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Levels of some heavy metals in six species of fish obtained from Challawa River, Kano

Habib Y. TAOHEED* and Dayyab M. SAID

Department of Pure and Industrial Chemistry, Bayero University, Kano, P.M.B 3011, Kano, Nigeria.

**Corresponding author; E-Mail: ayinde_hato@yahoo.com, Tel: +234 08062069691, 08058711697*

ABSTRACT

Concentrations of Co, Cr, Mn, Ni and Pb were determined in muscle, bone, skin and head of six species of fish obtained from Challawa River along Yan danko village in Kano State. The heavy metals content were determined using Atomic Absorption Spectroscopy (AAS) and expressed in μgg^{-1} after acid digestion of the samples. The mean concentrations range obtained for the metals analysed in the fish species are as follows; Co (3.93±1.58 - 7.09±1.56) μgg^{-1}, Cr (0.95±1.09 - 1.89±1.55) μgg^{-1}, Mn (3.63±1.40 - 6.07±4.21) μgg^{-1}, Ni (1.83±1.40 - 3.30±1.40) μgg^{-1}, Pb (0.53±0.61 - 1.06±0.86) μgg^{-1}. The trend of heavy metal concentration in the fish samples can be represented as: Co > Mn > Ni > Cr > Pb. The concentrations of Ni, Cr and Pb were below the permissible limits specified by most food regulatory bodies (FAO, WHO, FEPA and USFDA), while Co and Mn levels in the fish species was higher than the maximum permissible limits. Thus, fish species from Challawa River, harvested at Yan danko village are not fit for human consumption.

Keywords: AAS, acid digestion, Challawa River, fish species, heavy metals.

INTRODUCTION

The pollution of the aquatic environment with heavy metals has become a great concern worldwide in recent years, because they are indestructible and most of them have toxic effect on organisms (McFarlane and Burchett, 2000). Heavy metals may enter aquatic systems from different natural and anthropogenic (human activities) (Yilmaz, 2009).

Most heavy metals have no beneficial functions to the body and can be highly toxic. Depending upon their concentration, they may exert beneficial or harmful effects on plants, animals and human life (Forstner and Wittman, 1981). At low levels, heavy metals such as copper, cobalt, zinc, iron and manganese are essential for enzymatic activity and many biological processes, but metals such as cadmium, mercury and lead have no known essential role in living organisms, and are toxic at even low concentrations. The essential metals also become toxic at high concentration (Bryan, 1976). However, if they enter into the body through inhalation, ingestion and skin absorption they accumulate in the body tissue faster than the body's detoxification pathways can dispose of them

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(Ekpo et al., 2008). High concentration exposure is not necessary to produce a state of toxicity in the body tissue and, overtime, can reach toxic concentration levels (Prusty, 1994). Heavy metals acquired through the food chain as a result of pollution are potential chemical hazards, threatening consumers.

Aquatic foods have essential amino acids, fatty acids, protein, carbohydrates, vitamins and minerals. Among sea foods, fish is commonly consumed and, is a connecting link for the transfer of toxic heavy metals in human beings (Shrivastava et al., 2011). Fish samples can be considered as one of the most significant indicators in aquatic environment for the estimation of metal pollution (Rasheed, 2001). Fish and shell fish accumulate metals to concentration many times higher than present in water or sediment (Gumgum et al., 1994; Olaifa et al., 2004). Investigation of the distribution and concentration of heavy metals in water, sediment and biota is fundamental to the study of aquatic pollution (Al-Khafaji, 2001).

This study was aimed at assessing the levels of Co, Cr, Mn, Ni and Pb in six species of fish (*Alestes nurse*, *Lates niloticus*, *Heterotis niloticus*, *Synodontis betensoda*, *Tilapia zillii* and *Clarias gariepinus)* collected from Challawa River along Yan danko village in Kumbotso L. G. A., Kano State, Nigeria.

MATERIALS AND METHODS

Reagents

All reagents used were AnalaR grade. Deionised water was used throughout to avoid interferences by other ions. All plastic and glassware used were washed with detergent, rinsed with water and soaked in 10% (v/v) HNO_3 overnight. They were rinsed with deionised water and dried prior to use.

Sampling area and sampling

Sampling area is Challawa River (N 11°52.745´, E 008°28.473´) located along Yan danko village in Kumbotso Local Government Area of Kano State, Nigeria. This site is where raw industrial effluent, primarily from food, textile and tannery industries is discharged into the river.

Six species of fresh fish samples (3-6 individual of each species) namely, *Alestes nurse*, *Lates niloticus*, *Heterotis niloticus*, *Synodontis betensoda*, *Tilapia zillii* and *Clarias gariepinus* were collected directly from the River. These fish species were put in sterile polythene bags and taken in icebox and transported to the laboratory for identification by an expert in the Department of Biological Sciences, Bayero University, Kano, for analysis.

Sample Preparation and Digestion Procedure

The fish samples were rinsed with deionised water, scales were removed (where necessary). The head, bone, muscle and skin of each fish samples were oven dried at 105 °C until they reached a constant weight. Each dried tissue of the species was homogenized and ground into powder, using porcelain mortar and pestle. They were put in dry labelled plastic containers and stored in desiccators until digestion. 1.0 g of the fish sample was weighed in each case, transferred into a 100 cm^3 beaker, 15 cm^3 HNO_3 and 5 cm^3 $HClO_4$ were added respectively, the beaker with its content was covered with watch glass, and the solution was heated to dryness. The residue was allowed to cool, 5 cm^3 of 6 M HNO_3 was then added and the content boiled for 2 minutes; 15 cm^3 deionised water was then added to the mixture after cooling; it was transferred into 100 cm^3 volumetric flask and made up to the mark with deionised water (Sa'id, 2006).

Blank experiment was carried out involving all the reagents and procedure used for the actual digestion but without the sample (Sa'id, 2006). The digests were kept in labelled plastic bottles and later the heavy metal concentrations were determined using a Buck Scientific, 210VGP Atomic Absorption Spectrophotometer (AAS).

RESULTS AND DISCUSSION

The concentration of heavy metals in the various parts of the fish samples as well as mean concentrations, ranges and standard deviations are given in Tables 1 – 5.

From Table 1, the concentration of cobalt varied from ND (Not detected) in the muscles of *Synodontis betensoda*, and *Clarias gariepinus* to 9.43 µg/g in the head of *Tilapia zillii* and skin of *Heterotis niloticus.* Base on the mean concentration of cobalt in the fish species, the maximum concentration of cobalt of 7.08±1.57 µg/g and 7.09±1.56 µg/g were detected in *Tilapia zillii* and *Lates niloticus* respectively and the least cobalt concentration were detected in *Alestes nurse*, *Synodontis betensoda***,** and *Clarias gariepinus*; 3.93±1.58 µg/g, 3.93±3.02 µg/g and 3.94±3.02 µg/g respectively. Cobalt is an essential nutrient for humans, and also forms an integral part of vitamin B_{12} (Sivapermal et al., 2007). Co has also been found to enhance proper thyroid function. Deficiency resulting from Co intake causes anaemia. Excessive intake of Co is however, reported to cause congestive heart failure and polycythemia (Alexander, 1972).

Chromium is an essential trace metal and the biologically usable form of Cr plays an essential role in glucose metabolism. Chromium concentration in the various part of the fish sampled ranged from ND to 3.79 µg/g. The mean concentration of chromium revealed that the highest level of 1.89±1.55 µg/g, 1.89±1.54 µg/g, 1.89±1.55 µg/g were obtained in each of *Heterotis niloticus*, *Synodontis betensoda*, and *Tilapia zillii* respectively, while the lowest level of 0.95±1.09 µg/g was obtained in *Clarias gariepinus*. The maximum guideline, 12 – 13 µg/g stipulated by the USFDA (1993a) was however higher than the concentrations of Cr measured in all the fish samples. Chromium does not normally accumulate in fish and hence low concentrations of Cr were reported even from the industrialized parts of the world (Moore and Ramamoorthy, 1984).

Manganese was detected in the entire samples studied. The concentration in the various parts was between ND in the muscles of *Lates niloticus*, *Synodontis betensoda* and *Clarias gariepinus* to 9.72 µg/g in the skin of *Clarias gariepinus*. Levels of Mn accumulation in the fish species revealed that *Alestes nurse* have the lowest concentration of 3.63±1.40 µg/g, while *Clarias gariepinus* have the highest concentration of 6.07±4.21 µg/g. The concentration of Mn in all the fish samples exceeded the WHO (1989) guideline of 0.01 ppm and FEPA (2003) limits of 0.05 ppm. Mn is an essential element for both animals and plants. Deficiencies of Mn result in severe skeletal and reproductive abnormalities in mammals. It is widely distributed throughout the body with little variation and does not accumulate with age (Sivapermal et al., 2007).

Ni concentration in the various parts of the fish species varied from ND in the muscle of *Alestes nurse*, *Lates niloticus* and *Clarias gariepinus* to 4.42 µg/g in the skin of *Clarias gariepinus*. The lowest concentration of Ni was measured in *Alestes nurse*, 1.83±1.40 µg/g while the highest concentration, 3.30±1.40 µg/g of Ni was measured in *Heterotis niloticus*. The levels of Ni were found to be higher than the stipulated limits when compared with the estimated maximum guideline of 0.5 – 0.6 ppm (WHO, 1985; FEPA, 2003) in fish food. On the contrary, the concentrations of Ni were far below the recommended limits of 70 – 80 µg/g (USFDA, 1993B). The major source of Ni for humans is food and uptake from natural sources, as well as food processing (NAS-NRC, 1975). Increased incidence of cancer of the lung and nasal cavity caused by high intake of Ni has been reported in workers in Ni smelters.

Lead is classified as one of the most toxic heavy metals. The biological effect of sub-lethal concentration of lead include delayed embryonic development, suppressed reproduction and inhalation of growth, increased mucous formation, neurological problem, enzyme inhalation and kidney dysfunction (Rompala et al., 1984). The ranged of lead concentration in various parts of the fish species were between ND to 2.12 μgg^{-1}. Mean concentrations of the metal in the individual species showed that *Synodontis betensoda* had the highest concentration of 1.06±0.86 μgg^{-1} and *Tilapia zillii* and *Lates niloticus* both has the lowest concentration of 0.53±0.61 μgg^{-1}, Table 5. The concentrations of lead recorded in the fish species under this investigation were lower than the maximum recommended limits of 2.0 μgg^{-1} (WHO, 1985; FEPA, 2003; FAO, 1983) in fish food.

Table 1: Concentrations of cobalt (µg/g) in various parts of the fish samples.

Fish species	Muscle	Bone	Head	Skin	Mean±SD
Alestes nurse	3.14	6.29	3.14	3.14	3.93±1.58
Lates niloticus	6.29	9.43	6.29	6.33	7.09±1.56
Heterotis niloticus	3.14	6.29	6.29	9.43	6.29±2.57
Synodontis betensoda	ND	6.32	6.29	3.12	3.93±3.02
Tilapia zillii	6.29	6.29	9.43	6.29	7.08±1.57
Clarias gariepinus	ND	3.15	6.29	6.33	3.94±3.02

Table 2: Concentrations of chromium (µg/g) in various parts of the fish samples.

Fish species	Muscle	Bone	Head	Skin	Mean±SD
Alestes nurse	1.89	ND	1.89	1.89	1.42±0.95
Lates niloticus	1.89	ND	1.89	1.89	1.42±0.95
Heterotis niloticus	ND	1.89	3.79	1.89	1.89±1.55
Synodontis betensoda	1.89	ND	1.89	3.76	1.89±1.54
Tilapia zillii	ND	3.79	1.89	1.89	1.89±1.55
Clarias gariepinus	ND	ND	1.89	1.90	0.95±1.09

ND: Not detected

Table 3: Concentrations of manganese (µg/g) in various parts of the fish samples.

Fish species	Muscle	Bone	Head	Skin	Mean±SD
Alestes nurse	2.42	4.84	4.84	2.42	3.63±1.40
Lates niloticus	ND	4.84	4.84	7.31	4.25±3.06
Heterotis niloticus	2.42	4.84	7.26	2.42	4.24±2.31
Synodontis betensoda	ND	7.30	4.84	4.81	4.24±3.06
Tilapia zillii	2.42	7.26	4.84	4.84	4.84±1.98
Clarias gariepinus	ND	7.28	7.26	9.74	6.07±4.21

ND: Not detected

Table 4: Concentrations of nickel (µg/g) in various parts of the samples.

Fish species	Muscle	Bone	Head	Skin	Mean±SD
Alestes nurse	ND	2.93	2.93	1.47	1.83±1.40
Lates niloticus	ND	4.40	2.93	1.48	2.20±1.89
Heterotis niloticus	1.47	4.40	4.40	2.93	3.30±1.40
Synodontis betensoda	1.47	2.95	2.93	2.91	2.57±0.73
Tilapia zillii	1.47	2.93	2.93	1.47	2.20±0.84
Clarias gariepinus	ND	2.94	2.93	4.42	2.57±1.85

ND: Not detected

Table 5: Concentrations of lead (µg/g) in various parts of the samples.

Fish species	Muscle	Bone	Head	Skin	Mean±SD
Alestes nurse	ND	1.06	ND	2.12	0.80±1.02
Lates niloticus	ND	1.06	ND	1.07	0.53±0.61
Heterotis niloticus	ND	1.06	1.06	1.06	0.80±0.53
Synodontis betensoda	ND	1.07	1.06	2.11	1.06±0.86
Tilapia zillii	ND	1.06	1.06	ND	0.53±0.61
Clarias gariepinus	1.06	1.06	1.06	ND	0.80±0.53

ND: Not Detected

Conclusion

The higher levels of Co, Mn and Ni in the fish species may result in toxic health effects for humans consuming fishes from the river. Hence, the results can be used to evaluate the possible health risk associated with the consumption of the fish species that were analysed. The present study highlighted the need precaution measures to be taken in order to reduce the presence of heavy metals and also the need to enforce the existing environmental laws. The activities of industries located within the vicinity should be kept under strict surveillance as they are capable of increasing the heavy metals discharge into the river. The study shows a need for continuous pollution assessment study of aquatic organisms in the river.

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