ISSN-1996-918X

Pak. J. Anal. Environ. Chem. Vol. 12, No. 1 & 2 (2011) 25-31

# Bioaccumulation of Heavy Metals in Fish (*Tilapia Zilli* and *Clarias Gariepinus)* Organs from River Benue, North – Central Nigeria

Ishaq S. Eneji[*1], Rufus Sha'Ato[1] and P. A. Annune[2]

[*1]*Department of Chemistry and Centre for Agrochemical Technology, University of Agriculture P. M. B. 2373 Makurdi, Benue State, Nigeria.*

[2]*Department of Fisheries and Aquaculture, University of Agriculture P. M. B. 2373 Makurdi, Benue State, Nigeria.*

Received 19 July 2010, Revised 14 June 2011, Accepted 20 June 2011

**Abstract**

Heavy metals concentrations were determined in fish organs of *Tilapia zilli* and *Clarias gariepinus* from River Benue along Makurdi metropolis using atomic absorption spectrophotometer. The results indicated that *Tilapia zilli* gills contained the highest concentration (52.2%) of all the detected heavy metals, followed by the intestine (26.3%), while the muscle tissues appeared to be the least preferred site for the bioaccumulation of metals as the lowest metal concentration (21.5%) were detected in this tissue. Similarly, the *Clarias gariepinus* gills contained the highest concentration (40.3%) of all the detected heavy metals, followed by the intestine (31.6%), while the muscle tissue (28.1%) was the lowest. The trend of heavy metals concentration can be represented as: Cr > Zn > Cu > Fe > Mn > Cd > Pb for *Tilapia zilli*, while that of *Clarias gariepinus* was Cr > Zn > Fe > Cu > Mn > Cd > Pb. *Tilapia zilli* showed high bioaccumulation factors of 244, 229 and 178 for Cr, Zn and Cu, respectively. *Claria gariepinus* showed 232, 226 and 151 for Cr, Zn and Fe, respectively. This suggests that the fish samples could be used to monitor Cr and Zn pollution levels in the River Benue.

***Keywords:*** Bioaccumulation; Gills; Intestine; Tissue; *Tilapia zilli*; *Clarias gariepinus*.

## Introduction

Heavy metals are commonly found in natural waters and some are essential to living organisms, yet they may become highly toxic when present in high concentrations [1]. These metals also gain access into ecosystem through anthropogenic source and get distributed in the water body, suspended solids and sediments during the course of their mobility [2]. The rate of bioaccumulation of heavy metals in aquatic organisms depends on the ability of the organisms to digest the metals and the concentration of such metal in the river. Also it has to do with the concentration of the heavy metal in the surrounding soil sediments as well as the feeding habits of the organism. Aquatic animals (including fish) bioaccumulate trace metals in considerable amounts and stay over a long period. Fishes have been recognized as a good accumulator of organic and inorganic pollutants [3]. Age of fish, lipid content in the tissue and mode of feeding are significant factors that affect the accumulation of heavy metals in fishes. They are finally transferred to other animals including humans through the food chain. Odoemelam *et al*. [4] revealed high concentrations of heavy metals such as Cd, Pb, Cu, Ni, Zn, Mn, Mg and Co in some rivers within the proximity of some industrial cities in Nigeria. The discharge of industrial wastes containing toxic heavy metals into water bodies may have significant effects on fish and other aquatic organisms, which may endanger public

*Corresponding Author Email: eneji3@yahoo.com

health through consumption of contaminated seafood and irrigated food crops. Nwaedozie [5] reported that zinc contamination affects the hepatic distribution of other trace metals in fish. Zinc, copper and manganese, which are essential elements, compete for the same site in animals. This, no doubt, would affect tissue metal concentrations as well as certain physiological processes. Oboh and Edema [6] reported the pattern of metal content in fish (Fe > Mn > Cd) differed from that of the water (Fe > Cd > Mn). Eneji [7] reported the pattern of metal concentration in tilapia was Cr > Zn > Cu > Fe > Mn > Cd > Pb. However, this pattern was different from that of the River Benue water (Fe >Cr > Pb > Mn > Zn > Cu > Cd). They attributed this order to be due to bioavailability, intrinsic fish processes, and trophic structure variation. The high level of Fe in the fish species could be attributed to its bioavailability in the environment and its essential role in haemoglobin. Lawani and Alawode [8] working on the River Niger at Jebba, reported a bioaccumulation factor of 225 for lead in fish. Similarly, Okoye [9] working in Lagos lagoon, reported a bioaccumulation factor of 604 for manganese in *T. quineansis* and 248 for lead. Obodo [10] working on the lower reaches of River Niger at Onitsha, reported bioaccumulation factor of 300 and 220 for manganese and lead respectively in *Synodontis membranaceus* bioaccumulations of 254 and 250 for manganese and lead respectively in *Tilapia zilli.* Obodo [11] reported that catfish showed the highest bioaccumulation factor of 350 for manganese and 219 for lead. While tilapia, on the other hand, showed the highest bioaccumulation factor of 224 for lead and 210 for manganese. The objective of this work is to determine the levels of contamination and the bioaccumulation of these heavy metals in two most common and eatable fishes (*Tilapia zilli* and *Clarias gariepinus*) that are found in River Benue.

## Materials and Methods

The two most common fish types – *Clarias gariepinus* and *Tilapia zilli* were bought directly from the fishermen at the bank of River Benue (Fig. 1) at the Wurukum Abattoir and Wadata Fishing ports. A total of 8 matured fish samples, that is four (4) each of live matured *Clarias gariepinus* (mean weight 124 ± 2g and mean length 26.5 ± 2.2cm) and *Tilapia zilli* (mean weight 83.9 ± 0.3g and mean length 16.7 ± 1.7 cm) were obtained from the two sampling stations (up and down stream of River Benue). They were stored in a cooler packed with ice block in order to maintain the freshness and latter transported (1–hour) to the laboratory for dissection of the organs after removing the scales and washed thoroughly (especially the *tilapia zilli*). The fish samples organs (gills, intestine and tissues) were dried separately for 24 hours to constant weight in an oven at 105$^{o}$C. The various organs of each species collected were pooled and milled with a mortar and pestle. They were put in dry labeled plastic containers and stored in desiccator until digestion. A procedure similar to that described by Poldolski [12] was used to digest the samples. This involved digesting 10 g portion of the ground samples with 10mL $HNO_3$ and 2 mL $HClO_4$ was heated on a hot plate for one hour. After complete digestion, the residue was dissolved and diluted with 0.2%v/v $HNO_3$ to 20 mL. Digest was stored in pre-cleaned polyethylene bottles until analysis using atomic absorption spectrophotometer (Unicam 969, Analytical Technology Inc., Cambridge, United Kingdom).

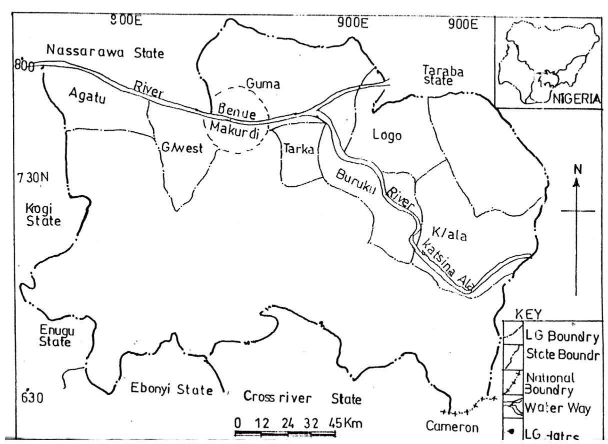


***Figure 1.*** **Base Map of Benue State Showing Local Government Areas along River Benue Course.**

## Results and Discussion

In this work, we also observed the trend that different metals are accumulated at different concentration in various organs (Table 1). The difference in the levels of accumulation in different organs of a fish can primarily be attributed to the differences in the physiological role of each organ. Other factors such as regulatory ability, behaviour and feeding habits may play a significant role in the accumulation differences in the different organs [13]. Also the chemical nature of the metals ionic stength and pH tends to be a master variable in the accumulation process. In acidic conditions, there are enough hydrogen ions to occupy many of the negatively charged surfaces and little space is left to bind heavy metals, hence more heavy metals remain in the soluble phase. The soluble form of heavy metals is thought to be more harmful because it is more easily transported and more readily available to aquatic organism. The result was in agreement with previous investigations on similar fishes from some Nigerian rivers as shown in (Table 2).

***Table 1.*** **Mean Concentrations (mg/kg) of heavy metals in fish species from River Benue.**

| Element | Tilapia Zilli | | | | Clarias gariepinus | | | |
|---|---|---|---|---|---|---|---|---|
| | ***Gill*** | ***Intestine*** | ***Tissue*** | ***BF*** | ***Gill*** | ***Intestine*** | ***Tissue*** | ***BF*** |
| Cd | 0.351 | 0.337 | 0.306 | 19.1 | 0.325 | 0.333 | 0.269 | 17.8 |
| Cr | 31.6 | 31.5 | 29.8 | 224 | 32.2 | 28.1 | 28.2 | 232 |
| Cu | 2.98 | 5.36 | 1.65 | 178 | 2.07 | 2.26 | 1.56 | 105 |
| Fe | 53.6 | 7.07 | 8.01 | 91.4 | 49.0 | 34.0 | 30.1 | 151 |
| Pb | 1.00 | 1.40 | 1.18 | 17.3 | 1.28 | 0.678 | 0.801 | 13.3 |
| Mn | 6.18 | 0.703 | 0.935 | 43.2 | 1.73 | 1.17 | 0.607 | 19.4 |
| Zn | 7.15 | 5.66 | 5.24 | 229 | 7.05 | 6.86 | 3.85 | 226 |

BF means bioaccumulation factor

***Table 2.*** **Heavy metals concentration (mg/kg) in some fishes of Nigeria Rivers.**

| Fish species | Location | Cd | Cr | Cu | Fe | Pb | Mn | Zn | Reference |
|---|---|---|---|---|---|---|---|---|---|
| *Clarias gariepinus* | River Benue | 0.927 | 88.5 | 5.89 | 113 | 2.78 | 3.51 | 17.8 | This work |
| *Tilapia Zilli* | River Benue | 0.994 | 92.9 | 9.99 | 68.7 | 3.58 | 7.82 | 18.1 | This work |
| *Clarias gariepinus* | River Niger | 0.183 | - | - | 1.263 | - | 0.292 | - | [6] |
| *Synodontis membranaceus* | Anambra River | - | - | 5.13 | 112.07 | 61.32 | 94.07 | 71.17 | [11] |
| *Tilapia Zilli* | Anambra River | - | - | 5.1 | 201.50 | 62.79 | 56.14 | 71.80 | [11] |
| *Clarias gariepinus* | Niger Delta Area | 0.030 | - | - | 2.300 | 0.480 | 2.390 | - | [16] |
| *Alestes nurse* | Oguta Lake | 1.50 | 1.86 | 12.4 | 110.0 | 10.9 | 79.3 | 119.6 | [25] |
| *Synodontis nigritis* | Oguta Lake | 1.23 | 0.68 | 14.0 | 120.0 | 14.5 | 13.1 | 156.0 | [25] |
| *Clarias gariepinus* | Warri River | 0.190 | 0.789 | - | 1.340 | 0.210 | 0.450 | - | [26] |
| *Sarotherodon melanotheron* | Lagos Lagoon | ND | ND | - | 16.750 | 7.850 | ND | - | [27] |

ND is not detected

(Fig. 2) present the concentrations of heavy metals in the River Benue. The *Tilapia zilli* gills contained the highest concentration (52.2%) of all the detected heavy metals, followed by the intestine (26.3%), while the muscle tissues appeared to be the least preferred site for the bioaccumulation of metals as the lowest metal concentration (21.5%) were detected in this tissue (Fig. 3). Similarly, the *Clarias gariepinus* gills contained the highest concentration (40.3%) of all the detected heavy metals, followed by the intestine (31.6%), while the muscle tissue (28.1%) was the lowest (Fig. 4). The general order of heavy metals concentrations in various organs of the two fish species used in this research can represented (Fig. 5) as follows: Gills > intestine > muscle tissues. Higher metal concentrations in the gills could be due to the element complexion with the mucus that is virtually impossible to completely remove from the gill lamellae before prepared for analysis [14].

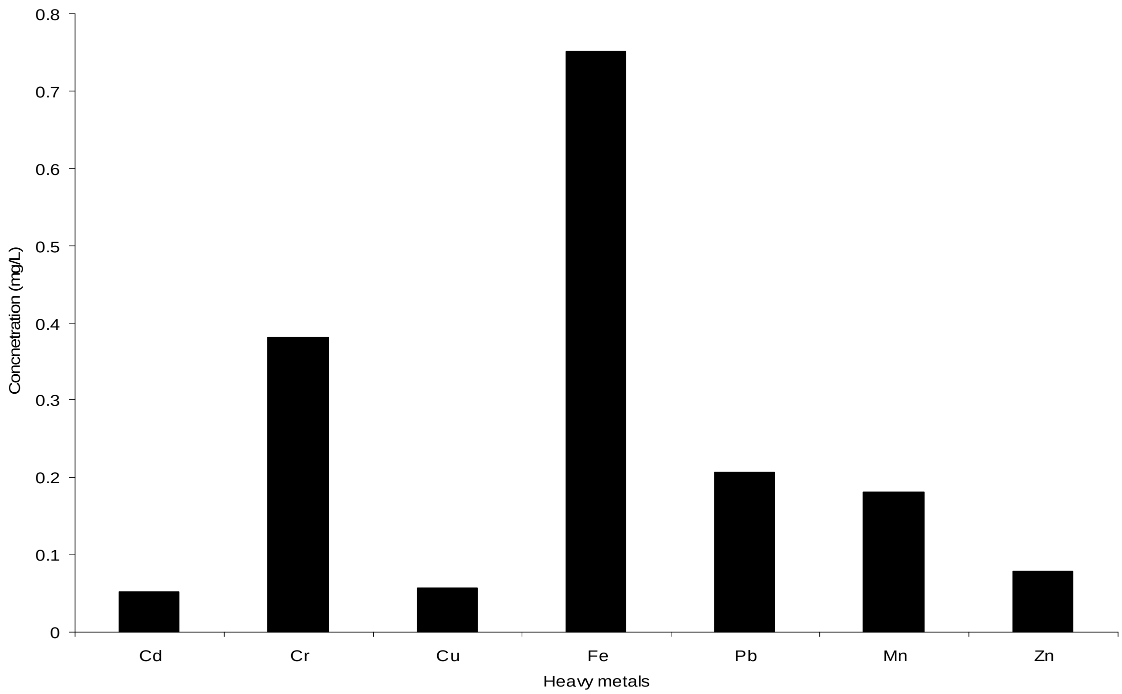


***Figure 2.*** **Average concentration of heavy metals in River Benue.**

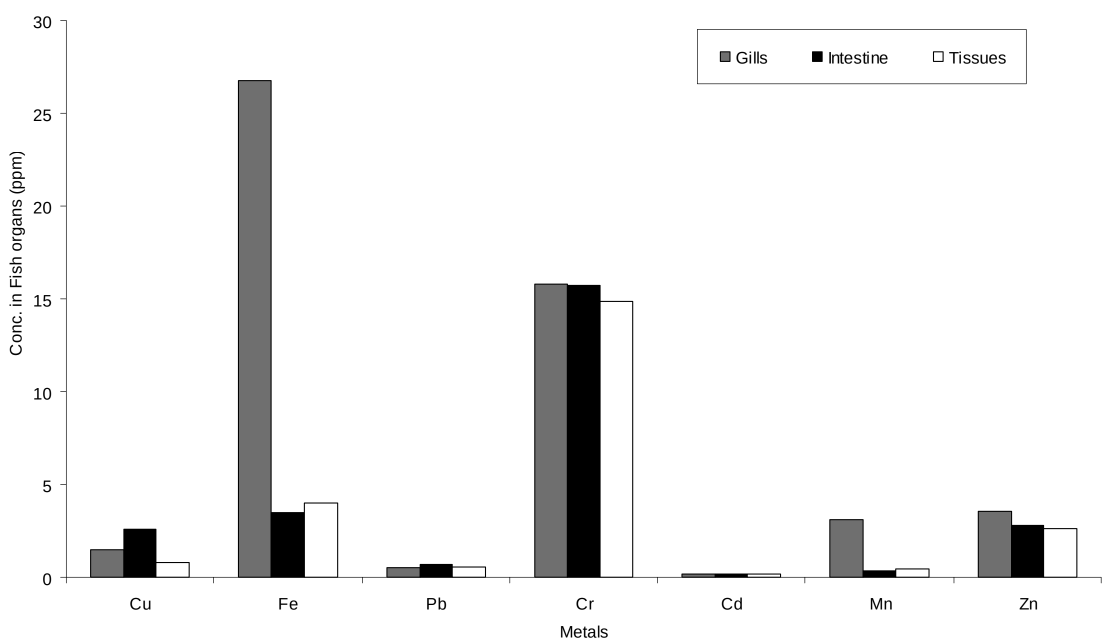


***Figure 3.*** **Average concentration of heavy metals in organs of *Tilapia zilli* from River Benue.**

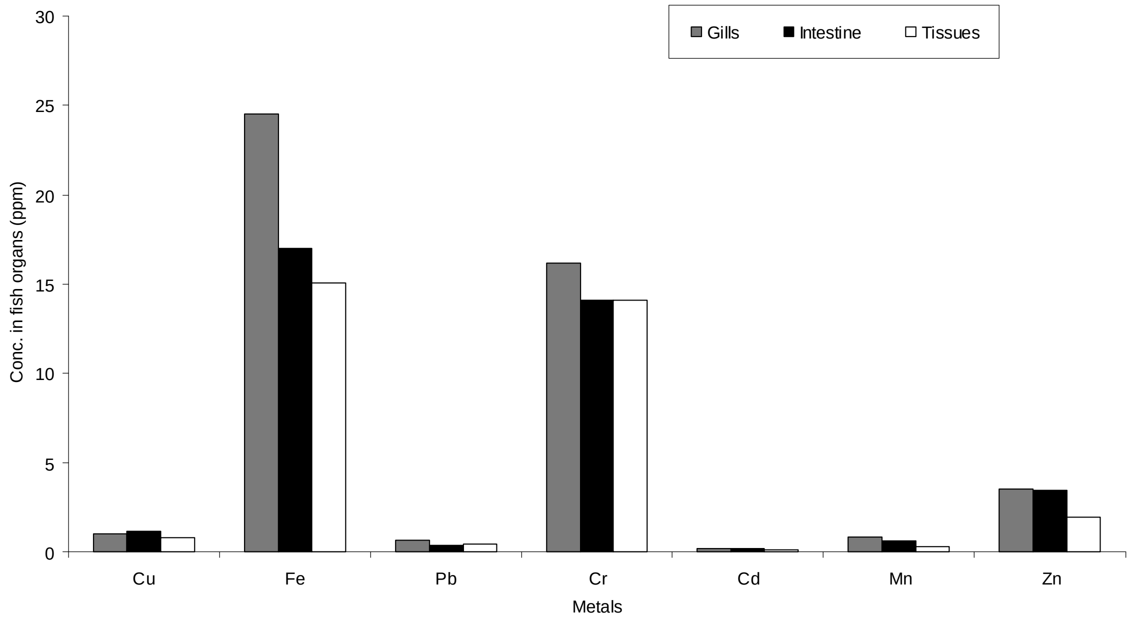


***Figure 4.*** **Average concentration of heavy metals in organ of *Clarias gariepinus* from River Benue.**

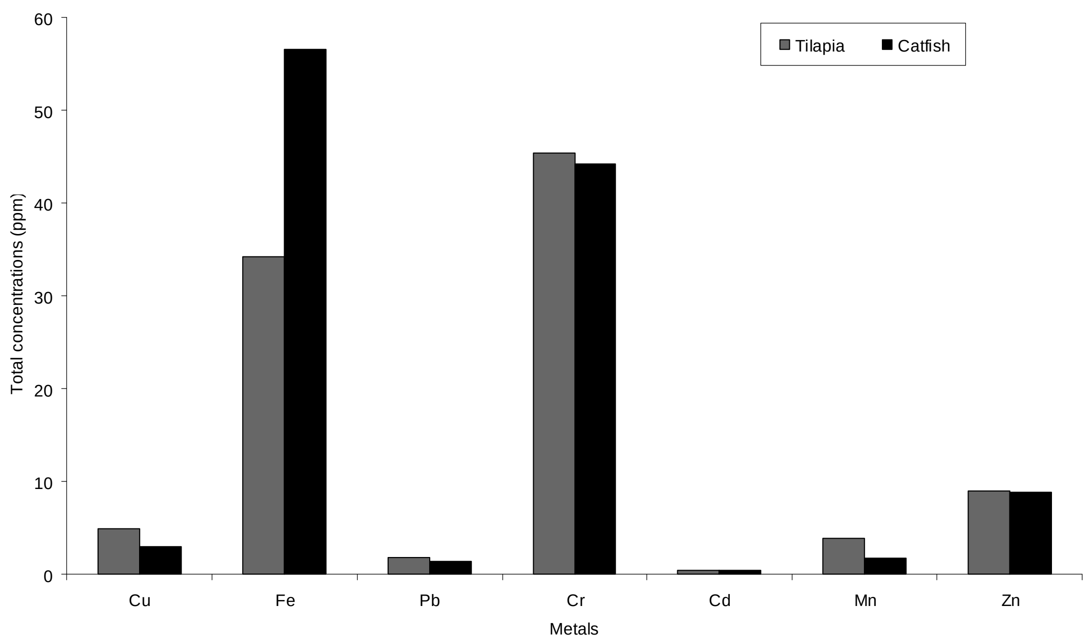


***Figure 5.*** **Average concentration of heavy metals in fish species from River Benue.**

Furthermore, the adsorption of metals onto the gills surface as the first target for pollutants in water could also be a significant influence in the total metal levels of the gill. Target organs such as gills and intestine are metabolically active parts that can accumulate heavy metals in higher levels, as shown in various fish species in *Cyprinus carpio* and *Tincatinca* from lake Beysehir, Turkey [14], in *Oreochromis mossambicus* and *C. gariepinus* from Olifant River, South Africa [13]. Deb and Fukushima [15] confirm this by reporting that metal may be in high concentrations in gill, lung and digestive gland because of relatively high potential for metal accumulation. In this work, tissues contained the least concentrations of heavy metals in both fish species that were investigated. This result was in agreement with many authors who reported that tissue is not an active organ in accumulation of heavy metals [14, 16 – 19]. The concentrations of heavy metals in the intestine were higher than in the muscle tissue. The motive for high metal concentration in the intestine could also be ascribed to the metal complexion with the mucus that impossibly be removed completely from the intestine before the analysis [20]. The results of the present study showed that metals were more concentrated in *Tilapia zilli* organs, hence has a greater capacity for metal bioaccumulation than that of *Clarias gariepinus* [21].

The pattern of metal concentration in *Tilapia zilli* was Cr > Zn > Cu > Fe > Mn > Cd > Pb, while that *Clarias gariepinus* was Cr > Zn > Fe > Cu > Mn > Cd > Pb. The patterns of metal concentrations in both fish species were almost similar except that Cu and Fe interchanged their trend at positions 3 and 4, respectively. Although, figure 2 showed a different trend of heavy metals concentration in River Benue water [22]. According to literature, it may be due to bioavailability, intrinsic fish processes, and trophic structure variation. The specificity of concentrations of heavy metals irrespective of the locality of fish capture and the route of uptake of the metals has been reported [6, 7]. The variability observed in the fish species is a reflection of different thresholds of metals which are a function of homeostasis. The thresholds of metals in fish can be considered as the concentration level where the metal starts to interfere with the variable physiology of the fish species in such manner that once a particular level of the metal has been sequested in the body, equilibrium is established between the fish burden and the ambience. Also, Olaifa *et al.* [23] reported that fish species can accumulate heavy metals above the abiotic environment to incur bioaccumulation. Species difference in heavy metals bioaccumulation could be linked to difference in feeding habits and behaviour of the species [24]. The *Tilapia zilli* showed the highest bioaccumulation factor of 244 for chromium and 229 for zinc. Similarly the *Clarias gariepinus* showed the highest bioaccumulation factor of 232 for chromium and 226 for zinc. This inferred that both *Tilapia zilli* and *Clarias gariepinus* would perhaps be a better indicator to monitor chromium and zinc pollution in the environment. The high bioaccumulation factor for chromium and zinc suggests that the concentration of these metal ions – as it sometimes serves as a harbourage or the fish species have poor mechanisms for digesting and eliminating these heavy metals. The rate of bioaccumulation of heavy metals in organisms depends on the ability of organisms to digest the metals and the concentration of such metals in the river. It also has to do with the concentration of the heavy metal in the surrounding soil as well as the feeding habits of the fish species. The lowest bioaccumulation was recorded for lead with *Tilapia zilli* having bioaccumulation factor of 17.3 while *Clarias gariepinus* has bioaccumulation factor of 13.3. Lead is a well – known toxicant that has several deleterious effects even at very low concentrations. The concentration of lead obtained in each of the fish samples may be considered as high considering the acute toxicity of the metal. The bioaccumulation factor for copper and iron were found to be 178 and 91.4 in *Tilapia zilli*, respectively. In *Claria gariepinus* the bioaccumulation were 105 and 151 for copper and iron, respectively. Copper as an essential element promotes the activity of certain enzyme systems in the body while iron is a component of haemoglobin which is responsible for the transport of oxygen in the body. Although, these two elements may also be toxic to man and animals when ingested in large amount. Generally, the metal concentrations in the fish species from river Benue were however, found to be low when compared with previous works from Nigeria Rivers. Lawani and Alawode [8] reported a bioaccumulation factor of 225 for lead in fish samples from River Niger at Jebba. A bioaccumulation factor of 604 for manganese and 248 for lead in *T. Quineansis* in Lagos Lagoon has also been reported [9]. Similarly, Obodo [10] working on the lower reaches of river Niger at Onitsha, reported bioaccumulation factor of 300 and 220 for manganese and lead respectively in *Synodontis membranaceus* and bioaccumulations of 254 and 250 for manganese and lead respectively in *Tilapia zilli*.

## Conclusions

The study clearly indicated significant accumulation of heavy metals in the organs of the two fish species from River Benue. This conforms to the previous studies which revealed that heavy metals were more concentrated in the gills than other parts of the fish organs in the water because of relatively high potential for metal accumulation [14, 16]. It is logical to say that the high concentration of metals in river become gradually accumulated on the sediments (as a function of pH) and in due course get transferred to fish. Finally, the high level of bioaccumulation factor of Zn and Cr shows that they were good bio-indicator to monitor pollution in the river for the two fish species. Although, we did not investigate the role of adsorption, precipitation of metal ions and influence of interference in this work these will be considered in our next work.

## Acknowledgements

Our appreciation goes to Pastor Gandu Isiah of National Research Institute for Chemical Technology (NARICT), Zaria for his assistance during the AAS analysis. We also appreciate the anonymous reviewers for their useful suggestions.

## References

1. U. J. Ibok, E. D. Udosen, and O. M. Udoidiong, *Nig. J. Tech. Res*., 1 (1989) 61.
2. A. A. Olaijire and F. E. Imeokparia, *Bull. Chem. Soc. Ethiop*., 14 (2000) 1.
3. R. P. King and G. E. Jonathan, Aquatic environmental perturbations and monitoring, African experience, USA (2003).
4. S. A. Odoemelam, C. C. Iwuazor and J. U. Ozuo, Tropical Environmental Forum (TEF) held at Calabar, (1999) May 18th.
5. J. M. Nwaedozie, *J. Chem. Soc. Nigeria*, 23 (1998) 21.
6. I. P. Oboh and C. U. Edema, *J. Chem. Soc. Nigeria*, 32 (2007) 29.
7. I. S. Eneji, *Spatial and temporal variation in the heavy metals loading of River Benue in Makurdi metropolitan area*, Ph. D. Thesis, Department of Chemistry University of Agriculture Makurdi, Nigeria (2010).
8. S. A. Lawani and S. A. Alawode, *Nig. J. of Biotech*., 4 (1987) 4.
9. B. C. O. Okoye, *Inter. J. Environ. Studies*, 57 (1991) 285.
10. G. A. Obodo, *J. Chem. Soc. Nigeria*, 27 (2002) 173.
11. G. A. Obodo, *J. Chem. Soc. Nigeria*, 29 (2004) 60.
12. J. E. Poldoski, *Anal. Chem*. 52 (1980) 1147.
13. M. Marzouk, *Vet. Med. J*. 42 (1994) 51.
14. M. Khail and H. Faragallah, *Egypt J. Aquat. Res.*, 34 (2008) 1.
15. S. Deb and T. Fukushima, *Int. J. Environ. Stud*., 56 (1999) 385.
16. S. E. Kakulu and O. Osibanjo, *J. Chem. Soc. Nigeria*, 13 (1987) 22.
17. L. Coetzee, H. H. du Preez and J. H. J. van Vuren, *Water SA.*, 28 (2002) 433.
18. H. Karadede, S. A. Oymak and E. Unlu, *Environmental International*, 30 (2004) 183.
19. L. Chouba, M. Kraiem, W. Njimi, C. Tissaoui, J. Thompsom and R. Flower, *Transitional water Bulletin*, 4 (2007) 45.
20. B. A. Yilmaz, *Turk. J. Vet. Anim. Sci*. 29 (2005) 257.
21. A. A. Adeniyi, *Environmental Monitoring and Assessment*, 137 (2008) 451.
22. I. S. Eneji, R. Sha'Ato and P. A. Annune, *Environmental Monitoring and Assessment*, Springer Publisher. Published online: 15 March (2011).
23. F. E. Olaifa, A. K. Olaifa, A. A. Adelaja and A. G. Omolabi, *African Journal of Biomedical Research*, 7 (2004) 145.
24. A. Altindag and S. Yigit, *Chemosphere*, 60 (2005) 552.
25. S. A. Odoemelan, *J. Chem. Soc. Nigeria*, 30 (2005) 18.
26. L. I. N. Ezemonye and A. B. M. Egbroge, National Seminar on petroleum: Petroleum Training Institute, Warri. Technical papers, 3. (1992) 91.
27. V. A. Fodeke and J. A. Ekundayo, *Nigerian Journal of Natural Sciences*, 4 (1989) 99.