SIGNIFICANCE OF THE AQUATIC MOSSES IN BIOGEOCHEMISTRY

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ABSTRACT

The Ayurvedic text, *Susruta Samhita*, points out the use of aquatic plants, such as mosses and water lilies, for water treatment. In order to elucidate the significance of this observation, made in this ancient Sanskrit text, multi-element analysis of aquatic mosses from three mining areas of mica pegmatite, barytes and lead in Andhra Pradesh was carried out. The results reveal that there is an unusually high enrichment of the respective ore element and other associated heavy metals in these plants owing to their remarkable cation exchange capacity. Based on this biogeochemical study, it is concluded that aquatic mosses are useful in (i) geochemical and agricultural reconnaissance surveys, (ii) monitoring of toxic heavy metals including radioactive pollutants in water bodies, and (iii) water treatment.

INTRODUCTION

AQUATIC plants (bryophytes), such as mosses, water lilies, water hyacinth, duckweed, etc. are important components of aquatic ecosystems throughout the world. The ancient Sanskrit text of Ayurveda, (the science of longevity), *Susruta Samhita*, in the 'Section on Water' (*Jala Varga*), suggests the use of aquatic plants, such as mosses, and the roots of water lilies for water treatment[1–3].

Most of the modern works have tended to eliminate these plants from water bodies on the plea that their rapid proliferation results in mechanical obstruction in water supplies and navigation and also poses a threat to ecological balance.

In spite of these nuisance characteristics, there is a growing interest in managing aquatic plants in various types of systems (natural and artificial or constructed wetlands, ponds, channels, lakes, streams and rivers), for purposes of water treatment (municipal, industrial, agricultural and non-point sources) and resource recovery (for water and nutrient reuse, wildlife habitat creation and maintenance, and biomass production for energy, feeds, fibre, etc). These details were discussed exhaustively at the 'Research and Application of Aquatic Plants for Water Treatment and Resource Recovery' conference held at Orlando, Florida, in 1986[4].

Mosses and other aquatic macrophytes behave essentially as simple ion exchangers[5,6]. These plants are capable of absorbing and accumulating heavy metals from water bodies[7]. Such enrichment of metals in plants, in comparison with water, increases the sensitivity of detection[8] by any analytical technique such as inductively coupled plasma emission spectrometry (ICP)[9]. This is particularly important when there is a need to monitor radioactive pollutants[10] and toxic trace metals[11,12]. Hence these aquatic species are most commonly employed specifically for monitoring heavy metals in waters[13–15] and for waste water treatment[16,17]. In view of the ecological and environmental significance of aquatic plants, a biogeochemical study of mosses was undertaken and the results are presented in this paper.

SAMPLING AND ANALYSIS

Five samples of mosses from surface water bodies were collected from the following three mining areas and analysed.

Nellore mica pegmatite belt

In this mineralized zone[18,19] (14°10′–14°19′N, 79°35′–79°45′E), one sample each was collected from two different abandoned and inundated mine pits located near the Sitharama Mica Mining Centre in the vicinity of Orupalle village (samples 1 and 2).

Mangampeta barytes mining area

From this area (14°01′N, 79°19′E) one moss sample was collected from a stream into which mine water was pumped (sample 4); and another from an abandoned mine pit inundated with water (sample 3).

Bandalamottu lead mining area

From this area (16°12′–16°15′N, 79°42′–79°45′E) one moss sample was collected from a streamlet traversing the mining area (sample 5).

Field collection and preparation of the moss samples for laboratory work were made as suggested by Brooks[7]. Moisture from each sample was removed by baking at 110°C in a hot-air oven; organic matter was eliminated by ignition at 450°C in a muffle furnace. The ashed samples were digested in aqua regia and multi-element analysis was carried out by ICP.

RESULTS AND DISCUSSION

From the data (table 1) it may be noted that there is a striking enrichment of (a) boron, uranium, strontium, vanadium, and cerium in the mica pegmatite area; (b) barium, zinc, and cobalt in the Mangampeta barytes mining area; and (c) lead and manganese in the Bandalamottu lead mining area. Cannon[20] has reported that the ash of five samples of mosses from a vanadiferous mineralized area contained 200 ppm of vanadium while the average content of this element in eleven categories of terrestrial vegetation ranged from 7 to 98 ppm.

Table 1 *Multi-element analysis of the ash of aquatic mosses from surface water bodies in mining areas*

	Sample				
Element	1	2	3	4	5
Aluminium	0.67	0.93	0.40	0.64	0.44
Calcium	8.75	14.65	7.40	24.16	8.98
Iron	0.71	1.09	0.49	1.37	3.27
Magnesium	6.19	6.86	0.46	1.57	2.60
Potassium	0.31	0.40	0.30	0.63	0.27
Sodium	1.09	1.70	0.08	0.46	0.02
Phosphorus	0.05	0.11	0.07	0.46	0.03
Titanium	32	200	10	22	21
Manganese	225	368	1843	606	3383
Boron	280	833	18	30	ND
Barium	35	134	303	836	191
Strontium	3864	876	83	636	104
Beryllium	0.11	—	0.18	0.10	0.30
Arsenic	ND	5	ND	10	ND
Cobalt	3	4	31	21	12
Chromium	8	18	8	6	8
Copper	20	30	14	25	18
Lithium	4	—	3	4	5
Nickel	8	12	22	27	15
Vanadium	22	35	7	7	6
Yttrium	3	—	5	3	3
Zinc	37	40	433	453	149
Molybdenum	ND	2	ND	ND	ND
Lanthanum	3	12	3	ND	2
Cerium	5	—	ND	ND	ND
Silver	ND	0.10	0.89	ND	ND
Lead	10	24	30	25	2119
Cadmium	ND	1	13	9	ND
Uranium	—	31	—	—	—
Thorium	—	4	—	—	—
Antimony	ND	2	—	—	—
Bismuth	—	2	—	—	—
Tungsten	ND	2	ND	ND	ND

Values for elements 1–7 are in per cent and for 8–33 in ppm; ND, Not detected.

In view of the unusually high absorption and accumulation of heavy metals in mosses and other bryophytes[11,12] from water bodies, these species have been suggested as indirect indicators of mineralization in catchment areas of drainage system[7]. Accordingly Whitehead and Brooks[21] observed in these aquatic species a positive response to uranium mineralization.

Welsh and Denny[22] stated that many aquatic macrophytes accumulate heavy metals and play an important role in biogeochemical cycling of these elements. Trace element studies in agricultural reconnaissance[23,24] and geochemical reconnaissance surveys are similar[25]. Hence biogeochemical study of mosses can be successfully employed for such surveys of the aquatic environment.

Whitten[8] has emphasized the most urgent priority of standardization of a method for biological monitoring of potentially toxic concentrations of heavy metals and radioactive pollutants. The trace element analysis of mosses provides one of the standard methods for this purpose.

Consumption of water from mines and mineralized strata leads to human health problems due to heavy metal contamination[26–29]. As suggested in the Ayurveda, mosses are ideally suited for purification of water, particularly for the elimination of toxic heavy metals.

Thus, in conclusion, it may be stated that aquatic mosses are useful in (i) geochemical and agricultural reconnaissance surveys; (ii) biomonitoring of pollution levels of aquatic environments and (iii) water treatment.

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