be due to the absorption of the heavy metals through their food and the polluted water that passes through their gills. Metal uptake is frequently affected by the amount of food consumed as well as the heavy metal content of the food. Accumulation takes time and can lead to high concentrations in higher organisms. Some long-lived species of fish are known to store higher concentrations of heavy metals in various organs. The liver, kidney, and bones are the primary organs in fish for heavy metal storage and detoxification. Cobalt and Cadmium concentrations in the river water, sediment and fish in this study were all within the WHO recommendations for the maximum acceptable limit. However, the level of Pb concentrations found in River Totowu water, segment and fish were high. Lead does not have essential functions in life and is toxic even at low concentrations when ingested over time [20]. This may be due to the high amount of electronic waste that was dumped into this river. The Chromium concentrations in river water and sediment in this study were higher than the maximum permissible level by WHO. The results obtained for the metal analysis of sediment in Chromium, Copper, and Lead follow the concentrations of metals that were determined in the sediments of river Ganga in the Kanpur-Unnao industrial region [21]. Generally, results obtained showed that there is an accumulation of metals in fish gills which is to be expected given that the gills serve as the principal filter for the river water taken in by the fish. This increases the likelihood of many metals, particularly lead, accumulating in the human body. As a result, the water is unsuitable for aquatic life and for domestic purposes. The copper concentrations in water in this study are higher than the WHO guidelines for the maximum permissible limit of copper in water hence, the water is unsuitable for aquatic life and domestic use [22]. The usage of river water that has been contaminated with heavy metals is not suitable for drinking purposes by humans and animals as it may result in negative health consequences [23].

4. Conclusion

The water, sediment and fish samples from River Totowu were analysed for Copper, Chromium, Cobalt, Lead and Cadmium using atomic absorption spectroscopy (AAS). The study showed that the concentrations observed for cadmium and cobalt are within the WHO acceptable limit of 0.01 mg/L except for lead, copper and chromium which gave higher values than the WHO limit. An increased level of Lead was observed in the fish, in comparison to values obtained for the water and sediments. The distribution of heavy metals in water, sediments and fish from the results obtained, suggested that the quantities of these metals may be from water contaminated by boat engine exhaust, and other food production activities around the water bank. Cadmium and Cobalt were not detected in all the samples. The obtained results showed that average value of Pb were high in sequence from Fish > sediment > water in the study. The result shows that Totowu River was contaminated with heavy metals and could be dangerous for human health.

5. Recommendations

1. The Lagos State Ministry of Environment and Lagos Environmental Protection Agency should regularly monitor River Totowu and prevent dumping of waste in the river to prevent further contamination and accumulation of heavy metals.
2. The agency should also embark on effective clean-up of the river
3. Environmental education should be used as a tool to create awareness about the effects of these heavy metals on environmental and human health.

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