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# Distribution and concentration of some mineral elements in soil sediment, ambient water and the body parts of *Clarias gariepinus* and *Tilapia quineensis* fishes in river Tammah, Nasarawa state, Nigeria

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**ABSTRACT**

An investigation into the concentrations and distributions of lead, magnesium, zinc, chromium, iron, manganese and copper in the soil sediment, river water and the organs of *Clarias gariepinus* and *Tilapia quineensis* was undertaken with a view to evaluating the interplay of these inorganic minerals in the various matrices. The fishes were of variable sizes while the organs investigated in them were head, intestine, gills and flesh. The lead, magnesium, zinc, chromium, iron, manganese and copper values were lower in fish organs than in the water and soil, thereby showing a low level of bioconcentration. The trace metals determined were below the deleterious level however there is a need for further monitoring.

**Keywords:**Soil sediments, River water, Fish organs, Metals

## INTRODUCTION

Many heavy metals such as lead (Pb), Zinc (Zn), Manganese (Mn), Iron (Fe), Nickel (Ni) and Copper (Cu) occur in nature in ore deposits[1,2]. These metals are released through leaching and weathering into the aquatic environment. Thus, areas characterized by metal bearing formation are expected to have elevated levels of metals in water and sediment. If mining operations are carried out in such areas, discharges and fallout from the industry would lead to further pollution[3,4]. The anthropogenic sources which have been reported to cause elevated concentrations in the aquatic environment include industrial and domestic effluents; industrial processing of ores or metals and the use of metals and metal components; metal leachates from solid waste dump; metals from agricultural lands due to use of fertilizers and other agricultural chemicals and fossil fuel combustion[4-6].

Sediments form the major repository of heavy metals in aquatic systems, in some cases holding over 90% of the total amount[7] while allochthonous and autochthonous influences could make concentrations of heavy metals in the water high enough to be of ecological significance. Moreover biological magnification could lead to toxic levels of these metals in fish, even when the exposure is low. The proven toxicity of high concentrations of heavy metals in water to fishery and wild life poses the problem of an ultimate disequilibrium in the natural ecological balance[8]. Apart from destabilizing the ecosystem, the accumulation of these toxic metals in the aquatic food organisms is a potential threat to public health. The Minamata Bay epidemics remains a classic example[9,10].

Evidence of potential and observed human hazard due to environmentally acquired heavy metals and their ecological impact have been extensively studied and documented[11-15]. River Tammah/Kwoto in Nasarawa town of Nasarawa State, Nigeria had been in existence before the settlement of the present dwellers. Water from this river is being supplied to the public for various purposes which include domestic, industrial and agricultural purposes. Also fishes from the water are being sold to the public for human consumption. There has been no information concerning the monitoring of the concentration of pollutants level in the water, sediment and fish from this river vis-à-vis heavy and toxic metals concentration assessment. Therefore, this work is aimed to provide information on the distribution and concentration of some heavy metals in water, sediment and fish from river Tammah/Kwoto while the data generated will serve as baseline for further studies.

## MATERIALS AND METHOD

### Collection of samples

Representative water samples were taken just below the water surface at three different locations from the river using one litre acid leached polythene bottle. The water samples were stored in a deep freezer at – 18°C prior analysis. A diver was used to take soil sediment samples from the surface down to a depth of about 15cm at locations where water samples were taken, stored in a polythene bag which had been washed and leached accordingly and kept in deep freezer prior analysis. Two pieces each of fresh fishes (*Clarias gariepinus* and *Tilapia quineensis*) were bought from fishermen at the river site. The fishes were washed with distilled deionised water to remove any adhering contamination, drained under folds of filter paper, weighed, measured, identified and wrapped in aluminum foil and deep frozen at – 18°C.

All samples were collected at 6.00 hours Green-Wich Mean Time or 7.00 local time while temperature of the water was 28°C at the time of collection.

### Treatment of samples

5cm$^3$ of concentrated hydrochloric acid were added to 250cm$^3$ of water sample and evaporated to 25cm$^3$. The concentrate was transferred to 50cm$^3$ standard flask and diluted to the mark with distilled de-ionised water[16]. The soil sample was air-dried, then sieved using 200mm mesh. 5g of the soil sample was weighed into 150cm$^3$ conical flask, digested using 15ml nitric acid, 2ml perchloric acid and placed on a hot plate for 3hours[17]. On cooling, the digest was filtered into 100ml volumetric flask and made up to mark with distilled water. The fish samples were separated into the head, intestine, gills and flesh. Different body parts of the fish samples were dried at 105°C until constant weight. The parts were blended and weights ranging between 0.25g and 0.80g were accurately taken for digestion. The weighed fish part samples (in crucibles) were ashed at a temperature of 540°C in the furnace (NEY-M 525) to constant weight. The ashed samples were each transferred into a 50cm$^3$ beaker, washed with 25cm$^3$ of 20%(v/v) nitric acid. The solution was carefully filtered and transferred into 50cm$^3$ standard volumetric flask and made up to the mark with distilled de-ionised water[18].

### Analysis of Minerals

Lead (Pb), magnesium (Mg), zinc (Zn), chromium (Cr), iron (Fe), manganese (Mn) and copper (Cu) were analysed in the four matrices using a Perkin Elmer model 306 atomic absorption spectrophotometer. All determinations were in duplicate.

### Statistical Analysis

Data obtained were subjected to statistical evaluation parameters evaluated. Were grand mean, standard deviation and coefficient of variation percent.

## RESULTS AND DISCUSSIONS

Table 1 presents the mean heavy metal concentrations, grand mean, standard deviation and coefficient of variation in soil sediment and water. The concentrations of Zn, Cr, Mn and Cu were low (<1.0mgL$^{-1}$) in both samples. The value of Zn in water is within the range suggested by O'Connor[19] which is 0.001 to 0.20mgL$^{-1}$. Among all the metals determined, Mg was found to be in the highest concentration with an average of 62.19mgL$^{-1}$ and 5.84mgL$^{-1}$ in the sediment and water respectively followed by Pb with 2.21mgL$^{-1}$ (sediment) and 4.24mgL$^{-1}$ (water) while Zn has the lowest concentration of 0.22mgL$^{-1}$ for both sediment and water. These results are in agreement with the results of Adeyeye *et al*.[20] in which Zn was found to be the lowest concentration in both sediment and water. Going by the calculated coefficient of variation percent (CV%), the highest variability was Mg (117.12%), the least was Fe (1.45%) while no variation was recorded in Zn between the levels of the metals in the soil and water. The order of variation was Mg > Cr > Pb > Mn > Cu > Fe.

Levels of the metals in the various parts of *Clarias gariepinus* are shown in Table 2. Each metal determined had the highest concentration either in the head or the intestine part of the fish except for Mg where flesh part had the highest concentration. The coefficient of variation percent of level of metals in the body parts of *Clarias gariepinus* varied between 6.42% in Zn to 70.29% in Cu. The concentration of the metals determined in the fish parts followed the order Mg > Pb > Fe > Cr = Cu > Mn > Zn.

The results of level of metals in the organs of *Tilapia quineensis* are presented in Table 3. The least concentration of each level of metal determined was found in the gills. Magnesium was the most highly concentrated metals in all the fish parts. The order being Mg > Pb > Fe > Cu > Cr > Mn > Zn. Mg showed the least variability while Cu had the highest value of 153.85%. Mg which was the highest concentrated metal in the flesh part of both fishes indicates nutritional potential of these fishes. Mg apart from its involvement in bone formation[20], it is an activator of many enzyme systems and maintains the electrical potential in nerves[21]. The observed value of Fe in *Clarias gariepinus* intenstine compares favourably with the observation in *Illisha africana* fish[22]. Fe occurs in the prosthetic group of certain proteins notably the cytochromes which function in electron transport and in the enzyme, peroxides and some dehydrogenases. Iron in animal source is well absorbed (15 – 35%) in contrast with other forms of iron, such as that from plant foods at 1 – 10%[23]. In addition, it enhances the absorption of iron from other sources, for example, the addition of fish to a legume cereal diet can double the iron absorbed and so contributes significantly to the prevention of anaemia, which is so wide-spread in developing countries like Nigeria[24].

The high levels of some metals (Pb, Mg, Fe and Cu) in the head part of both fishes are as a result of the gills, which help in respiration and filtration of water. This result agrees with findings of Ayejuyo *et al*.[25] in which Zn was found in the highest amount in the gills of *Clarias lazera* as compared with all the other body parts studied. In the present study although the gills were separated from the head but the values obtained were close with that of the head's (Tables 2 and 3).

Lead was detected in every part of the bodies of fishes studied. Lead is toxic even at low concentrations and has no known function in bicochemical processes. Sources of lead include storage batteries, cable sheaths, solder, pigments, mining and smelting activities, sewage sludge, anti-knock compounds in petrol and manufacture of products containing lead[26,27]. The onset of lead pollution of surface waters has been reported, the major source being the use of leaded gasoline[29]. Lead is known to inhibit active transport mechanisms involving ATP, to depress the activity of the enzyme cholinesterase, to suppress cellular oxidation-reduction reactions and to inhibit protein synthesis[30]. The lead level in *Tilapia quineensis* head (1.44mgL$^{-1}$) was the highest detected, although this value is below the US FDA maximum permissible level[31] for lead whose value in the fish head is 2.0mgkg$^{-1}$ wet weight. Since the fish samples were determined on a dry weight basis, one may conclude that the levels of these metals in the samples analysed do not constitute any health hazard. However, there is a need for further monitoring.

The values of zinc and manganese in the head and flesh are useful to man since these are the areas of fish mostly consumed, although the fish head is just now becoming a delicacy [32] in Nigeria. Zinc is present in all tissues of the body of man and is a component of more than 50 enzymes[33]. Families and individuals who may be using vegetable and cereal sources of protein may not be able to meet the zinc allowances per day. This is because the zinc in these sources is not as available as in animal sources[34]. Manganese functions as an essential constituent for bone structure, for reproduction and for normal functioning of the nervous system. It is also part of

**Table 1: Mean concentration of metals in the soil sediment and ambient water (mgL$^{-1}$)**

| Parameter | Pb | Mg | Zn | Cr | Fe | Mn | Cu |
|---|---|---|---|---|---|---|---|
| Soil sediment | 2.21 | 62.19 | 0.22 | 0.50 | 2.05 | 0.29 | 0.83 |
| Water | 4.24 | 5.84 | 0.22 | 0.33 | 2.14 | 0.22 | 0.64 |
| Grand mean | 3.23 | 34.02 | 0.22 | 0.42 | 2.10 | 0.26 | 0.74 |
| SD | 1.44 | 39.84 | 0.0 | 0.12 | 0.06 | 0.05 | 0.13 |
| CV% | 44.44 | 117.12 | 0.0 | 60.21 | 1.45 | 19.23 | 18.18 |

SD standard deviationCV% coefficient of variation percent.

**Table - 2: Distribution and concentration of the various metals in the body parts of *Clarias gariepinus* (dry weight in mgL$^{-1}$)**

| Parameter | Pb | Mg | Zn | Cr | Fe | Mn | Cu |
|---|---|---|---|---|---|---|---|
| Head | 1.00 | 3.44 | 0.09 | 0.28 | 1.10 | 0.41 | 0.58 |
| Intestine | 1.20 | 4.10 | 0.09 | 0.34 | 0.58 | 0.10 | 0.09 |
| Gills | 1.04 | 3.29 | 0.09 | 0.28 | 0.71 | 0.11 | 0.20 |
| Flesh | 1.01 | 4.22 | 0.08 | 0.32 | 0.82 | 0.11 | 0.33 |
| Grand mean | 1.15 | 3.76 | 0.09 | 0.30 | 0.80 | 0.12 | 0.30 |
| SD | 0.14 | 0.47 | 0.00 | 0.02 | 0.22 | 0.02 | 0.21 |
| CV% | 11.95 | 12.38 | 6.42 | 6.94 | 27.67 | 15.21 | 70.29 |

SD standard deviationCV% coefficient of variation percent

**Table -3: Distribution and concentration of the various metals in the body parts of *Tilapia quineensis* (dry weight in mgL$^{-1}$)**

| Parameter | Pb | Mg | Zn | Cr | Fe | Mn | Cu |
|---|---|---|---|---|---|---|---|
| Head | 1.44 | 3.32 | 0.09 | 0.21 | 1.11 | 0.10 | 0.45 |
| Intestine | 1.03 | 3.43 | 0.10 | 0.31 | 1.26 | 0.19 | 0.14 |
| Gills | 1.38 | 2.68 | 0.09 | 0.21 | 1.01 | 0.13 | 0.50 |
| Flesh | 1.03 | 3.70 | 0.15 | 0.29 | 1.39 | 0.11 | 0.16 |
| Grand mean | 1.22 | 3.28 | 0.11 | 0.26 | 1.19 | 0.13 | 0.31 |
| SD | 0.25 | 0.43 | 0.03 | 0.14 | 0.17 | 0.04 | 0.40 |
| CV% | 20.24 | 13.18 | 26.24 | 52.50 | 14.04 | 31.01 | 153.85 |

SD standard deviationCV% coefficient of variation percent

the enzyme system[20]. All the fish samples will complement the supply of Zn and Mn in food.

Tables 4 and 5 show bioconcentration factors for the various organs of *Clarias gariepinus* and *Tilapia quineensis* respectively. The values obtained for various fish organs were relative low (<1) which showed there was no biological magnification of metal concentration in the fish samples. However, the two Tables reveal the relative dependency of metal concentrations of fish samples on water sample. Order of bioconcentration factor of various metals in the body parts of *Clarias gariepinus* is Cr > Mg > Mn > Cu > Zn > Fe > Pb while that of *Tilapia guineensis* is Cr > Mn > Mg > Fe > Zn = Cu > Pb.

**Table - 4: Bio-concentration factors of the various metals in the body parts of *Clarias gariepinus***

| Parameter | Pb | Mg | Zn | Cr | Fe | Mn | Cu |
|---|---|---|---|---|---|---|---|
| Head | 0.24 | 0.59 | 0.41 | 0.85 | 0.51 | 0.64 | 0.91 |
| Intestine | 0.29 | 0.70 | 0.41 | 0.94 | 0.27 | 0.45 | 0.14 |
| Gills | 0.25 | 0.56 | 0.41 | 0.85 | 0.33 | 0.50 | 0.31 |
| Flesh | 0.24 | 0.72 | 0.36 | 0.97 | 0.38 | 0.50 | 0.52 |
| Grand mean | 0.26 | 0.64 | 0.40 | 0.90 | 0.37 | 0.52 | 0.47 |
| SD | 0.02 | 0.20 | 0.03 | 0.06 | 0.10 | 0.08 | 0.37 |
| CV% | 9.42 | 30.58 | 6.29 | 6.88 | 27.61 | 15.74 | 78.72 |

SD standard deviationCV% coefficient of variation percent

**Table - 5: Bioconcentration factors of the various metals in the body parts of *Tilapia quineensis***

| Parameter | Pb | Mg | Zn | Cr | Fe | Mn | Cu |
|---|---|---|---|---|---|---|---|
| Head | 0.34 | 0.57 | 0.41 | 0.64 | 0.46 | 0.45 | 0.70 |
| Intestine | 0.23 | 0.59 | 0.45 | 0.94 | 0.59 | 0.86 | 0.22 |
| Gills | 0.33 | 0.46 | 0.41 | 0.64 | 0.47 | 0.59 | 0.78 |
| Flesh | 0.24 | 0.63 | 0.68 | 0.88 | 0.65 | 0.50 | 0.25 |
| Grand mean | 0.29 | 0.56 | 0.49 | 0.78 | 0.54 | 0.60 | 0.49 |
| SD | 0.06 | 0.07 | 0.02 | 0.15 | 0.09 | 0.18 | 0.29 |
| CV% | 20.11 | 13.0 | 4.08 | 18.86 | 17.21 | 30.46 | 59.93 |

SD standard deviationCV% coefficient of variation percent

## Conclusion

This study has presented data on the concentrations of some heavy metals in soil sediments, water and two different fishes from river Tammah/Kwoto in Nasarawa State, Nigeria. This being the most detailed study of its kind on the area. The data generated from this study could serve as baseline information with which future environmental impact assessment of solid minerals exploitation in Nasarawa town and its environ could be progressively monitored.

## REFERENCES


1. Laws, E. A. Aquatic Pollution. John Willey and Sons, New York, 301-369 (1981).
2. Ezeigbo, H. I. Geological and hydrological influences on the Nigeria environment, *Water Resources*, **1**(1), 37 – 44 (1989).
3. Forstner, U and Wiltman, G. T. W. Metal pollution in aquatic environment 2nd Edn. (Springer-Verlag, Berlin, 486 (1983).
4. Preston, M. R. and Chester, R. Chemistry and pollution of the marine environment. In: (Harison, R. M. edn.), Pollution, causes, effects and control, 3rd Edn. Royal Society of Chemistry, UK. 26 – 51 (1996).
5. Ajakaiye, D. E. Environmental problems associated with mineral exploitation. *Bull Sci. Assoc.*, Nigeria, **3**(2), 259 – 265 (1977)
6. Bowen, H. J. M. Environmental chemistry of the elements. Academic Press, Inc. London, 75 (1979).
7. Renfro, W. C. *Marine Biology,* 305 (1973).
8. Can, J. R., Paschal, D. C. and Hayden, C. M. Arch. *Environmental Contamin. Toxicol*. **9**(2)

271-278 (1980).

9. Goldwater, L. *J. Scientific American,* **15**, 224 (1971).
10. Adeyeye, E. I. *Ghana Journal of chemistry,* **3**(2), 42 – 50 (1997).
11. Aremu, M. O., Olonisakin, A. and Ahmed, S. A. Assessment of heavy metal content in some selected agricultural products planted along some roads in Nasarawa State, Nigeria. *J. Engineering and Applied Sciences,* **1**(3), 199 – 204 (2006).
12. Adeyeye, E. I., Akinyugha, N. J., Fesobi, M. E. and Tenabe, V. O. Determination of some metals in *Clarias gariepinus, Cyprinus carpio* and *Oreochomis niloticus* fishes in a polyculture fresh water pond and their environments, *Aquaculture,* **147,** 205-214 (1996).
13. Ipinmoroti, K. O. and Oshodi, A. A. Determination of trace metals in fish, associated waters and soil sediments from fish ponds. *Discovery Innovation,* **5,** 135-138 (1993).
14. Murphy, C. B. Bioaccumulation and toxicity of heavy metals and related trace elements. *J. Wat. Pollut. Contr. Federation,* **53**(6), 993-999 (1981).
15. Aiyesanmi, A. F. Baseline concentration of heavy metals in water samples from rivers within Okitipupa southeast belt of the Nigerian bitumen field, *J. Chem. Soc. Nigeria,* **31**(1-2), 30 – 37 (2006).
16. Parker, R. C. Water Analysis by Atomic Absorption Spectroscopy. Varian Techton, Switzerland, 130 (1972).
17. Nwajei, G. E. and Gagophien, P. O. Distribution of heavy metals in the sediments of Lagos Lagoon, *Pak. J. Sci. Ind. Res;* **43**(6), 338-340. (2000).
18. A. O. A. C., Official Methods of Analysis, 15th Edition, Association of alytical Chemists, Washinton, D. C (1990).
19. O'Connor, J. T. Fate of Zinc in Natural surface waters. University III Bull. Department, Civ, Engng. Saint Engng Ser., 49, Iilinois (1968).
20. Fleck, H. Introduction to Nutrition, 3rd edn. Macmillian, New York, USA 7 – 219 (1976).
21. Shills, M. E. Magnesium. In: Introduction to Nutrition. H. Fleck (ed.) 3rd ition Macmillan Publishing Co. Inc. New York 215 (1976).
22. Adeyeye, E. I., *Intern. J. Environmental studies,* **45**(3-4), 231-237 (1994).
23. Carter, D. E. and Fernando, Q. *Journal of Chemical Education,* **56,** 490 – 494 (1979).
24. Wheby, M. S. Synthetic Effects of Iron Deficiency In: W. H. Crosby (edn.) Iron. Midicom Inc. New York, 39 (1974).
25. Ayejuyo, O. O., Olowu, R. A, Megwa, K. C., Denloye, A. A. B., Owodehinde, F. G. Trace metals in *Clarias lazera*, water and sediments from Majidun River, Ikorodu, Nigeria, *Res. COMMN. Fisheries,* **1,** 27 – 31 (2003).
26. Crosby, N. T. Determination of metals in Foods a review. Analyst, 102, 225 – 268 (1977).
27. Osibanjo, O. Ajayi, S. O. and Mombershora, C. O. Pollution studies on Nigerian rivers. Toxic heavy metal status on surface waters in Ibadan city. *Env. Int.*, **5,** 45 – 53 (1981).
28. Mombershora, C. O., Osibanjo, O. and Ajayi, S. O. Pollution studies on Nigerian rivers. The onset of lead pollution of surface waters in Ibadan. *Environ. Int.,* **9,** 81 – 84 (1983).
29. Osibanjo, O. and Ajayi, S. O. Trace metal levels in the tree barks as an indication of pollution. Environ. Int., **4,** 236 – 244 (1980).
30. Waldron, H. A. and Stofen, A. Sub-clinical lead poisoning. Academic press, New York, 1 – 224 (1974).
31. Adeyeye, E. I., Trace heavy metal distribution in *Illisha Africana* fish organs and tissue I: lead and cadmium. *Ghana J. Chem;* **1,** 377 – 384 (1993).
32. Okoye, B. C. O. Heavy metals and organisms in the Lagos Lagoon. *Int. J. Environ. Stud.,* **37**, 285 – 292 (1991).
33. Bender, A. Meat and meat products in human nutrition in developing countries. FAO Nutrition paper 53, FAO, Rome 91 (1992).
34. National Academy of Sciences Food Nutrition board; Zinc in human nutrition. In: H. Fleck (Edn.), Introduction to Nutrition, 3rd edn. Macmillian Publ. Co., Inc. New York 235 (1971).