Bull. Environ. Contam. Toxicol. (1986) 37:395–401
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Bulletin of Environmental Contamination and Toxicology

Bioaccumulation of Lead, Copper, Iron, and Zinc by Fish in a Transect of the Santa Catarina River in Cadereyta Jiménez, Nuevo León, México

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Bioaccumulation is the ability that an organism has to concentrate an element or compound from food and water to a level higher than that of its environment (Menzer and Nelson 1980).

The availability and toxicity of heavy metals to aquatic biota are primarily determined by the chemical nature of the aqueous environment and speciation of the metals. Most investigations of trace metal dynamics and their bioavailability in freshwaters indicate that toxicity of those metals depends on the alkalinity of the water (Pagenkopf et al. 1974).

Lloyd and Jordan (1964), reported that heavy metals such as copper, zinc and lead are present in domestic drainage pipes increasing the toxicity of the flows when they join to industrial wastes. According to Fisher (1975), zinc and copper are essential metallo-enzyme components; lead and cadmium have not been shown to play functional roles in fishes, but they rather inhibit biological systems and are capable of interfere with zinc and copper (Niklowitz and Yeager 1973; Hill et al. 1963). According to Ozoh (1980), lead produces changes in the pigmentation patterns of certain fish species and modifies the physicochemical changes of the cellular pigment by direct interference with the germinal plasma. Brungs (1969) and Eaton (1973), reported that zinc affects the reproductive cycle, reducing the egg production of Pimephales promelas in waters with 200 ppm of hardness, and concluded that this fact can be considered as an indicator of poisoning.

Villarreal-Treviño (1983), observed changes in the ichthyic species community, upriver in the San Juan River in Nuevo León, México. He found a disappearance of Notropis amabilis, Notropis stramineus, Dionda episcopa and Campostoma anomalum and an increased mortality of Astyanax mexicanus, Lepomis macrochirus and Cichlasoma cyanoguttatum. These changes were probably due to industrial and domestic discharges wich produced high levels of lead, copper, iron and detergents in the water.

The investigation reported here was done in order to detect the possible presence of lead, copper, iron and zinc in the river

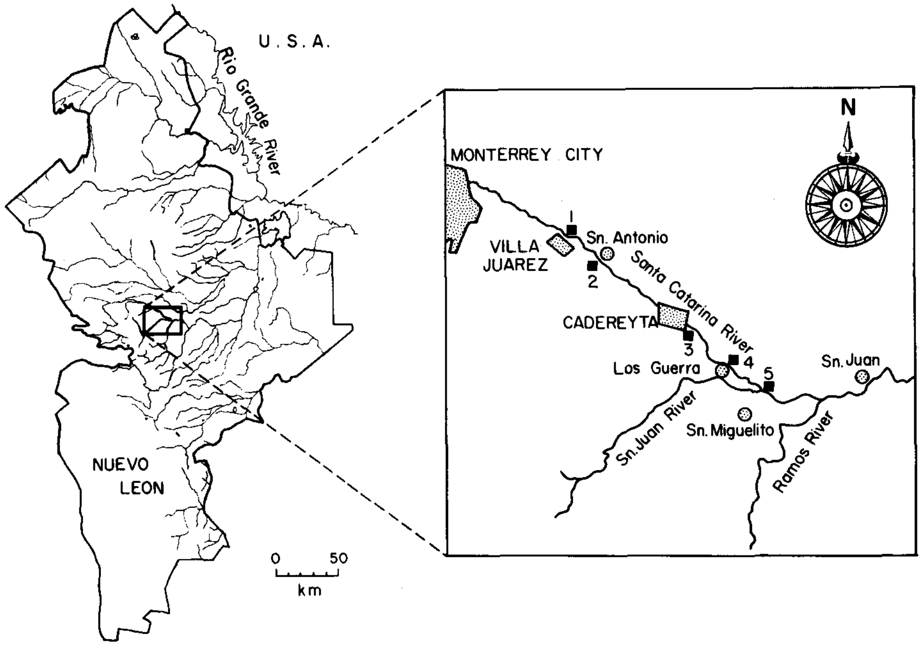

Figure 1. Sampling stations (■) in a transect of the Santa Catarina River in Cadereyta Jiménez, Nuevo León, México.

waters and also, to determine a probable bioaccumulation of these metals in fish species of the Santa Catarina River in the state of Nuevo León in northeastern México (Figure 1), since this river transports domestic and industrial wastes of urban and suburban zones.

MATERIALS AND METHODS

Five sampling stations were established in a transect (Figure 1) of the Santa Catarina River in Cadereyta Jiménez, Nuevo León: 1) Villa Juárez, 2) Hacienda San Antonio, 3) Cadereyta Jiménez, 4) Los Guerra (discharge pipe site of an oil refinery) and 5) San Miguelito. These stations are located between 25° 30' to 25° 37' latitude N and 99° 51' to 100° 5' longitude W.

For each station, collection was performed every 30 days during May, June and July with 30 min of fishing effort with a 3 m x 1.5 m (0.5 cm mesh) seine and the fish samples were placed in plastic bags. Water samples were collected in plastic tappered glass bottles at 50 cm of depth. The samples were transported to the laboratory at low temperature (4°C) and later frozen at -20°C.

The species used for this analysis were selected in accordance to their relative abundance. For the analyses, the fish samples were thawed and washed with deionized water in order to remove adhering particles, mucus and other materials that can adsorb metals. The whole fishes from the same species were homogenized by sequence of collection, removing any excess of water. The samples were crushed in a plastic mortar. After obtaining an homogeneous sample, one gram was taken and transferred to a 250-mL Kjeldahl flask; 2 mL of nitric acid were added and then the flask was placed on an electric heating pad to digest the tissue in aproximately 4 h. The precision and accuracy of the concentration of the elements were estimated by their recovery from four spiked samples (99% ± 1.55; mean ± SEM); analyses for each sample were done in triplicate. The concentrations of Pb, Cu, Fe and Zn were determined in the digested tissue and in water samples in a Perkin Elmer atomic absorption spectrophotometer, Model 5000, with direct aspiration of the sample, and in a direct acetylene-air flame (Perkin Elmer, 1976). Levels are reported as µg/g of digested tissue and µg/mL of water.

RESULTS AND DISCUSSION

The samples, taken in the spring and summer of 1984, were collected only at the third, fourth and fifth station because in the first two stations no fishes were found. The species most often collected were: Poecilia formosa > Astyanax mexicanus > Cichlasoma cyanoguttatum > Gambusia affinis > Notropis lutrensis > Micropterus salmoides (Table 1).

In the fish bodies, zinc and iron were found in greater amounts than lead and copper (Table 1). The species that contained the greatest quantities of these four metals were Poecilia formosa and Cichlasoma cyanoguttatum and the species that had the least was Astyanax mexicanus (however, some exceptions were found with Zn levels in this species). Figure 2 shows that Poecilia formosa and Cichlasoma cyanoguttatum, have greater quantities of Zn and Fe, concentrating up to 195.7 µg of Zn/g of tissue in Poecilia formosa and 152.7 µg of Fe and 142.5 µg of Zn both by gram of tissue in Cichlasoma cyanoguttatum. With these results and a series of determinations done with these elements in water (Table 2), a bioaccumulation of Zn and Fe can be observed in the analysed species because the levels of these metals are much higher in fish than in their aquatic environment. Thus, Poecilia formosa has in average 107.6 µg Zn/g of tissue in the fourth sampling station, whereas in the water there is a mean concentration of 0.017 µg Zn/mL.

Lloyd and Jordan (1964) reported that Pb, Cu and Zn are present in domestic sewage effluents and this fact increases their concentration in receiving waters. Domestic and industrial wastes of Monterrey, which is a highly industrialized city (metallurgical, petrochemical, car batteries, etc.), are the main cause of excessive pollution and possibly caused impact on the ichthyofauna of the Santa Catarina River.

The present results, in accordance to Menzer and Nelson (1980) permitted us to conclude that a notable bioaccumulation of Zn and Fe exists in several common species from this river (Poecilia formosa and Cichlasoma cyanoguttatum), since the body burden of these elements is much higher than the levels found in the flowing waters. Lead has not been shown to have essential functions in fishes,

Table 1. Levels of Pb, Cu, Fe and Zn (µg/g of wet weight) determined in several species of fishes from Santa Catarina River. The number of fishes for each species, collection time and place was four.

Species and Month of collection	Sampling Station and Metal Levels											
	Cadereyta Jiménez				Los Guerra				San Miguelito			
	Pb	Cu	Fe	Zn	Pb	Cu	Fe	Zn	Pb	Cu	Fe	Zn
Poecilia formosa												
May	6.5	2.2	32.3	49.5	5.0	2.5	52.5	57.5	—	—	—	—
June	6.5	4.3	178.5	81.7	10.8	4.3	77.4	195.7	14.0	4.0	142.0	66.0
July	6.5	2.2	251.6	68.8	4.5	2.3	97.8	69.8	11.3	4.5	888.8	94.5
Astyanax mexicanus												
May	—	—	—	—	7.5	2.5	12.5	35.0	4.0	2.0	28.0	48.0
June	—	—	—	—	4.3	2.2	15.0	30.1	4.0	2.0	42.0	58.0
July	23.7	2.2	49.5	83.9	5.0	2.5	37.5	115.0	4.5	2.3	27.0	42.8
Cichlasoma cyanoguttatum												
May	2.0	2.0	108.0	36.0	4.3	6.5	75.3	49.5				
June	2.5	2.5	20.0	57.5	6.5	0.0	152.7	142.5				
July	—	—	—	—	6.8	2.3	36.0	56.3				
Gambusia affinis												
May	6.5	2.2	64.5	83.9	2.3	2.3	11.3	65.3	—	—	—	—
Notropis lutrensis												
July	—	—	—	—	4.0	2.0	66.0	124.0	—	—	—	—
Micropterus salmoides												
June*	2.3	2.3	31.5	63.0	—	—	—	—	—	—	—	—

* This values correspond to one fish.

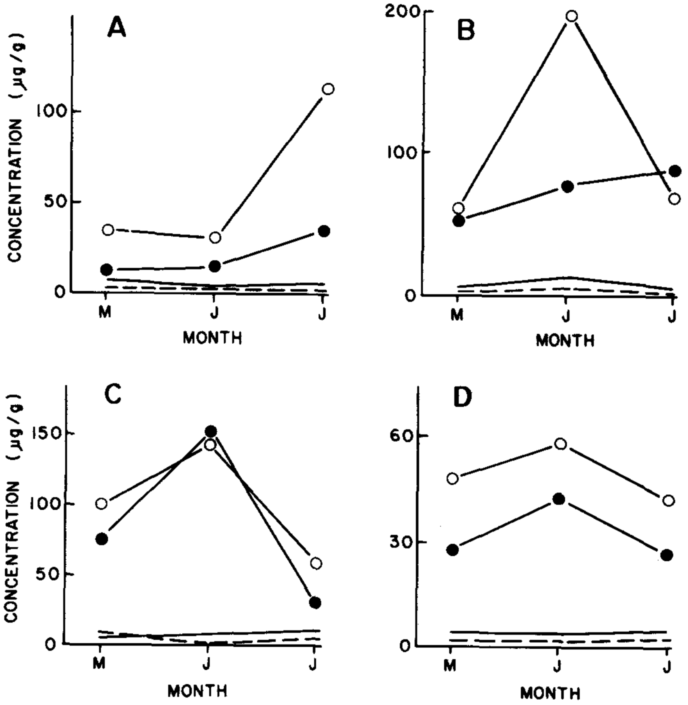

Figure 2. Levels of Pb,——; Cu, ---; Fe,-●-; Zn,-o- in the fishes: A) *Astyanax mexicanus*; B) *Poecilia formosa*; C) *Cichlasoma cyanoguttatum* in the station Los Guerra and D) *Astyanax mexicanus* in the station San Miguelito, during May, June and July of 1984.

buth rather inhibits biological systems and competitively interferes with Zn and Cu (Niklowitz and Yeager 1973). Ozoh (1980) showed that lead interferes with pigmentation patterns in fishes. Brungs (1969) and Eaton (1973) reported that zinc can affect fish reproduction reducing the number of fertilized eggs. On these bases and concentration values of Pb, Cu, Fe and Zn observed in this study, an extensive variety of biological changes are expected to occur in the fishes of Santa Catarina River, but a more detailed observation is needed.

Acknowledgements. The authors thank D. Gonzâlez R. for his manuscript criticisms.

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Table 2. Concentration of Pb, Cu, Fe and Zn (µg/mL) in the water of each sampling station in the Santa Catarina River. Each value correspond to one sample for each time and place.

Sampling Station and Month of Collections	Pb	Cu	Fe	Zn
1.- Villa Juárez				
June	0.012	0.019	0.008	0.021
July	0.020	0.023	0.012	0.045
$\overline{X}$	0.016	0.021	0.010	0.033
2.- Hacienda San Antonio				
June	0.011	0.020	0.005	0.006
July	0.008	0.019	0.008	0.019
$\overline{X}$	0.010	0.019	0.007	0.013
3.- Cadereyta Jiménez				
June	0.009	0.017	0.006	0.016
July	0.004	0.015	0.008	0.003
$\overline{X}$	0.007	0.016	0.007	0.010
4.- Los Guerra				
June	0.010	0.023	0.005	0.016
July	0.014	0.014	0.017	0.018
$\overline{X}$	0.012	0.019	0.011	0.017
5.- San Miguelito				
June	0.007	0.031	0.007	0.012
July	0.012	0.018	0.010	0.032
$\overline{X}$	0.010	0.025	0.009	0.022

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Received October 17, 1985; accepted February 4, 1986