INTRODUCTION

Rivers are globally crucial freshwater resources, yet face escalating threats to their quality, quantity, and accessibility due to burgeoning human development, industrialization, and population expansion (UN Water, 2018). The ingress of toxic chemicals and heavy metals into river systems arises predominantly from industrial and anthropogenic activities in urban settlements surrounding river basins (Eruteya et al., 2024). Anthropogenic activities in adjacent farmlands heavily influence the types of pollutants introduced into aquatic ecosystems (Adamu et al., 2023; Idris et al., 2019). Notably, mining and smelting operations, untreated effluent disposal, metal chelates from industries, and indiscriminate use of heavy metal-containing fertilizers and pesticides in agriculture represent significant sources of heavy metal contamination (Abubakar et al., 2015; Bashir et al., 2023; Zhang et al., 2023). These activities deteriorate water quality, altering both its physicochemical and biological parameters, rendering it unsuitable not only for domestic purposes but also for various other uses. Consequently, habitat degradation occurs, prompting species migration and endangering reproductive capabilities, these and many other factors are the challenges that prompted this research to determine the level of heavy metal contamination in water and fish tissue within the study area. Heavy metal pollution in aquatic environments has emerged as a global concern due to the indelible nature of these contaminants on aquatic organisms, animals, and humans (JECFA/WHO, 2011). Metals, as environmental pollutants, warrant particular attention owing to their intensive effects on ecosystems, toxicity, and propensity to bioaccumulate in aquatic ecosystems and organisms' body tissues and organs (Bashir et al., 2023; Rinklebe et al., 2019). While certain heavy metals like copper, iron, chromium, and nickel are essential and play crucial roles in biological systems, non-essential metals such as cadmium and lead exhibit toxicity even in trace amounts (Ren et al., 2022). Some heavy metals, notably chromium, lead, cadmium, arsenic, and mercury, pose severe health risks to both humans and aquatic life, including liver and kidney ailments, and act as genotoxic carcinogens (Guo et al., 2010; Jeyakumar et al., 2023; Sarala & Vidya, 2013). Human exposure to heavy metals occurs through various pathways, including ingestion via the food chain, direct ingestion, dermal contact, inhalation of fumes, and ingestion of particles through the mouth and nose (Alizahraei et al., 2023). In surface water environments, ingestion and dermal absorption represent primary exposure routes. Water quality assessment incorporates evaluating the chemical, physical, and biological characteristics of water, considering natural quality, human impacts, and intended uses, particularly those affecting human health and aquatic ecosystems (Idris et al., 2019; U.S. Environmental Protection Agency, 2011). Water quality standards, tailored to specific environmental conditions, ecosystems, and intended uses, vary significantly for surface waters like lakes, rivers, and oceans (JECFA/WHO, 2011). These standards aim to safeguard human health, ecosystem integrity, and recreational activities, especially concerning fisheries and endangered species. Furthermore, recent research revealed that, there is prevalent increase in kidney related problems within Hadejia Emirate, and Babban Wuya River have been the source of water and fish for the community within the study area. Therefore, the objective of this study is to assess the levels of selected heavy metal contamination in water and fish tissues from Babban Wuya Madachi River using Atomic Absorption Spectroscopy (AAS).
MATERIALS AND METHODS

Description of the Study Area
Madachi village is situated in the Kiri Kasamma Local Government Area of Jigawa State, Nigeria, at geographical coordinates 12°34’27.9”N (12.575601 North) and 10°12’19.6”E (10.205350 East). Babban Wuya Madachi River has been extensively utilized by the local populace for various purposes including domestic use, transportation, agricultural activities, plantation irrigation, and small-scale fishing.

Water Sample Collection
The water samples were collected using the grab sampling technique, where samples were manually collected by directly submerging the bottle into the water. To minimize the risk of contamination, polyethylene sampling bottles were utilized for sample collection and accurately labeled. Prior to sample collection, the sampling bottles were pre-conditioned with 5% nitric acid and thoroughly rinsed with distilled deionized water. Upon reaching the sampling site, the polyethylene sampling bottles underwent three rinses before sampling commenced. These pre-cleaned bottles were then submerged approximately 10 cm below the water surface, and approximately 0.5 L of water sample was collected at each sampling site. To preserve the samples, they were acidified with 10% HNO3, placed in an ice bath for temperature control, and promptly transported to the laboratory for analysis.

Fish Sample Collection
The samples of Tilapia and Catfish were purchased at the riverbank of Babban Wuya River after being caught by a fisherman using fishing net. Fish samples were promptly placed in bags and preserved on ice to maintain freshness for undergoing heavy metals analysis, ensuring compliance with the required analytical holding times. The fish samples were collected at 3 different location within the riverbank of the study area to ensure spatial validity of the study.

Water Sample Digestion
About 100 mL of the water sample was measured using a measuring cylinder, and 5 mL of concentrated hydrochloric acid (HCl) was added to it. The solution was then transferred into a conical flask and heated on a hot plate for approximately one hour and thirty minutes at 100°C. After reducing the volume to 25 mL, it was transferred into a 100 mL volumetric flask, and distilled water was added to fill it up to the mark. The solution was then filtered using a 0.45 μm filter and transferred into a pre-cleaned sample bottle for further analysis using Atomic Absorption Spectrometry (AAS).

Results and Discussion

Table 1: Mean concentration of heavy metals in water samples with WHO standard limit in mg/kg

<table>
<thead>
<tr>
<th>Samples</th>
<th>Zn</th>
<th>Cu</th>
<th>Pb</th>
<th>Cd</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.056 ± 0.001</td>
<td>0.262 ± 0.002</td>
<td>BDL</td>
<td>BDL</td>
</tr>
<tr>
<td>B</td>
<td>0.049 ± 0.002</td>
<td>0.022 ± 0.003</td>
<td>BDL</td>
<td>BDL</td>
</tr>
<tr>
<td>C</td>
<td>0.095 ± 0.001</td>
<td>0.125 ± 0.002</td>
<td>0.063 ± 0.026</td>
<td>BDL</td>
</tr>
<tr>
<td>D</td>
<td>0.090 ± 0.001</td>
<td>0.053 ± 0.004</td>
<td>0.048 ± 0.019</td>
<td>BDL</td>
</tr>
<tr>
<td>E</td>
<td>0.075 ± 0.000</td>
<td>0.050 ± 0.003</td>
<td>0.022 ± 0.011</td>
<td>BDL</td>
</tr>
<tr>
<td>F</td>
<td>0.050 ± 0.001</td>
<td>0.250 ± 0.003</td>
<td>0.080 ± 0.021</td>
<td>BDL</td>
</tr>
<tr>
<td>G</td>
<td>0.068 ± 0.001</td>
<td>0.275 ± 0.003</td>
<td>0.007 ± 0.015</td>
<td>BDL</td>
</tr>
<tr>
<td>H</td>
<td>0.060 ± 0.001</td>
<td>0.058 ± 0.001</td>
<td>0.110 ± 0.023</td>
<td>BDL</td>
</tr>
<tr>
<td>I</td>
<td>0.057 ± 0.001</td>
<td>0.046 ± 0.004</td>
<td>0.049 ± 0.032</td>
<td>BDL</td>
</tr>
<tr>
<td>J</td>
<td>0.068 ± 0.001</td>
<td>0.038 ± 0.006</td>
<td>0.020 ± 0.027</td>
<td>BDL</td>
</tr>
<tr>
<td>WHO</td>
<td>3.00</td>
<td>2.00</td>
<td>0.01</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note: BDL = Below detection limit, WHO = World Health Organization.
Figure 1: Concentration of Heavy Metals in Water in mg/L.

Tilapia Fish

Table 2: Mean concentration of heavy metals in Tilapia fish samples with WHO standard limit in mg/kg

<table>
<thead>
<tr>
<th>Samples</th>
<th>Zn</th>
<th>Cu</th>
<th>Pb</th>
<th>Cd</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>56.15 ± 0.38</td>
<td>2.96 ± 0.12</td>
<td>8.40 ± 0.17</td>
<td>0.89 ± 0.02</td>
</tr>
<tr>
<td>B</td>
<td>45.54 ± 0.05</td>
<td>2.71 ± 0.42</td>
<td>7.37 ± 1.38</td>
<td>0.70 ± 0.02</td>
</tr>
<tr>
<td>Mean</td>
<td>50.85 ± 0.22</td>
<td>2.84 ± 0.27</td>
<td>7.89 ± 0.78</td>
<td>0.80 ± 0.02</td>
</tr>
<tr>
<td>WHO</td>
<td>5.00</td>
<td>2.25</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Figure 2: Concentration of Heavy Metals in Tilapia Fish in mg/kg
Discussion

Table 1 shows the concentration of heavy metals in the water samples in mg/L. Concentration of Zn is found to be 0.056, 0.049, 0.095, 0.090, 0.075, 0.068, 0.060, 0.057 and 0.068 mg/kg respectively for all the samples, which is far below the standard limit set by WHO of 3 mg/kg. Similarly, concentration of Cu was revealed to be 0.262, 0.022, 0.125, 0.053, 0.050, 0.250, 0.275, 0.058, 0.046 and 0.038 mg/kg respectively in all the samples is below the WHO standard limit of 2 mg/kg. However, concentration of Pb in sample A & B are not detected. Similarly, concentration in other samples are reported to be above the WHO standard limit of 0.01 mg/kg as 0.063, 0.048, 0.022, 0.080, 0.0110, 0.049 and 0.020 mg/kg for samples C, D, E, F, H, I and J respectively, except for sample H as 0.007 mg/L which is almost in line with the standard. Moreover, Cd is not detected in all samples as reported in Table 1 and this can all be seen in figure 1.

Table 2 and 3 shows the total extractable concentration of heavy metals in fish samples (Tilapia and Catfish) in mg/kg. For Table 2, the result shows that the concentration of Zn for samples A and B are 56.15 and 45.54 mg/kg respectively, which is far above the World Health Organization (WHO) standard of 5.00mg/kg and this can also be seen in figure 2, it was reported by () that, Zinc poisoning may results in constipation, abdominal pain, headache and loss of appetite. Similarly, for Table 3, the result is 33.28, 34.46 for samples A and B respectively and this presented in figure 3.

Furthermore, concentration of Cu in both samples is within WHO standard limit of 2.25mg/kg, except for sample D which is Catfish with concentration of 0.67mg/kg which is below the standard limit this can be seen from figure 3. Lead and Cadmium were also detected in both samples of Tilapia as 8.40 and 7.37 mg/kg for Pb and 0.89 and 0.70 mg/kg for Cadmium. Similarly, 4.59 and 2.89 was reported for Pb and 0.44 and 0.21 mg/kg for Cadmium in Catfish respectively and this exceeded WHO standard limits of 0.01 mg/kg and 0.01 mg/kg respectively, this can be observed in figure 2 and figure 3. Cadmium as a byproduct of zinc, it has a unique behavior that once absorbed by man it retained in the body system for long and accumulate to cause kidney problems and born demineralization through direct bone damage or indirect through renal dysfunction. However, Pb poisoning is as a result of consistent absorption over time and it can cause loss of memory, weakness and tingling in feet and hands.

CONCLUSION

This study was carried out to provide information on heavy metal concentration in water and fish which can cause health risk to the human beings that consume them. The level of heavy metals in fish tissue indicates the presence of the heavy metals in fishes from Babban Wuya Madachi River. The Concentration of Zinc (Zn), Lead (Pb), and Cadmium (Cd) exceeded respective maximum limits, while concentration of Copper (Cu) is within the standard in all fish samples. Whereas the concentration of Zn, and Cu in water are below the limits with exception Pb that exceeded the limit,
Cd that is not detected in all water samples. The result further indicated that the fishes highly contaminated by heavy metals and exceeded WHO recommended limit. Meanwhile the water is safe.

Consequently, implementing stricter regulations on industrial discharges, promoting sustainable agricultural practices to minimize runoff, or implementing community-based initiatives for water quality management is highly recommended.

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REFERENCES


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