Concentration of Cadmium, Copper, Lead, and Zinc in Thirty-Five Genera of Freshwater Macroinvertebrates From the Fox River, Illinois and Wisconsin

Richard V. Anderson*
Department of Biological Sciences
Northern Illinois University
DeKalb, Ill. 60115

The study of trace metals in aquatic systems has increased with the increasing awareness of possible contamination of biota by these metals. Relatively few reports, however, concern trace metal concentrations in freshwater macroinvertebrates. WARNICK and BELL (1969) and REHWOLDT et al. (1973) deal with the acute toxicity of selected heavy metals to some aquatic invertebrates. There have also been investigations which give metal concentrations in a few taxa from field samples (MATHIS and CUMMINGS, 1973; GALE et al., 1973; NAMMINGA et al., 1974). LEVY AND CROMROY (1973) have reported trace element concentrations in 41 species of insects, although only a few of the larval forms were aquatic. The present study is an initial report of the concentration of cadmium, copper, lead, and zinc in 35 genera of aquatic macroinvertebrates collected in the Fox River, Illinois , and Wisconsin.

Methods

The invertebrates were collected during the summer of 1973 from five locations on the Fox River north and west of Chicago at Big Bend and Waterford, Wisconsin, and Algonquin, Elgin, and Geneva, Illinois. Specimens were taken in 60 cm of water below small flood control dams at all sampling sites except Big Bend where the samples were collected from the river channel. The two Wisconsin sites are located in an agricultural area while the Illinois sites are in industrial-urbanized areas. Potential trace metal input is primarily from runoff of both paved and unpaved surfaces and from industrial and domestic sewage effluents.

After collection and identification specimens were prepared for analysis using a dry ashing technique modified from MIDDLETON et al. (1973). Samples were ashed in a muffle furnace at 450°C for 12 hours and the ash was dissolved in 5 ml of concentrated HNO_3. The resulting solution was diluted with 10 ml of double

*Present address: Natural Resources Ecology Laboratory, Colorado State University, Ft. Collins, Colo. 80523

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distilled water and filtered through No. 44 Whatman ashless filter paper into 25 ml volumetric flasks. The flasks were brought to volume with double distilled water. The digested samples in aqueous solution were analyzed for trace metals using a single beam Varian Techtron Atomic Absorption Spectrophotometer, Model AA5, with direct aspiration of the sample into an air-acetylene flame and with output to a Varian chart recorder, Model G-2000. The sensitivity of analysis for each of the metals is: Cd, 0.02 μg/ℓ; Cu 0.04 μg/ℓ; Pb, 0.16 μg/ℓ, and Zn, 0.012 μg/ℓ. All values were corrected for sample preparation losses, proportional matrix effects, and spectrophotometric background absorption.

Results and Discussion

The total invertebrate body concentration for each of the studied metals is given in Table 1. Table 1 also gives confidence limits of the means for taxa where more than two samples were collected and analyzed. While there is a wide range of values within the taxa and in some cases a high confidence limit, the general relationship between the metal concentrations is $Cd<Cu\leq Pb<Zn$, except in the crustaceans where $Cd<Pb<Cu\leq Zn$.

With some notable exceptions there are no significant trends between the classes and orders represented. One of the exceptions is the high copper values found in crustaceans. This high Cu concentration is believed to be due to the presence of Cu as a pigment in crustacean hemocyanin. Although zinc, a physiologically important trace metal, occurs at significantly higher concentrations than the other metals, it is found in very high concentrations in pelecypods. It should be noted that the clam shell contains very low concentrations of zinc. This fact is the reason for the low zinc concentration found in Sphaerium as well as the gastropods, since the shell and soft body parts of these invertebrates were analyzed together. Zinc is also found in relatively high concentrations in caddisfly larvae and mayfly nymphs. These higher concentrations reflect either a physiological need for Zn or the ability of those invertebrates to concentrate higher levels of the metals. Neither cadmium nor lead concentrations occur as specific trends within a particular group of invertebrates studied.

There are relatively large variations in values among all the taxa studied. The variation in concentrations within metals is in part a function of the sampling location. Inputs of metals into the habitat may vary considerably, particularly at sampling sites in urbanized areas. As indicated in Table 1, organisms

TABLE 1

Mean concentration of trace metals found in thirty-five genera of aquatic macroinvertebrates collected in the Fox River, Illinois.

	Number of samples (sites)	Number of organisms	Total dry weight (g)	Mean metal concentration and (confidence limits of the mean) μg metal/g dry weight			
				Cd	Cu	Pb	Zn
Insecta							
Trichoptera (Caddis Fly larvae)							
Hydropsyche	49 (4)	13,384	45.74	1.52 (0.76)	11.88 (0.56)	18.81 (0.74)	220.04 (0.38)
Cheumatopsyche	11 (3)	4,393	5.98	1.49 (0.46)	14.10 (0.26)	23.72 (0.63)	270.82 (0.39)
Ephemeroptera (Mayfly nymphs)							
Stenonema	20 (2)	5,472	13.62	5.55 (0.46)	17.55 (0.54)	30.04 (0.34)	252.92 (0.11)
Potamanthus	2 (2)	29	0.34	6.33	12.96	39.48	229.62
Hexagenia	5 (1)	48	1.02	*	11.29 (0.09)	29.12 (0.26)	177.83 (0.04)
Baetis	1 (1)	35	0.10	*	12.12	***	206.30
Diptera (Fly larvae)							
Simulium	6 (2)	1,802	1.25	2.53	14.00	24.04	102.77
Chironomidae	10 (4)	25,806	2.22	2.17	13.05	29.74	144.21
Odonata (Dragonfly and Damsel Fly nymphs)							
Argia	1 (1)	10	0.10	*	74.21	23.71	183.41
Amphiagrion	2 (1)	84	0.23	*	26.52	***	113.25
Anax	3 (1)	10	0.99	*	27.79 (0.06)	20.20 (0.06)	75.52 (0.16)
Hemiptera (True Bugs, adults)							
Sigara	3 (3)	237	0.65	*	19.47 (0.13)	19.51 (0.24)	172.78 (0.08
Ranatra	1 (1)	27	0.14	*	15.75	***	103.40
Belostoma	2 (1)	7	0.18	*	18.50	***	228.01
Notonecta	1 (1)	13	0.12	*	20.09	***	163.52

TABLE 1--Continued

	Number of samples (sites)	Number of organisms	Total dry weight (g)	Mean metal concentration and (confidence limits of the mean) μg metal/g dry weight			
				Cd	Cu	Pb	Zn
Coleoptera (Beetles)							
Helophorus (adult)	1 (1)	4	0.11	*	16.22	***	119.26
Berosus (larval)	2 (1)	9	0.06	*	**	***	160.92
Tropisternus (larval)	1 (1)	6	0.03	*	**	***	170.51
Dineutus (larval)	1 (1)	3	0.04	*	**	***	107.50
Crustaceana							
Orconectes	79 (4)	225	135.38	1.60 (0.50)	86.61 (0.45)	25.68 (0.53)	107.12 (0.24)
Procambarus	3 (1)	3	9.21	2.77 (0.04)	58.10 (0.05)	15.73 (0.01)	64.68 (0.04)
Cambarus	3 (1)	2	6.81	1.74 (0.05)	94.76 (0.04)	15.62 (0.01)	93.43 (0.03)
Asellus	6 (3)	1,533	1.68	2.62 (0.66)	99.19 (0.11)	22.05 (0.38)	124.94 (0.39)
Gammarus	2 (1)	224	0.26	*	70.74	***	101.19
Gastropoda (Snails)							
Physa	6 (2)	96	1.24	2.97 (0.44)	22.01 (0.21)	21.64 (0.31)	69.93 (0.74)
Campeloma	2 (2)	2	3.70	1.76	18.37	21.79	99.58
Gonaobasis	5 (2)	31	9.12	2.19 (0.37)	13.40 (0.29)	19.73 (0.48)	22.69 (0.24)
Pleurocera	7 (1)	35	14.17	2.31 (0.03)	10.70 (0.12)	24.08 (0.03)	19.19 (0.02)
Pelecypoda (Clams)							
Sphaerium	13 (2)	992	12.56	1.99 (0.19)	10.06 (0.41)	32.18 (0.28)	61.07 (0.19)
Lampsilis (body parts)	5 (3)	5	5.63	2.23 (0.27)	12.67 (0.13)	21.93 (0.14)	353.04 (0.10)
Anodonta (body parts)	1 (1)	1	3.78	1.78	6.88	13.73	232.10
Lasmigona (body parts)	2 (2)	2	13.25	1.43	5.15	23.70	317.63
Strophitus (body parts)	1 (1)	1	1.48	2.52	8.68	27.25	208.80
Anodonta (shell)	5 (1)	3	10.31	1.35 (0.26)	9.30 (0.14)	10.19 (0.11)	3.70 (0.11)
Hirudinea (Leeches)							
Erpobdella	7 (3)	145	0.81	3.80 (0.30)	16.83 (0.36)	39.78 (0.08)	136.23 (0.54)
Placobdella	2 (2)	29	0.45	*	7.59	***	148.37

*Trace amount of Cadmium = 0.5 μg/g or less
**Trace amount of Copper = 1.0 μg/g or less
***Trace amount of Lead = 4.0 μg/g or less

collected at only one sampling site have lower confidence limits of the mean than organisms collected from several sites. This indicates higher variability in metal concentrations found in organisms taken at different sampling sites. The variability may also be a result of the trophic position of a particular taxa since this would determine some degree of exposure to the metals through the food chain.

In conclusion, while there is considerable variability in the data and few specific trends, the data do present a reference point for further investigations of uptake and concentration of trace metals by aquatic macroinvertebrates.

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