Cadmium, copper and lead in aquatic macrophytes in Shoal Lake (Manitoba-Ontario)

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Abstract

Cadmium, copper and lead concentrations were surveyed in several species of submerged aquatic macrophytes in a Precambrian Shield Lake. Values were variable within each species and interspecific differences in metal concentration were not significant over the season as a whole. Cadmium concentration increased during the season in *Potamogeton foliosus* and *Myriophyllum exalbescens*, while copper and lead declined in *P. foliosus*. No identifiable seasonal trends were seen in *P. zosteriformis* and *P. robbinsii*. In *P. foliosus*, copper and lead concentrations increased with water depth. Few significant correlations were found between metal concentrations in the shoots and each of several water chemistry parameters, temperature, and shoot chlorophyll, soluble sugar and starch content. Roots yielded greater metal concentrations than shoots.

Introduction

Macrophytes form a substantial component of the primary production in many Precambrian Shield lakes. Of particular interest is the role of macrophytes in the cycling of metals within aquatic ecosystems (McIntosh, 1975). Not only do aquatic macrophytes take up metals from the sediments and water, and subsequently release these elements on aging and decomposition (Mayes *et al.*, 1977; McIntosh *et al.*, 1978), they also serve as food for higher trophic levels which can obtain a significant proportion of their body burdens of metal from this source (e.g. Newman & McIntosh, 1983). A number of workers have examined metal concentrations in various macrophytes growing in natural and metal-enriched water bodies (e.g. Allenby, 1968; Adams *et al.*, 1971, 1973; Gale *et al.*, 1973; Cowgill, 1973, 1974; Leland & McNurney, 1974; Mathis & Kevern, 1975; Harding & Whitton, 1978; Aulio, 1980; Welsh & Denny, 1980; Kimball & Baker, 1982; Peverly, 1985). Yan *et al.* (1985) implicated elevated metal concentrations in the reduction of species richness of vascular plant communities. Some experimental studies of metal uptake and toxicity are also available for aquatic plants (e.g. Sutton & Blackburn, 1971; Stanley, 1974; Cearley & Coleman, 1973; Merchyulenene & Nyanishkene, 1976; Behan *et al.*, 1979; Peter *et al.*, 1979; Raghi-Atri, 1980).

The present study was a continuation of previous investigations of the submerged macrophyte communities of Shoal Lake, a Precambrian Shield lake (Pip, 1987; Pip & Sutherland-Guy, 1987). The present paper examines the seasonal concentrations of cadmium, copper and lead in several species of submerged aquatic macrophytes, and determines whether these concentrations can be related to metabolic status of the plants, or to external environmental factors.
Site description

The study was carried out in Indian Bay and adjacent parts of the main body of Shoal Lake (49° 36'-40' N, 95° 04'-12' W). Shoal Lake has a mean elevation of 323 m above sea level and is contained in an irregular basin of Early Precambrian metavolcanic bedrock. Thermal stratification is minimal or absent in the study area during the ice-free season; localized thermoclines are of limited duration. The bay has a maximum depth of 10 m and a surface area of 21.7 km².

The macrophyte stands in Indian Bay are dense and intermixed (Pip & Sutherland-Guy, 1987). The latter authors have described water chemistry, characteristics of the bottom sediments, thermal regimes, dissolved oxygen concentrations and light attenuation patterns during the study season.

Materials and methods

Macrophyte sampling was conducted during the 1985 season at 8-25 stations ranging in depth from 1-13 m located within and just outside Indian Bay of Shoal Lake (Pip & Sutherland-Guy, 1987). Sampling dates were: April 27 (immediately after ice breakup), May 2, May 16, May 30, June 13, June 27, July 10-11, August 8 and August 29. Plant material was collected by dredging with a rake and by using SCUBA. Plants were washed in the lake to remove as much periphyton as possible, placed into plastic bags and transported on ice in lightproof containers to the laboratory, where they were frozen.

Sediment samples were collected with an unweighted Ekman dredge; water samples (including winter samples under ice cover) were obtained 0.5 m above the bottom with a van Dorn sampler. All samples were frozen on return to the laboratory.

Frozen plants were freeze-dried and ground to a powder in a stainless-steel mill. Each sample was a mixture of different individuals. For shoots, only green parts were used. Samples were extracted as 3 replicates of 0.5 g each. Each replicate was digested in 7.5 ml conc nitric acid and 1.5 ml 70% perchloric acid. The mixture was heated below boiling for 1 h, followed by addition of 10 ml 1% nitric acid. The material was filtered through Whatman No. 541 hardened ashless filter paper and the filtrate was made up to 50 ml with 1% nitric acid, then aspirated into a lean air-acetylene flame using a IL151 atomic absorption spectrophotometer (Instrumentation Laboratory Inc., Wilmington, Mass.). The standard additions method was used, in order to compensate for matrix absorption effects (e.g. Willis, 1963); additions of certified standards were made prior to initiation of digestion. Procedural controls were run with each series and consisted of all steps and reagents in the procedure less the sample material. All glassware was acid-washed prior to use.

Sediment metal concentrations were highly variable at the different sampling sites and ranged from <1-3.7 µg/g dry weight for cadmium, 15-43 µg/g for copper and 18-61 µg/g for lead. Water concentrations also differed greatly with location and time; maximum measured winter values for total dissolved and particulate metals