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# Assessment of heavy metals levels in Dadin Kowa Dam,Yamaltu Deba, Gombe State , Nigeria

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**Abstract**
Farming activities and sewage sludge discharge in the Dadin Kowa dam of Gombe state posed serious environmental challenges to the communities. Based on these incidents, investigation was conducted on heavy metal contamination levels from copper (Cu), Managanes (Mn), Lead (Pb), Chromium (Cr), Cobalt (Co), Nickel (Ni), Cadmium (Cd), and Magnesium (Mg) in sediments, water surface , and in three selected fish species (Common cap, African catfish and Tilapia) in the Dadin Kowa dam. Sixteen samples were collected (5 water samples, 8 sediment samples, and 3 fish samples). The means of Cu, Mn, Pb, Cr, Co, Ni, Cd, and Mg in water were 0.110, 0.430, 0.010, not detected (ND), 0.054, ND, 0.072 and 4.395 ppm, respectively. Sediment mean levels were 0.046, 108.670, 0.034, 0.030, 0.055, 0.064, 0.064 and 5.00 ppm. The respectively means of the corresponding heavy metals in the fish were 0.014, 10.787, 0.017, 0.080, 0.03, 0.03, 0.04, and 03.217 ppm. (Mn) mean levels in all the three categories of samples were detected higher than World health organization (WHO) maximum contamination level. Cd in sediment and water samples is also above the WHO maximum level. This assessment offers an opening for continuous monitoring of the environment heavy metals.

**Keywords:** Heavy metals; anthropogenic sources; Atomic Absorption Spectroscopy; Dadin kowa dam

## 1. Introduction

Persistent of heavy metals in the environment and the aquatic sediments contamination has caused serious challenges that need to urgently redress (Ali et al., 2016; Bhuyan et al., 2017). Anthropogenic and natural activities have been identified as causes of abundant heavy metals in the environment (Munir et al.,2016). Heavy metals is defined as metallic element with possession of density higher than 4 g/cm$^3$ (Offor eat al., (2014). They are peculiar with the characteristics such as malleability ductility, cation stability, conductivity, and legend specificity. Typical example of heavy metals are the Iron (Fe) , Cadmium (Cd), Mercury (Hg), Lead (Pb), Zinc (Zn), Arsenic (As), Copper (Cu), Silver (Ag), Chromium (Cr), Platinum (Pt) group elements (Paul, 2017). Little quantity of heavy metals as Fe, Co, Mo, Cu, Mn, Ni, Zn, and Vanadium (V) are required by some organisms. The cumulative pollution rate by heavy metals had shown trends of adverse health effects for invertebrates, fish, and the humans (Chowdhury et al., 2016; Khan et al., 2013; Sánchez-Chardi et al., 2007).

The outcome of human activities, chemical, and geochemical processes into the ecological system has lately become the issue of global concern due to heavy metals identification. In the course of the heavy metals conveyance within the river environment, transformation may occur as a result of sorption phenomena, dissolution and precipitation (Abdel-Ghani and Elchaghaby, 2007), Accumulation of these metals to higher toxic levels results to serious effect on the aquatic organisms, performance of the organism and environment bioavailability are also altered (Astel et al., 2018; Zheng et al., 2008). These phenomena demand an investigation on the concentrations of water heavy metals and ecosystem of the river, these problems is more typically found in most developing countries, Nigeria is not an exception. Industrialization and disposal of city litters and untreated effluents from various activities into the open water bodies and rivers sediments have reached an alarming situation in most countries with persistent rise in the heavy metal bodies resulting to decline in the water quality of the communities.

In addition, heavy metals with high concentration can be discharged into the aquatic ecosystem due to leaching from discharge of industrial and urban wastewaters, atmospheric deposition, bedrocks, water drainage, and runoff from riverbanks (Yi et al., 2011). Sediment is an important and vibrant part that constitutes difference the environment, and the habitats (Morillo et al., 2004). At the same time, the fish samples assessment can be a measured of one of the significant pointers in the systems of freshwater occurrences at pollution level (Salem et al., 2000). (Yi et al., 2011) reported heavy metals effect from commercial and edible fish species hazardous to human health. Meanwhile, heavy metals as Cr, Cu, Fe, and Ni play significant activities in a biological system as vital metals. Though, the (Pb) and (Cd) are non-importance contaminated metals that are poisonous at little quantities (Wilson and Pyatt, 2007). Toxic effect can equally be produced from high intake of these essential metals in the fish species and water environment. The toxicity of these heavy metals are reliant on the amount, the chemical method, storing and excretion conditions, exposure route, bioavailability, and dissemination in the body. The dam ecosystem under study has witnessed activities from agriculture and human debasing its quality. To the best of our knowledge, study and literatures are still rare on the environmental quality of the water, sediments, and biota of this dam.

Therefore, the aim of this study is to gather experimental evidence on the examination of heavy metals levels such as (Co), (Cd), (Cu), (Ni), (Pb), (Cr), (Mn), and (Mg) in fishes, sediment and water of Dadin Kowa Dam. The fish is also considered a significant index because it is an important human diet component within the community. Finally, environmental quality and the health impact from this study on water with heavy metals, the sediment, and fish species of the dam will be comprehended for future mitigation measures.

## 2. Materials and Methods

### 2.1. Samples collection

Samples varieties (water, fish, and sediment) collected for the analysis of heavy metals were collected from DadinKowa dam, Gombe State (North-East, Nigeria), within the coordinates10°19′19″N 11°28′54″E. Samples from different sources was collected at the locations within the lengthways of the flowing dam by means of an hygienic plastic container washed with a deionized water. Fresh fish samples obtained from the dam were the common cap, Africa cat fish and Tilapia with the help of fishermen. This was achieved with the aid of a cast net thrown and withdrawn from the dam by the aid of a line connected to its opening. Fish samples obtained were kept in pre-cleaned polythene sack and stored in the ice box for transportation to the laboratory for further analysis. The top (1-2 cm thick) of the sediment was collected with a spade and stored in a sealed polythene bags.

### 2.2. Analytical methods

#### 2.2.1. Digestion of samples

Water samples digestion was done in triplicates using a concentrated acid of nitric solution (Analytical Grade) according to the method previously described elsewhere(Öztürk et al., 2009). Concentrated acid (5 ml) is mixed to 200 ml of sample water in beaker, subsequently heated on a hot plate to boil till its volume lessens to 20 ml. Separate 5ml of HNO concentrated solution was added, further heated for 10 minutes and kept to cool. About 5 ml acid of nitric concentration was utilized to wash the sides of the beaker, while the solution was filtered with Whatman 0.42 µm filtering paper into a 50 ml volumetric flask and top-up to the spot with deionized water. Each sediment sample was thawed at room temperature (25 – 28 $^oC$) and stored inside a pre-acid prepared evaporating beakers. Drying of the sediments at the temperature of 500 $^oC$ with an oven till a stable weight was attained. Grounding of the sediment dried samples with a porcelain mortar and pestle was conducted and further sieved via a 2 mm plastic mesh sieve. Mettler tolede electronic weighing balance (Model PR 2003) of 2 g into 100 ml acid cleaned beakers was conducted. Digestion was conducted utilizing acid of concentrated nitric solution (Analytical grade) and hydrogen peroxide. All the samples digested were filtered with a Whatman 0.42 µm filtering paper inserted inside a 50 ml flask volumetric size and top-up with deionized water. The entire fish was dried for three days with an electric oven at 70-80 $^0C$.

The samples of fish were crushed with a clean mortal and pistil into the form of powdered. 2 g of the completed mixed grounded fish was weighed with measuring balance and furnace for the ash obtained at 550 $^oC$. The samples were put in flask and 10 ml each of concentrated $HNO_3$ and HCl was added. Digested of the samples was conducted for 2-3 hours and the solution filtered into standard volumetric flask of 100 $cm^3$ , mark with deionized water and stored in the refrigerator at 4 $^oC$. Blank solutions were prepared in a similar manner for the three categories of samples. Similarly prepared blank solution was conducted, while, the heavy metal analysis was done using Atomic Absorption Spectrophotometer (AAS) model: Buck-205 from the department of biochemistry Gombe State University (G.S.U.) Gombe. The blank was enunciated along with the analytical samples to enable us have a precise background adsorption. The instrument (AAS) operating conditions were set in line with the manufacturer's specifications.

## 3. Results and discussion

### 3.1. Physical parameters of dam water

The dam water is above neutral with a pH range of 7.34 to 8.04 for the five samples of water (Table 1).

**Table 1**: Physical parameters of the water sample.

| Samples | Temperature | Conductivity (us/cm) | Turbidity (mg/L) | pH | TDS (ppm) |
|---|---|---|---|---|---|
| $W_1$ | 29.9$^oC$ | 93.00 | 1.07 | 7.90 | 46.00 |
| $W_2$ | 30.9$^oC$ | 95.00 | 2.45 | 8.04 | 47.00 |
| $W_3$ | 30.5$^oC$ | 93.00 | 3.30 | 7.90 | 46.00 |
| $W_4$ | 32.0$^oC$ | 93.00 | 1.45 | 7.34 | 46.00 |
| $W_5$ | 32.5$^oC$ | 93.00 | 0.25 | 7.70 | 46.00 |

The water surface pH was in the range of 6.5- 8.5 specified for domestic and drinking purpose, according to the World Health Organization (WHO, 2008). Electrical Conductivity (EC) ranges from 93 to 95 µs/cm which complied with the WHO limit of 700 µs/cm. The range of Total Dissolved Solids (TDS) was from 46 to 47 mg/L. The dam water Total Dissolved Solids (TDS) was within the WHO guideline value of 1000 mg/L. There was no floating material in the water sample indicating the absence of oil and grease.

### 3.2. Heavy metal concentration in water, sediments and fish species

The heavy metals concentrations determined on the samples sediments, water and three selected food fish species (Tilapia, Common Carp, and African catfish) are shown in Tables 2. Cu, Fe and Pb were evident in the sediment whereas Cd and Antimony (Sb) were not detectable. Cu is a vital constituent of living systems (Carolyn et al.,2004;Nicholas et al.,1998; Rand and Petrocelli, 1988) . It is among essential metals for the humans and extensively dispersed. The Cu concentration phases in the dam were found in the range: 0.0143 to 0.110 mg/L in the three samples. The maximum allowable concentration of copper stipulated by the WHO was 0.11 mg/L.

**Table 2**: Mean concentrations of heavy metals in the three samples (Water, sediment and fish).

| Elements | water samples | Sediment Samples | Fish samples |
|---|---|---|---|
| Cu | 0.110 ± 0 | 0.046 ± 0.018 | 0.0143 ± 0.035 |
| Mn | 0.430 ± 0.406 | 108.67 ± 61.015 | 10.787 ± 0.8919 |
| Pb | 0.010 ± 0 | 0.033 ± 0.002 | 0.0167 ± 0.0058 |
| Cr | N.D | 0.03 ± 0.013 | 0.0800 ± 0.0781 |
| Co | 0.054 ± 0.018 | 0.055 ± 0.041 | 0.0300 ± 0.0100 |
| Ni | N.D | 0.0638 ± 0.038 | 0.0300 ± 0.0000 |
| Cd | 0.072 ± 0.061 | 0.0638 ± 0.0406 | 0.0400 ± 0.0200 |
| Mg | 4.390 ± 0.185 | 5.383 ± 0.0525 | 3.2167 ± 0.1193 |

The mean value of (Cu) content in the water sample of Dadin Kowa dam was found highest among the three samples (Table 2), but the three samples permissible level were noticeably to be less. Higher level of (Cu) in water sample may be as a result of weathering of rock and disposal of both electronic waste and other solid waste inside the erosion close to the water source, as some electronic waste contains Cu and some rocks are compost of Cu. This might also be as a result that in water, (Cu) move countless distances either as suspended on dust matters or as free ions(Adelekan, 2011). (Cu) concentrations in higher dose can lead to neurological complications, hypertension, abdominal pain, diarrhea, kidney and liver dysfunctions (Tirkey et al.,2012).

(Mn) is generally a compound present at all places on earth. It belongs among one of the important toxic trace elements, indicating it is not only essential for survival of humans, but at higher concentrations, it can also be toxic. All the three samples from Dadin Kowa dam contained (Mn) which was above the limit 0.1 ppm stipulation of WHO. It can also be attributed to leaching of burning fossil fuel. Contact with higher (Mn) concentrations over several years impact negatively on the nervous system generating a resemblance of the Parkinsonism syndrome. Such health effect can be severe among elderly people if impacted. Mn can also probably generate other types of health problems associated with multiplicative disorder or damage, and cancer.

(Pb) arises in the environment both in natural and manmade sources. Its natural compositions of biosphere, water, and air (Bhardwaj et al., 2017). (Pb) is plentifully found in earth's crust as an unwanted trace metal. Contact can exist via air, drinking water, food, soil and dust of painted materials over long time containing Pb. The mean Pb concentration levels recorded in water, sediment and fish in the course of the study indicate uncertain variations (Table 2). It is varied from 0.010 to 0.033 ppm in all the concentration which is less than the WHO maximum limit 0.11ppm. In previous study, (Pb) was stated to influence human body organ and system (Alala, 1981). Exposure over a long-term can result in reduced functionality in some tests that measure the nervous system, most especially in the adults; small increases in blood pressure; weakness in fingers and ankles, wrists, and or anemia. Exposure to (Pb) with high concentration can seriously destroy the brain and the kidneys and eventually result to death. High concentrations exposure to (Pb) may cause miscarriage in women that are pregnant. Men reproductive organs can lead to low functionality and low sperm production on exposure to high lead concentrations.

(Cr) is an important micro-nutrient for plants and animals. It is known as a comparative biological and significance pollution element (Rajappa et al.,2010). The highest concentration of Cr was indicated in fish with the concentration 0.08 ppm (Table 2). The WHO permissible limit is within the range of 0.07 to 0.23 ppm while the concentration of Cr in water was not detected and that of sediment and fish were within the permissible limit. Elevated amount can emanate from mining and industrial processes (Datar and Vashishtha,1990).

(Co) is known as an crucial element that is required in the normal human diet in the form of vitamin $B_{12}$ (Tirkey et al., 2012). The concentrations of (Co) in all the three samples complied with the world health organization value of 0.08 ppm. (Co) with higher concentrations is toxic to animals ecosystem, plants and affect quality of the water environment (Ruqia et al., 2015). This could have come from improper disposal of waste and batteries dumped in the area, as these areas lack proper dumping site. Symptoms or diseases associated with cobalt contamination water includes accumulation in muscles, liver, and gills (Ruqia et al., 2015).

(Ni) occurs as an element in the environment only at very low levels and is essential in small doses but it can be unsafe when the extreme bearable quantities are exceeded. Applications vary in the areas of alloys and as corrosion resistance materials, and in the production of batteries. It is considered as an important trace metal while toxicity at large quantity to human health is evident, it is regarded as carcinogenic to human. (Carolyn et al.,2004) in their study reported (Ni) metal at high dosage in rats and dogs were meaningfully reducing the weights of their body. Detection of (Ni) in the water sample was not identified, while the mean (Ni) detected in sediment and fish samples below 0.07 ppm limit given by the WHO.

(Cd) and (Zn) has a chemical resemblance as an important micronutrient for humans, plants and animals. (Cd) is highly bio tenacious with few toxicological features and once exposed to an organism, it stay put for several years deteriorating human health, The (Cd) mean concentrations in water and sediment surpassed the (WHO,2011) limit of 0.05 ppm, while the concentration of fish complied. The occurrence of the (Cd) might emanate from fertilizer and other agricultural chemicals such as pesticide, herbicide e.t.c. Consumption of higher concentration seriously aggravates stomach pain leading to diarrhea and vomiting. The exposure over a long-term at less concentration can leads to a accumulation in the kidneys and probably result to kidney disease, lung damage, and fragile bones (Carolyn et al.,2004).

(Mg) is abundant as the fourth cation in the body and most abundant second cation in the intracellular fluid. All three samples contain (Mg) below the limit 20 ppm given in WHO Standard. The mean (Mg) levels in the dam were found in the range: 3.216 to 5.383 mg/L in the three samples. Excess intake of (Mg) is the core source of hypomagnesaemia a renal inadequacy linked with a crucial reduced aptitude to excrete (Mg) (WHO, 2011). Increased intake of (Mg) salts may cause a temporary adaptable alteration in bowel manners (diarrheal), but rarely causes hypomagnesaemia in humans with usual kidney function. From (Table 3), the Ni, Cr, Cu and concentrations of fish intake were higher in sediment samples compared with the water samples, and they have all exceeded the calculated standard fish intake from the WHO. It was only Cd that is higher in the sediment, but below the WHO calculated standard. In addition, Pb and Co were higher in water samples than sediment samples but in both samples (water and Sediment) they were higher than calculated WHO standard. While the Mn and Mg was higher in water but within the calculated WHO permissible limit.

**Table 3:** Fish intake of the determined elements compared with water, sediment and WHO standards, 2011.

| Elements | * Intake from water | *Intake from sediment | *Intake standard from WHO |
|---|---|---|---|
| Cu | 0.130 | 0.311 | 0.13 |
| Mn | 25.09 | 0.099 | 107.9 |
| Pb | 1.67 | 0.506 | 0.152 |
| Cr | ND | 2.667 | 0.53 |
| Co | 0.565 | 0.545 | 0.38 |
| Ni | ND | 0.470 | 0.43 |
| Cd | 0.556 | 0.627 | 0.80 |
| Mg | 0.733 | 0.598 | 0.75 |

* Calculated as heavy metals concentration in fish compared with sediment, water, and WHO standards.

Fig. 1 below was the fish intake of heavy metal from water surface compared with Figure 3 which was the WHO Maximum permissible concentration of heavy metals in fish. It was shown that Cu, Mn, Cr, Ni, Cd, and Mg were all below the calculated WHO limit for the intake, while Pb and Co exceeded the limit.

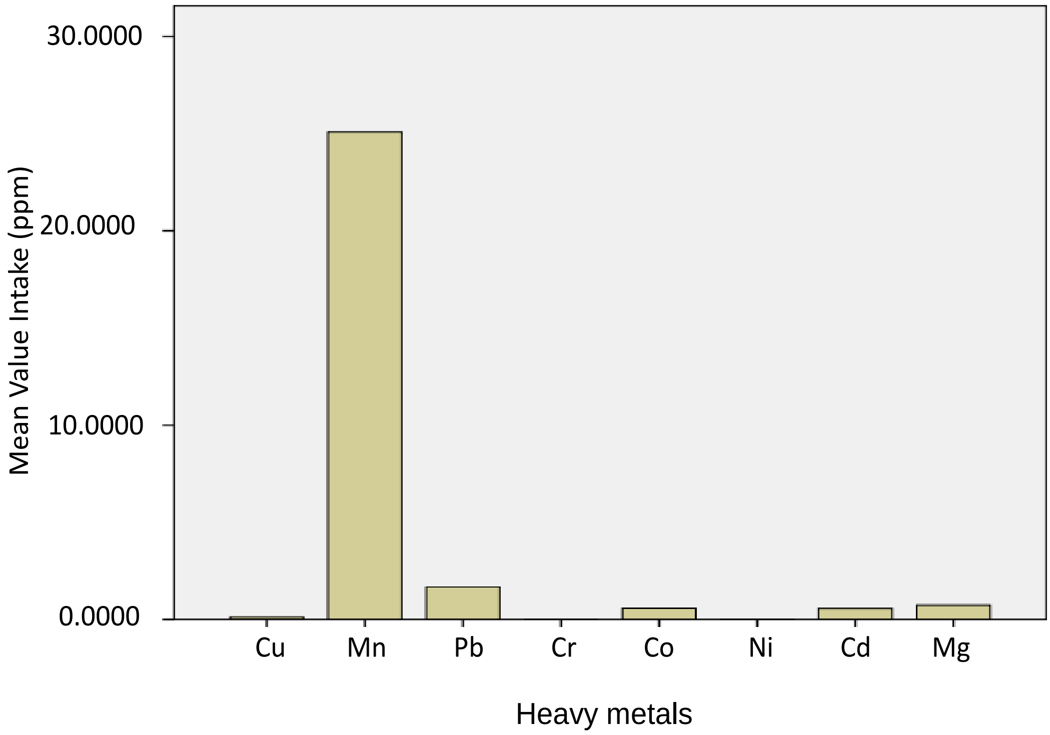


**Fig. 1**: Heavy metals levels on fish intake from dam water surface.

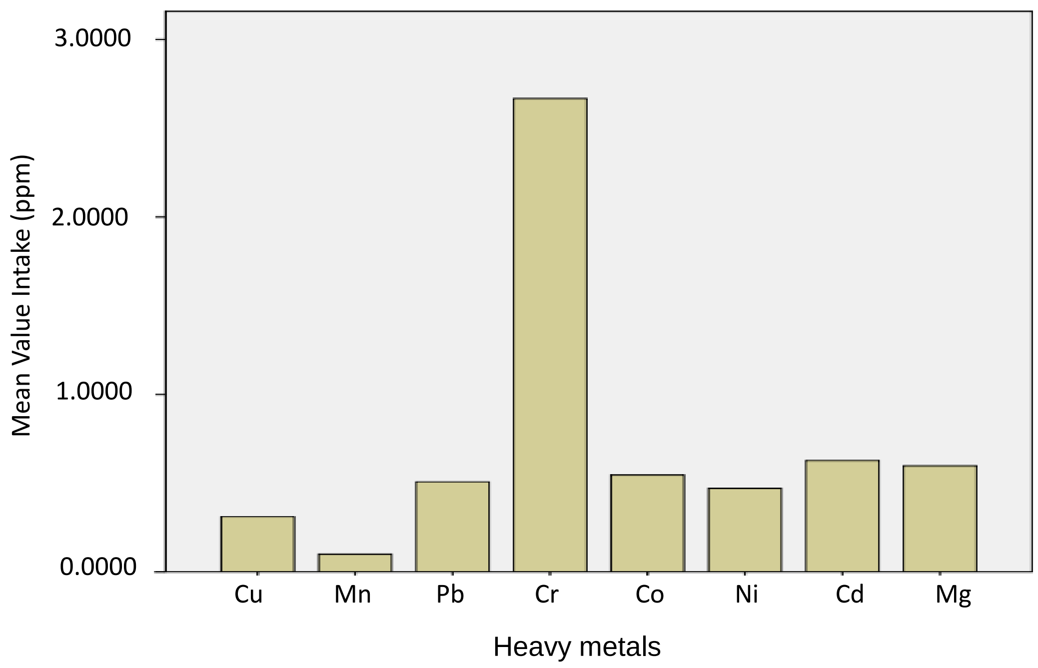


**Fig. 2:** Heavy metals levels on fish intake from sediment.

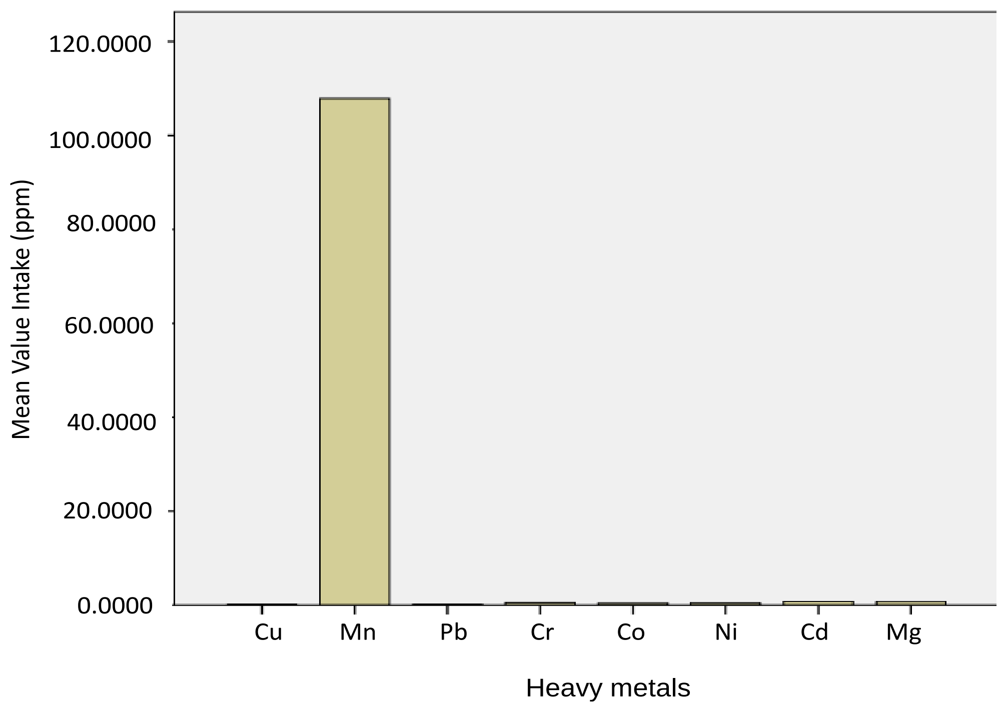


**Fig. 3**: WHO maximum permissible concentrations of heavy metals in fish (WHO, 2011)

Further, comparing Fig. 2 with Fig. 3, only Mn, Cd, and Mg were below the calculated permissible limit for the fish intake from the sediment, other elements exceeded the limit. This shows that the sediment contamination from a high concentration of heavy metals levels affects the fish.

### 3.4. Strategies to mitigate the heavy metal pollution of Dadin Kowa dam

The heavy metal pollution of the Dadin Kowa dam has drawn the attention of various experts such as scientist and regulatory agents concerned with the current situation. There should be the need to enforced regulatory standard and emission of discharges from industries. The discharge of effluents/waste water needs stringent measures not only for health purposes but for ecological and resource conservation. The government should have a framework strategy to broadly survey the Dadin Kowa dam, whereby specific sources of pollution will be identified. Based on the routine monitoring of heavy metals and data analysis, appropriate mitigation measures can be implemented.

The various heavy metals unavoidable anthropogenic activities leading into the dam investigated must be monitored. Engagement in activities such as inorganic fertilizer application to the plants and rearing of the animals around the dam should be stopped to avoid contamination of the dam. Inhabitants health examinations should be conducted occasionally for some heavy metals contamination symptoms. In addition, there are some crucial methods to fight heavy metal poisoning and also completely eliminate the exposure. These are; Investment in good drinking water sources and totally avoids direct water tap source. Consumption of different sea food and also the gastro intestinal cleansing if infected. Consumption of liver supporting diet composed of a chelating feature (metal-binding) to ensure total healing among others.

Further research should be conducted on the concentration of additional heavy metals such as As, Fe, Hg, Zn and others that were not studied. Organic constituents such as detergents, mineral oil, pesticides etc, are also recommended for further study.

## 4. Conclusions

The study has shown that in the dam, there was a substantial quantity of heavy metals, though the levels were below WHO maximum permissible levels for Pb, Cu,Cr, Ni, Mg, and Co for the three-categories of samples. The mean of Cd was above the WHO maximum permissible limits in sediment and water in the dam. The study also shows that the concentration mean of Mn was higher in the sediment compared to the water and fish with range 0.43 ppm- 108 ppm. The dam sediment was more polluted than water and fish. This could be credited to the supply of water contaminated with heavy metals flowing into the dam.

Contamination is usually due to surface run-off from surrounding farmlands and other anthropogenic or human activities around the dam. However, the heavy metals accumulate alongside the sediment at the bottom of the dam, without any possibility of flowing out, outflow from the dam only occurs at the surface level. These findings justify the high rate of concentrations of the heavy metals found in the sediment.

## Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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