African Journal of Biotechnology Vol. 5 (12), pp. 1284-1287, 16 June 2006
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2006 Academic Journals

Full Length Research Paper

Uptake and loss of absorbed dissolved cadmium to *Clarias angullaris* fingerlings

OBANO, Efosa Emokpae* and ORONSAYE, Jude Aigbokhaevbo Osamuede

Department Of Fisheries, Faculty Of Agriculture, University Of Benin, P.M.B. 1154, Benin City, Nigeria.

Accepted 9 May, 2006

The uptake and loss of dissolved cadmium in media by the African mud fish (*Clarias angullaris*) fingerlings was studied in water of 25 mg/ L hardness, pH 6.8, at 27 ±2°C in a static test system. The uptake experiments involved exposure of fish to 0.5 and 1.0 mg Cd^{2+}/L test solutions from which the fish absorbed and retained 1.1011 mg and 1.3060 mg Cd^{2+}/g wet fish weight, approximately 550 and 653 times the recorded normal tissue level, respectively, after 8 days. In the loss experiments, after fourteen (14) days, the fish that had 0.8320 mg Cd^{2+}/g wet weight in the 0.5 mg Cd^{2+}/L test medium reduced the internal concentration to 0.1121 mg Cd^{2+}/g; and in the 1.0 mg Cd^{2+}/L test solution, the reduction is from 0.9820 mg Cd^{2+}/L to 0.1142 mg Cd^{2+}/L wet weight.

Key words: Dissolved cadmium, uptake, loss, *Clarias angularis*.

INTRODUCTION

Heavy metals in solution have been found to be absorbed and retained by fish (Coombs 1974). Bryan (1976) reported that such absorption is probably due to passive diffusion down a gradient between the mucus covering the entire body surface and the gills on one hand and the internal organs on the other hand. Diffusion is presumably responsible for the uptake at zinc by the eggs of cohosalmon (*Oncorhynchus kisutch*) (Wedemeyer, 1968) and by the adults of numerous fish species (Skidmore, 1964). So uptake of cadmium is also likely to be due to simple diffusion.

Mount and Stephan (1967) studied the uptake and accumulation of cadmium by bluegill (*Lepomis macrochirus*) and reported that when fish were exposed to a high concentration (10 mg/liter of cadmium), the gills were the major site of uptake. These authors found that cadmium accumulated in *L. macrochirus* and that within 30 to 60 days, an equilibrum was established between the concentrations of cadmium in the water and in the fish tissue. Spehar (1976) reported that cadmium uptake increased with increasing exposure concentration but leveled off at 16 µg/l, and suggested that a possible equilibrium was reached between cadmium concentrations in the water and in the tissue.

Cadmuim often occurs in the environment along with other heavy metals. The uptake of cadmium together with other heavy metals, principally zinc, has been studied. Eisler and Gardner (1973) reported that the uptake of zinc by mummichog (*Fundulus heteroclitus*) was reduced in the presence of cadmium. This study examines the uptake, retention and loss of the metal from fish previously exposed to the metal.

MATERIALS AND METHODS

The fish, *Clarias angullaris*, fingerlings were obtained and transported to the laboratory in river water contained in 60 L capacity plastic containers. The fish were held in the laboratory for three weeks in aerated laboratory water having pH of 6.8 and total hardness of 25 mg/ L as $CaCO_3$ at 27 ± 2°C to acclimatize to the diluted water. During the holding period, the fish were fed a daily ration of live earthworm (*Lumbricus* sp.). Holding conditions are similar to previous practices in this laboratory (Oronsaye and Obano, 2000).

For the uptake experiments, the fish in batches of 25 were exposed to 0.5 and 1.0 mgCd^{2+}/l in 14 litres of tap water in glass aquaria in two separate experiments. To avoid the uptake of cadmium by the gut, the fish were not fed during exposure to the metal. The length of exposure ranged between 1 – 8 days.

In the experiments on the loss of cadmium after previous exposure to the metal, new batches of fish were exposed to 0.5 and 1.0 mg Cd/L. Exposure was for eight days and surviving fish were

*Corresponding authors E-mail: efeobano2002@yahoo.com.

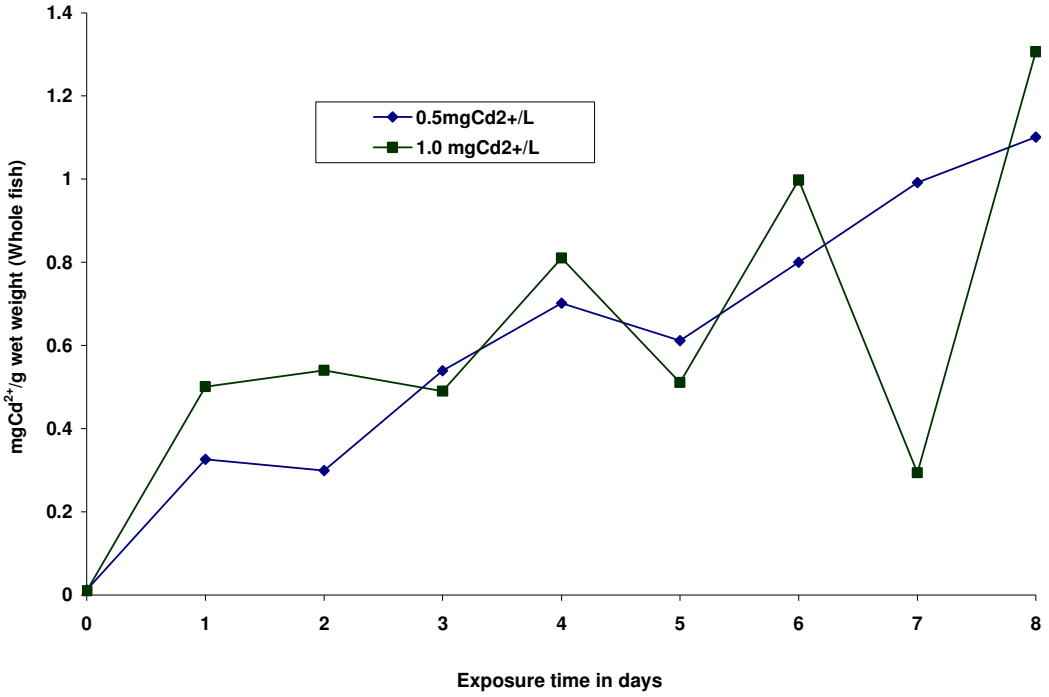

Figure 1. Whole body tissue levels of cadmium in fish exposed to 0.5 mgCd^{2+}/L

allowed to recover in fresh uncontaminated water for periods ranging from one to fourteen days. Only fish which recovered were fed a daily ration of live earthworm (*Lumbricus* sp.). All the experiments were carried out using the static system and a control experiment was run in each series of experiments.

The experimental tanks and the 50 cm^3 Pyrex breakers used for "wet digestion" of fish were washed with detergent, soaked overnight in 5% nitric acid and rinsed with distilled water (Leonard, 1971; Oronsaye, 1987). The experimental fingerlings, along with their controls were removed at daily intervals and their cadmium content was measured after they were allowed to swim in uncontaminated water for 5 min to remove traces of cadmium adhering to their body surface. The fish were then pitched and dried between a filter paper. One fingerling was placed in each beaker. The wet weight and dry weight (after drying in an oven 80 ± 5°C to constant weight) were recorded. Each dried fish was milled separately and stored in polythene bags in a dessicator. The fish were not ashed.

Perchloric acid, nitric and concentrated sulphuric acids (Analer Grades in ratio of 1:5:1) were added to one gram of each milled specimen in conical flasks (Oronsaye and Obano, 2000). The conical flask and content were transferred to a hot plate at 80 ± 5°C in a fume chamber and allowed to boil. Digestion lasted about 12 h due to the sulphuric acid. When fats appeared in solution as indicated by a colour change from pale yellow to brown, additional nitric acid was added. Evaporation was continued until the white fumes of perchloric acid ceased. Each residue was allowed to cool and 5 ml of distilled water was added and boiled for half a minute in the same hot plate at medium heat. The residue was cooled and filtered completely with a wash bottle into a 100 ml pyrex volumetric flask and made up to mark with distil water.

The amount of cadmium in each sample was measured by a Varian Techtron, Spect AA 10, an Atomic Absorption Spectrophotometer calibrated previously. The levels of cadmium found in fish issue are shown in Figure 1 to 3 in which one fish sample represents one point. All experiments were run in tap water, at temperature of 27 ± 2°C.

RESULTS AND DISCUSSION

The fish that died in experiments were not analysed for cadmium residue in their tissue. The stickleback, *Gasteroteus aculeatus*, (Oronsaye 1987) have been shown to accumulate heavy metal after death, so analysis which could have resulted in very high cadmium concentrations in tissue was avoided.

The mean concentration of cadmium in whole body preparation of 4 unexposed *C. angullaris* fingerlings was less than 0.001 mg Cd^{2+}/g wet weight and the range 0.0013-0.0006 mg/g. Fish exposed to 0.5 mg Cd^{2+}/L for 24 h showed an increase in body cadmium, 0.3260 mgCd^{2+}/g, which represent a total nearly 148 times the normal mean value. A longer exposure of fish (up to 8 days) to 0.5 mgCd^{2+}/L resulted in an erratic decline in body load (Figure 1). Fish exposed to 1.0 mgCd^{2+}/L showed a high increase of cadmium with time. After 8 days exposure, body burden was 400 times the normal level (0.8241 mg/g wet weight as against 0.0123 mg/g wet weight).

When fish exposed to either 0.5 or 1.0 mg Cd^{2+}/L for 8 days were allowed to recover in cadmium free water, approximately 50% of the absorbed mean was lost from the body after 3 days. Figures 2 and 3 indicate that increasing the recovery period beyond 14 days could

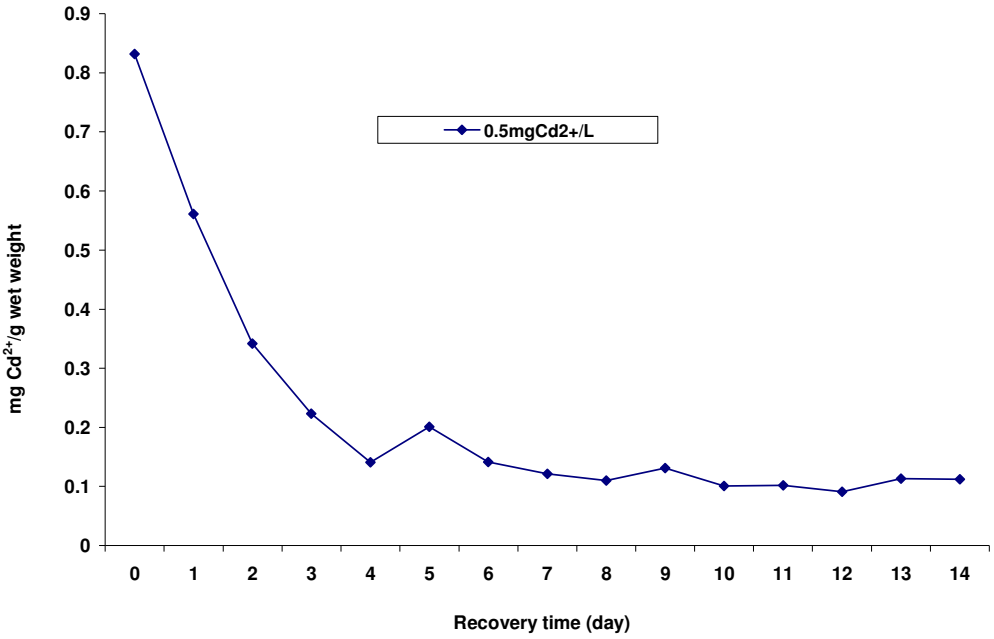

Figure 2. Loss of Cadmium from the tissue of fish while in clean water after previous exposure to 0.5mgCd^{2+}/L for 14 days.

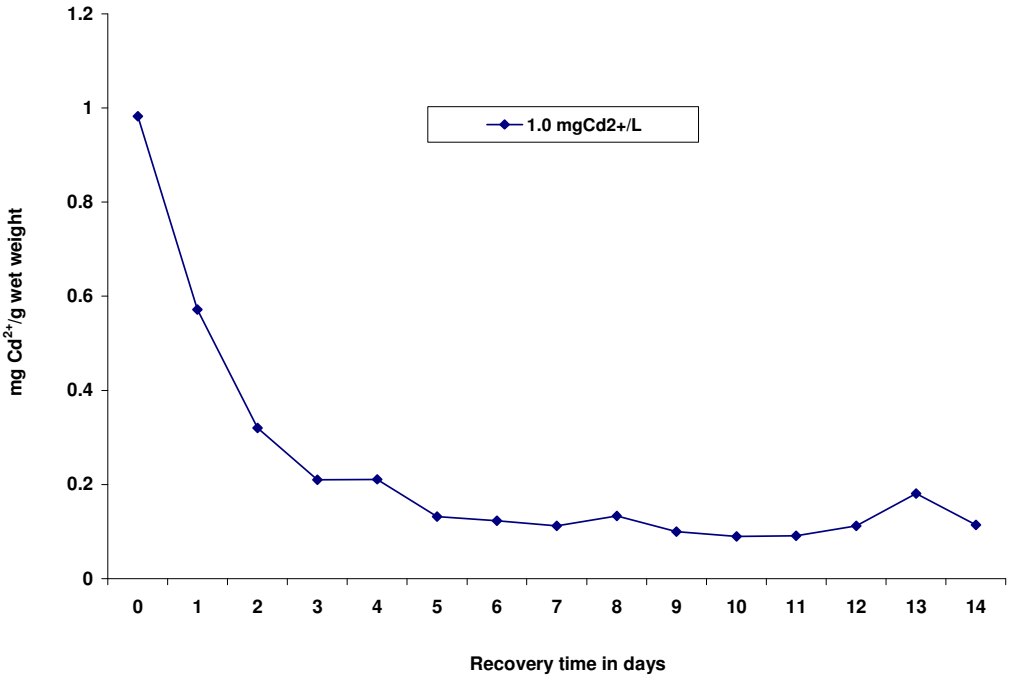

Figure 3. Loss of Cadmium from the tissue of fish while in clean water after previous exposure to 1.0 mgCd^{2+}/L for 14 days.

result in almost all previously absorbed metal being lost from the body although, the rate of efflux shows with time. Fish in both experiments still held approximately 15% of the absorbed cadmium in the close of the experiment.

The whole body digests of *C. angullaris* fingerlings were examined for cadmium. The mean concentration obtained were 0.001 mg/g wet weight of fish for 4

unexposed normal fish Cadmium is not normally found in tissue because it has no biological or biochemical function. The result obtained differs from that by Methiessen (1973) and Oronsaye (1987) on the stickleback, *Gasterosteus aculatus*, which contains approximately 0.072 mg Cd^{2+}/g wet weight of fish. However, the stickleback they analysed were from a canal whose bottom sediments contained traces of cadmium.

When *C. angullaries* fingerlings were exposed to 0.5 or 1.0 mg Cd^{2+}/L for 8 days, the fish absorbed and retained the metal. The fish are able to reduce the concentration of the metal absorbed (Figure 2 and 3). This phenomenon was also reported when stickleback were exposed to solutions containing cadmium Oronsaye (1987) and has been explained by the fact that these fishes are euryhaline and so adapt to sudden influx of ions. Similar observation has been reported for *C. angullaris* exposed to copper (Oronsaye and Obano, 2000). In the higher concentration of 1.0 mg Cd^{2+}/L uptake experiment which lasted for 8 days, more cadmium in mg/g wet weight of fish was retained. This observation agrees with those of Eisler (1974) on munnichog (*Fundulus heteroclitus*) and Pascoe and Mattey (1977) on *Gasterosteus aculaeatus*. The latter authors found that *G. aculeatus* exposed to Cd^{2+} in water, increased the body load of the metal with increasing external concentration of 0.90 µg/g fresh weight at 0.001 mg/g Cd^{2+}/L to 5.70 mg/g fresh wet weight at 100 mg/Cd^{2+}/L. Exposed of the fish to cadmium was reported to have lasted 79 days at which time about 80% of the fish in each test concentration had died.

It appears that the excretion of cadmium by *C. angullaris* exposed to 1.0 mg Cd^{2+}/L was poor when compared with the lower concentration of 0.5 mg Cd^{2+}/L. It is likely that the cadmium diffusing into the fish after the 6^{th} day reached a level high enough to inhibit the excretion of the metal, presumably through poisoning of the gill ion excretory cells. This suggestion may explain why the fish exposed to 1.0 mg Cd^{2+}/L built up a body load of 0.54 mg Cd^{2+}/L wet weight; whereas in 0.5 mgCd^{2+}/L, fish accumulated only 0.07 mgCd^{2+}/g over the same period of times (8 days).

The study has revealed that when cadmium containing compounds are been applied to live fish, the metal is absorbed and retained. Also when the source of cadmium is removed, there is a corresponding loss of the metal from the fish. It is conceivable therefore, that even though cadmuim may be lost from fish after exposure, the cadmium may eventually kill fish through cadmium poisoning

ACKNOWLEDGEMENTS

We are grateful to the staff of Benin Owena River Basin Development Authority, Research Laboratory, and University of Benin, Benin City, who assisted in preparation of samples for Atomic Absorption Spectrophotometer analysis.

REFERENCES

Bryan GW (1976). Some aspects of heavy metal tolerance in aquatic organism: In Effects of pollutants on Aquatic Organism, (A.P.M. Lockwood Ed.) Cambridge University Press, pp. 7-34. London.

Coombs TI (1974). The significance of multi element analysis. In metal pollution studies, ed Melntyre AD, Mills FF, Ecolog, Toxicol Res NATO Sci. Comm. Conf. 7: 187-195 London.

Eisler R, Gardner GR (1973). Acute toxicology to an estuarine teleost of mistures of cadmuim, copper, and zinc salts. J. Fish Biol. 5: 131 – 142

Eisler R (1974). Radio cadmium exchange with seawater by *Fundulus heteroclitus* (L) (Pisces: Cyprinodontidae) J. Fish Biol. 6: 601 –612.

Leonard EN (1971). The determination of copper in fish tissue by atomic absorption spectrophotometer , At. Absorpt. Newsl. 10, 84-85.

Mount DI, Stephen CE (1967). A method for detecting cadmium poisoning in Fish. J. Wild.Manage 31:168 – 172

Oronsaye JAO (1987). The uptake and loss of absorbed cadmium by the stickleback (*Gasterosteus aculeatus*) Ecotoxicol and Envi. Safety. 14: 88-96.

Oronsaye JAO, Obano EE (2000). The uptake and loss of dissolved copper by *Clarias angullaris* fingerlings Pak. J. Sci. Ind. Res 43(6): 359-362.

Pascoe D, Mattey DL (1977). Studies on the toxicity of cadmium to the three-spined stickleback *Gasterosteus aculeatus* (L). J. Fish Biol. 11: 207-215.

Skidmore JF (1964). Toxicity of Zinc compounds to aquatic animals with special reference to fish. Q.* Rev. Biol. 39: 227-248.

Spehar RL (1976). Cadmuim and Zinc toxicity to Flagfish, *Jordanella Floridae* J. Fish Res. Bd. Canad. 33: 1939 – 1945

Wedemeyer G (1968). Uptake and distribution of Zn^{65} in the cohosalmon egg (*Oncorhynchus kistuch*) Comp. Biochem. Physiol. 26: 271 – 279.