Bull. Environ. Contam. Toxicol. (1985) 35:345–347

Bulletin of Environmental Contamination and Toxicology

Effects of Gut Sediment Contents on Measurements of Metal Levels in Benthic Invertebrates—a Cautionary Note

Peter M. Chapman

E.V.S. Consultants Ltd., 195 Pemberton Avenue, North Vancouver, B.C., V7P 2R4 Canada

Studies of heavy metal levels in benthic organisms typically do not correct for gut sediment metal levels other than by allowing a period of depuration in clean water. The effectiveness of depuration has recently been questioned in British Columbia in the particular case of the marine clam Yoldia. This clam has been used in a variety of bioaccumulation studies with mine tailings, but recent evidence suggests that previous bioaccumulation results may be an artifact of high gut tailings levels (Amax of Canada 1984). In light of this controversy, it appears appropriate to present data from a study of heavy metal levels in sediments and benthic organisms in the Lower Fraser River, B.C. (Chapman 1979; Chapman et al. 1980), regarding the effects of gut sediment contents.

MATERIALS AND METHODS

Sediments were collected subtidally by Ponar grab and organisms were sorted from the sediment using stainless steel sieves and forceps. Three groups of organisms were collected in sufficient biomass for heavy metals analysis: tubificid oligochaetes (a mixture of Limnodrilus hoffmeisteri and Tubifex tubifex), chironomid larvae (family Chironomidae) and ammocoetes (lamprey) larvae.

Sediments were analyzed for metals by drying them at 50°C, then sieving them through a 63 µm mesh stainless steel sieve and analyzing this sediment fraction by using a flameless atomic absorption spectrophotometer following metals extraction by hydrogen peroxide-nitric acid (4 mL of 30% H_2O_2, 1 mL HNO_3 extracted at medium heat for 2½ hours). Benthic organisms were also analysed by this method.

The effects of gut sediment metal contents were determined as proposed by Bindra and Hall (1977) by collecting undigested sediment from the peroxide-nitric acid digestion of tubificid, chironomid and ammocoetes larvae tissue on pre-weighed, acid-washed (0.2% HNO_3) 0.45 µm Sartorius membrane filters. The filters and sediment were dried to constant weight and weighed. The metal levels in the sediment at the time of collection were used to calculate gut sediment metal levels.

Blanks were run for all samples. Additionally, recovery rates were determined on bovine liver standards of known metal concentration and similar chemical composition to the samples.

Table 1: The contribution of gut sediment metal contents to tissue metal levels.[a]

Metal	Tubificids		Ammocoetes Larvae		Chironomid Larvae	
	Mean Percent	Sample Size	Mean Percent	Sample Size	Mean Percent	Sample Size
Cu	31	23	41	8	17	5
Zn	26	23	35	8	29	5
Pb	61	22	86	7	62	2
Fe	72	23	97	8	58	5
Mn	70	23	97	8	65	5
Ni	73	20	77	2	below detection limits	
Co	55	8	80	3	2	2

	Tubificids		Ammocoetes Larvae		Chironomid Larvae	
	Mean Percent Weight and 95% Confidence Limits	Sample Size	Mean Percent Weight and 95% Confidence Limits	Sample Size	Mean Percent Weight and 95% Confidence Limits	Sample Size
Gut Sediment	14.9 ± 3.0	23	13.0 ± 3.0	8	16.8 ± 7.3	5

a. Extraction was by peroxide-nitric acid; metals extracted from gut sediments are shown as a percentage of total metal levels.

RESULTS AND DISCUSSION

The percent contribution of gut sediment metal contents to metal levels in tubificids, chironomid and ammocoetes larvae is shown in Table 1. Gut sediment weight of tubificids averaged 14.9% of total weight, however the metal load contributed by the gut sediment varied from a mean value of 16.4% for zinc to a mean value of 39.7% for nickel. In the case of ammocoetes larvae, average gut sediment weight was less than that for tubificids, but the metal load contributed by this sediment was much higher than in tubificids. Values varied from a mean of 20.7% for zinc to a mean of 62.0% for lead. Chironomid larvae were only occasionally collected so sample size is small, but gut sediment metal contents also comprised a high percentage of the total metal load.

The fact that sediment gut contents significantly influence determinations of tissue metal levels in invertebrates has also been shown by Flegal and Martin (1977), who worked with rocky intertidal gastropods and estuarine copepods. These authors noted that inorganic matter present in these invertebrates was often significantly correlated with their apparent metal concentrations.

Thus it is important that digestions of whole benthic animals for tissue metal analysis include a gut sediment correction. Although many studies have attempted to correct for gut contents by keeping live animals for periods of up to 48 h in water to empty their guts, this procedure appears to be ineffective in the case of the marine clam Yoldia (Amax of Canada 1984). This procedure is also doubtful in the case of tubificids which, along with many other benthic animals, engage in coprophagy.

Acknowledgements. I thank Dr. L. Churchland, P. Thomson and E. Michnowsky for their contributions to the initial study from which these data are derived, R. Deverall for encouraging publication of the data, and M. Mees for word processing the paper. Funding for the original study was supplied by the Inland Waters Directorate, Canada.

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Received August 22, 1984; accepted September 12, 1984