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Trophic Variations in Uptake and Assimilation of Cadmium, Manganese and Zinc: An Estuarine Food-Chain Radiotracer Experiment

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Abstract : Nearly half of the world's population live near the coast, and as a result, estuaries and coastal bays in populated or industrialized areas often receive metal pollution. Heavy metals have a chemical affinity for sediment particles and can be stored in estuarine sediments and become biologically available under changing conditions. Organisms inhabiting estuaries can be exposed to metals from a variety of sources including metals dissolved in water, bound to sediment or within contaminated prey. Metal uptake and assimilation responses can vary even between species that are biologically similar, making pollution effects difficult to predict. A multi-trophic level experiment representing a common Eastern Australian estuarine food chain was used to study the sources for Cd, Mn and Zn uptake and assimilation in organisms occupying several trophic levels. Sand cockles (Katelysia scalarina), school prawns (Metapenaeus macleayi) and sand whiting (Sillago ciliata) were exposed to radiolabelled seawater, suspended sediment and food. Three pulse-chase trials on filter-feeding sand cockles were performed using radiolabelled phytoplankton (Tetraselmis sp.), benthic microalgae (Entomoneis sp.) and suspended sediment. Benthic microalgae had lower metal uptake than phytoplankton during labelling but higher cockle assimilation efficiencies (Cd = 51%, Mn = 42%, Zn = 63 %) than both phytoplankton (Cd = 21%, Mn = 32%, Zn = 33%) and suspended sediment (except Mn; (Cd = 38%, Mn = 42%, Zn = 53%)). Sand cockles were also sensitive to uptake of Cd, Mn and Zn dissolved in seawater. Uptake of these metals from the dissolved phase was negligible in prawns and fish, with prawns only accumulating metals during moulting, which were then lost with subsequent moulting in the depuration phase. Diet appears to be the main source of metal assimilation in school prawns, with 65%, 54% and 58% assimilation efficiencies from Cd, Mn and Zn respectively. Whiting fed contaminated prawns were able to exclude the majority of the metal activity through egestion, with only 10%, 23% and 11% assimilation efficiencies from Cd, Mn and Zn respectively. The findings of this study support previous studies that find diet to be the dominant accumulation source for higher level trophic organisms. These results show that assimilation efficiencies can vary depending on the source of exposure; sand cockles assimilated more Cd, Mn, and Zn from the benthic diatom than phytoplankton and assimilation was higher in sand whiting fed prawns compared to artificial pellets. The sensitivity of sand cockles to metal uptake and assimilation from a variety of sources poses concerns for metal availability to predators ingesting the clam tissue, including humans. The high tolerance of sand whiting to these metals is reflected in their widespread presence in Eastern Australian estuaries, including contaminated estuaries such as Botany Bay and Port Jackson.

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