

ASSESSMENT OF INDUSTRIAL EFFLUENTS ON WATER QUALITY OF CHALLAWA RIVER, KANO, NORTH-WESTERN NIGERIA

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Abstract

Challawa River provides the nearby communities and parts of Kano municipality with various domestic and economic benefits. However, urbanization industrialization, agrochemicals input via human activities increasingly polluted the water body leading to depletion of biota and water quality. The present study assessed the pollution status of Challawa River, Kano State using heavy metals concentrations in water and sediment between January and August, 2024. Heavy metals concentrations analyses were carried out standard protocols. Samples were collected monthly between 7:00 – 8:00am from four (4) sampling sites designated as A, B, C and D based on differences on the impact of human input along the River channel. The results revealed that concentrations in water followed the order: Copper (Cu) with 1.51mg/L > Chromium (1.17mg/L) > Lead (0.94mg/L) > Cadmium (0.31mg/L). Heavy metals concentration in sediment had the following means with Cu 2.45mg/kg > Cr (1.87mg/kg) > Pb (1.85mg/kg) > Cd (0.55mg/kg). Heavy metal concentrations in vegetables revealed a significant decrease ($p < 0.05$) in lettuce in the order of decreasing concentration in lettuce (Cu > Pb > Cr > Cd), However, a corresponding increase ($P < 0.05$) was obtained in the tissues of tomatoes in the following order: (Cr > Pb > Cd > Cu). Heavy metals concentrations recorded were higher than FAO/WHO (2023) recommended limit with the exception of Cd. Pearsons' correlation coefficient revealed a strong positive correlations with pH, turbidity, EC, Cr Cc, Cd and Pb ($P < 0.01$) while negative correlations were reported with temperature, TDS and Cr ($p < 0.01$). It can be deduced that heavy metals bioaccumulation in the samples examined is attributed to the influx of contaminants into the river usually from the industrial effluent which altered the water quality leading to depletion of biota. It is recommended that indiscriminate release of pollutants should be minimized in order to avert degradation of the river in the long run.

Key words: Bioaccumulation, Pollution, Heavy metals, Irrigation, Vegetables, Challawa River

Introduction

Water is an essential and invaluable resource provided by nature that plays a vital role in the existence of all living organisms (Nascimento *et al.*, 2020). The significance of water extends to sustaining sustainable livelihoods, as it is impossible for any individual to survive without it (Matta *et al.*, 2022). The importance of water to life on earth, particularly to human beings, becomes clearer when one considers its role or usefulness in various aspects of human endeavor (Yaradua *et al.*, 2018). Availability of portable public water supply in Kano is of great concern to communities especially in urban areas where provision of portable water is lacking (WHO, 2021). Unavailability of safe drinking water is a threat to public health and well-being of the people and exposes them to risk of waterborne diseases such as diarrheal and dysentery as well as chemical intoxication (Sani *et al.*, 2020). With the rapid increase in urbanization of Kano metropolis and its surroundings, contamination of the ground water become a devastating issue by industrialization, domestic input, waste disposal, among other causes which contributes significantly in altering the ground water quality (Jibrin *et al.*, 2021).

Heavy metal pollution is a worldwide issue that has drawn the attention of researchers, and one of the main challenges in cleaning up heavy metal-polluted soil is that these metals are not biodegradable (Jamila and Sule, 2023). Heavy metals are now the most prevalent environmental contaminants in Kano State as a result of its fast industrialization (Sani *et al.*, 2020). Long-term ingestion of foods tainted with heavy metals causes the body to continuously accumulate poisons, especially in sensitive organs, which disrupts biochemical pathways (FAO/WHO, 2023). According to Amao *et al.* (2018), phytotoxicity, or the toxicity of heavy metals in vegetables, impacts their growth and development and results in oxidative stress, cytotoxicity, and genotoxicity. Heavy metals in aquatic environment alter water quality, adsorbed on to sediments, biomagnify in aquatic biota leading to of morpho-physiological alteration and DNA damage (Habu *et al.*, 2021). In Kano, the socioeconomic activities along Challawa River are observed to pollute the water body. Notable among industries that use water from the Challawa River and discharge wastewaters into the river are textile, plastic, tin factories among others. Therefore, the aim of this research is to investigate assessment of impact of industrial effluents on the water quality of Challawa River, Kano, North-western Nigeria.

MATERIALS AND METHODS

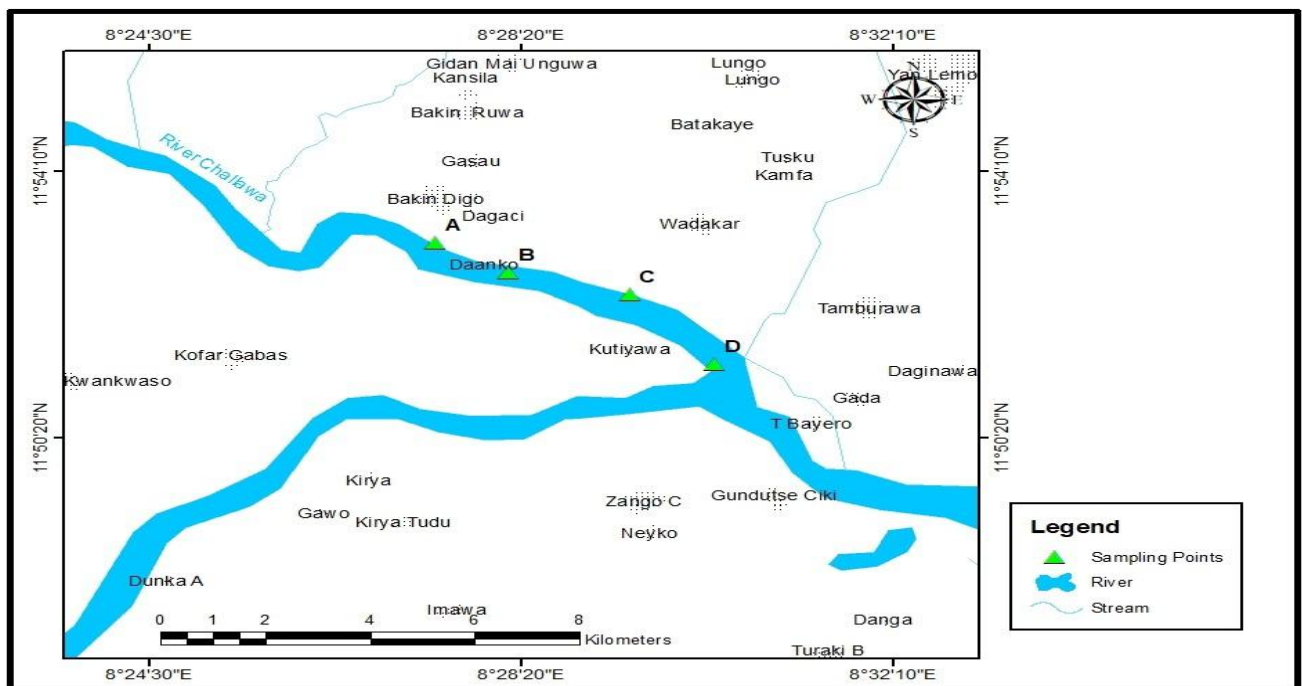
Study Area

Challawa River originates from the Challawa Gorge dam in Challawa village, Kano, Northwest Nigeria. River Challawa is the second largest river system in Kano state after river Kano. It is about 50 km in length flowing northeast to finally join river Hadejia. It has a confluence with river Kano at Tamburawa that is located around 20km south of Kano metropolis. The river represents a major source of water for agricultural, industrial and domestic activities in Kano metropolis and its environs. This is obvious in the fact that the main waterworks of Kano state that supply drinking water is located by the river and source freshwater therein. Major industrial layouts, Sharada Industrial Estate and Challawa industrial Estate are situated around the river and largely depend on the water works for its water needs. Effluents from the industrial estate, often, ends up drained into the river.

Challawa River is located within latitude 11°55'N and longitude 8°22'E and is considered as second largest river in Kano State after Kano River. It made a confluence with Kano River at Tamburawa village, about 20km from Kano closed settled zone and flows to the northeast joining Hadejia River. Geomorphologic characteristics and the climate of the area were well

described by Olofin (2011). For decades; this river basin sustains local communities along its course particularly for agricultural activities. Similarly, the Kano State main waterworks treatment plant (Challawa Waterworks) is situated on this river, thus, providing source of water for agricultural, industrial and domestic purposes in Kano metropolis.

Thus, the river provides sources of water for agricultural, industrial and domestic purposes in Kano metropolis. In addition, one of the major industrial estates in Kano is located around the river system i.e. the Challawa Industrial Estate and depends largely on the waterworks for its water needs. Similarly, significant parts of the urban Kano population rely heavily on the water for their domestic activities although the new Tamburawa Waterworks in alleviating some of the water needs in the state. This waterworks was hoped to provide 150 million M³ of potable water daily.



Source :Cartography Lab Geography Department BUK

Figure 1: Map of Challawa River Showing Marked Sampling Sites (Source: Cartography Lab, Bayero University, Kano)

3.2 Sampling Sites

Four (4) sampling sites were selected for the purpose of this study based on differences in their anthropological conditions as follows:

Site A: (Challawa) this site (N 11°52.718', E 008°28.183') is near the river intake point (the point at which the Kano State Waterworks draws its raw river water to the treatment plant for purification purposes).

Site B: (Dandanko) this site (N 11°52.689', E 008°28.001') is on the watercourse of the Challawa River and extends some 120 meters west to the edge of the new bridge leading to Garu village. At this site, human activities such as fishing, washing, sand collection and other domestic activities are taking place regularly.

Site C: (Tsamawa) this is the site (N 11°52.745', E 008°28.473') where raw industrial effluent, primarily from food, textile and tannery industries is discharged in to the river. At this site, agricultural activities, fishing and other activities are taking place.

Site D: This is at Tamburawa, near the bridge (N 11°45'61'', E 8°7'89''); where Challawa River forms a confluence with Kano River along Kano-Zaria Road. At this site, agricultural activities, fishing and other activities are taking place. This site is near the new Tamburawa Water Treatment Plant.

Water Sampling

Water samples were collected from the four sampling sites on monthly basis for a period of eight (8) months (January to August, 2024) cutting across two seasons (rainy and dry season). Water samples were collected monthly between 7:00am to 7:30am from the four sampling sites. The choice of the sapling sites is based on the ecological setting and impact of human activities around the river. Site A, Site B, Site C and Site D on the watercourse of the river with 500m distance apart between the sampling sites.

Sample Collection and Analysis

Water and fish sampling were conducted fortnightly for a period of eight months in triplicate. Fish samples were collected using gill nets with the help of the fishers as adopted by Ahmad *et al.* (2018). Sample fishes were immediately, counted, chilled and labeled in ice blocks at the point of collection before being transported to the aquarium at Biological Sciences Department, Bayero University Kano. Sampled fish were weighted to the nearest 0.01g using weighing balance (Ming Heng Digital scale Model MH-777). The total lengths were obtained to the nearest 0.1cm on a modified measuring board and fish species identification was carried out according to the guide of Olaosebikan and Raji (2004).

Collection and Analysis of Heavy metals in Water

Water samples were collected from the three sampling sites in 80ml dark plastic container. The water sample collected was transferred into 250ml beaker and 10ml of HNO₃ was added and heated at 100°C. the samples were allowed to evaporate to about 50ml, later 5ml HNO₃ was further added with continuous heating to a final volume of 15ml. The digested samples were filtered and diluted with distilled water to a final volume of 20ml. Cadmium, Chromium, Copper and Lead concentrations were analyzed in water using Micro Plasma Atomic Emission Spectrometry (MP-AES model) at Centre for Dry land Agriculture Laboratory, Bayero University Kano.

Analysis of Heavy metals in fish organs (gills and liver)

Fish samples were examined for presence heavy metals in the liver and gills using the procedure adopted by Saiyadi *et al.* (2021). The fish samples were carefully cut and the gills and liver were removed and dried in an oven of about 105°C for 24 hours. After drying, the tissues were grounded and milled using a blender. The powdered form was sieved and put in a plastic container and stored in desiccators until digestion. About 0.2g of each sample was weighed and transferred into 250ml beaker of the digestion rotors. Seven (7ml) of HNO₃, 2ml of H₂O₂ and 1ml of HClO₄ were added to the sample, the rotor for the digestion was placed into microwave digestion system and set under animal tissue programming setting. After complete digestion, the digest were filtered through whatman filter paper and diluted to a volume of 20ml. Ten (10ml) of the samples were taken to microwave plasma atomic

spectroscopy (MP-AES) to determine the concentrations of Cu, Cd, Cr and Pb at center for dry land Agriculture (CDA), Bayero University, Kano.

Bio-Accumulation Factor (BAF)

Bioaccumulation factor (BAF) was determined using the protocol described by (Vaseem and Banerjee, 2013):

$$BAF = \frac{M_{\text{tissue}}}{M_{\text{water}}}$$

Where; M tissue is the metal concentration in fish tissue mg/kg and M water, metal concentration in water mg/L.

Statistical Analysis

Data was analyzed using descriptive statistics. The data was also subjected to one way analysis of variance (ANOVA) to determine differences between sites, and where differences existed, they were separated with Duncan multiple range test (DMRT) at 0.05%. Seasonal variations were analyzed using student's independent T-test. All analyses were carried out using SPSS version 20.0 software.

Results and Discussion

Mean concentration of Cu during dry season was 1.92 ± 0.03 mg/L while 1.71 ± 0.91 mg/L was recorded in wet season (Table 1). Cu concentration differed between seasons indicated no significant difference ($p > 0.05$). Seasonally, the highest mean Cr concentration of 0.25 ± 0.14 mg/L was obtained during wet season while was recorded 0.97 ± 0.01 mg/L in dry season. Seasonal variation of Cr differed significantly between seasons ($P < 0.05$). The seasonal variations in the mean Cd concentrations indicated that dry season had 0.01 ± 0.00 mg/L while wet season recorded 0.03 ± 0.10 mg/L. Statistically there was significant difference in Cd concentration between the seasons ($p < 0.05$). The mean seasonal variation of Pb showed that wet season had 1.69 ± 0.56 while 1.07 ± 0.11 mg/L was recorded during dry season. Statistically, Pb revealed significant difference between the two seasons ($p < 0.05$).

Table 1: Seasonal Variation of Heavy metals Concentrations across the Study Sites from Challawa River, Kano State

Water Parameters	Dry season	Wet season	FAO/WHO (2018)
Cu (mg/L)	1.92 ± 0.03^a	1.71 ± 0.91^b	0.2
Cr (mg/L)	0.25 ± 0.14^a	1.97 ± 0.01^b	0.1
Cd (mg/L)	0.01 ± 0.00^b	0.30 ± 0.10^a	0.01
Pb (mg/L)	1.07 ± 0.11^a	1.69 ± 0.01^d	0.05

Values are mean $\pm$ standard deviation. Superscript with same letters in a row revealed no significant differences ($P > 0.05$), F. crit value = 1.09

Table 2: Spatial Variation of Heavy Metals (mg/L) Concentrations in Water from Challawa River, Kano, Nigeria

Parameters	A	B	C	D	BAF	FAO/WHO (2018)
Cu (mg/L)	1.16±0.02 ^a	1.21±0.08 ^a	0.81±0.01 ^a	1.51±0.06 ^a	0.06	2.0
Cr(mg/L)	0.55±0.01 ^a	1.70±0.01 ^a	2.12±0.01 ^a	2.94±0.10 ^a	0.01	0.05
Pb (mg/L)	0.83±0.10 ^a	0.99±0.01 ^a	0.70±0.01 ^a	1.56±0.00 ^a	0.06	0.001
Cd(mg/L)	0.001±0.01 ^b	0.13±0.00 ^a	0.02±0.01 ^b	0.49±0.03 ^b	0.001	0.05

The mean monthly range of Pb values varied from 0.45±0.10mg/L to 1.83±0.13 in September and June respectively. Pb concentrations differed significantly ($p<0.05$) between the months. Significant difference ($p<0.05$) was recorded in Cu concentrations with August having highest concentration of 1.86±0.27mg/L while the lowest concentration was recorded in September of 0.56±0.04mg/L (Table 4.4). Mean monthly values of Cr ranged between 1.89±0.23mg/L in July to 0.17±1.21mg/L in September. Mean monthly Cd values recorded the highest value of 0.67±0.01mg/L in August while 0.61±0.02mg/L was obtained February. Monthly values of Cd did not differ significantly ($p>0.05$) (Figure 2).

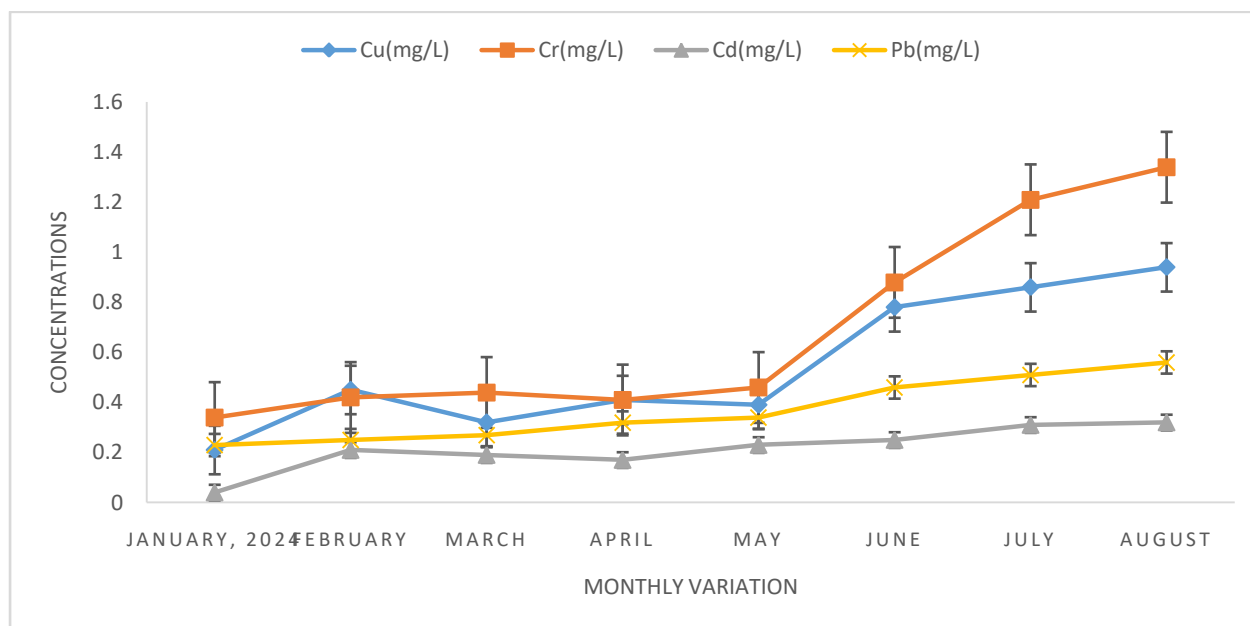


Fig. 2: Mean Monthly Values of Heavy metals in Water obtained from Challawa River, Kano State

Table 3, illustrates the values for Pearson Correlation Coefficient of different physicochemical parameters and fish species composition in Challawa River. Temperature showed strong positive correlation with pH, Cd species composition and Electrical Conductivity ($P < 0.01$). Strong positive correlation was recorded between pH and Cu ($P < 0.01$). Turbidity and TDS also had strong positive correlation with Dissolved Oxygen ($P < 0.05$). Electrical conductivity had positive correlation with turbidity. Temperature had negative correlation with BOD, TDS and turbidity ($p < 0.05$). Temperature showed strong positive correlation with pH and Electrical Conductivity ($P < 0.01$). Strong positive correlation was recorded between pH and Cr. ($P < 0.01$). Turbidity, Cu and Pb also had strong positive correlation with Dissolved Oxygen ($P < 0.05$). Electrical conductivity had positive correlation with turbidity. Temperature had negative correlation with BOD, TDS and turbidity ($p < 0.05$). Negative correlation was also reported between Cr and Cd.

Table 3: Pearson's Correlation Coefficient Showing Inter Ion Matrix Relationship between Physical Parameters and Heavy metals Concentration in water

	Temp.	pH	DO	BOD	TDS	Turb	EC	Cr	Cd	Cu	Pb	A	B	C	D
Temp.	1.00														
pH	.456	1.00													
DO	.832*	.465	1.00												
BOD	.328	.320	.209	1.00											
TDS	.726	.758*	-.509	-.189	1.00										
Turb	.474	.338	-.468	-.004	.784*	1.00									
EC	.877*	.361	.753*	.175	.767*	-.801*	1.00								
Cr	.529	.724*	.632*	.242	.764	.794*	.695*	1.00							
Cu	.799*	.257	.238	.287	.429	-.516	.679*	.745*	1.00						
Cd	.775*	.442	.287	.205	-.124	.278	.154	-.011	.219	1.00					
Pb	.826*	-.632*	.253	-.124	.687*	.524	-.630*	-	-.635*	.392*	1.00				
A	.783*	.441	.229	.278	-.360	.012	.256	.385	.631*	.241	.693*	1.00			
B	.562	.382*	.479	.154	-.528	-.420	.577*	.704*	.859*	.272	.595	.655*	1.00		
C	.898*	.392	.430	-.011	-.489	-.468	.495	.352	.236	.403*	-.677*	.309	.578	1.00	
D	.573	-.670*	.451	.219	.263	.263	-.402	-.326	-.498	-.264	.749*	-.410	.562	.863*	1.00

*Correlation Significant at 0.05 (2-tailed) ** Correlation highly Significant at 0.01 (2- tailed)

Seasonal variation of heavy metals in Challawa River is presented in Table 4. The mean concentration of Cu during dry season was $1.92 \pm 0.03 \text{ mg/g}$ while $1.71 \pm 0.91 \text{ mg/g}$ was recorded in wet season. Cu concentration differed between seasons indicated no significant difference ($p > 0.05$). Seasonally, the highest mean Cr concentration of $0.25 \pm 0.15 \text{ mg/g}$ was obtained during wet season while was recorded $0.97 \pm 0.41 \text{ mg/g}$ in dry season. Seasonal variation of Cr differed significantly between seasons ($p < 0.05$). The seasonal variations in the mean Cd concentrations indicated that dry season had $0.01 \pm 0.01 \text{ mg/g}$ while wet season recorded $0.02 \pm 0.10 \text{ mg/g}$. statistically, there was significant difference in Cd concentration between the seasons ($p < 0.05$). The mean seasonal variation of Pb showed that wet season had $1.69 \pm 0.56 \text{ mg/g}$ while $1.07 \pm 0.11 \text{ mg/g}$ was recorded during dry season. Statistically, Pb revealed significant difference between the two seasons ($p < 0.05$).

Table 4: Seasonal Variation of Heavy metal Concentrations in Sediments across the Study Sites from Challawa River, Kano State

Water Parameters	Dry season	Wet season	FAO/WHO (2018)
Cu (mg/g)	1.92 ± 0.03^a	2.11 ± 0.91^b	2.00
Cr(mg/g)	0.97 ± 0.14^a	3.35 ± 0.15^b	0.05
Cd (mg/g)	0.45 ± 0.01^b	1.72 ± 0.10^a	0.01
Pb (mg/g)	1.97 ± 0.11^a	2.10 ± 0.56^d	0.05

Table 5: Spatial Variation of Heavy Metal concentrations in Sediments Obtained from Challawa River, Kano, Nigeria

Parameters (mg/g)	Site A	Site B	Site C	Site D	FAO/WHO (2018)
Cr	0.02 ± 0.10^a	1.03 ± 1.01^a	0.21 ± 0.01^a	3.89 ± 0.10^a	0.05
Cu	1.07 ± 0.01^{ab}	1.15 ± 0.01^{bc}	1.15 ± 0.06^a	1.37 ± 0.01^{ab}	2.0
Pb	0.12 ± 0.02^{ac}	0.06 ± 0.01^a	0.01 ± 0.012^a	2.12 ± 0.02^{ac}	0.001
Cd	0.01 ± 0.01^a	0.11 ± 0.00^{ab}	0.21 ± 0.01^a	1.81 ± 0.01^a	0.05

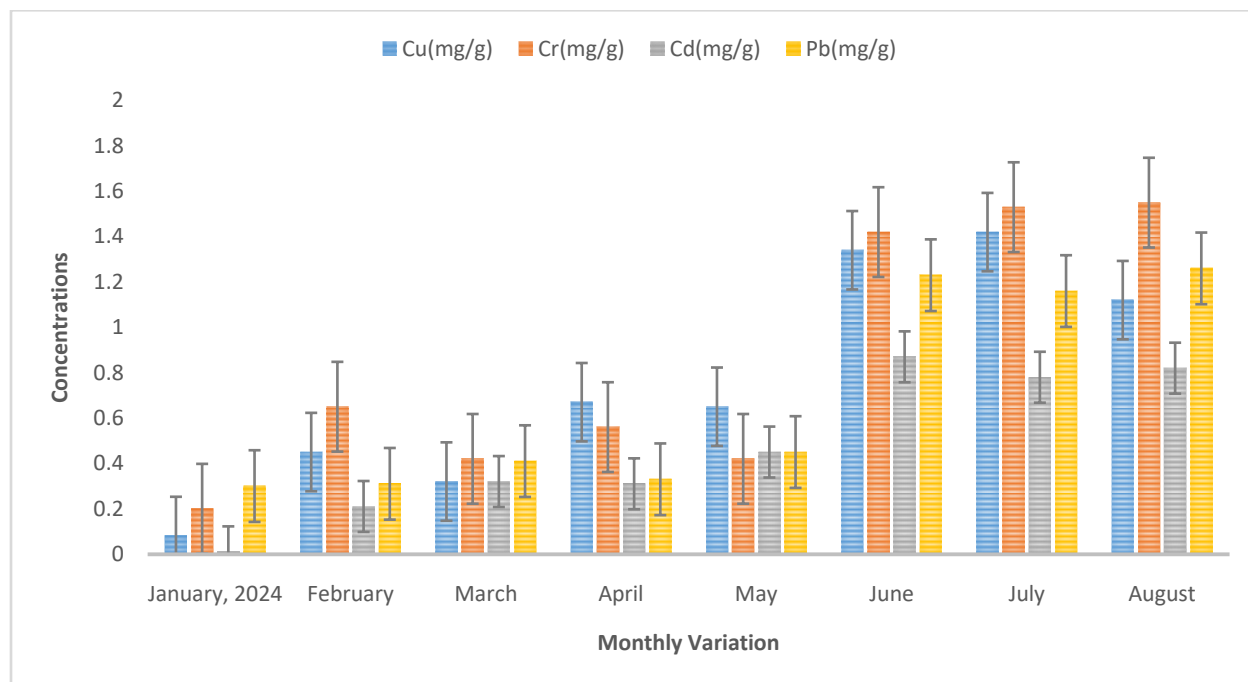


Fig. 3: Mean Monthly Values of Heavy metals in Sediment obtained from Challawa River, Kano State

Discussion

Heavy metals conditions are indispensable ecological factors regulating the physiological activities and distribution of aquatic organisms (Ali *et al.*, 2021). During the study periods, heavy metals concentrations in the water samples decreased in the order of Cr>Pb> Cu> Cd which is in consistent with the findings of Butu *et al.* (2018) from Kafinchiri Reservoir and Thomas Reservoir, Kano State. They reported significantly high chromium concentration in water of 1.4mg/L and 1.51mg/L respectively above the limit set by WHO (2011) of 1.0mg/L. Seasonal variation indicated higher mean Cr values in wet season than in the dry season. Higher mean Cr values in wet season high nutrient from runoff and agrochemical input from nearby farmland as reported by Butu *et al.* (2019). It could also be due to the geological distribution of minerals (organic and inorganic) within the ecological zone.

Chromium is an essential micronutrient in trace quantities for fat and carbohydrate metabolism in living organisms. It is used in industries in steel alloys making, plating and in leather tanning. The concentrations of Cr in the River water ranges from 0.55 – 2.94mg/L, sediment (0.02 – 3.89mg/kg), Lettuce (1.98 – 2.33mg/kg) and Tomatoes (1.01 – 1.71mg/kg) at site A and site D respectively. The range surpasses the recommended limit of FAO/WHO (2018). The mean concentration recorded is lower than what was recorded (432.86 mg/L) by Bichi *et al.* (2013) in Hadejia River. The concentration of Cr recorded is attributed to the presence of industrial activities such as tannery sludge from the tannery industries in the study area. In the Challawa industrial area, there are many functional tannery industries like Globus Tannery, Multitan limited, Ayafa Concepts and Tannery, Gods' Little Tannery, White Gold, Luquat Tannery and so on. The presence of Cr in other sites in River Challawa could be attributed to its natural occurrence in the geology of the area and possible dissolution of Cr bearing minerals beneath the river bed. Similar observation was recorded by Imam(2012) in Jakara River, Kano. The presence

of chromium could be explained by loading the river with debris and effluents produced by various human activities within the reservoir catchment area and disturbance of sediments known to contain high concentration of heavy metals. The presence of Chromium could be due to green leafy vegetables such as spinach, carrots predominantly produced washed in the catchment area.

Pb had the highest mean concentration in sediment of 0.02 – 3.89mg/kg at sampling sites D while lowest range concentrations of 0.02mg/L was recorded at site A. High concentrations of Pb might be due to the deposition and mobilization from gills as reported by Mustapha *et al.* (2013) from Jakara River, Kano, Nigeria. It could also be due to the large influx of runoff from domestic wastes discharged into the River. Introduction of agrichemicals, leaded gasoline by vehicles, paints and cosmetics particles into the reservoir might also contributed in high Pb concentrations. Similar observation for high value of Pb was reported by Imam *et al.* (2020). The concentrations of Pb recorded were above the permissible limit of 0.01mg/kg set by FAOWHO (2018).

High concentrations of heavy metals examined could possibly be due to runoff, from garage and car washes, use of pesticides, fertilizers and discharge of untreated urban and industrial waste (Adamu *et al.*, 2016). This means that Lead is present and poses a threat to the ecosystem and indirectly to man through food chain (Abdullahi *et al.*, 2021). Aquatic environments are very sensitive to trace elements through the coexistence of two phenomena of bioaccumulation and bio magnification through which trace elements are concentrated as they are absorbed into the food chain (Roquia *et al.*, 2022). Heavy metals accumulate in sediments and can eventually be mobilized into the reservoir during the rainy and dry season. The heavy metal in water during the study period exhibited this trend in concentration $Cr > Pb > Cu > Cd$. Samir *et al.* (2008) observed similar trend in Lakes Edku and Borollus Egypt. The variations in the concentrations of heavy metals could be due to natural contact of water with rock and soil containing large deposits, increased urbanization and industrialization. Similar observations were reported by Zira and Edward (2021).

The result of lead in sediment shows statistical significance ($p < 0.05$) between the months sampling sites and seasons in sediment. The high concentration of Lead in sediment could be from anthropogenic sources such as to discharge of huge amount of industrial effluent from Kano, agrochemicals from farms, plumbing materials, gasoline, paints, batteries from the catchment areas and dust that holds large amount of lead from combustion of petrol in automobile cars that find their ways in to the reservoir. This is similar to the result of Butuet *al.* (2019) in Galma reservoir, Ibrahim *et al.* (2018) In Lake Njuwa, Adamawa State, Nigeria Lead poisoning is linked to crime and anti-social behavior in children. Bichi *et al.* (2017) described that Pb deposition in aquatic ecosystem is as a result of superficial soil erosion and atmospheric deposition process. As mentioned previously, both these metals are non-fundamental; hence, only low amounts of these metals are required by living organisms for their survival.

Copper is among the most abundant elements measured in the sediment sampled and this increase in copper in the sediments mainly come from domestic sewage release from nearby areas, and other industrial waste discharge. Similar observation was reported by Vaseem and Banerjee (2013). Hence, compound fertilizers that consist of Cu and Zn as part of their elements may have increased the Cu level in the sediment. It was further reported that the essential metals, which are Cu, Zn, and Fe, can get through living organisms via three pathways, namely: food, water, and sediment. However, the effectiveness uptake of heavy metals might differ due to

several factors, including ecological needs and metabolism of animals; contaminant gradients of water, food, and sediment; as well as physicochemical parameters, such as pH, salinity, temperature, and interacting agents. Copper, though essential in human diet can be harmful when large intake occurs. At excessive levels, copper can cause anaemia, disorders of bone and connective tissues and liver (Al-weher, 2008). The harmful toxicity is largely attributed to its cupric (Cu^{2+}) form, which is the most commonly found specie in the environment (Abdullahi *et al.*, 2021b).

Low concentration of Cd recorded of 0.001 – 0.49mg/L in water, 0.01 – 1.81mg/kg in sediments, 0.01 – 0.94mg/kg in lettuce and 0.01 – 0.81mg/kg is attributed to the geological pattern in the study area and runoff from agricultural activities around the River. Similar observation was reported by Abdullahi *et al.* (2021a) and Butu *et al.* (2018) from Challawa and Thomas reservoir, Kano respectively. Cd concentrations recovered might be due to contamination of River water by the industrial effluent containing phosphate pesticides and other domestic sewage which are regarded as prominent sources of Cd pollution in the water (Shawaiet *al.*, 2018). Fabio *et al.* (2016) reported that waste water contaminated with Cd can results in anemia, vertebral fractures, and osmoregulatory problems.

The concentrations recorded could be attributed to variations in mud present and increase in Cd metal rich urban effluents draining into the river. This research agrees with report of Sharfudden *et al.* (2020) and Ekevwe and Bartholomew (2015) in Jakara River, Kano State. Cadmium concentrations in sediment show significant difference between months, sampling points and season. Cadmium had mean concentrations below the acceptable limit in aquaculture 3 mg/Kg by FAO (2013). Cadmium concentration may be due to pluvial discharge of manmade debris such as corroded galvanized pipes, batteries from homes and shops, natural and industrial activities such as volcanic emissions, geologic processes and leachates from landfill, electroplating, metallurgy of zinc and cement production all release cadmium. High concentration could be implicated to the use of phosphate fertilizer in farms along the river tributaries.

The results revealed that concentrations in water followed the order: Copper (Cu) with 1.51mg/L > Chromium (1.17mg/L) > Lead (0.94mg/L) > Cadmium (0.31mg/L). Heavy metals concentration in sediment had the following means with Cu 2.45mg/kg > Cr (1.87mg/kg) > Pb (1.85mg/kg) > Cd (0.55mg/kg). Heavy metal concentrations in vegetables revealed a significant decrease ($p < 0.05$) in lettuce in the order of decreasing concentration in lettuce (Cu > Pb > Cr > Cd), However, a corresponding increase ($P < 0.05$) was obtained in the tissues of tomatoes in the following order: (Cr > Pb > Cd > Cu). Heavy metals concentrations recorded were higher than FAO/WHO (2018) recommended limit with the exception of Cd. Pearsons' correlation coefficient revealed a strong positive correlations with pH, turbidity, EC, Cr Cc, Cd and Pb ($P < 0.01$) while negative correlations were reported with temperature, TDS and Cr ($p < 0.01$).

Conclusion

Heavy metals concentrations revealed spatial and seasonal variation during the study period. Bioaccumulation Factor of heavy metal concentrations in water decreased in the order of Cr > Pb > Cu > Cd. Gills had the highest value of Cr, followed Pb, Cu and Cd recorded the lowest. BAF in liver tissues decreased in the order of Cu > Pb > Cr > Cd. The increasing concentration of

the chemical contaminants affects the fish wellbeing. Consumption of this aquatic biota by humans may pose risk from ingestion of contaminated water at unacceptable concentration of heavy metals through bioaccumulation. This indicates that the sampled water, sediment and vegetables from all the sampling sites were exposed to high concentration of heavy metals contaminants via anthropogenic input. The present study showed that River Challawa is impacted by various pollutants from the river tributaries which harbour the industrial effluent mainly from Challawa and Sharada Industrial areas. The study highlights the implications of contaminant intake within the aquatic ecosystem—particularly in freshwater—and its long-term effects on both vegetables and the environment.

Recommendations

It is therefore recommended that:

1. Adequate monitoring of the water quality and regulation of human activities in and around the River should be enforced.
2. Government should through its appropriate agencies ensure that industries located along the tributaries adhere strictly to the set emission guidelines of their effluent into the water body and governmental and non-governmental organizations should encourage and sponsor joint research on the general biological and physicochemical condition of the Challawa River on a continual basis since it is essential for tracking adverse environmental changes in an aquatic environment.
3. Farmers along the River channel should be enlightened on the effect of their activities into the body of the water, especially application of both organic and inorganic fertilizers and chemical pesticides during period of rainy season farming and irrigation activities.

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