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Concentration of Cadmium (Heavy Metal) in Water, Sediments, and Catfish in River Benue at Mayo Renawo, Taraba State, Nigeria.

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ABSTRACT
The objective of the research was to ascertain the cadmium levels in water, sediments, and the catfish species (*Clarias anguillaris*) collected at River Benue in Mayo Renawo, Taraba State, Nigeria. The river is exposed to high input of agricultural run-off, waste dumping, bathing, washing, market waste. In this study Cadmium (Cd) was seasonally determined in wet and dry seasons. Analysis of the concentrations of the Cadmium was carried out using spectroscopy. This study revealed that Cd has the lowest value of the concentration in Munci and Mabaka stations with an equal value of (0.02 ± 0.00) in fish during dry season and increase progressively in Mahanga station with (0.03 ± 0.01). Cd was not detected in all the whole stations in wet season. In water it indicated that station 1 with 0.09± 0.02 has the highest concentration in both dry and wet and lowest in station 2 in wet with 0.01 ± 0.00 but not detected in station 2 in wet. In sediment it revealed that the concentration was high in dry season with highest in station Munci and Mahanga with equal concentration of 0.04 ± 0.02 but differ in Mahanga station with 0.03 ± 0.01 while wet season has the lowest concentration in station 3 with 0.01 ± 0.003 and with 0.01 ± 0.01 in station 2 while station 1 with 0.02 ± 0.003 with a seasonal variation of 0.04 in dry and 0.02 in wet. The following recommendation is noteworthy: As opposed to being disposed of haphazardly, all solid waste should be recycled.

Keywords:
Cadmium, fish, Sediment, water, Concentration.

INTRODUCTION

Cadmium is heavy metal described as element possessing high atomic number and atomic weight (Smaila *et al.*, 2025) Heavy metals in environmental trash continue to be extremely harmful to aquatic life because they are not biodegradable, in contrast to other types of pollutants that can be fully removed by biodegradation (Sivabalan V., & Aruldoss K., 2022). Considering their possible health effects, heavy metals like cadmium can pollute fish and water sources and provide a major risk to human health when ingested (Samaila *et al.*, 2025). Usually inhaled, this metal is carcinogenic and corrosive that damages tissue. Because it is more mobile in the aquatic environment than most other metals and is a by-product of the mining and smelting of zinc and lead, cadmium toxicity is characterized by chest discomfort and lung lining caused by an excessive collection of watery fluids (Muazu *et al.*, 2023). However, the environment and human health may suffer if these heavy metals are found in surface soil, water, air, and sediments (Emmanuel *et al.*, 2018).

The depletion of red blood cells, kidney damage, and severe osteomalacia (bone disease) are all consequences of cadmium, which has been discovered to be bio-accumulated by benthic bacteria, plants, and other aquatic biota (Barau *et al*., 2020). Although cadmium does not decompose in its elemental state, it can transform into various species and compounds. Depending mostly on how acidic the surrounding water is, certain species can cling firmly to soil or sediment particles.However, Since fish cannot escape the negative effects of pollutants, they are more vulnerable and heavily exposed to cadmium because they feed and live in aquatic environments (Mehana *et al.*, 2020). Because aquatic life and water bodies are in close proximity to one another, aquatic life is capable of taking in heavy metals from water bodies (Hong *et al.*, 2020). Although they live and feed in the water environment by nature, fish are particularly vulnerable to heavy metal insults and have significant limitations when it comes to avoiding the harmful effects of heavy metal pollution (Ahmed *et al.*, 2020; Keke *et al.*, 2020).

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Through their skin and gills, as well as by consuming food contaminated with heavy metals, fish eventually absorb heavy metals directly from the water (Hassan *et al.,* 2018; Keke *et al.,* 2020. Since this was the first study conducted in those areas, it was known that the water there was unfit for human consumption, and that eating fish from those areas would undoubtedly have an adverse effect on human health because of the harmful effects of cadmium.

MATERIALS AND METHODS

Study Area

The present study focuses on three locations that are located at the bank of river
Benue, Taraba state at Mayo Renawo. The Benue River, previously known as the Chadda River is a major tributary of the Niger River. It is approximately 1,400km (870 mi) long and is almost entirely navigational during the summer (dry) months. As a result, it provides an important transportation route in the regions through which it flows. The river rises from the Adamawa Plateau of Northern Cameroun, flowing West through the town of Garoua and Lagdo Reservoir into Nigeria South of the Mandara Mountains, and through Jimeta to Numan, Lau, Mayo Ranewo, Ibi and Makurdi before meeting at the confluence town, Lokoja-Kogi State, Nigeria.. (Barau *et al.,* 2020). A greater part of the Benue traverse through Taraba State providing enormous opportunity for farming and fishing activities (Barau *et al.,* 2020).It has a population of about 11,000 people (NPC, 2006; Barau *et al.,* 2020).

Sampling Sites

Three sampling sites were located along the River Benue stretch of Mayo Renawo community.
For accurate sampling, the river was divided in to three sampling stations of about two kilometers distance from each station, namely as station Munci, Mabaka and Mahanga. The sampling stations were selected basically after prefatory study, based on this, Samples were collected on monthly bases from the three sampling sites from consideration as susceptibility, sediment composition, human impact and different events occurring both inside and outside the stations. On the bases of sample locations. the Munci which is station 1 has the latitude of 8^0 48^l $30''$ N while the longitude is 10^0 52^l $00''$ E and approximate location was somewhat upstream or west bank. But Mabaka which is station 2 has the latitude of 8^o $50'$ $00''$ N and has the longitude of 10^o 54^l $00''$ E with the approximate location near middle of the stretch. And Mahanga which is station 3 has the latitude of 8^o 50^l $30''$ and the longitude was 10^o 53^l $30''$ E with the approximate location more toward downstream side.

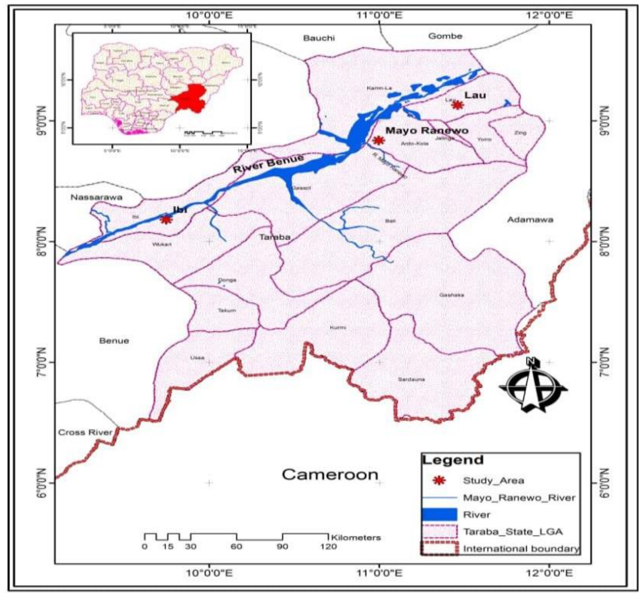

Figure 1 Map of study Area (Barau *et al.,* 2020)

Sampling Method

Six complete months of field work were carried out in mayo ranewo of river Benue which covered both dry and rainy seasons (January to march) and rainy from (July to September). The three sample stations were visited on the same day. Surface Samples of water and bottom were gathered from the three distinct stations. (Munci, Mabaka and Mahanga) within the same river collected randomly from the three sampling stations of River Benue at Mayo Renown for the period of six months. Nine fish species were bought from local fishermen at three landing sites at the river in the two seasons. These fish species were promptly kept in an ice box and transported to the Federal University of Wukari's Central Laboratory where they were kept frozen at −20 ^{0}C until further analysis. (Barau *et al.,* 2013) state that water samples were taken using a 1-liter water sampler, then put into a sterile 250-ml plastic bottle and acidified with nitric acid (HNO3).

Procedure for the collected samples (water, sediments, and fish) were taken to the laboratory of the Federal University of Wukari in Taraba State for heavy metals examination using a Spectrophotometer for Atomic Absorption (AAS).

Analysis of Metals via Sample Digestion

Digestion of Water Sample

The digestion of water sample was done according to Rahmanian *et al.* (2015).
The steps involved in the digestion process are listed below:

100 ml of 10 ml of concentrated HNO3 were added to a 250 ml beaker containing the measured water sample.After being place on a hot plate, the mixture boiled until the color of the solution become colorless, clear and the volume reduce to about 30 ml of volume, making certain that the sample does not boil.The mixture was filtered and transferred into a 100 ml sample bottle and filled it with deionized water to the 100 ml mark for metal analysis with an AAS device. The flame atomic absorption spectrophotometer was aspirated with standard solutions and samples. Plotting the calibration curves and determining the samples' concentration through extrapolation.

Digestion of Fish Samples for Metal Analysis
The digestion of fish sample was according to Plessis (2012). The steps involved in the digestion process are listed below:
1.0 g of fish sample into a 25 ml beaker, Add 10 ml of analytical-grade concentrated HNO3 into the beaker, a watch glass was positioned at the beaker's mouth; the beaker was set on a hot plate, magnetic stirrer, or other device; the temperature was controlled to 40°C for an hour to avoid a strong reaction; the temperature was then kept at 140°C for three more hours; the d igestion was finished when all tissue samples had fully dissolved in the acid. Room temperature.
To dilute the liquid for heavy metal AAS detection, double as much distilled water was was used to cool the mixture added to the vessel.Whatmann No.1 grade filter paper was used to filter the sample. The filterate was kept at 4°C until AAS determined the metal content.

Digestion of sediment sample
The digestion was carried out according to the method of Awode *et al.* (2008)
The steps involved in the digestion process are 1000 g of sediment sample was air-dried on a clean table surface in the Laboratory for 48 hours, It was further dried to a constant weight in an Oven at a relatively low temperature of 30℃, The dried sediment sample was crushed using pistle and mortar.The crushed sediment sample was sieved using 2 mm mesh to provide a more uniform grain distribution and to prevent the impact of particle size, 20 ml of nitric acid (HNO3) and 10 ml of perchloric acid (HCLO4) were added to a 250 ml beaker containing 2 g of the sieved sediment sample. The combination was heated for two hours at 120 °C in a Foss digester. The digested sample was then allowed to cool before being diluted with deionized water. The diluted digested sample was then filtered and kept at 4 °C in preparation for heavy metal AAS analysis.

- **Preparation of Sample and Aqueous Stock Solutions for AAS Analysis**

Cadmium solution
The solution was 2.744 g of Cd (NO3)2. 4H2O will be dissolved in 5 ml of concentrated HNO3 to create a solution that may be filled to 1000 ml with distilled water in a volumetric flask, obtaining 1000 mg/L of cadmium stock solution.

Data Analysis
The Statistical Package for Social Sciences (SPSS) 22.0 was used to analyze the data. Analysis was done on the averages and standard deviations of the metal concentrations in fish species. The significant differences at $p < 0.05$ for the metal among several seasons, stations, and fish species were examined using multivariate post hoc Duncan multiple range tests and the Pearson correlation coefficient.

RESULTS AND DISCUSSION

Mean Variations of Cadmium.
Tables 1: showed the mean variations of Cadmium (heavy metal) in fish from River Benue at Mayo Ranewo in dry and wet seasons. It was observed that cadmium concentrations was not detected in wet season in all the three stations

Heavy Metal	Munci 1	Mabaka 2	Mahanga 3	FAO/WHO 2021
Cadmium (mg/kg)-Dry	0.02 ± 0.00	0.02 ± 0.00	0.03 ± 0.01	2.0
Cadmium (mg/kg)-Wet	ND	ND	ND	2.0

FAO/WHO (2021) = Joint FAO/WHO Food Standards Programme Codex Committee on Food Contaminants. Commission on Codex Alimentarius

[a, ab] (significant values)

Mean Variations of Cadmium of (Heavy Metal) in Water from River Benue at Mayo Ranewo, Taraba State.
Table 2. Mean variations of Cadmium concentration in water from River Benue at Mayo Ranewo in dry season according to sampled stations in this table it was revealed that dry season had the highest concentration of cadmium which is above the standard limit.

Heavy Metal	Munci 1	Mabaka 2	Mahanga 3	FMENV 2011	SON 2015
Cadmium (mg//)-Dry	0.09 ± 0.02	0.05 ± 0.01	0.07 ± 0.01	0.005	0.003
Cadmium (mg//)-Wet	0.01 ± 0.00	0.00	0.01 ± 0.003	0.005	0.003

Mean Variations of Cadmium (Heavy Metal) in Sediment from River Benue at Mayo Ranewo, Taraba State

The mean variations of cadmium (heavy metal) in sediments in dry and wet season is presented in Table 3, The concentrations of cadmium in the three sampled stations varies from each other according to the seasons, it revealed that there was an increase in concentration of cadmium in dry season than the wet.

Table 3: Mean variations of Cadmium

Heavy Metal	Munci 1	Mabaka 2	Mahanga 3	CCME (2002)
Cadmium (mg/kg)-Dry	0.04 ± 0.02	0.03 ± 0.01	0.04 ± 0.02	0.6
Cadmium (mg/kg)-Wet	0.02 ± 0.003	0.01 ± 0.01	0.01 ± 0.00 3	0.6

CCME (2002) = Canadian Sediment Quality Guidelines for the Protection of Aquatic Life.
[a, ab] (significant values)

Globally, contaminations are washed into water bodies from industrial, agricultural and domestic activities. Among these contaminants is the cadmium (heavy metals), which is a significant contaminant of waterways. Both plants and animals contain cadmium, which when consumed as food can have negative health effects (Shirani *et al*., 2020). The detrimental effects of heavy metals on the body when they are taken in excess of the permissible limits are known as the bio-toxic effect of cadmium (Buba *et al*., 2022). The effects may be mutagenic, teratogenic, neurotoxic, or carcinogenic (Goje *et al*., 2017). The amounts of cadmium (Cd) in the catfish used in this study ranged from 0.02 to 0.3 mg/kg during the dry season and 0.0 mg/kg during the wet season.with no Cd detected in wet seasons in fish were both at low the standard limit concentration in fish according to FAO/WHO (2021).

Cadmium (Heavy Metal) in Water from River Benue at Mayo Ranewo

The Cadmium concentrations recorded in the studied river was higher than standard limits(FMENV, 2011) for portable water, especially during the dry season. In the wetseason, cadmium was recorded to be higher than the standard limits (FMENV, 2011). Also, the heavy metals in water had higher concentrations than the standard limits according to SON (2015). This study recorded a range of 0.05-0.09 mg/L for Cadmium during the dry season, and 0.01 – 0.003) mg/L during the wet season. There was an indication that inhabitants of the area drink from the river, aquatic life abound in the water and can bio accumulate this metal and subsequently transfer it to consumers. Similar finding was reported in the work by Tyovenda *et al*. (2018) which showed that Cadmium had values above the maximum permissible limits for drinking water. The study by Membere and Abdulwasiu (2020) also reported higher levels of cadmium in water samples is higher than the acceptable limit. The previous work by (Briffa *et al*., 2020) reported that cadmium concentrations averaged 0.024 mg/L and 0.015 mg/L, respectively and above the allowable limits. Cadmium concentration above the established standard is possibly as a result of agrochemicals rich in its compounds which eventually enter the water and raise the concentration. Cadmium is harmful at extremely low level in humans, with long term exposure leading in renal failure, symbolized by tubular proteinuria Sivabalan & Aruldoss (2022).

Cadmium (Heavy Metal) in Sediment from River Benue at Mayo Ranewo

Since the three stations are not above the limit, they aren't contaminated. With a maximum concentration of 0.04 ± 0.02 mg/kg below the levels reported by (Shirani *et al*.,2020) and Emmanuel *et al*. (2018), the cadmium concentrations in the three locations are below the reference value. Contaminant is a worldwide problem that builds up in the liver, kidneys, spleen, aorta, and bones as people age. Through ingestion of food, water, or air, this metal can enter the body. Emmanuel & associates (2018). According to (Zheng *et al.*,2012), sediment has the ability to retain metal elements over time and then release them into the water column during re-suspension periods. The higher levels of heavy metals in the sediment, as opposed to the lower levels in the water from the current study, were consistent with their findings. Research also showed that the concentrations of heavy metals in sediment are higher than those in water (Tabrez *et al.*, 2021).

CONCLUSION

This study showed high level of Cadmium pollution in River Benue at Mayo Renawo, Taraba State. The pollutions occurred at the fish and water samples, at levels that can constitute serious health problems for the inhabitants of this area. The fish in Station 3 appeared to be safe for human consumption as the heavy cadmium levels fall within the standard limits. Increased concentrations of the cadmium were observed to be greater in the dry season instead of to the wet one. The sediment had lower concentrations of the cadmium than the standard limits. The heavy metal site pollution assessed in this study demonstrates that the level of contamination ofcadmium varied according to the stations. It can be concluded that the water of the River Benue at Mayo Renawo is rather of poor quality, as shown by its elevated levels of cadmium which is above the standard allowable limits. Therefore, further supervision is needed in the river to preserve biodiversity and aquatic biota in the future. Efforts should be directed towards remediating the water body and stopping the discharge of pollutants into the river. The following recommendations are noteworthy: (i) All solid waste should be recycled rather than disposed of carelessly; (ii) liquid wastes, like industrial effluents, should be treated before being disposed of; and agricultural operations should use as few or no environmentally harmful chemicals as possible.

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