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Copper, Zinc, Nickel and Chromium Uptake by "Kangkong Air" (*Ipomea aquatica* Forsk).

K. S. LOW and C. K. LEE

Department of Chemistry, Faculty of Science and Environmental Studies, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia.

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RINGKASAN

*Pengambilan kuprum, zinkum, nikel dan kromium dari larutan berzat yang bercampur dengan logam-logam itu dengan menggunakan kangkong air (*Ipomea aquatica *Forsk) telah dikaji. Tumbuhan akuatik ini menunjukkan kebolehan menyerap kuprum dan nikel dengan cepat dan menyerap zinkum dan kromium dangan kadar yang kurang cepat oleh proses penyerapan dan kepekatan akar.*

Kangkong air boleh menyerap hingga 0.552 mg kuprum, 0.213 mg nikel, 0.090 mg kromium dan 0.009 mg zinkum per gram bahan tumbuhan yang kering apabila didedah selama 48 jam kepada larutan berzat yang mengandungi 5.00 ppm logam-logam itu.

Satu kajian penyerapan kuprum, nikel dan kromium oleh kangkong air dan 'water hyacinths' (Eichhorria crassipes) *(Mart.) Solms dari air buangan kilang sador-elektrik juga dibincangkan.*

SUMMARY

*The uptake of copper, zinc, nickel and chromium from nutrient solutions enriched with these metals using "Kangkong air" (*Ipomea aquatica *Forsk) was studied. This aquatic plant demonstrated the ability to remove copper and nickel rapidly and to remove zinc and chromium less rapidly by root absorption and concentration.*

"Kangkong air" showed the ability to absorb up to 0.552 mg of copper, 0.213 mg of nickel, 0.090 mg of chromium and 0.009 mg of zinc per gram dry plant material when exposed for a 48 hour period to nutrient solutions containing 5.00 ppm of their metals.

A study of the uptake of copper, nickel and chromium by "Kangkong air" and water hyacinths (Eichhorria crassipes) *(Mart.) Solms in wastewater from an electroplating plant is also discussed.*

INTRODUCTION

Many studies on the use of aquatic plants in removing heavy metals from polluted waters have been reported. The most common aquatic plant used is water hyacinths *(Eichhorria crasspies)* (Mart.) Solms.

Boyd (1970, 1976) reported the use of water hyacinths, amongst other aquatic plants, for the removal of metals, nitrogen and phosphorus from polluted waters. Using the same plant Cooley *et al.* (1978) found that Fe and Mg are actively absorbed by the root systems, but the rates of absorption and translocation differ markedly. Wolverton (1975) reported that water hyacinths are able to remove Cd and Ni rapidly from the aqueous system by root absorption and concentration. A similar finding was also reported by Widyanto and Susilo (1978). Sutton and Blackburn (1970) found that hydrilla (*Hydrilla verticillata* Casp) was effective in removing Cu in solutions.

Widyanto (1975) suggested that a combination of water hyacinths and other weed species more tolerant to polluted water was worth considering in cases where water hyacinths do not survive too well. The wastewater with high sulphate content (718 mg dm^{-3}) is not conducive for vegetative growth of water hyacinths. Other aquatic plants may have to be used.

"Kangkong Air" (*Ipomea aquatica,* Forsk), is a common aquatic plant in Malaysia. In certain areas both "Kangkong Air" and water hyacinths thrive together. Wood *et al.* (1976) used "Kangkong Air" to remove wastes from rubber effluents. Its use as a bioagent for heavy metal removal has not been previously reported.

In this paper the results of using "Kangkong Air" as a bioagent filter in the removal of Cu, Zn, Ni and Cr in nutrient solutions enriched with these metals, either singly or as a mixture, are reported. These metals were selected for this investigation since they were found to be common pollutants in untreated wastewaters from electroplating factories (Lee *et al.* 1980).

A comparative study of the absorption abilities of water hyacinths and "Kangkong air" on heavy metals in wastewaters from electroplating factory is also reported.

METHOD AND MATERIALS

"Kangkong air", (*Ipomea aquatica* Forsk) were collected from a stream approximately 3.5 km from Universiti Pertanian Malaysia, Serdang, Selangor. They were thoroughly washed. Withering and damaged parts of the plants were removed. No attempt was made to select only the mature plants. The 'clean' plants were kept in a stainless steel tank containing tap water for 24 hours at room temperature prior to experimentation.

Sach's solution was used as a nutrient solution for the cultivation of "kangkong air" (Douglas, 1970). A series of enamelled troughs (3 dm^3 – capacity) were filled with 2 dm^3 of the nutrient solution enriched with 5 ppm of Cu as $CuCl_2.2H_2O$, Zn as $ZnCl_2$, Ni as $NiCl_2.6H_2O$ and Cr as $K_2Cr_2O_7$ either individually or as a mixture of two or three metals. "Kangkong air" (each lot of approximately 80 g) was cultivated in each of the troughs for 48 hours. Plant controls free of heavy metals and metal controls free of plants were also established for each set of experiment. No special arrangement was made to control light intensity and temperature.

At the end of the 48-hour period, the plants were removed and rinsed with tap water. Each lot was segmented into roots, stems and leaves. They were thoroughly rinsed with distilled water before drying in an oven at 90°C until constant weight was obtained.

Each portion of the dry plant materials was ground using an aluminium mill. Plant tissue samples were prepared for analysis by the method as reported by Little and Martin (1972).

The concentrations of Cu, Zn, Ni and Cr in water were determined before plants were placed in the troughs at intervals of 1, 3, 6, 24 and 48 hours after cultivation. At the time the solutions were sampled the plants were lifted and solutions thoroughly stirred and 10 cm^3 of the sample was withdrawn in duplicates and filtered to remove any suspended solid particles. They were kept at 5°C until further analysis.

In another experiment water hyacinths and "kangkong air" were cultivated in wastewater collected from an electroplating factory. The analysis of this wastewater has been reported earlier (Lee *et al.,* 1980).

The plants were harvested and analysed after a 24-hour exposure in the manner described earlier.

All heavy metals were determined using an IL651 atomic absorption spectrophotometer. The values recorded were means of four readings.

RESULTS AND DISCUSSION

The dry weight of "kangkong air" used in each of the experiments was in the range of 7.16–12.09 g with an average weight of 9.42 g.

Copper

After 48-hour exposure, Cu content in "kangkong air" under different experimental conditions was found to be 0.563 mg/g dry weight of plant material when the metal was present singly in the media; 0.392 mg in the presence of Ni and 0.441 mg in the presence of Ni and Cr compared to 0.011 mg/g of Cu in the control. In all cases the Cu concentrations in the root system were highest accounting for 93.6, 93.7, 72.2 and 70.5% of the total metal uptake in each case respectively; these were substantial considering that the percentages of the weight of root were 15.5, 10.6, 8.3 and 11.4% respectively. There were some variations in the metal uptake, dependent on the age and size of the plants as was to be expected. A similar observation was also made by Wolverton (1975) in his study of heavy metal uptake in water hyacinths.

It appears that Cu removal from polluted solutions using "kangkong air" as a bioagent is

most efficient when the metal is present singly. Translocation to other parts of the plant appears to be slow.

The removal rates of Cu under various experimental conditions are shown as percent of initial metal concentration remaining as a function of time for the metal control and metal-exposed plant system (Fig. 1). In all cases the rates of Cu absorption by "kangkong air" decreased rapidly after 24-hour exposure, indicating that this duration would be the probable optimum period for harvesting "kangkong air" if it were used as an absorption filter for the removal of copper.

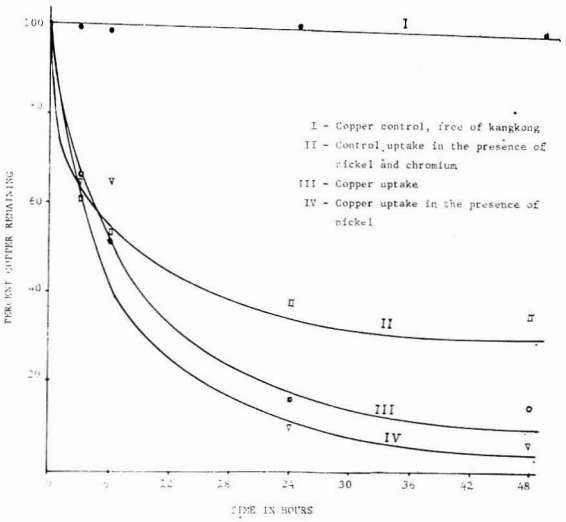

Figure 1. Graphic representation of removal rates of copper from various water systems containing kangkongs and copper control free of plants.

Zinc

Zinc content in 48-hour exposed "Kangkong air" was found to be 0.252 mg/g dry plant material as compared to 0.153 mg/g in the control plant (Table 1). The high concentration of Zn in the control plant suggests selectivity of this metal on the part of the plant in its natural environment. The root systems account for 76.3% and 65.7% of the total uptake respectively. These values are lower than those for Cu, possibly indicating a more rapid translocation of zinc from the root to other parts of the plant. The total uptake of Zn was 0.009 mg/g of dry plant material indicating a low affinity of this metal by "kangkong air". Hence it would appear that "kangkong air", as an aquatic plant, may not be suitable in the removal of zinc from wastewater.

The rate of Zn removal by "kangkong air" was less rapid compared to that of Cu absorption (Fig. 2).

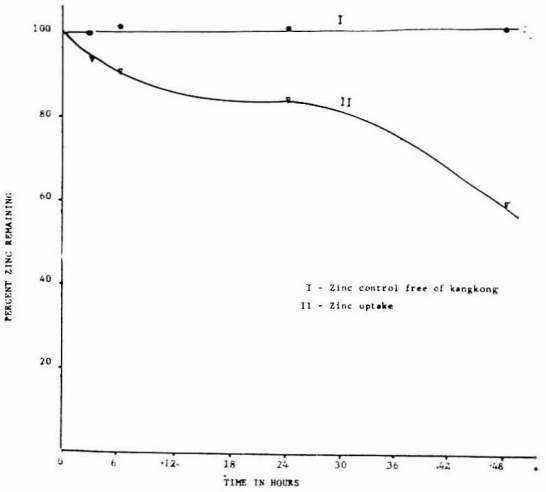

Figure 2. Graphic representation of removal rate of zinc from water system containing kangkongs and zinc control free of plants.

Nickel

Nickel content in dry plant after 48-hour exposure was 0.22 mg/g dry plant material when nickel was added singly to the media. In the presence of Cu it was reduced to 0.183 mg and 0.099 mg in the presence of both Cu and Cr. "Kangkong air" grown in the absence of nickel gave a value of 0.009 mg/g dry weight of plant material. As observed for Cu and Zn, most of the nickel was concentrated in the root system, accounting for 61.7, 80.3 and 85.5% of the total absorption. The difference could be due to the variation in the age of the plants. The absorption of nickel was less than that for copper showing that "kangkong air" had a greater selectivity for Cu than Ni. Wolverton (1975) reported that water hyacinth was able to absorb 0.50 mg Ni from a static water system per gram dry weight of water hyacinths during a 24-hour period. In his experiment using similar plants, Widyano (1978) reported a value of 1.16 mg when Ni was present singly. In the presence of Hg and Cd, the value dropped to 0.38 mg per gram dry weight of water hyacinths. The same trend was also observed in our study with "kangkong air" although it was less dramatic.

The rate of Ni uptake by "kangkong air" under various conditions is shown in Fig. 3.

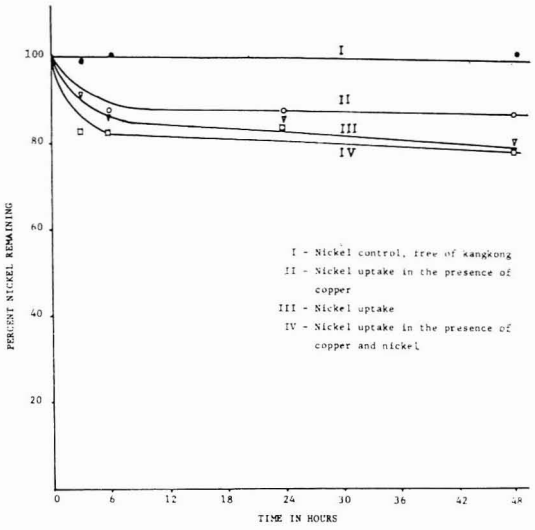

Figure 3. Graphic representation of removal rates of nickel from various water systems containing kangkongs and nickel control free of plants.

Chromium

"Kangkong air" was found to absorb 0.071 mg of Cr per gram dry plant material 48 hours after the metal was added singly to the media. However, the absorption increased to 0.092 mg in the presence of Ni and Cu. As was the case with the other metals studied, absorption was concentrated in the root system, which accounted for 85.4 and 87.4% of the total Cr uptake. The Cr concentration in the control plant was found to be 0.002 mg per gram dry plant material. Of the four metals studied chromium showed the least tendency to be absorbed by "kangkong air", reflecting the low efficiency of "kangkong air" in removing chromium from polluted waters.

The rate of Cr uptake is shown in Fig. 4.

"Kangkong air" versus water hyacinths

The ability of "kangkong air" and water hyacinths to remove Cu, Ni and Cr from electroplating wastewater is shown in Table 2. The wastewater was a mixture of acid and alkali

TABLE 1

Removal values of Copper, Zinc, Nickel and Chromium during a 48-hour period using kangkong as absorption filters.

Heavy metals	1hr (ppm)	3hr (ppm)	6hr (ppm)	24hr (ppm)	48hr (ppm)	mg of metal removed per gram of dry plant material
Cu	3.45	3.25	2.58	0.81	0.75	0.563
Cu (Ni)	3.32	3.25	3.20	0.50	0.48	0.392
Cu (Ni, Cr)	3.05	3.05	2.69	1.90	1.79	0.441
Cu (Control free of plant)	4.94	4.99	4.90	4.99	4.90	–
						0.011 (plant in copper-free media)
Zn	–	4.84	4.74	4.42	3.18	0.252
Zn (Control free of plant)	5.20	5.20	5.30	5.30	5.30	–
						0.153 (plant in zinc-free media)
Ni	4.54	4.56	4.36	4.36	4.07	0.222
Ni (Cu)	4.58	4.25	4.39	4.39	4.39	0.183
Ni (Cu, Cr)	4.30	4.11	4.11	4.24	4.03	0.099
Ni (Control free of plant)	4.97	4.97	5.05	5.19	5.10	–
						0.009 (plant in nickel-free media)
Cr	5.00	4.80	4.75	4.60	4.30	0.071
Cr (Ni, Cu)	3.48	3.49	3.35	2.65	2.64	0.092
Cr (Control free of plant)	5.00	4.90	5.10	5.20	5.10	–
						0.002 (plant in Cr free media)

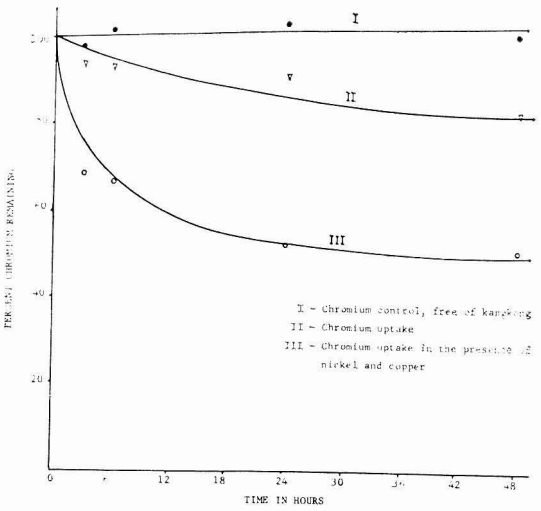

Figure 4. Graphic representation of removal rate of chromium from water systems containing kangkongs and chromium control free of plants.

wastes obtained from a chrome-plating factory. Water hyacinths showed a slightly higher absorption for Cu, but lower absorption for Ni than "kangkong air". However, the uptake of Cr by both water hyacinths and "kangkong air" was low. The low uptake was also observed earlier in "kangkong air" cultured in a nutrient solution enriched with chromium. Thus, it would appear that both aquatic plants showed comparative uptake levels of Cu, Ni and Cr under this particular condition.

TABLE 2
Removal of Cu, Ni and Cr from electroplating wastewater during a 24-hour period using water kangkong and water hyacinths as absorption filters.

Heavy metals in Wastewater	mg of metals removed per gram of dry plant material	
	Water kangkongs	Water hyacinths
Cu	0.232 (0.007)*	0.321 (0.020)
Ni	0.112 (0.008)	0.124 (0.039)
Cr	0.014 (0.003)	0.008 (0.003)

*Values in brackets indicate heavy metal concentrations in plants cultured in tap water.

CONCLUSION

The results show that "kangkong air" (*Ipomea aquatica* Forsk) is not very effective as an agent for the removal of heavy metals from polluted waters. Further work along this line is not expected to yield significant results.

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