Concentration of Cadmium, Copper, Lead, and Zinc in Six Species of Freshwater Clams

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Reports of the occurrence and accumulation of heavy metals in pelecypods have generally been limited to salt water forms (AYLING, 1974; IRELAND, 1973; KOPFLER and MAYER, 1973; PENTREATH, 1973; VALIELA and BANUS, 1974; WINDOM and SMITH, 1972). This is apparently due to the concern over contamination of commercial oyster and mussel beds. Few reports of heavy metal concentrations in freshwater bivalves occur. The most notable being those of MATHIS and CUMMINGS (1973) for three species of Unionidae collected in the Illinois River and SMITH et al. (1975) which was a study of both field and laboratory uptake of Mercury. The objective of this study was to determine concentrations of Cadmium, Copper, Lead, and Zinc in six species of clams collected in the Fox River, Illinois and Wisconsin.

Methods

Clams were collected from the Fox River at random points between Big Bend, Wisconsin and Geneva, Illinois during the summer of 1973. This section of the river passes through agricultural and urbanized areas. Clams were collected by hand in soft sand-silt or gravel substrates below riffle-rapid areas in the river. *Sphaerium* were collected in riffle-rapid areas. The clams were identified and separated into soft body parts and shells. Two large species, *Anodonta marginata* and *Lasmigona complanata*, were divided into general body regions: gills, muscle including the foot and abductors and adductors, viscera, and shell.

Preparation for analysis of metals involved a dry ashing technique modified from MIDDLETON et al. (1973). Dried body samples were ashed at 500°C for 12 hours. The ash was dissolved in 5 ml of concentrated nitric acid, diluted with 10 ml of double distilled water, filtered through No. 44 Whatman ashless filter paper into 25 ml volumetric flasks and analyzed for metals using a single beam Varian Techtron Atomic Absorption Spectrophotometer, Model AA5, with an air-acetylene flame.

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The sensitivity of analysis for each of the metals was; Cd 0.02 µg/ℓ; Cu, 0.04 µg/ℓ; Pb, 0.16 µg/ℓ; and Zn, 0.012 µg/ℓ. Values were corrected for sample preparation losses, proportion matric effects, and spectrophotometric background absorption by using standard additions and nonspecific wave lengths.

Results and Discussion

While there was considerable variability between the taxa, see Table 1, there were consistent trends in relationships between the metals. The order of metal concentrations in the shells was Cd < Cu < Zn < Pb and for the body it was Cd < Cu < Pb < Z Associations between metals as well as variability between meta where also reported by MATHIS and CUMMINGS (1973) in the clams they investigated.

As shown in Figure 1, the body concentrations of the metal were higher than the concentrations in the shells. The body generally reflected the concentrations found in the sediment (silt); Cd 1.0-10.7 µg/g, Cu 13.8-51.5 µg/g, Pb 5.2-89.6 µg/g, and Zn 75.1-128.7 µg/g, while being much higher than the concen trations in the water; Cd 0.00006 µg/ℓ, Cu 0.001-0.006 µg/ℓ, Pb 0.021 µg/ℓ, and Zn 0.001-0.008 µg/ℓ. These values were ranges of metal concentrations from data collected at five locations between Waterford, Wisconsin and Elgin, Illinois. Th high standard deviations for metal concentrations, where they could be determined, indicate the high variability between individuals. Since effluents from urban-industrial, stormwater and rural areas empty into the Fox River the probability of an individual being near a pollution source varies considerably. Consequently there may be a wide range of metal concentrations found in the clams depending on their location in the river. LELAND et al. (1974) indicated that animals confined to the sediment reflect the concentration of trace metals, particular if in the proximity of a pollution source.

The concentrations of the metals in the shell were lower than those found in the sediment. The metals found in the she were adsorbed on its surface or incorporated into the shell fr the water as the shell was formed and were closely associated with the low metal concentration in the water. Sediment was washed from the clam shell prior to digestion. The clam shell also had comparatively lower concentrations than the body. Similar low shell concentrations compared to soft body parts were reported by BROOKS and RUMSBY (1964) for salt water shell

When the body was separated into general regions it was found that the metal concentrations were the highest in the gi (Table 1). The gills, acting both as a filtering mechanism fo food material and as a respiratory organ, adsorb and absorb th metals from both the water and substrate. This results in accumulation of the metals in this tissue relative to the othe body tissues. The viscera were also found to have relatively high concentrations of the metals. This would result when the material filtered by the gills was flushed into the digestive track. The general relationship for all the metal concentrati between the organs is shell < muscle < viscera < gills. These

TABLE 1

Mean concentration of metals in six species of clams collected in the Fox River, Illinois and Wisconsin

Taxa and Body Parts	Number of Samples	Total Dry Weight (g)	µg metal / g dry weight tissue (standard deviation)			
			Cd	Cu	Pb	Zn
Lampsilis siliquoidea						
shell	3	4.50	3.66 (1.23)	7.18 (2.34)	20.92 (6.33)	8.33 (1.97)
body	7	9.90	5.89 (2.20)	7.41 (3.65)	23.16 (8.82)	319.85 (67.91)
Lampsilis ventricosa						
shell	2	5.64	2.69	7.01	16.34	8.22
body	1	0.30	2.71	22.35	17.64	173.45
Strophitis rugosus						
shell	2	2.03	3.36	8.40	22.66	8.05
body	2	0.71	4.36	13.52	25.61	129.72
Sphaerium						
shell	1	1.26	2.85	10.90	32.96	11.68
body	1	0.33	2.49	18.90	48.17	146.52
Anodonta marginata						
shell	5	10.31	1.35 (0.09)	9.30 (3.62)	10.19 (0.55)	3.70 (0.20)
muscle	4	3.40	0.47 (0.19)	4.11 (1.23)	1.92 (0.45)	22.11 (4.67)
gills	3	8.45	4.75 (1.71)	12.89 (1.20)	17.53 (2.69)	211.10 (21.84)
viscera	4	7.46	2.19 (0.73)	7.89 (2.24)	13.81 (1.57)	223.52 (10.63)
Lasmigona complanata						
shell	2	5.64	1.24	3.36	9.15	5.10
muscle	3	2.94	0.36 (0.11)	2.75 (1.25)	5.24 (2.83)	61.71 (22.91)
gills	2	2.76	1.11	4.05	24.92	420.69
viscera	2	4.93	0.90	2.17	13.87	270.64

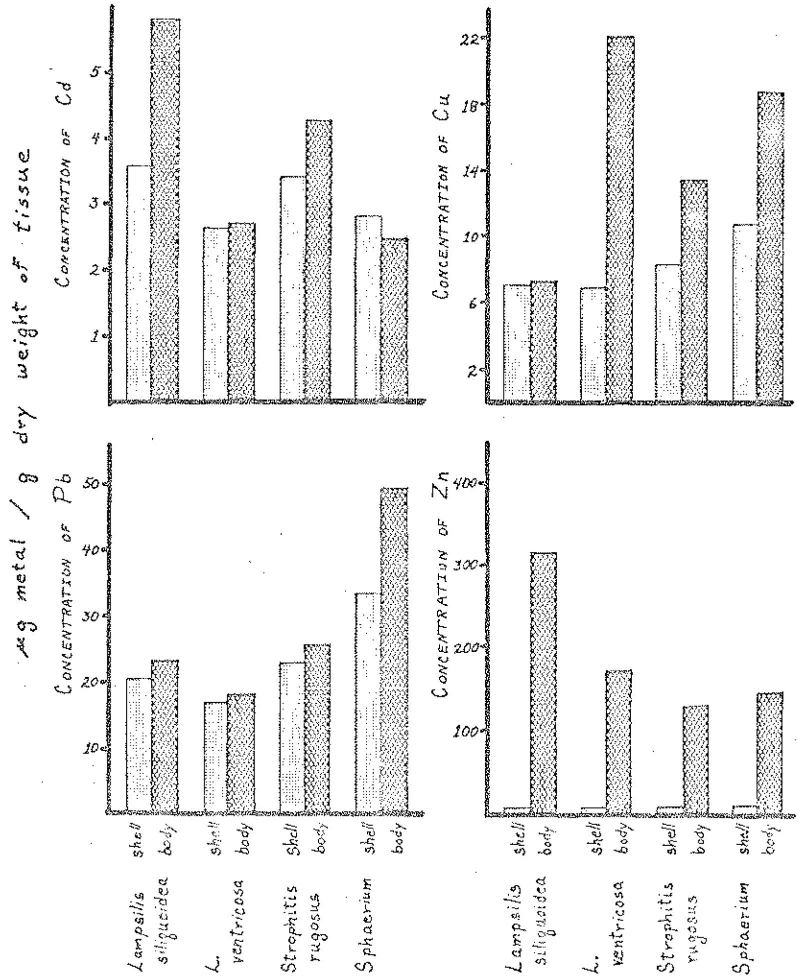

Figure 1. A comparison of the concentrations, in micrograms of metal per gram dry weight of body tissue, of Cadmium, Copper, Lead, and Zinc in the body and shell of four freshwater clams.

results were again similar to those reported by BROOKS and RUMSBY (1964) and reflect the more active association of selected organs with the environmental input of the metals.

For Cu, Cd, and Pb the concentrations found in the body were at or below those found in the sediment. However, Zn concentrations in the body were much higher than Zn sediment concentrations. This is particularly true for the gills and viscera. It was felt that Zn may play an important physiological role in molluscs and thus be actively taken up and concentrated. YAGER and HARRY (1964) found higher uptake rates for body tissues than for the shell in a freshwater snail and BROOKS and RUMSBY (1964) reported Zn concentrations in tissues were much higher than sediment concentrations.

In conclusion the metal concentrations in the bodies of the freshwater clams studied generally reflected that found in the environment, with the exception of Zn. The shell had comparatively lower concentrations of all metals which reflects its inactive role in filtering and feeding. While concentrations of the studied metals are not the same between salt water and freshwater clams the relationships between the metals, body parts, and environment were similar.

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