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# Determination of Selected Heavy Metals in Gills and Livers of some Catfish (*Clarias gariepinus*) from Two Dam Reservoirs in Katsina State, Nigeria

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## Abstract
*Fishes are a great dependable source of protein and assessment to determine their safety or otherwise is very crucial. In this work, two vital organs (liver and gills) in catfish samples (Clarias gariepinus) collected from Ajiwa and Jibiadams in Katsina state were analyzed for some heavy metals (Zinc, Cadmium, Copper, Nickel, Cobalt, Lead, Manganese, and Chromium).After sample digestion, Micro Plasma Atomic Emission Spectroscopy (MP-AES) was used to determine the heavy metal concentrations in the samples and their levels compared with WHO/FAO specified maximum levels. The mean concentrations (mg/kg)of the metals in the fish organs from Ajiwa dam were zinc (270.00±0.00 and 55.83±2.93), cadmium (1.17±0.29 and ND), copper (64.30±1.61 and 1.33±0.29), lead (5.00±0.00 and 1.83±0.29), manganese (9.83±0.29 and 10.67±1.15) and chromium (5.00±0.00 and 0.83±0.29) for liver and gills respectively. Similarly, the mean concentrations (mg/kg) of metals in the fish organs collected from Jibia dam were zinc (217.00±0.00 and 61.00±0.50), cadmium (0.50±0.00 and ND), copper (25.67±0.29 and 2.00±0.00), lead (2.50±0.00 and 3.00±0.00), manganese (11.00±0.00 and 5.00±0.00) and chromium (0.50±0 1.00±0.00) for liver and gills respectively. Nickel and cobalt were not detected in all the samples from the two dams. Results indicate significant difference in the concentrations of metals between gills and liver of the fish species from the two dams as p-value was less than 0.05 ($P < 0.05$) in each case. Some metal concentrations mostly in the liver were higher than the maximum permissible limit recommended by standard bodies and therefore the gills is safer for consumption compared to the liver.*

**Keywords**: Catfish, Dam, Gills, Heavy metals and Liver

## INTRODUCTION
The contamination of water bodies with a variety of pollutants has become an issue of concern over the last few decades, not only because of the threat to public water supplies, but also the hazards to human consumption of fishery resources and other aquatic biotas (Terra *et al.*, 2008). Heavy metals are natural trace components of the aquatic environment (Al-Weher, 2008) and enter the aquatic environment through the earth crust, which has led to a steady-state background level in the aquatic environment. As a result of anthropogenic activities, the concentrations of heavy metals have increased (Ukachukwu, 2012) and their accumulation leads

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to heavy metal contaminations in the aquatic system. Being non-biodegradable, the heavy metals can be concentrated along the food chain, producing their toxic effect at points far away from the source of pollution (Ahmad *et al.,* 2010).

Heavy metals in fish Gonads may be transferred to the next fish generations resulting into diseases or illnesses (Terra *et al.,* 2008) and the significant parts of the fish, usually affected with highest load of such metals include the liver, kidney and gills. Accumulation of heavy metals in an aquatic environment has direct consequences on man and the ecosystem. (Joy *et al.,* 2013). The presence of heavy metals in the aquatic organism depict the past as well as the current pollution load in the environment in which the organism lives (Joseph *et al.,* 2012). Monitoring heavy metal contaminations in water bodies using fish tissues is considered as one of the most indicative factors for the estimation of heavy metal pollution in water systems (Rasheed, 2011; Batvari *et al*., 2007). Since fishes are always in contact with aquatic pollutants, their analyses could serve as excellent biological indicators of heavy metals in the aquatic environment (Nsikak *et al.,* 2007). High levels of heavy metals in water are often detected in skin or gill tissue of pelagic fishes. The metals can be absorbed by fish skin through dermal contact or accumulate in the gills through breathing (Zhao *al.,* 2012),it is also apparent in the liver (Agah, 2009).

The aim of this work is to evaluate the levels of heavy metals in the liver and gills of the major fish species (*Clarias gariepinus*) from two dam reservoirs in order to ascertain how safe the consumption of these fish organs is. From the results obtained, appropriate conclusions can be drawn on the safety of these organs as recent literatures revealed scanty information on the levels of such metals in the fish organs analyzed especially from Jibia dam reservoir.

## MATERIALS AND METHODS

### Sampling Area

Ajiwa dam (Figure 1)is located at Batagarawa local government area of Katsina state and it lies on the coordinates 12° 55'51" N 7° 45'31"E**.** The Jibia dam (Figure 2) lies on the coordinates 13° 04'09" N 7° 13'31"Eand located at Jibia local government area of Katsina state.

**Figure 1:** Ajiwa Dam

**Figure 2:** Jibia Dam

**Sample Collection**

Twenty fish samples of considerable sizes and weights from each reservoir were sourced from the local fishermen immediately after the fishing activities. The organs (liver and gills) were removed using a plastic knife, allowed to dry in a shade and transported to the laboratory for preparations.

**Sample Preparation and Digestion**

A sample (1g) was placed in a porcelain crucible and inserted into a furnace. The furnace temperature was set at 450˚Cand the sample heated for 5hr until a white-grey ash residue was obtained. The residue was then dissolved in 5 $cm^3$ of $HNO_3$ (25% v/v) and the mixture was heated slowly to dissolve the residue. The solution was then transferred into a 50 $cm^3$ volumetric flask and made up to volume (Vaidya & Rantala, 1996).Triplicate digestion of each sample was carried out.

After digestion, three (3) replicate concentration measurements of all metals in the various samples were carried out using an Agilent Microwave Plasma Atomic Emission Spectrometer (MP-AES) equipped with an inert nebulizer and a double-pass glass cyclonic spray chamber.

**Results and Discussion**

Table 1 presents the mean concentrations (mg/kg) of the metals analyzed in the fish samples.

Zinc is known to be involved in most metabolic path-ways in humans and its deficiency can

**Table 1:**Mean concentrations (mg/kg) with standard deviations of heavy metals in fish samples

| | Zn | Cd | Cu | Ni | Co | Pb | Mn | Cr |
|---|---|---|---|---|---|---|---|---|
| AL | 270.00±1.00 | 1.17±0.29 | 64.30±1.61 | ND | ND | 5.00±0.00 | 9.83±0.29 | 5.00±0.00 |
| AG | 55.83±2.93 | ND | 1.33±0.29 | ND | ND | 1.83±0.29 | 10.67±1.15 | 0.93±0.29 |
| JL | 217.00±1.00 | 0.50±0.00 | 25.67±0.29 | ND | ND | 2.50±0.00 | 11.00±0.00 | 0.50±0.00 |
| JG | 61.00±0.50 | ND | 2.00±0.00 | ND | ND | 3.00±0.00 | 5.00±0.00 | 1.00±0.00 |

Key: AL=Ajiwa liver, AG= Ajiwa gills, JL= Jibia liver and JG= Jibia gills

lead to growth retardation, loss of appetite and immunological abnormalities that may cause the condition of the skin to change (Malakootian *et al.*, 2011). Fish takes up Zn directly from water, especially via gills. The concentrations of Zn in fish in the present work were all above the maximum zinc level permitted for fish (50 mg/kg) according to Food Codex and WHO, (2004). In a separate study, 0.33 to 1.32 μg/g of Zn was reported to have been found in the liver of a fish sampled from a river in Adamawa state, Nigeria(Akan *et al.,* 2012). Similarly, 65.04 ± 19.39 mg/kg and 10.45 ± 0.60 mg/kg were reported in liver and gills respectively of catfish sampled from lake Geriyo of Adamawa state (Bawuro *et al.,* 2018). As found in this work, the mean zinc levels in the fish liver (270.00±1.00 mg/kg from Ajiwa and 217.00±1.00 mg/kg from Jibia) were higher than in the gills of the samples analyzed. This finding is in line with most literatures on level of Zn in freshwater fish as reported by Lynch, (2016). Similar higher values of 167 mg/kg in *L. aeneus* and 222 mg/kg for *L. umbratus* of zinc in fish liver were reported by Christof *et al.* (2019) in China.

The concentration of Cd was found to be 1.17±0.29 mg/kg in Ajiwa fish liver while the level in Jibia fish liver was 0.5±0 mg/kg which is almost half of that from Ajiwa liver. However, Cadmium was not detected completely in both the Ajiwa and Jibia gills. In a separate work, 0.904 mg/kg was reported for Cadmium in catfish liver from Bakolori dam of Zamfara State (Moses, 2018). Similarly, 0.16 to 0.54 µg/g of Cd was obtained by Akan *et al.* (2012) when they analyzed the liver of a fish sample in Vinikiland of Adamawa state. Likewise, a value of 0.09 mg/kg was reported by Ibrahim *et al.* (2018) in the liver of catfish species sampled from Lake Njuwa of Adamawa state. Another study by Faye-ofori *et al.* (2015) on the level of Cd in the liver of catfish species from Okilo Creek of Rivers state, Nigeria reported a value of 0.001mg/kg which is lower than the ones obtained in this study. A higher value for Cadmium was obtained by Brightone (2015) in a tilapia sample from a river in Libya to be 7.41 ± 1.45 mg/kg. The high level of Cd above the findings of the present work, as reported above could be due to accumulation of the metal in water bodies as a result of agricultural and/or anthropogenic activities taking place around the water source. The concentrations of Cd in fish liver analyzed in this research were all above the 0.01 mg/kg maximum permissible level in fish (WHO, 2004) while those of gills are not detected. This result is in agreement with that reported by Christof *et al.,* (2019) in which cadmium was not detected completely in the gills but found at lower concentration in the liver. The level of Cd in the liver of *L. capensis* reported by Lynch (2016) was 1.03 ± 0.61 mg/kg which is almost the same as that obtained in the liver of catfish from Ajiwa. The high levels of Cd in the study areas might be attributed to contamination of the water with heavy metals through agricultural and domestic run-off.

Cadmium is one of the most toxic elements with reported carcinogenic effects in humans. High concentrations of Cd have been found to lead to chronic kidney dysfunction. Cd can bio-accumulate at all levels of aquatic and terrestrial food chains (Moses, 2018).

The concentration of Cr was generally high in both livers and gills of fishes from the two sampling dams. This could be as a result of run-offs around the sampling areas where Chromium rich fertilizers are applied during agricultural activities. A similar higher concentration of chromium was reported by (Moses, 2018) in Abare River of Zamfara state to be 1.313 mg/kg. Likewise, Ibrahim *et al.* (2018) reported 0.77 mg/kg in gills of catfish sampled from Njuwa lake of Adamawa state. In a separate study, Chromium was detected within the range of 0.18 to 0.74 µg/g in the liver of fish samples from river Vinikilang of Adamawa state, values lower than the maximum permissible limit set by WHO/FAO (1993). Another study reported the level of Chromium in catfish sampled from Kiru dam and River Gongola of Adamawa state to be 0.136 ppm (Orosun *et al.,* 2016). With the exception of Ajiwa liver where the concentration is high, chromium levels in this research did not show significant differences in the samples analyzed.

Lead is non-essential element that constitutes body burden and a great threat to life if present in substantial quantity. It is toxic even at minimal concentrations and has no known function in biochemical processes (Moses, 2018). The standard level of Pb was reported to be 0.5 mg/kg dry weight (FAO, 2007). Similar to Cd, lead concentration in this work was also found to be higher than the recommended limit. Faye-ofori *et al.* (2015) in a one study reported 0.039±0.009 mg/kg and 0.048±0.024 mg/kg for Pb in the liver and gills of catfish species respectively from Okilo Creek of Rivers state, Nigeria. Similarly, 1.19 mg/kg was reported to have been found in dry season in the gills of catfish sampled from lake Njuwa of Adamawa state (Ibrahim *et al.,*2018). In related study conducted by Bawuro *et al.* (2018) with catfish sampled from Lake Geriyo of Adamawa state, it was found that the concentration of lead in liver and gills were 3.5 ± 0.00 mg/kg and 3.42 ± 1.97 mg/kg respectively. Brightone (2015) reported a higher value of 59.14 ± 6.67 mg/kg indicating a significant contamination of the source water. This high concentration of lead might have come from sewage, agricultural and mining wastes discharged into the dams (El-Nagger *et al*., 2009). The concentration of lead in all the sampled gills and livers posed a great health risk not only to the fish species but to the end chain consumers.

Copper being micronutrient is needed in trace amount for proper body functions, however, copper at high concentration can affect the brain, liver, or kidneys resulting in mental illness and death. (Ukachukwu, 2012). The recommended concentration of copper in fish established by WHO/FAO (1993)is 30 mg/kg. The samples analyzed in this research were all found to be below the standard limit with the exception of Ajiwa liver (64.30±1.61 mg/kg) which was found to be above the limit. This result agrees with the information that Cu levels in fish samples were higher in the liver than in the gills (Plessl, 2017). The concentration of copper obtained in gills (1.33±0.29) from Ajiwa samples is closely in agreement with what has been reported by Gilbert (2017) as 0.916 ± 0.378 mg/kg from a lake in China. Likewise, 1.164±0.006 mg/kg and 0.934±0.572 mg/kg of copper in liver and gills of catfish species respectively were reported in a study carried out from Okilo Creek of Rivers state, Nigeria (Faye-ofori*et al.,* 2015). Similar lower concentration of 0.18 to 0.67 µg/g for Cu was reported by Akan *et al.* (2012) in liver of fish sampled from a river in Vinikilang of Adamawa state. However, the high mean concentration (64.30±1.61 mg/kg) in the liver of Ajiwa fish samples is in agreement with that reported by Christof *et al.*(2019) as 63.7±17.0 mg/kg in *L. aeneus* specie from China, and in tilapia species from Libya (830.98 ± 178.58 mg/kg)as reported by Brightone (2015).

Nickel was not detected in all the liver and gill samples from the two sampling sites in this research which tallies with a report by El-Nemr, (2003). However, in a research conducted by Brightone (2015) in some tilapia fish samples from some selected water sites in Libya, the nickel was found in varying concentrations in gills but completely not detected in the liver. About 0.14 to 0.54 µg/g Ni was reported in a liver of a sampled fish from Vinikilang of Adamawa state by Akan *et al.* (2012). A slightly higher value of 2.617±0.046 mg/kg and 1.243±0.128 mg/kg for Nickel was reported by Faye-ofori *et al.* (2015) in a study of liver and gills of catfish species respectively in Okilo Creek of Rivers state, Nigeria. Also 0.38 mg/kg was reported by Ibrahim *et al.* (2018) from catfish species sampled from Lake Njuwa of Adamawa state.

The concentrations of manganese analyzed in organs of all the samples were found to be higher than the recommended value of 1.00 mg/kg by WHO/FAO (1993). A significantly lower value of 0.14 to 0.74 µg/g was reported in a liver of a sampled fish from Vinikilang of Adamawa state by Akan *et al.* (2012). The mean manganese concentration in gills of catfish was detected to be 0.014 mg/kg in the dry season in lake and fish farm of Ibadan, Oyo state, Nigeria (Olaifa *et al*., 2004). In a different research conducted by Emurotu *et al*. (2014), they reported the value of manganese in the liver of dried catfish samples to be 3.70 mg/kg while it was not detected in fresh ones. This indicates the possibility of high accumulation of manganese in dried fish samples than in fresh samples.

At lower concentration, cobalt is essential for enzymatic activity and many biological processes. (Ukachukwu, 2012). Just as nickel, cobalt was not detected in all the liver and gills from both sampling sites. However, small values in a range of 0.22 to 0.45 µg/g for the copper were found in fish as reported by Akan *et al.* (2012). Similarly, 4.00 ± 0.71 mg/kg was reported to have been obtained in the gills of catfish analyzed in Tiga Dam of Kano state, Nigeria (Sani, 2016). These values were higher than those reported by Akan *et al.* (2012) in Adamawa state. Andreji*et al.* (2006) reported a similarly low value for cobalt analyzed in catfish samples to be 0.10 ± 0.02 mg/kg in Lower Nitra river of Slovakia.

## CONCLUSION

It can be summed up that almost all the metal concentrations in sampled gill and Liver of some fish were higher in the liver than in the gills in both the two sampling sites, which is in agreement with most of the reported researches.The concentrations of the metals (Zn, Cd, Cu, Pb, Mn and Cr) in the liver were higher than the maximum permissible limit recommended by standard bodies and therefore the gill is safer for consumption compared to the liver.The P values for the liver and gills are lower than 0.05 ($P<0.05$) indicating significant difference between the gills and the liver samples of the fish species from the two dams.

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