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COMMUNICATION II

The Accumulation of Heavy Metals in *Hydrostemma Motleyi* Hook. f. Mabberlay and *Hydrilla verticillata* Casp.

RINGKASAN

Pengambilan logam berat (kuprum, zink, nikel, kadmium dan kromium) oleh Hydrostemma motleyi (Hook.f.) Mabberlay dan Hydrilla verticillata *Casp. telah dikaji. Umumnya pengambilan logam bertambah bila kepekatan logam bertambah. Faktor pertambahan yang menghubungkan paras logam dalam tubuhan dengan paras logam dalam larutan berkurang bila kepekatan logam bertambah. Tindakan antagonistik diperhatikan bila* Hydrostemma motleyi *dikaji dalam larutan campuran yang mengandungi kuprum, zink dan nikel. Bagi* Hydrilla verticillata *kesan sinergistik diperhatikan pada kepekatan rendah bagi larutan campuran, tetapi pada kepekatan yang lebih tinggi, kesan ini disongsangkan. Pengambilan logam oleh tumbuhan kelihatan bergantung kepada spesis tumbuhan.* Hydrilla verticillata *telah menunjukkan kebolehan yang lebih tinggi untuk menahan dan mengambil logam berat daripada* Hydrostemma motleyi. *Tumbuhan ini mempunyai potensi sebagai satu spesis penunjuk bagi pencemaran logam dalam air.*

SUMMARY

The uptake of neavy metals (copper, zinc, nickel, cadmium and chromium) by Hydrostemma motleyi *(Hook.f.) Mobberlay and* Hydrilla Verticillata *Casp. was studied. The uptake generally increased with increasing metal concentrations. The enrichment factor which relates the metal content in plants to the metal content in cultivation media generally decreased with increasing metal concentrations. Antagonistic action was observed when* Hydrostemma motleyi *was cultivated in mixed solutions of copper, zinc and nickel. For* Hydrilla verticillata, *synergistic effect was observed at low concentration of the mixed solution, but at higher concentrations, the effect was reversed. Metal accumulation appears to be species specific.* Hydrilla verticillata *exhibited a higher tolerance and accumulation capacity for heavy metals than* Hydrostemma motleyi. *It has the potential of being an indicator species for metal pollution in water.*

INTRODUCTION

Several studies on the enrichment of heavy metals by aquatic plants and their possible use as biological indicators have been reported. Dietz (1972) found that enrichment of heavy metals in submerged plants was primarily dependent on plant species and specific selectivity. This was also observed by Denny (1980) and Aulio and Salin (1982). Nakada and co-workers (1979) reported that enrichment factors of submerged plants decreased with increasing metal concentrations in water in their study of metal uptake by *Elodea nulttali.*

The accumulation of heavy metals by *Ottelia alismoides* Pers., *Fimbristylis panciflora* R. Br. and *Blyxa malayana* Ridley and their suitability as biological indicators have been reported earlier by the authors (Low *et al.*, 1984). In this paper we further report the study of two other submerged plants, namely *Hydrostemma motleyi* (Hook. f.) Mabberlay and *Hydrilla verticillata* Casp. These plants are commonly found in streams in Malaysia. The possibility of using these two submerged plants as biological monitors of heavy metal pollution has been evaluated.

METHODS AND MATERIALS

Plant samples were collected from the Serdang stream adjacent to the Food Technology Research Unit in Serdang. They were thoroughly washed in stream water and later tap water. The damaged parts of the plants were removed. The clean materials were left overnight in plastic containers containing tap water prior to experimentation.

Knop's solution (Douglas, 1977) was used as nutrient solution for the cultivation of plants. A series of 2-liter pyrex beakers were filled with respective volumes of nutrient solution enriched with 5, 10, 20, 50 and 100 mg dm^{-3} of Cu as $Cu(NO_3)_2 3H_2O$, Zn as $ZnCl_2$, Ni as $NiCl_2 6H_2O$, Cd as $CdCl_2 2H_2O$, Cr as CrO_3, either singly or as a mixture of three metals (Cu, Zn and Ni). After rinsing with deionized water, the aquatic plants, around 80g wet weight, were cultivated in each of the beakers. Plant control free of metals and metal control free of plants were established for each set of experiments. The experiments were carried out at room temperature (30°C).

At the end of experimentation (exposure time depending on the toxicities of the metal) the plants were lifted out and washed with tap water, followed by deionised water. Damaged and decayed parts of the plants were removed. The materials were then dried at 80°C for 48 hours, and ground in a stainless steel blender. The dry weight of the control material was determined before and after exposure.

The ground plant materials were prepared for analysis by the wet-ashing method using nitric acid and perchloric acid in the ratio of 4:1 as reported by Little and Martin (1972).

The heavy metal concentrations were determined by inductively coupled plasma emission spectrometry using a Labtest 710-2000 ICP spectrometer.

All the values, recorded are means of three reading with RSD's ranging from less then 1 to 2 percent.

RESULTS AND DISCUSSION

The heavy metal contents in *Hydrostemma motleyi* and *Hydrilla verticillata* are given in Table 1. Zinc is essential for the development of higher plants and is contained in abundance in the plants.

The relationship between metal uptake and concentration of metal in water is given in Table 2. The results indicate that the uptake of copper, zinc, nickel, cadmium and chromium increased with the increase in metal concentration in water. However, the enrichment factor which relates metal concentration in the plant to that in the water generally decreased with increasing metal concentrations. For *Hydrostemma motleyi*, enrichment factors for copper and nickel appeared to reach a maximum value at the concentration of 20 mg dm^{-3}, and decreased subsequently. The general decrease of enrichment factor with increasing metal concentrations in the cultivation media has also been observed by Sutton and Blackburn (1971) and Nakada *et al.* (1979). The higher concentrations of metals may have been more toxic to the plants, resulting in a decline of accumulation of metals (Sutton and Blackburn, 1971). The decrease could also be due to the impairment of physiological functions at the higher level of metals (Cearley and Coleman, 1973).

The uptake of the metals was in the order of Cr > Cu > Zn > Cd >. Ni for *Hydrostemma motleyi*, and high vaules of enrichment factors on chromium were observed even at a concentration of 100 mg dm^{-3}. The uptake of metals was in the order of Cu > Cd > Cr > Zn, Ni for *Hydrilla verticillata.* However, the enrichment factors on copper and chromium were comparable at concentrations below 50 mg dm^{-3}, and were

TABLE 1
Heavy metal contents of aquatic plants
collected from stream (mg kg^{-1} dry weight)

	Cu	Zn	Ni	Cd	Cr
Hydrostemma motleyi	27.3(3.5)	202.5(32.5)	55.3(8.7)	9.7(0.9)	9.3(2.1)
Hydrilla verticillata	47.3(34.8)	794.3(244.1)	59.7(6.8)	10.7(0.7)	14.5(0.5)

The values are means of four samples with their standard deviations in brackets.

TABLE 2
Uptake of heavy metals and concentration in water when the plants were cultivated separately in solutions containing single heavy metal for 6 days*

Heavy metal concentration in water ($mg\ dm^{-3}$)	Cu content of uptake ($mg\ kg^{-1}$)	Ef	Zn content of uptake ($mg\ kg^{-1}$)	Ef	Ni content of uptake ($mg\ kg^{-1}$)	Ef	Cd content of uptake ($mg\ kg^{-1}$)	Ef	Cr content of uptake ($mg\ kg^{-1}$)	Ef
H. motleyi										
5.0	247	49	603	121	79	16	172	34	1039	208
10.0	709	71	1036	104	298	30	344	34	1914	191
20.0	1606	83	1279	64	799	40	615	31	2480	124
50.0	2601	52	1595	32	1503	30	1209	24	5706	114
100.0	4038	40	2525	25	1778	18	2521	25	8837	88
H. verticillata.										
5.0	1566	312	1002	200	841	168	903	181	1795	359
10.0	3434	343	1957	196	1947	194	2856	286	3313	335
20.0	6814	341	3105	155	3224	161	4048	207	5655	283
50.0	9202	184	5556	111	5034	101	12357	247	8781	173
100.0	28684	287	6220	62	9945	99	20889	209	12974	130

$$\text{Ef (Enrichment factor)} = \frac{\text{concentration of heavy metals in plants } (mg\ kg^{-1})}{\text{concentration of heavy metals in solution } (mg\ dm^{-3})}$$

* The exposure time for Zn and Ni are 9 and 7 days respectively.

higher than that on cadmium. It thus appears that chromium was the most highly accumulated by both plants and copper was more toxic to *Hydrostemma motleyi* than to *Hydrilla verticillata.*

The metal uptake and enrichment factor were higher for *Hydrilla verticillata* than for *Hydrostemma motleyi.* This indicates that *Hydrilla verticillata* has a higher capacity to tolerate and accumulate metals than *Hydrostemma motleyi.* The enrichment of metals thus appears to be species specific. This observation agrees with that reported by Dietz (1972), Denny (1980) and Aulio and Salin (1982)

Table 3 gives the relationship between heavy metal concentration in water and their uptake when the plants were cultivated in mixed solutions of copper, zinc and nickel for three days. Values of enrichment factors were relatively lower but the ranking of copper, zinc and nickel showed similar results for *Hydrostemma motleyi.* The lower uptake of metals suggests the existence of antagonistic actions of the three metals.

The uptake and enrichment factor of metals at the concentration of 5 mg dm^{-3} were higher in Table 3 than in Table 2 for *Hydrilla verticillata.* This indicates synergistic action of the three metals at low concentrations. At higher concentrations, however, the reverse was observed. The antagonistic action was most pronounced for nickel.

CONCLUSION

In the present study *Hydrilla verticillata* exhibited a high tolerance and enrichment capacity for heavy metals. It is also easy to identify, collect and digest. It thus appears to meet the requirements to be an applicable indicator species for metal pollution in water as set out by Ray and White (1979).

TABLE 3
Uptake of heavy metals and concentration in water when the plants were cultivated separately in mixed solutions containg three heavy metals (Cu, Zn and Ni) for 3 days

Heavy metal concentration in water (mg dm^{-3}).	Cu content of uptake (mg kg^{-1})	Ef	Zn content of uptake (mg kg^{-1})	Ef	Ni content of uptake (mg kg^{-1})	Ef
H. motleyi						
5.0	258	52	53	11	86	17
10.0	671	67	144	14	150	15
20.0	1304	60	337	17	249	13
50.0	1792	35	647	13	443	9
100.0	3057	31	1954	20	1528	5
H. verticillate						
5.0	1919	384	1342	268	949	190
10.0	3347	335	2159	216	1310	131
20.0	6219	311	2991	150	1710	86
50.0	12022	240	4031	81	2522	50
100.0	18875	189	4765	48	2489	25

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