UMYU Scientifica, Vol. 2 NO. 4, December 2023, Pp 130 – 135
https://doi.org/10.56919/usci.2324.016
ISSN: 2955 – 1145 (print); 2955 – 1153 (online)
A periodical of the Faculty of Natural and Applied Sciences, UMYU, Katsina

ORIGINAL RESEARCH ARTICLE

Analysis of Heavy Metals Contaminating Water and Fish Species in Kwanar-Are Dam, Katsina State, Nigeria

Yusuf Isah Shinkafi*[1], Babangida Mubarak Kurfi[2], and Mohammed Abdulhamid[3].
[1]Department of Chemistry, Federal University Dutsin-ma, Katsina State, Nigeria.
[2]College of Nursing and Midwifery, Nana Babajo School of Midwifery Malunfashi Katsina State, Nigeria.
[3]Department of Physical and Chemical Sciences, Federal University of Health Sciences, Ila-Orangun, Osun State, Nigeria.

ABSTRACT
This work is aimed to determine the quantities of heavy metals in the water, and three different fish species (*Bugrus bayad*, *Tilapia*, and *synoduntis*) present in Kwanar Are Dam. In the adjacent villages, the dam provides the main water supply for domestic uses, agriculture, fishing, and drinking. Water and fish samples were examined using an Atomic Absorption Spectrophotometer (AAS) to measure the levels of heavy metals. The water sample tested positive for Cd 0.183 mg/l, Cu 0.286 mg/l, Cr 0.233 mg/l, Mn 0.081 mg/l, Ni 0.179 mg/l, Pb 0.166 mg/l, and Zn 0.145 mg/l, according to the results. Cu, Mn, and Ni were below the World Health Organization (WHO) recommended levels. However, Cd, Cr, Pb, and Zn exceeded these limits. The levels of heavy metals in the fish samples ranged from 0.275 to 0.581 mg/kg for Cadmium, 0.520 to 0.837 mg/kg for Copper, 0.205 to 0.512 mg/kg for Nickel, 0.205 to 0.512 mg/kg for Lead, and 0.333 to 0.611 mg/kg for *Tilapia*, *Bugrus*, and *Synoduntis* fish, respectively. Chromium, Lead, Cadmium, Nickel, Zinc, and Manganese levels were lower than copper concentrations. Manganese and nickel concentrations in the fish exceeded what the WHO considered safe. The results of this study show that heavy metals have accumulated in the fish species that live in the Kwanar Are Dam, proving that the dam is contaminated. While some heavy metals in the water and fish samples were within the World Health Organization (WHO)'s (recommended limits), others, including Cd, Cr, Pb, and Zn, were over these levels. This suggests a possible health danger for the locals who depend on the dam as their main water source for daily activities.

ARTICLE HISTORY
Received June 29, 2023.
Accepted December 20, 2023.
Published December 30, 2023.

KEYWORDS
Wastewater, Heavy metals, Concentration, Atomic absorption spectrophotometer (AAS).

INTRODUCTION
Rodrigues-Filho et al. (2023) state that water bodies are essential for maintaining various ecological functions and aquatic life, including fish species. However, the aquatic life and human populations that depend on these resources are seriously threatened by heavy metal poisoning of water bodies (Farhan et al., 2023). Like many other nations, Nigeria experiences environmental problems because of heavy metal pollution, especially in its waterways (Richard et al., 2023).

One such water body impacted by heavy metal pollution is the Kwanar-Are Dam in Katsina State, Nigeria. The dam supports nearby communities by providing a crucial water source for domestic consumption, fishing, and irrigation. However, heavy metals have accumulated in the dam's water due to anthropogenic activities, industrialization, and poor waste management techniques, generating worries about the possible effects on aquatic life, notably fish species, and human health (Lubchenco et al., 2023). Heavy metals of concern include Lead, mercury, Cadmium, arsenic, chromium, Copper, and Nickel. These metals are released into the environment through activities such as mining, manufacturing, and the burning of fossil fuels. Once released, heavy metals can persist in the environment for extended periods, posing risks to ecosystems and human health. (Richard et al., 2023). The effects of heavy metals on living organisms are diverse and can range from subtle biochemical changes to acute toxicity. In aquatic ecosystems, these elements accumulate in fish and shellfish, posing a threat to aquatic life and human consumers. Furthermore, the ability of heavy metals to bioaccumulate in the food chain amplifies the potential for adverse effects on higher trophic levels (Rodrigues-Filho et al., 2023).

Correspondence: Yusuf Isah Shinkafi. Department of Chemistry, Federal University Dutsin-ma, Katsina State, Nigeria.
ishinkafi@fudutsinma.edu.ng. Phone Number: +234 813 652 4042.
How to cite: Shinkafi, I. Y., Mubarak, B. K., & Abdulhamid, M. (2023). Analysis of Heavy Metals Contaminating Water and Fish Species in Kwanar-Are Dam, Katsina State, Nigeria. UMYU Scientifica, 2(4), 130 – 135. https://doi.org/10.56919/usci.2324.016

Human exposure to heavy metals occurs through various routes, including inhalation, ingestion, and dermal contact (Lubchenco et al., 2022). Chronic exposure to even low levels of certain heavy metals has been linked to a myriad of health issues, such as neurological disorders, developmental abnormalities, organ damage, and an increased risk of certain cancers. Vulnerable populations, such as children and pregnant women, are particularly at risk due to the potential for developmental impacts (Yaradua et al., 2023).

To assess the level of heavy metal contamination and its potential effects, it is crucial to analyze the fish species and heavy metal concentrations in water taken from the Kwanar-Are Dam (Yaradua et al., 2022). The health of people is impacted both directly and indirectly by heavy metal pollution. If these compounds are used in excess, they harm the productivity of soils, plants, animals, and the entire environment (Golden et al., 2023). Fish species are sensitive to changes in water chemistry and serve as bioindicators of environmental quality (Biswaset al., 2023). Evaluating the degree of contamination in the water and its potential transfer via the food chain is feasible by examining the presence and accumulation of heavy metals in fish tissues (Impellitteriet al., 2023).

Both in terms of availability and quality, there is less excellent water for agriculture. As a result, people consume raw municipal sewage, which contains various carcinogens like bacteria, heavy metals, and organic pollutants. Even at low concentrations in the soil-water system, heavy metals persist longer in the soil, absorbed by plants and moving up the food chain (Hansa et al., 2023). According to Alghamdiet al. (2023), domestic emissions, tire wear, weathering of street surfaces, coal combustion in power plants, the metallurgical industry, auto repair shops, and chemical plants, as well as atmospheric deposits, are the primary anthropogenic causes of heavy metal pollution in the environment.

Investigating the presence of heavy metals in fish species and water collected from the Kwanar-Are Dam in Katsina State, Nigeria, is crucial for assessing the extent of pollution and its potential impact on the ecosystem and human health. The study findings will contribute to our understanding of the environmental quality of the dam, raise awareness about the associated risks, and provide insights for the development of effective remediation strategies.

MATERIALS METHODS

Study Area

The research location is in Nigeria's Kwanar-Are Dam Rimi Local Government of Katsina State. it lies in the region between longitude 7o41'00" to 7o43'00" East and latitude 12o46'30" to 12o47'30" North. Its catchment area is 1,382,470 square meters in total. It may be reached through the Katsina-Kano road. The area around the dam is in a tropical wet and dry climate zone, and the average annual rainfall ranges widely from 600 to 700 millimeters. The average yearly temperature is 270°C, with mean monthly temperatures ranging from 24 to 310°C (Yar'adua et al., 2022). The basin region is quite high, with an average elevation of 300 m above mean sea level. The Kuraye River provides water to water for local agricultural activities provided by the Kwanar-Are dam. When it rained, the relative humidity in the area was high, and when it was dry, it dropped quickly. More clay is present in surface soils, which are primarily sandy loam. Fine-grained gneisses, quartzite, and magnetite comprise most of the area's subsurface geology, with a few outcrops of coarse-grained granitic rock (Yar'adua et al., 2022).

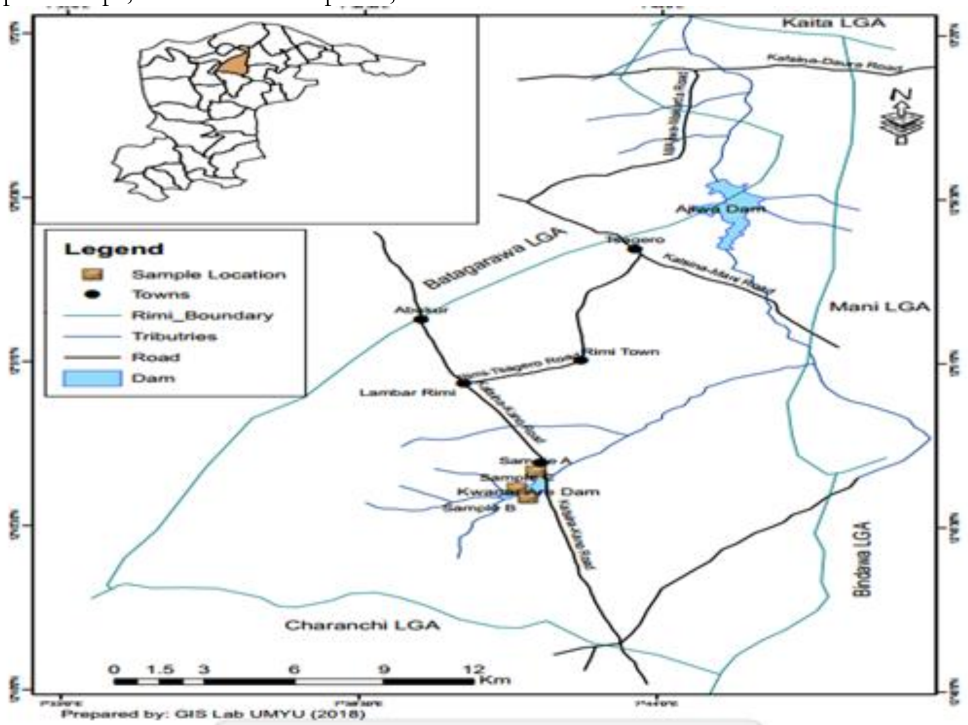

FIGURE 1: Map of Charanci Local Government Showing Kwanar Are Dam.

Sample collection and pre-treatments

Water samples were collected from designated sampling points in the wet season using plastic containers at a minimum depth of two to three feet. Before sampling, the bottles were rinsed with deionized water and then three times with the sample water. The Samples were labeled with the date of collection and sampling points, transported to the laboratory, and kept for analysis (Kumar et al.,2015). The water samples for heavy metals determination were preserved by the addition of $5cm^3$ diluted HNO_3 acids to each liter of sample to adjust pH to 2 and also to prevent metals from adhering to the wall of the containers. The samples were stored in a refrigerator at about 4^oC before analysis (Anuo et al., 2012).

Three fish samples were obtained directly from Kwanar Are-Dam, labeled as A, B&C, transported to the laboratory, and identified by a Zoologist from the Biological Science Department UMYU. The sample was dissected, and the Gills, lever, and tissue were removed before the analysis. The organs are frozen and stored at -20^oC (Akpanyung et al., 2014).

Water Sample collection and digestion

At the upper, middle, and lower streams, water samples were taken from predetermined sampling points using plastic containers at a minimum depth of two to three feet. The bottles were rinsed twice with deionized water and three times with the sample water before sampling. The samples were transferred to the lab and stored for examination after being labeled with the date of collection and sampling locations (Kumar et al., 2015). Each 1000 cm^3 of water sample received ten (10 ml) of strong hydrochloric acid, which evaporated to yield fifty (50 ml). According to Olowu et al. (2010), the concentrate was transferred to a 100 ml flask and diluted to the desired strength with deionized water.

Fish Samples collection and digestion

Fish samples from commercial fishermen in the study region (three samples of each species: Bugrus bayad, tilapia, and synoduntis) were collected In sterile polythene bags. The fish samples were transported in an icebox to the lab, where they were cleaned with running tap water to eliminate debris. After being preserved separately and frozen in a deep freezer, each fish sample was taken out, labeled, and put into sterile sample bottles for digestion and heavy metal analysis. Fresh fish organs (gills, lever, and tissue) were dried at 105°C for 24 hours to a consistent weight before being ground in a mortar and pestle. The sample was put into plastic bags with dry labels and kept in desiccators until it was needed for digestion. 1 g of pulverized materials was heated for an hour on a hot plate with 10 ml of concentrated HNO_3 and 2 ml of concentrated $HClO_4$. 20 cc of 0.2% conc. HNO_3 was used to dissolve the residue and dilute it. The concentrated substance was transferred to a 50 ml flask and diluted with deionized water to the desired consistency (Yar'adua et al., 2022).

Heavy Metals Determination

The metals contents (Cr, Ni, Mn, Zn, Cd, Cu) were determined in water and fish using the Atomic Absorption Spectrophotometer (AAS) (BULK Scientific/210VGP model) whereby the machine gives out the absorbencies of each metal, the concentration of each metal was then determined by interpolation from its standard calibration curves (Akpanyung et al., 2014). Where AG, AL, AT, BG, BL, BT, CG, CL, and CT= Tilapia Gills, Tilapia Liver, Tilapia Tissue, Synoduntis Gills, Synoduntis Liver, Synoduntis Tissue, Bugurus Gills, Bugurus Liver and Bugurus Tissue. Where DT and DB= Water, respectively, were obtained from Kwanar Are-Dam. The analysis was done in triplicate (Akpanyung et al., 2014).

RESULTS AND DISCUSSION

WATER

According to our analysis of the heavy metal concentrations in water taken from the Kwanar-Are Dam in Katsina State, Nigeria, during the wet season, the mean concentrations of Cadmium (Cd), copper (Cu), chromium (Cr), manganese (Mn), Nickel (Ni), Lead (Pb), and zinc (Zn) were all above the recommended levels. The findings show that Cd, Cr, and Pb concentrations were higher than the World Health Organization/Food and Agriculture Organization's (WHO/FAO, 2011) recommended tolerable levels, whereas Ni, Cu, and Mn concentrations were below those limits. The WHO/FAO standards indicate allowed levels of 2 mg/l for Copper, 0.001 mg/l for chromium, 0.01 mg/l for Cadmium, 0.20 mg/l for Nickel, 0.005 mg/l for Lead, 3 mg/l for zinc, and 0.50 mg/l for manganese in water. It is clear from comparing these limitations to the measured concentrations that Cd, Cr, and Pb concentrations surpassed the suggested limits, although Ni, Cu, and Mn concentrations fell within the permissible range. This agrees with the finding of Hassan and Mohammed (2023), who reported a higher concentration of cd and a lower concentration of Zn and Cu. High levels of Cadmium in drinking and household water can seriously harm the lungs and induce vomiting, diarrhea, and excruciating stomach discomfort. There are various sources where Cadmium enters the groundwater. Consuming foods that have been cultivated, particularly grains and leafy vegetables, which easily absorb Cadmium from the soil, is one source (Hassan and Mohammed, 2023). Due to industrial waste that contains Copper, agricultural pesticides, and copper pipe corrosion, Copper is released into drinking water (Coupe et al., 2013). Copper is a trace element that is crucial to human health. However, a high concentration of Copper can have serious health effects. Some people's kidneys and livers have been discovered to be harmed by high copper levels in drinking water. Copper can be toxic to infants under one year old because it cannot be easily excreted from their systems. Long-term exposure to Copper causes nose, mouth, and eye irritation, headaches, dizziness, nausea, and loose stools (Coupe et al., 2013).

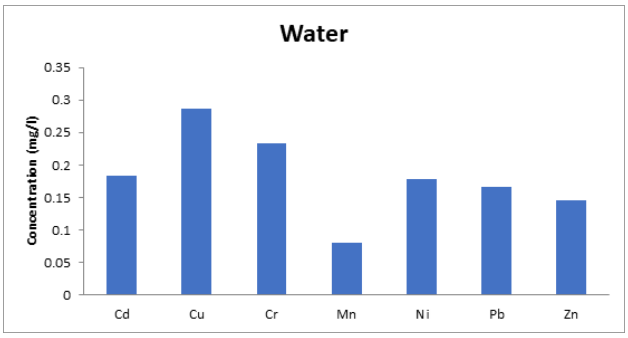

FIGURE 2: Mean concentration of Heavy metals mg/kg in water samples.

FISH

The mean heavy metal concentration in fish, as shown in Figure 3, revealed that the concentrations (mg/kg) for (Tilapia, Bugrus, and Synoduntis in both Gills, Liver, and Tissue) Tilapia accumulated more heavy metals, followed by Burgus and the least was recorded inSynoduntis. Numerous studies have found that heavy metal buildup in fish varies by species according to ecological demands, metabolism-feeding behaviors (as carnivores, herbivores, omnivores, and limnivores) (Watanabe et al., 2003), and ecology (Canli and Atli, 2003; Yilmaz, 2005). The study indicated that the concentrations in the tilapia, bugrus and synoduntis fishes are higher in the liver and gills but low in the tissue and higher than in the water samples. This agrees that aquatic organisms accumulate metal concentration in fishes much higher than t in water and sediment (AL-Weher, 2008). However, the excessive concentration of these bioactive metals may pose serious threats to normal metabolic processes (Paithankar et al., 2021).

The concentration of the heavy metals revealed that Cadmium ranged between 0.28 to 0.58, Copper 0.52 to 0.83, Chromium 0.37 to 0.73, Manganese 0.18 to 0.33, Nickel 0.21 to 0.51, Lead 0.33 to 0.61, and Zinc 0.21 to 0.46 many researchers mentioned similar circumstances (Tepe et al., 2008; Türkmenet al., 2008; Uluozlu et al., 2007; Al-Halani et al., 2021 and Mohamed et al., 2023). The heavy metal concentration was observed to be in ascending order of Cu>Cr>Pb>Cd>Ni>Zn>Mn. The study found that Ni and Mn are within the recommended limit, while Cu, Cr, Cd, Pb, and Zn exceed permissible fish limits (WHO/FAO, 2010). The findings in this study contradict another finding that reported Cu, Zn, Cd, Pb and Cr did not exceed permitted limits, according to WHO and FAO organization (Mokhtar et al. 2009).

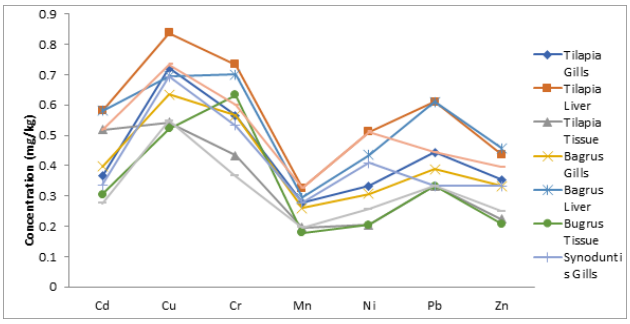

FIGURE 3: Mean concentration of Heavy metals mg/kg in fish samples.

CONCLUSION

Heavy metal concentrations in water from the Kwanar-Are Dam in Nigeria during the wet season were analyzed in this study. Cadmium, chromium, and lead levels were above recommended levels, while Copper, manganese, and Nickel were below. Heavy metal concentrations in fish were also analyzed, with tilapia having the highest levels. Cadmium, Copper, chromium, Lead, and zinc exceeded recommended limits in fish. Cadmium in drinking and household water can cause serious health problems, and Copper can be toxic in high concentrations. These findings indicate that local communities that consume Kwanar-Are Dam water and fish are at high risk of heavy metal exposure and toxicities.

RECOMMENDATION

It is recommended that further metals of concern, such as Lead mercury, should be investigated and determined. Also, routine monitoring and public enlightenment should be enforced to ensure adherence to drinking water standards, and other sources of potable water for irrigation, fishing, and domestic uses should be provided to the community.

ACKNOWLEDGEMENT

The authors acknowledge the support of the Department of Chemistry and Biology of Umaru Musa Yar'adua University Katsina for providing research materials and Laboratory equipment.

REFERENCES

Akpanyun, O, Ekpe, M., and Okon, B. (2014). Levels of heavy metal Ni, Pb and Zn in water and fish species collected from the Northern Jordan Valley, Jordan. *Jordan journal of biological sciences* 5(1) Pp 21-40.

Alghamdi, M. A., Hassan, S. K., Al Sharif, M. Y., Khoder, M. I., and Harrison, R. M. (2023). Pollution characteristics and human health risk of potentially toxic elements associated with deposited dust of sporting walkways during physical activity. Atmospheric Pollution Research, 101649**[Crossref]**

Al-Halani, A. A., Soliman, A. M., Shady, S. H.H., (2021). The seasonal assessment of heavy metals bioaccumulation in European seabass (Dicentrarchus labrax) inhabiting Damietta fishing harbor, Egyptian Journal of Aquatic Biology and Fish. **25** (5), 607-626, **[Crossref]**

Al-Weher, S. M. (2008). Levels of heavy metal Cd, Cu and Zn in three fish species collected from the Northern Jordan Valley, Jordan. *Jordan journal of biological sciences,* 1(1), Pp 41-46.

Anuo,A.U,Egereonu U.N.J, and Egereonu, J.C. (2012). Comparative Analysis of the Degree of Pollution of Okintankwo River along Border Communities, Mbaitoli, Ekeduru, Emekuku, and Ultra of Imo State Nigeria. Analytical Science Journal. **1**(1):9-14.

Biswas, J. K., Pramanik, S., and Kumar, M. (2023). Fish parasites as proxy bioindicators of degraded water quality of River Saraswati, India. Environmental Monitoring and Assessment, **195**(7), 818. **[Crossref]**

Canli M., A.Y. O., Kalay M. (1998). Levels of heavy metals (Cd, Pb, Cu, Cr and Ni) in the tissue of Cyprinus carpio, Barbus capitoandChondrostoma regiumfrom the Seyhan River, Turkey.Turkish Journal of Zoology.**22** Pp. 149-158

Canli, M., and Atli, G., (2003). The relationships between heavy metal (Cd, Cr, Cu, Fe, Pb, Zn) levels and the size of six Mediterranean fish species. Environmental Pollution**121**. Pp129-136. **[Crossref]**.

Coupe, S. J, Sallami, K., and Ganjian, E., (2013). Phytoremediation of heavy metal contaminated soil using different plant species. African Journal of Biotechnology.**12**(43):6185-92. **[Crossref]**.

Farhan, A., Zulfiqar, M., Samiah, Rashid, E. U., Nawaz, S., Iqbal, H. M., (2023). Removal of toxic metals from water by nanocomposites through advanced remediation processes and photocatalytic oxidation. Current Pollution Reports, 1-21. **[Crossref]**

Goldan, E., Nedeff, V., Barsan, N., Culea, M., Panainte-Lehadus, M., Mosnegutu, E., and Irimia, O. (2023). Assessment of Manure Compost Used as Soil Amendment-A Review. Processes, **11**(4), 1167. **[Crossref]**.

Hansa, A., Devi, A., Upadhyay, M., Gupta, H., Syam, K., Asgari Lajayer, B., and Sharma, R. (2023). Toxicological implications of industrial effluents on plants: a review focusing on phytoremediation techniques. International Journal of Environmental Science and Technology, 1-16. **[Crossref]**.

Hassan, N. E., and Mohammed, S. J. (2023). Assessment of Ground Water Pollution by Heavy Metals in Some Residential Areas in Kurdistan Region of Iraq. Environmental Science and Architecture.**2**. Pp. 35-44.

Impellitteri, F., Multisanti, C. R., Rusanova, P., Piccione, G., Falco, F., and Faggio, C. (2023). Exploring the Impact of Contaminants of Emerging Concern on Fish and Invertebrates Physiology in the Mediterranean Sea. Journal of Biology, **12**(6), 767. **[Crossref]**.

Kumar, S.N.C. Ghosh, R.P. Singh, M.M. Sonkusare, S. S., and Sanjay M., (2015). Assessment of Water Quality of Lakes for Drinking and Irrigation Purposes in Ibom State, Nigeria. African Journal of Environmental Science and Technology.**8**(7),

Lubchenco, J., & Haugan, P. M. (2023). Leveraging Multi-target Strategies to Address Plastic Pollution in the Context of an Already Stressed Ocean. In The Blue Compendium: From Knowledge to Action for a Sustainable Ocean Economy. Pp. 141-184). Cham: Springer International Publishing. **[Crossref]**

Mohamed, M. G. Mousa, A. O., Chuang, C. H., and Kuo, S. W., (2023). Strategic design and synthesis of ferrocene linked porous organic frameworks toward tunable CO2 capture and energy storage. *International Journal of Molecular Sciences*, 24(15), Pp12371. **[Crossref]**

Muktar, M., Bin, A. A.Z., Munusamy, V., Praveena, S.M., (2009). Assessment level of heavy metals in Penaeus monodon and Oreochromis spp. in selected aquaculture ponds of the high densities development area. European Journal of Scientific Research., **30** Pp. 348-360

Olowu, R. A., Ayejuyo, O. O., Adewuyi, G. O., Adejoro, I. A., Denloye, A. A. B., Babatunde, A. O., and Ogundajo, A. L. (2010). Determination of heavy metals in fish tissues, water and sediment from Epe and Badagry Lagoons, Lagos, Nigeria. *Journal of Chemistry*, 7, Pp 215-221. **[Crossref]**

Paithankar, J. G., Saini, S., Dwivedi, S., Sharma, A., and Chowdhuri, D. K. (2021). Heavy metal associated health hazards: An interplay of oxidative stress and signal transduction. Chemosphere, **262,**Pp. 1-63 **[Crossref]**.

Richard, G., Izah, S. C., Morufu, O. R., and Austin-Asomeji, I., (2023). Public and environmental health implications of artisanal petroleum refining and risk reduction strategies in the Niger Delta region of Nigeria. Journal of Biological Research, **21**(1), 1896-1910.

Rodrigues-Filho, J. L., Macêdo, R. L., Sarmento, H., Pimenta, V. R., Alonso, C., Teixeira, C. R., and Cionek, V. M. (2023). From ecological functions to ecosystem services: linking coastal lagoons biodiversity with human well-being. Hydrobiologia, 1-43 **[Crossref]**.

Tepe, Y., Turkmen M., Turkmen A. (2008). Assessment of heavy metals in two commercial fish species of four Turkish seas. Environmental Monitoring Assessment, 146 Pp. 277-284, **[Crossref]**.

Uluozlu, O.D., Tuzen M., Mendil D., and Soylak M., (2007). Trace metal content in nine species of fish from the Black and Aegean Seas, Turkey Journal for Food Chemistry. **104** pp. 835-840. **[Crossref]**

Watanabe, K.H., Desimone F.W., Thiyagarajah, A., Hartley, W.R., (2003). Fish tissue quality in the lower Mississippi River and health risks from fish consumption. Journal of Science Total and Environment. **302**, Pp. 109-126, **[Crossref]**.

WHO, (2011). Drinking Water Quality Guideline 4th Edition. World Health Organization Geneva, Switzerland. Pp. 1-28.

WHO,(2010). Diet, nutrition and the prevention of chronic diseases. Report of a joint WHO/FAO expert consultation. WHO Tech. Report Ser.916 World Health Organization, Geneva, Switzerland.

Yaradua, A. I., Bungudu, J. I., Shuaibu, L., Nasir, A., Usman, A., Kankia, I. H., and Muhammad, A. N. (2023). Health Risk Assessment of Heavy Metals in Vegetable: The Contribution of Illegal Mining and Armed Banditry to Heavy Metal Pollution in Katsina State, Nigeria. Journal of Scientific Research and Reports.**29**(5), 19-27. **[Crossref]**.

Yilmaz, A. B. (2005). Comparison of heavy metal levels of grey mullet (Mugil cephalus L.) and sea bream (Sparus aurata L.) caught in Iskenderun Bay (Turkey). Turkish Journal of Veterinary Animal Science.**29** Pp. 257-262