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REMOVAL AND LEACHING OF NUTRIENTS BY *SALVIN1A MOLESTA* MITCHEL AND *EICHHORNIA CRASSIPES* (MART.) SOLMS

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ABSTRACT

Profuse growth of *Eichhornia crassipes* and *Salvinia molesta* in Singapore reservoirs required their regular manual removal as their prolonged presence can lead to deterioration in the quality of the potable water. Clearing of the reservoir catchments, together with regular removal of the weeds and dumping them away from the catchments, should, in the long term, reduce their presence in the reservoirs. Laboratory experiments showing the removal of chloride, sulphate, phosphorus and nitrate from the growing medium and the release of chloride, phosphorus and nitrate by rotting plants should convince the administrators of the benefit of proper management of the problem.

INTRODUCTION

Eichhornia crassipes (water hyacinth) and *Salvinia molesta* (water spangle) are two of the most troublesome water weeds of Southeast Asia. The former is bulky and grows profusely in eutrophic waters, doubling its number every eight to ten days (Wolverton and McDonald 1976). The latter, a water fern of oligotrophic waters, is similarly profuse in growth, with a doubling time under favorable growth conditions of four to ten days (Mitchell and Tur 1975).

Both plants were introduced into the country: water hyacinth as an ornamental in 1893 and water spangle as a teaching specimen around the 1950s (Wee 1986, Wee and Corlett 1986). Water hyacinth existed in rural fish ponds where it was grown as a feed for pigs. It became a problem when the Kranji reservoir was constructed in 1970 by the barraging of the Kranji River. As the catchment of this reservoir was agricultural areas, pollutants from pig farms and run-off fertilizers from fruit and vegetable farms provided enough nutrients to trigger a population explosion five years later. Problems of water spangle was seen in the Seletar Reservoir. Its catchment of secondary forests ensured less pollution but, agricultural pollutants still found their way into the water, resulting in proliferation of the plants around 1978.

Removal of these plants has traditionally been by mechanical means but use of herbicides like 2,4-D and paraquat has proven to be more efficient (Penfound and Earle 1948, Widyanto 1976). As both bodies of water were reservoirs, use of herbicides was not considered. The use of beetles to control water spangle, as reported in Australia (Room 1984) has yet to be tried in this region. Thus, at the two reservoirs, mechanical removal of the weeds was regularly undertaken, as the presence of large quantities of the weeds besides being aesthetically objectionable could cause deterioration of the quality of the potable water.

This work investigated the removal and leaching of nutrients by these plants under laboratory conditions, as under proper supervision, these plants could be used to our advantage, to remove the pollutants from the water.

MATERIALS AND METHODS

Water spangle and water hyacinth were obtained from the garden of the Department of Botany, National University of Singapore. They were grown in rain water contained in concrete tanks. For experiments, 35 x 29 x 12 cm plastic trays were used to contain the plants.

Uniform sized plants were first washed in tap water a few times, then rinsed twice with distilled water. Five to ten water spangle plants (total weight 250 g) and five water hyacinth plants (total weight 350 g) were placed in each basin containing 5 1 Hoagland's complete nutrient solution (Hewitt 1952). Nine replicates per plant material were set up. The basins were left in the greenhouse partially exposed to sunlight. Loss of water through evaporation was made up by the addition of distilled water up to the original level.

Samples of water were removed at regular intervals and analyzed for sulphate, chloride, nitrate and phosphorus using standard chemical methods (Anonymous 1973). The nutrient uptake by the plants was then calculated, based on the amount of nutrient left in the medium.

A parallel series of experiments were conducted using tap water (43.6 ppm chloride, 656 ppm sulphate, 3 ppm phosphorus) instead of the complete solution. The fresh weight of water hyacinth used here was 612 g while that of water spangle was 555 g.

Leaching experiments were done by leaving 100 g fresh weight each of water hyacinth and water spangle in basins to rot. At regular intervals the rotting plants were washed with 300 ml distilled water and the water analyzed for sulphate, chloride, nitrate and phosphorus.

RESULTS AND DISCUSSION

Figure 1 shows the removal of chloride, sulphate, phosphorus and nitrate from the complete media by water spangle and water hyacinth on a per gram fresh weight basis with time. Chloride removal was rapid, 0.54 mg and 0.29 mg were removed

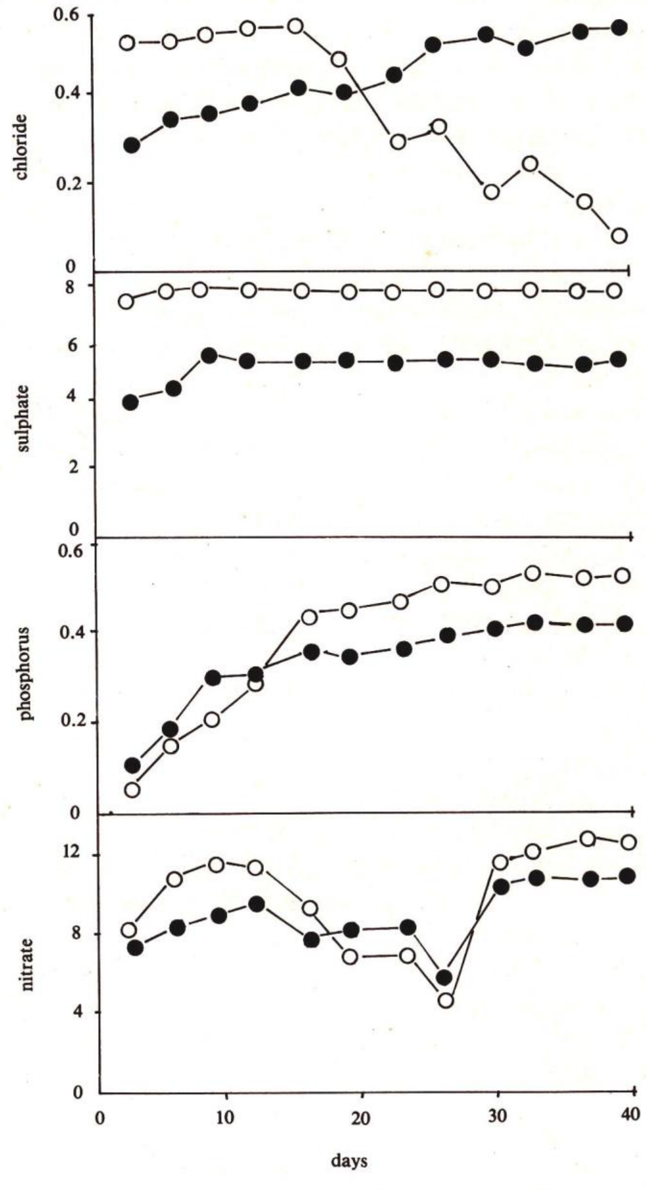

Figure 1. Removal of nutrients (mg g fr wt^{-1}) by water hyacinth (•) and water spangle (o) from Hoagland's complete solution with time.

by water spangle and water hyacinth, respectively, by the third day. The former removed 0.57 mg of the chloride after 16 days, after which there was a net decrease in chloride removal, perhaps due to the leaching of the anion into the growing medium from decaying leaves. Water hyacinth however, showed a constant and gradual increase in removal of the anion with time, resulting in 0.57 mg removal after 40 days. Sulphate was also efficiently removed; within three days water spangle removed 7.88 mg and water hyacinth 4.43 mg of the sulphate present. Phosphorus was slowly removed from the nutrient solution by both plants. Water spangle took 33 days to remove some 0.53 mg of the phosphorus while water hyacinth removed about 0.43 mg. Nitrate removal showed a rather erratic course. It was rapidly removed during the first 12 days by both plants, after which there was a net decrease in nitrate removal, attributed to leaching of the nutrient from the plants before a further increase.

The data showed that the anions, chloride, sulphate and nitrate were rapidly removed while phosphorus uptake by these plants was generally slower. Water spangle and water hyacinth grown in tap water also showed uptake of chloride and sulphate (Figure 2), but the profiles were different from those of plants grown in

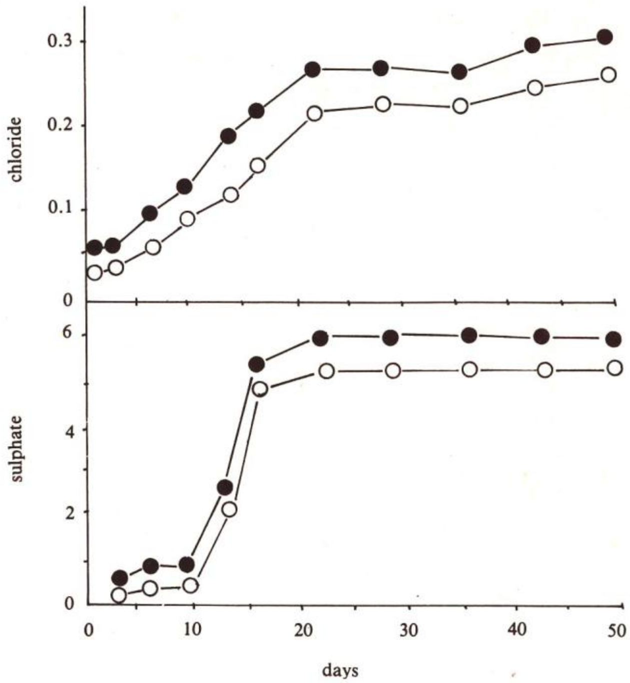

Figure 2. Removal of nutrients (mg g fr wt^{-1}) by water hyacinth (•) and water spangle (o) from tap water with time.

the complete medium. It took water spangle and water hyacinth 22 days to remove 0.19 mg and 0.23 mg of the chloride respectively after which removal was very gradual. Sulphate removal, however, was slightly more efficient. By 16 days, 5.22 mg and 5.07 mg were removed by water hyacinth and water spangle respectively. There were no further removals of sulphate after this period. No data were available for phosphorus and nitrate as there was only a trace of the former and no trace of the latter at all in the tap water.

Rotting plants were also observed to release chloride, phosphorus and nitrate into the water (Figure 3). These were found to increase with time over a period of

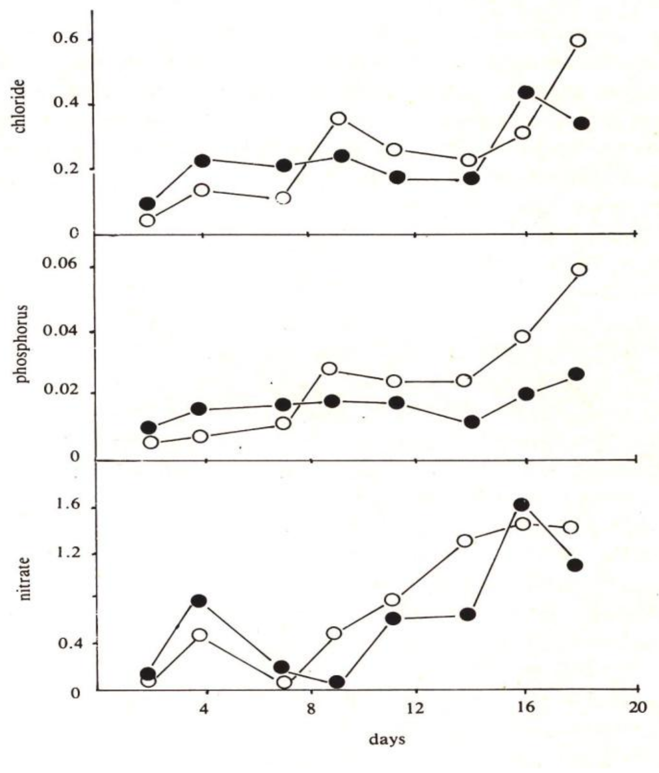

Figure 3. Nutrients leached into distilled water (mg g fr wt^{-1}) during decay of water hyacinth (•) and water spangle (o).

18 days, after which the plants were totally disintegrated. Sulphate released by both plants was negligible. The general profiles for both water spangle and water hyacinth were much the same.

The use of aquatic plants to bring eutrophic waters into proper nutrient balance is well known (Steward 1970). So far, most have been with water hyacinth. Their abilities to remove phosphorus from sewage effluent (Ornes and Sutton 1975) and nitrogen and phosphorus from eutrophic waters (Duningan, Phelan and Shamsuddin 1975) have also been reported. Wolverton and McDonald (1976) showed that in an experimental lagoon enriched with sewage effluent, these plants can reduce the pollutant level by 75-80%. The plants can also absorb toxic heavy metals like gold, silver, cobalt, strontium, cadmium, nickel, lead and mercury (Wolverton and McDonald 1976).

The excessive presence of nitrogen and phosphorus is the main cause of eutrophication and the consequent prolific growth of aquatic weeds (Sheffield 1967). Thus removal of these primary nutrients can significantly reduce weed growth. A single water hyacinth plant has been shown capable of absorbing over 3 mg of phosphorus per day (Rogers and Davis 1972). However, Haller and Sutton (1973) showed that the maximum accumulation of 9.07 mg phosphorus per g dry plant weight was seen after four weeks when the phosphorus content of the growing medium was around 40 ppm.

Results from the experiments show that the presence of water spangle and water hyacinth in the two reservoirs can be put to advantage if they are allowed to proliferate, regularly harvested and the harvested plants dumped. The ability of these plants to remove nutrients as well as pollutants rapidly from the water means that with every harvesting, the water gets a little cleaner. In time, the purity of the water would be such that it would not be able to support the excessive growth of these weeds. However, low nutrient status does not necessarily mean that growth will be eradicated as it has been shown that water spangle can survive for long periods under conditions of severe limiting nutrient status (Gaudet 1973). The above practice will need to go hand in hand with the cleaning of the reservoir's catchments, which, since 1977, has been in progress as a result of resettlement of pig farms elsewhere (Wee and Corlett 1986). However, the past practice of dumping the harvested plants along the edge of the reservoirs just to save cost of transportation was counter-productive in that, nutrient leached from the rotting plants gets back into the water to support growth of a new crop of plants. Data collected in the above experiments should go a long way in convincing administrators the advantages of investing in transportation costs in the long term.

ACKNOWLEDGMENTS

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