LEVELS OF HEAVY METALS IN WATER AND FISHES FROM LANGTANG DAMS, LANGTANG NORTH, PLATEAU STATE, NIGERIA

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Abstract

The concentrations of Iron (Fe), Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni) and Manganese (Mn) in water and five random fish species obtained from Langtang-North dams, were investigated by atomic absorption spectrophotometry. The pattern of distribution of the metals showed a preponderance of Fe over other metals in each of the dams. Cr, Pb, and Ni were not detected in water and fish samples. The mean concentrations of Cd, Fe and Mn in water were significantly different from that of the fishes. The mean concentrations of the heavy metals in the big dam for Cd, Fe, and Mn in water are 0.101, 0.392 and 0.0252mg/kg respectively while 0.121, 1.302 and 0.211 mg/kg of Cd, Fe and Mn were present in the fish samples. For the small dam, 0.093, .464 and 0.310mg/kg for Cd, Fe and Mn were obtained from the water samples while 0.114, 1.405 and 0.314mg/kg for Cd, Fe and Mn were obtained from the fish samples. All the detected heavy metals concentration were found to be below the world health organization standard (WHO).

Keywords: heavy metal, langtang, dam, toxicity

Introduction

The discharge of household, agricultural, and industrial wastes into dams, rivers, lakes, and other water bodies results in the pollution of the water because the majority of agricultural and industrial wastes contain heavy metals, which are chemical elements with an atomic density greater than 4 g/cm3 (Agbaghare and Agbaghare, 2024) and have unquantifiable negative effects on the health of humans, animals, and plants. The classification of chemical ingredient sources by the World Health Organization is shown in Table 1.1.

Table 1.1: WHO categorization of source of chemical constituents

Source of chemical constituents	**Examples of sources**
Naturally occurring	Rocks, soils and the effects of the geological setting and climate; eutrophic water bodies (also influenced by sewage inputs and agricultural runoff)
Industrial sources and human dwellings	Mining (extractive industries) and manufacturing and processing industries, sewage (including a number of contaminants of emerging concern), solid wastes, urban runoff, fuel leakages
Agricultural activities	Manures, fertilizers, intensive animal practices and pesticides
Water treatment or materials in contact with drinking-water	Coagulants, DBPs, piping materials
Pesticides used in water for public health	Larvicides used in the control of insect vectors of disease

Source: WHO (2011)

It is evident that agricultural techniques such manures, fertilizers, intensive animal husbandry, and pesticides, as well as natural sources like rocks, soils, geological settings, and climates, can produce heavy metals (WHO, 2011). The main industry of Langtang-North is agriculture, and the region is naturally composed of plateaus and rocks. Thus, it is reasonable to state that there is a chance that heavy metals will accumulate in the Langtang-North dams, which are utilized for home activities like fishing and irrigation.

One cannot stress the harmful effects of heavy metals enough. Because they are found in water bodies, they accumulate in marine species and are absorbed by plants, which leads to a variety of toxicological symptoms when they are consumed by humans. The following discusses a few heavy metals and their toxicological consequences.

Potential toxicological effects of some heavy metals

The toxicity of some heavy metals to human health are discussed below:

Cadmium (Cd)

High levels of cadmium irritate the stomach epithelium. Severe cadmium ingestion symptoms include cramping and soreness in the abdomen, nausea, vomiting, diarrhea, and tenesmus (Rahimzadeh, 2017; Drebler et al. 2002). In addition, renal damage, respiratory issues, a higher chance of lung cancer, and bone disorders might result from excessive Cd (Oiganji *et al.*, 2023).

Iron (Fe)

Groundwater and surface water are popular places to find iron, a naturally occurring mineral. Its presence in drinking water can lead to bacterial infections, anemia, and gastrointestinal disorders, among other health problems (Shailesh, 2023).

Lead (Pb)

Lead (Pb), while primarily targeted at the brain, also accumulates over time and damages other organs, with children being the most vulnerable (WHO, 2018). Lead poisoning from mining-related lead-contaminated soil and dust killed a number of little children in Zamfara, Northern Nigeria, in 2010 and again in 2015. When adults and pregnant women inhale or consume lead, they raise their risk of high blood pressure and birth defects, respectively, which can have long-term effects (WHO, 2018).

Chromium

The most stable oxidation state for chromium is the trivalent state, which ranges from +2 to +6. Despite reports that this stable chromium is a necessary nutrient, high levels of ingestion, inhalation, or interaction with it can have negative health consequences on humans (Wilbur *et al.*, 2012). Skin irritation, headaches, nausea, dizziness, kidney damage, blood disorders, and stunned mental faculties are some of these side effects.

Nickel

According to Giuseppe *et al.* (2020), nickel exposure can have a number of negative health impacts on people, including allergies, lung fibrosis, kidney and cardiovascular disorders, lung and nose cancer. It is believed that oxidative stress and mitochondrial dysfunctions play a fundamental and significant part in the toxicity of nickel, even though the molecular processes underlying this metal's toxicity are still unclear (Sureshkumar, 2015).

Manganese

One typical contaminant in water is manganese. Manganese poisoning, which manifests as muscle tremors, insomnia, hearing issues, appetite loss, sadness, irritability, headaches, and weakness, can be brought on by drinking water containing extremely high levels of manganese (Brian, 2022).

According to Mafuyai *et al.* (2020), heavy metal contamination in Jos is a result of lead, iron, arsenic, zinc, cadmium, and copper. According to Abdulaziz and Mohammed (2020), exposure to heavy metals has been connected to renal impairment, several malignancies, developmental retardation in children, and even death. A study conducted in 2020 by Oiganji and Dikam evaluated the state of various heavy metal concentrations in Jos North, Plateau State, Nigeria. According to reports, the levels of iron, lead, cadmium, and manganese were 277, 6,400, 1,233, and 580% more than the suggested threshold. Without any baseline data, Langtang-North dams are currently being used for irrigation purposes. This is concerning because the dam is being used to irrigate potatoes, sorghum, millet, acha, and other vegetables in the research region (Oiganji *et al.,* 2023).

Given the aforementioned toxicological consequences of heavy metals on aquatic life and humans, it is imperative to know the levels of heavy metals in water bodies around Langtang-North dams in order to take the appropriate measures. In light of this, the study evaluated the concentrations of Cd, Cr, Ni, Mn, Fe, and Pb in the water and fish of the Langtang dams, located in the northern region of Langtang state in Nigeria, as well as in the main and small dams.

Study Area

The Lantang Dam Site runs through Wallang, Pyar, Lazhan, Zanzat, Zunzun, and Bankun settlements in the Langtang North Local Government region of Plateau state. Its geographic coordinates are Latitude 090 7' 22.72'' N and 090 8' 46.17'' N and Longitude E0090 46' 37.72'' and E0090 47' 5.95''. According to Nanpon et al. (2014), the Langtang Water Board primarily uses the dams in Langtan-North as a source of water for water distribution across the town. The local farmers and settlers also utilize the dams for irrigation, drinking, washing, and cooking. A photograph of the large and small dams in Langtang North may be found on Plates 1.1 and 1.2.

Plate 1.1: A cross-section of Zangzat Langtang-North Big Dam

Plate 1.2: A cross-section of Nasarawa Langtang-North (Small) Dam

Materials and Methods

The Oboh and Edema approach (2007) was used to gather and conserve water samples from both small and large dams. Fishermen collected five distinct fish specimens from the dams, labeled, and stored in plastic containers in a laboratory. In order to determine the presence of heavy metals, the fish's gills and tails were removed. They were then dried at 100 degrees Celsius for a full day, ground in an electric blender, and put into sample bottles with labels before being dehydrated until they were digested. For digestion, perchloric acid, nitric acid, and sulphoric acid were utilized in accordance with Sreedevi *et al*. (1972) protocol. Using the Perkin Elmer atomic absorption spectrophotometry model 306, the amounts of Iron (Fe), Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Manganese (Mn) in the fish samples and the water were measured.

Results and Discussion

Fe, Cd, and Mn concentrations were found in the corresponding fish and water specimens, however Cr, Pb, and Ni concentrations were not detected in the corresponding samples. Figure 1 displays the average amounts of heavy metals in fish specimens and water samples taken from the large and small Langtang-North Dams.

Table 1.2: Heavy metal concentration in water and fishes from Big and Small Dams

Big Dam						
Samples	**Cd**	**Fe**	**Pb**	**Cr**	**Ni**	**Mn**
Water (mg/kg)	0.101	0.392	ND	ND	ND	0.025
Av. Fish Specimen (mg/kg)	0.121	1.302	ND	ND	ND	0.211
Small Dam						
Samples	**Cd**	**Fe**	**Pb**	**Cr**	**Ni**	**Mn**
Water (mg/kg)	0.093	0.464	ND	ND	ND	0.031
Av. Fish Specimen (mg/kg)	0.114	1.405	ND	ND	ND	0.314

ND = Not Detected

The mean concentration of heavy metals show that the water and fishes of Langtang-North big and small dams are free of industrial pollutions. This is evident in the absence of industrial activities in Langtang-North. A clear representation of the level of heavy metals in figures 1.1 and 1.2 shows that higher levels of Cadmium, Iron and Manganese are present in the big dam than the smaller dam and the amount of these metals are more present in the fish samples than the water samples. This is similar to the findings of Oboh and Edema (2007).

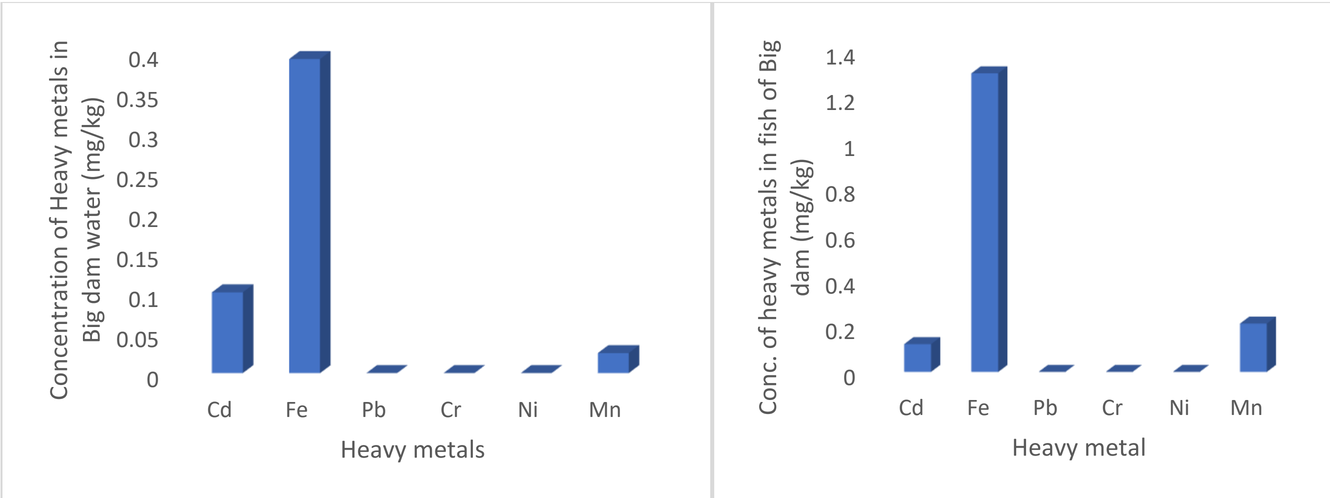

Figure 1.1: Levels of heavy metals concentration in water (mg/kg) and fishes (mg/kg) in the Big Langtang-North Dam

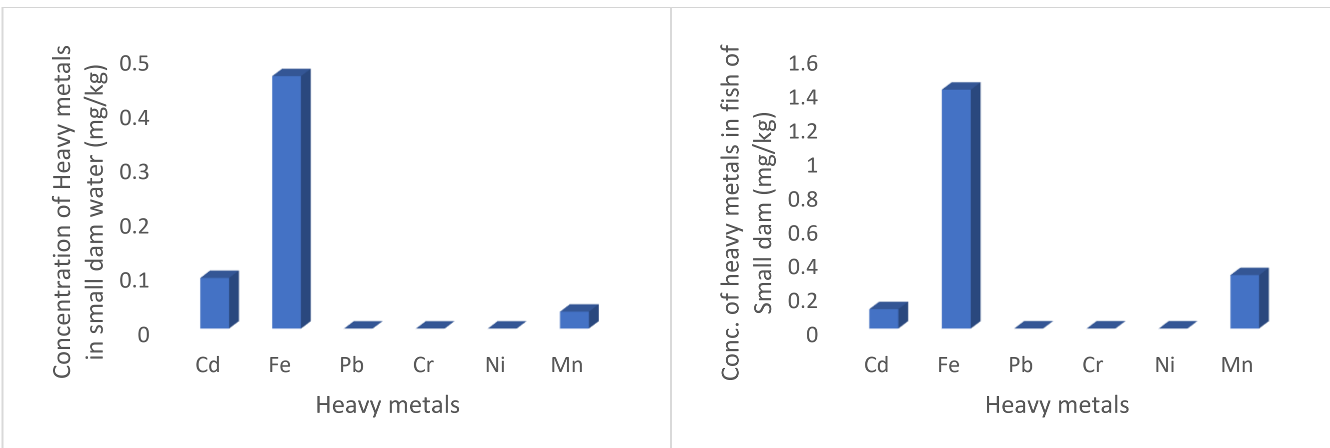

Figure 1.2: Levels of heavy metals concentration in water (mg/kg) and fishes (mg/kg) in the Small Langtang-North Dam

Comparison with WHO standard

The detected mean values of Cd, Fe and Mn were compared to the WHO standard as presented in table 3

Table 1.3: Comparison with WHO maximum standard limit

Heavy metal	**Cd**	**Fe**	**Mn**
WHO Maximum limit (mg/l)	0.003	2	0.5
Langtang-North Big Dam(mg/l)	0.000111	0.000847	0.000118
Langtang-North Small Dam(mg/l)	0.000104	0.000935	0.000173

Figure 1.3: Comparison with WHO standard

Detected amount of cadmium, iron and manganese are all below the maximum limit of the world health organization (WHO).

Table 1.4: Comparison of overall mean heavy metal levels (mg/kg) of fishes from water bodies					
Water bodies	**Cd**	**Cr**	**Fe**	**Pb**	**Mn**
Langtang Big Dam (Present work)	0.101	-	1.302	-	0.211
Langtang Small Dam (Present work)	0.093	-	0.464	-	0.031
River Niger	0.112	-	0.408		0.035
Warri River	0.229	0.539	1.9	1.081	1.101
Ogumpa River, Ibadan	0.00-0.001	-	0.80 -3.60	0.001-0.40	0.70-11.74
Rimi River, Kaduna	0.04	-	3.8	-	1.3

Source: Oboh and Edema (2007)

The average cadmium value (0.101 mg/kg) is less than that of industrial areas, like Warri River (0.229 mg/kg), as shown in table 2. Cadmium is carried by airborne particulate matter from industrialized areas, according to Mathis and Kevern in Oboh and Edema (2007). This occurs from distant lakes and streams. Given that Jos City is located many kilometers away from Langtang North and that there aren't many other enterprises in the vicinity, it seems unlikely that the sources of cadmium found in the Langtang-North dams come from industrial locations.

Figures 1.1 and 1.2, which show that iron (Fe) was the most often observed metal in both large and small dams relative to other metals, also indicate that Fe concentrations are still lower than those in industrial regions. The most obvious source of Fe might be leaching, ore production, and natural soil weathering. Due to its widespread distribution, iron is the second most common metal and the fourth element found in the environment by nature (Silberge, 2000).

Moreover, complexation leading to particle sedimentation of rocks surrounding the dams could be the cause of the low Mn levels in the water in the dams. Through the creation of complexes, iron and manganese are thought to function as carrier particles that influence the hydrodynamics of other metals (Oboh and Edema, 2007).

Conclusion

The investigation makes it quite evident that Cd, Fe, and Mn are somewhat contaminated at the Langtang-North Big and Small Dams. According to the study's findings, the Big Dam, which supplies the Langtang North Water Board with water for the purification of all Langtang-North settlers, should be avoided because the water's quality is only moderately affected by Cd, Fe, and Mn, with Fe having the highest concentration of these heavy metals (albeit still below WHO standards).

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