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INTRODUCTION

The use of water hyacinths, *Eichhornia crassipes* (Mart) Solms as a bioagent in removing pollutants has been extensively studied. Ornes and Sutton (1975) investigated the removal of phosphorus from static sewage effluents by water hyacinths. Dunigan and co-workers (1975) reported the reduction of phosphorus and nitrogen from eutrophic waters using the same plant. Similar studies were also conducted by Roger and Davis (1972), Steward (1970), Boyd (1970, 1976) and Widyanto (1978). They concluded that nutrient absorption by controlled populations of water hyacinths could reduce concentrations of nitrogen and phosphorous in eutrophic lakes or in effluents prior to their release into natural waters.

Rao *et al.*, (1973) studied the uptake of fluoride by water hyacinths to determine its suitability to defluoridate natural waters. Although the plant could take up fluoride it could not be used for defluoridation of natural waters on account of its relatively high threshold.

Using water hyacinths as a filtration medium, Wolverton (1977) demonstrated that it could be used effectively to remove organic compounds and heavy metals from wastewaters of photographic and chemical laboratories.

The ability of water hyacinths to remove phenol from natural waters was also reported by Wolverton and McKown (1976).

Other studies involving the use of water hyacinths as a bioagent in the removal of heavy metals were also reported: silver, cobalt and strontium, mercury and cadmium (Wolverton, 1975; Widyanto, 1978). Radio-manganese, -iron and -phosphorous uptake by hyacinth and its economic implication was discussed by Cooley *et al.*, (1978).

Lee *et al.*, (1980) reported that the extent of cyanide pollution in the untreated wastewater of local electroplating factories is a potential threat to human health as well as aquatic life. Although there exists several chemical methods for destroying cyanide, the use of water hyacinths as a bioagent filter to remove cyanide has not been reported.

The present report describes the rate of uptake of cyanide by water hyacinths in nutrient solutions enriched with various concentrations of cyanide and its possible use in removing cyanide from electroplating wastewater.
100 ppm cyanide level, plants in the pond water system accelerated the loss of cyanide in the solution in the 48-hour period. However, this pattern was not noticeable in the distilled water system. The control lost cyanide more rapidly. This could be attributed to the difference in pH's in the system. (Table 2).

No indication was evident that cyanide toxicity levels had been exceeded at this concentration of cyanide when the health of control plants was compared to those exposed to cyanide.

At concentrations of 200 and 300 ppm cyanide, the uptake of cyanide by water hyacinths was apparent in the two water systems. In the pond water system, the percentages of cyanide left at 72-hour cycle were 2.5 and 4.5 respectively in the 200 and 300 ppm levels in the plant exposed solutions. These are contrasted with 7.3 and 14.7% in the controls at the same levels. Thus it would appear that water hyacinths could be utilized effectively in reducing the high cyanide concentration in untreated wastewater from electroplating factories. However, at this level of cyanide, the plants suffered from cyanide toxicity. After the 72-hour cycle all outer leaves of water hyacinths were wilted and only one or two inner leaves remained turgid.

Each sequence of experiment was repeated three times in order to establish the reproducibility of results. The variability is expected as the materials of the water hyacinths used in cyanide uptake experiments here sufficiently varied to contribute somewhat to the observed variations in cyanide removal rates both within each system and between the two separate systems. Wolverton (1976) made the same observation in the study on the removal rate of phenol from three different water systems using the same aquatic plant. Boyd (1970) observed that aquatic plants absorbed mineral nutrients more slowly as the plant aged. The rate increases for plant in a rapid growth phase.
<table>
<thead>
<tr>
<th>Water system</th>
<th>Cyanide Addition</th>
<th>0 hour Specimen*</th>
<th>0 hour Control*</th>
<th>24 hours Specimen</th>
<th>24 hours Control</th>
<th>48 hours Specimen</th>
<th>48 hours Control</th>
<th>72 hours Specimen</th>
<th>72 hours Control</th>
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</thead>
<tbody>
<tr>
<td>Pond</td>
<td>0.0</td>
<td>7.4 ± 0.2</td>
<td>7.4 ± 0.2</td>
<td>7.0 ± 0.0</td>
<td>8.4 ± 0.4</td>
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<td>Pond</td>
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<td>9.3 ± 0.1</td>
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<td>9.5 ± 0.1</td>
<td>7.3 ± 0.0</td>
<td>9.0 ± 0.0</td>
<td>7.3 ± 0.0</td>
<td>8.6 ± 0.0</td>
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<td>Pond</td>
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<td>9.7 ± 0.0</td>
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<td>10.0 ± 0.0</td>
<td>7.9 ± 0.2</td>
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<tr>
<td>Distilled</td>
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<td>5.7 ± 0.1</td>
<td>6.1 ± 0.1</td>
<td>5.7 ± 0.0</td>
<td>6.3 ± 0.1</td>
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<td>9.7 ± 0.1</td>
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</tbody>
</table>

*Specimen : solution containing plant
*Control : solution without plant
Attempts to recover the cyanide from the plants proved unsuccessful. Silver nitrate titration with the steam distillate failed to indicate any trace of cyanide from the leaves/floaters and roots of water hyacinths grown in 300 ppm cyanide medium. A total of twenty samples was attempted.

The failure to recover cyanide from plants could mean that the cyanide is removed and metabolised to other compounds. The identity and location in water hyacinth of metabolites produced by cyanide assimilation may be established by the use of $^{14}$C labelled cyanide.

**CONCLUSION**

It is known that cyanide concentration in untreated wastewater from local electroplating factories generally exceeded 200 ppm (Lee et al., 1980); it would appear that water hyacinths could be used to reduce the level of cyanide in one 72-hour sequence. In pond water systems at 300 ppm cyanide, the water hyacinths effectively removed 6.68 mg per g dry weight of plant material. Since one ha contains approximately $1.79 \times 10^6$ plants (Low and Lee, 1981) and the average dry weight of plant is 4.78 g, one ha of water hyacinths could conceivably absorb 56.8 kg of cyanide in a 72-hour period.

**REFERENCES**


(Received 10 March 1981)