Asian Journal of Biological and Life Sciences | Short Communication

Uptake and bio-concentration of manganese in the african catfish, *Clarias gariepinus*

Olojo, E.A.A. And Afisunlu, O.A

Department of Plant Science and Applied Zoology, Olabisi Onabanjo University, P.M.B. 2002, Ago-Iwoye, Ogun State, Nigeria.

E-mail : emmanuelolojo@yahoo.co.u

Submitted : 01.03.2012 Accepted : 05.05.2012 Published : 10.9.2012

Abstract

Adult African catfish, *Claria gariepinus* body weight >500g were exposed to two concentrations of manganese (T_1= 6.76mg/l and T_2 = 8.45 mg/l) and the uptake and bioconcentration of Mn at these concentrations were monitored under laboratory conditions. Tissues obtained from the specimens were analyzed for Mn at 24h interval for 144h with the use of Pye Unicam 960 atomic absorption spectrophotometer with deuterium correction. The pattern of Mn uptake in the tissues was in the order: gill>liver>flesh. Highest concentration of 52.52mg/g was obtained in gill T_2 at 120h while the least concentration was found in flesh T_2 (1.95mg/g) at 144h.

INTRODUCTION

Increased industrialization and human activities have impacted on the environment through the disposal of waste containing heavy metals. These metals build up in the food chain and are responsible for chronic illness and death in aquatic organisms and also move up in the food chain [1]. Manganese is essential to human health and is required at low concentrations in the body. However, at high concentrations it acts as a toxicant which may cause wide-ranging toxicological effects in these organisms as the metal tends to accumulate in several tissues [2].

Since the degree of contamination in aquatic environment is frequently assessed by comparing contaminant concentration in associated biota [3], fish have been used by various workers in the study of aquatic pollution. Heavy metals generally are dangerous because they tend to bio-accumulate in tissued and organs. These metals usually in the ionic form cause fish mortality, but under chronic exposure, complex metal compounds act by accumulating in the body tissues over a period of time [4,5].

Manganese is generally used in the manufacture of steel, particularly stainless steel and other metal alloys. It is one of the major toxic essential trace elements found in the body. The buildup of these trace elements in the food chain is largely due to poor management of industrial wastes. Thus, the elevated level in the tissues has been noted to have profound deleterious effects on cellular function and is also known to cause neuro-toxicity by increasing oxidative stress and also disturbing neurotransmitter [6]. Manganese at a very small dose induces symptoms of slow suffocation, paralysis and mucus cell depletion in several freshwater fishes. The impact of pollutants on aquatic ecosystems is either acute due to exposure to immediate dose, or insidious/chronic due to gradual accumulation of lethal concentrations in the body tissues [5]. The extent of physiological disturbance depends on factors such as the metal concentration, water hardness, and also water salinity, temperature and pH and its influence on metal speciation [3].

Currently, fishes are considered to be an extremely reliable component of aquatic monitoring system because they integrate the effect of detrimental environmental changes as consumers, which are relatively high in the aquatic food chain [2]. The objective of this study therefore, is to determine the uptake and bioconcentration of manganese in the gill, liver and flesh of *C. gariepinus,* which will provide an early warning of potential environmental problems.

MATERIALS AND METHODS

Adult *Clarias gariepinus* of mean body weight 520.00g±5.0 and mean total length 45.00cm±8.0 were obtained from a local fish farm, transported to the laboratory in oxygenated polythene bags, half filled with water. They were fed with Coppens floating feed and kept in two stock aquaria for two weeks to acclimatize to laboratory conditions before the commencement of treatment. Forty-eight adult fish were divided into six experimental vats containing fresh water (pH 7.7) and allowed to rest for 72 hrs after which manganese was introduced in form of manganese sulphate salt. Two treatments: T_1=6.76mg/l and T_2=8.45mg/l having three replicates each were used based on [7,8] while two vats served as the control.

Specimens were randomly selected from each vat at 24-hr intervals, blotted dry with soft absorbent paper and dissected to remove the gill, liver and flesh just below the dorsal fin. Tissues removed were analyzed for Mn concentration with the use of Pye Unicam 960-Atomic absorption spectrophotometer (AAS) with deuterium correction.

RESULTS

The target organs, gill, liver and flesh of *Clarias gariepinus* showed variations in the uptake of manganese throughout the experimental period.

Highest concentration of Mn was recorded in gill (52.52mg/g) T_2 at 120h (Fig. 1) while the least concentration was found in flesh T_2 (1.95mg/g) at 144h (Fig. 3). Mn concentration in the tissues followed the order gill>liver>flesh.

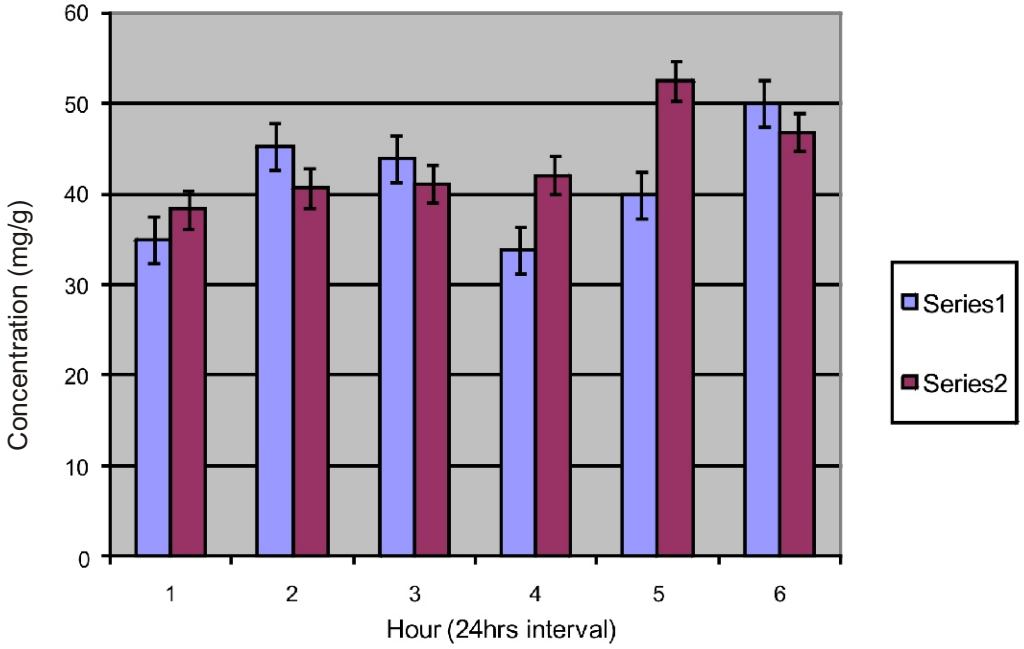
Liver and flesh showed higher mean concentration values of Mn in T_1 (min 8.94±3.94 at 120h; max 29.52±32.70 at 144h) than in T_2 (min 7.88±3.04 at 96h; max 14.53±3.58 at 48h) for liver; and min-max values T_1 (2.67±0.62 4.56±6.55) and 1.97±2.7 4.28±1.75 for T_2 for flesh respectively. However, the concentration in gill showed higher values in T_2 (min 38.35±11.18 max 52.52±13.10) mg/g than in T_1 (min 33.67±13.42 max 50.00±7.96) mg/g (Table 1).

In the three target organs, the variations in minimum-

maximum values increased as the time of exposure progressed. The trend was that of alternating peak and crescendo (Figures 1-3). The gill appeared to take up Mn at a fairly consistent rate in T_2 throughout the experimental period (Fig. 1) while liver and flesh showed lower concentrations at T_1 than T_2 with the former peaking at 144h; T_1 and T_2 reaching their peak at 96h and 144h respectively (Figs. 2 and 3).

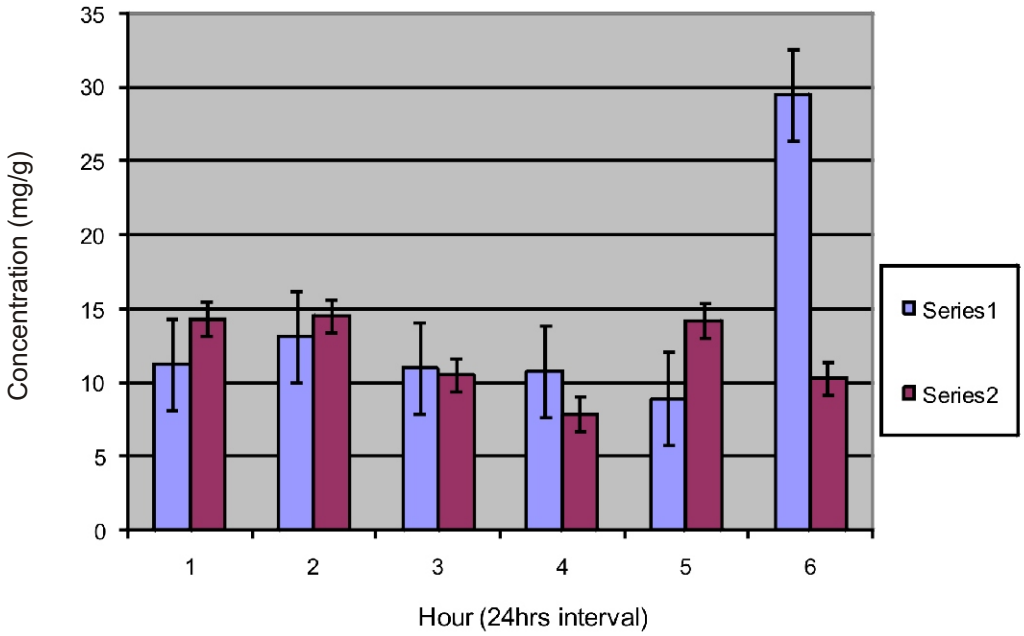
DISCUSSION

Mn concentration which occurred in the order: gill>liver>flesh agrees with the earlier works done by [10,11]. Manganese uptake into the body system is primarily through the gills [12,13]. The heavy accumulation of Mn in the gills has direct



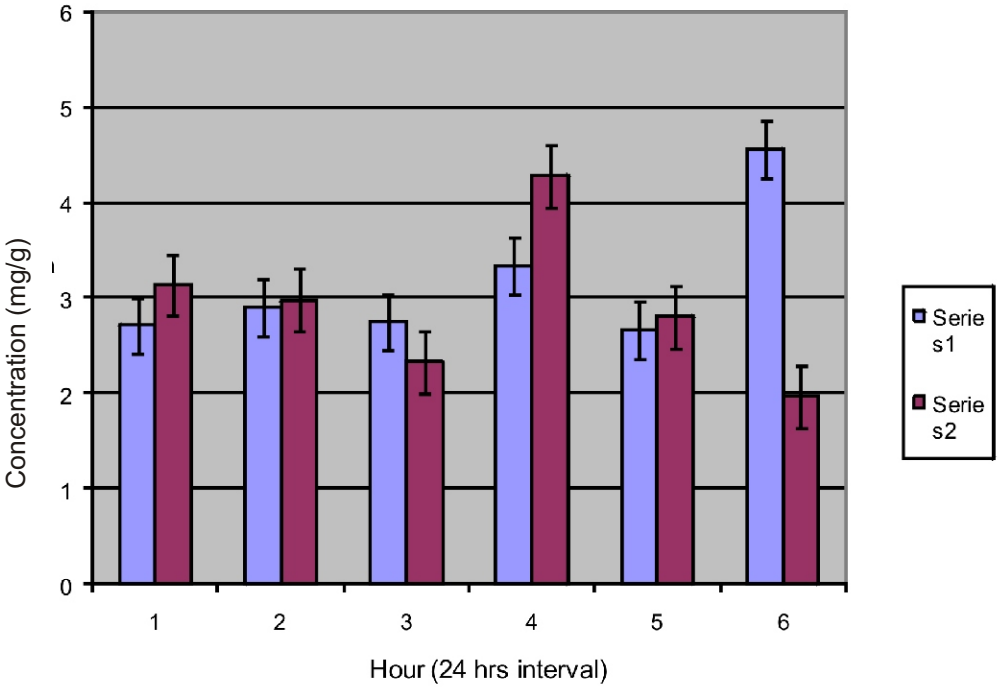
Series 1: concentration 1 (6.76 mg/g Mn)
Series 2: concentration 2 (8.45mg/g Mn)

Fig 1: Variation in bioconcentration of Mn in the gill of *Clarias gariepinus*



Series 1: concentration 1 (6.76 mg/g Mn)
Series 2: concentration 2 (8.45mg/g Mn)

Fig 2: Variation in bioconcentration of Mn in the liver of *C. gariepinus*



Series 1: concentration 1 (6.76 mg/g Mn)
Series 2: concentration 2 (8.45mg/g Mn)

Fig 3: Variation in bioconcentration of Mn in the flesh of Clarias gariepinus

bearing with their external location and necessary intimate contact with water that allows for dissolved or suspended materials in the water to be absorbed through their delicate epithelium.

Gill is described as a deposit tissue where the uptake metals are temporarily retained for subsequent elimination. However, when the quantity of uptake significantly exceeds the elimination level, metals will begin to accumulate leading to transfer to other parts of the system [12]. This probably is the rationale for varied concentration of manganese in the tissues assayed. Mn negatively affects glycolysis in that it obstructs oxocinase and glucosinase early in the metabolic pathway and also pyruvate kinase later in the pathway [2]. Mn has also been reported to influence protein metabolism, which is important for all living cells in the body.

When fish are exposed to elevated metal levels in the aquatic environment, they can absorb the bio-available metals directly from the environment via the gills and skin or through the ingestion of contaminated water and food. Metals in the fish are then transported through the blood stream to various organs and tissues [10,11]. Fish can regulate metal concentrations to a certain extent after which bio-accumulation will occur [12]. Therefore, the ability of each tissue to either regulate or accumulate metal can directly be related to the total amount of metal accumulated in that specific tissue. Furthermore, physiological difference and deposition of each tissue in the fish can also influence the bio-accumulation of a particular metal [13].

It has been shown that Mn can be taken up directly via the gills or indirectly from the food and ingested sediment via the gut [14]. The high Mn concentration detected in the gill of the various fish species shows that the main route of Mn uptake is through the gills because little absorption of metals occurs in the gut via the food [15]. Results and bioaccumulation patterns obtained in this study agree with earlier reports [9, 10,13,16, 17,18].

The second highest level of Mn occurred in the liver. This could be traced to the major function that the liver plays in the storage and detoxification of heavy metals.

REFERENCES

1 Farkas, A., Salanki, J., and Specziar, A., (2002). Relationship between growth and heavy metal concentration in organs of bream, *Abramis brama* L. populating lake Balaton. *Archives of Environmental Contamination and Toxicology*. 43(2):236-243.

2 Strydom, C., Robinson, C., Pretorious, F., Whitcutt, J.M., Marx, J. and Bornman, M.S., (2006). The effect selected metals on the central metabolic pathway in biology: A review. Water SA. 32(4):543-554.

3 Yang, H.N. and Chen, H.C., (1996). Uptake and elimination of cadmium by Japanese eel, *Anguila japonica* at various temperatures. *Bulletin of Environmental Contamination andToxicology. 56(4):670-676.*

4 Ellis, K.V., (1989). *Surface water pollution and its control.* The Macmillan Press limited. London. England. 373pp.

5 Heath, R.G..M. and Claasen, M., (1999). An overview of the pesticide and metal level present in populations in the larger indigenous fish species of selected South African Rivers, WRC Report No428/1/99. *Water Research Commission, Pretoria, South Africa*. p.318

6 Erickson, K.M., Dobson, A.W, Dorman, D.C. and Aschner, M., (2004). Manganese exposure and induced oxidative stress in the rat brain. *Sci. Total Environ.* 334-335.

7 USEPA, Environmental Protection Agency, 1976. Water quality criteria. Washington DC. 256pp.

8 EIFAC. Working party on water quality criteria for European fresh water fish with the co-operation of the United Nations Environment Programme (UNEP). EIFAC Technical Paper No. 30, 21pp.

9 Coetzee, L., 1996. Bioaccumulation of metals in selected fish species and effect of pH on Aluminum toxicity in cichlid *Oreochromis mossambicus*. M.Sc. Thesis. Rand Afrikaans University, South Africa.

10 Nussey, G., Van Vuren, J.H.J., Du Preez, H.H., 2000. Bioaccumulation of chromium, manganese, nickel and lead in the tissues of the moggel, *Labeo umbratus*. *Water SA,* 26(2):269-284.

11 Coetzee, L., Du Preez, H.H. and Van Vuren, J.H.J., 2002. Metal concentration in *Clarias gariepinus* and *Labeo unmbratus* from the Olifants and Klein rivers, Mpumalanga, South Africa: Zinc, copper, manganese, lead, chromium, nickel, aluminum and iron. *Water SA*. 28(4): 433-448.

12 Heath, A.G., 1991. Water pollution and fish physiology. Lewis Publishers, Boca Raton, Florida, USA.359 pp.

13 Kotze, P.J., 1997. Aspects of water quality, metal contamination of sediment and fish in the Olifants River, Mpumalanga. M.Sc, Thesis, Rand Afr. Univ., South Africa.

14 Bendell-Young, L.I. and Harvey, H.H., 1986. Uptake and tissue distribution of manganese in the white sucker *Catostomus commersoni* under conditions of low pH. *Hydrobiology* 113: 117-125.

15 Katz, M., Legore, R.S., Weitkamp, D., Cummins, J.M., Anderson, D. and May, D.R., 1972. Effects on freshwater fish. *J. WPCF.* 44(6): 1226-1250.

16 Barnhoorn, I.E.J., 1996. Effect of manganese on the haematology of *Oreochromis mossambicus* and the bioaccumulation of metals in *Labeo umbratus. M.Sc. Thesis. Rand Afrikaans University, South Africa.*

17 Seymoore, T., Du Preez, H.H. and Van Vuren, J.H.J., 1995. Manganese, lead and strontium bioaccumulation in the tissues of the yellow fish, Barbus marequensis from the lower Olifants River, Eastern Transvaal. *Water SA*. (2):159-172.

18 Wepener, V., 1997. Metal ecotoxicology of the Olifant River in the Kruger National Park and effects thereof on fish haematology. Ph.D. Thesis. Rand Afrikaans University, South Africa.