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NOTE

Study of Synergistic Effects of Heavy Toxic Metals on Aquatic Plants

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Effects of heavy metals on biological systems have created interest following the increase in global use of these elements. These toxic heavy metals are being added continuously to the environment in large amounts. Synergistic effects of these heavy toxic metals have been studied and concluded that a number of factors like species, strain, concentration and time period of exposure affect the interaction between metals. The possibility of complex formation of any two metals cannot be ignored.

Key Words: Synergistic, Heavy, Toxic, Metals, Aquatic plants.

According to carrier hypothesis, an ion is bound in a transitory manner to carrier. It implies that carriers possess active sites which bind the ions. There is much evidence for specificity or selectivity in carrier mediated ion transport[1]. The importance of interactions of metals in increasing and decreasing their activities in biological systems has also been emphasised[2, 3]. In certain cases, ions resemble so closely to each other that the cellular transport mechanism fail to discriminate between them. Such ions compete with each other in the process of absorption. There are reports[4] which suggest that lead, cadmium and copper exhibit affinity for binding with protein and as carriers are protein molecules they may compete with essential elements or with themselves[5]. It is also reported that toxicity of heavy metals depends not only on the chemistry of the metal ions but also on the nature of the ligands in the reagent and the medium[1].

For the study of synergistic effect of heavy metals, when they are present together, three aquatic plants *Cyprus papyrus, Hydrilla verticillata* and *Azolla pinnata* were provided with lead, cadmium and copper concentrations in 1 : 1 : 1 ratio giving final concentration of 200 μg/mL. Accumulated metals were then determined spectrophotometrically and polarographically to have a clear picture of the influence of one heavy metal on the other.

Tables-1 and 2 record the data of the bioaccumulation of lead, cadmium and copper in presence of each other determined spectrophotometrically and polarographically. Table-3 presents the data of competitive bioaccumulation of cadmium by aquatic plants in presence of lead and copper.

It was observed that accumulation of cadmium was maximum by the three

aquatic plants. *C. papyrus* accumulated 0.2491 μg/mg dry weight, *H. verticillata* 0.0945 μg/mg dry weight and *A. pinnata* accumulated 0.0870 μg/mg dry weight of cadmium. Lead showed least accumulation. Table 3 explains inhibition in accumulation of lead and enhancement in accumulation of cadmium and copper when all the three metals were present together. Accumulation of copper by *A. pinnata* was maximum and equal to the accumulation of cadmium. Individually, copper was not tolerated by *A. pinnata* after eight days of dosimetry. It shows copper behaves differently in presence of other metals. On the other hand lead facilitates the accumulation of cadmium at its own cost. Similar observations have been reported by Sharma et. al.[1] They observed modification in cadmium toxicity in the presence of other trace metals in biological systems.

TABLE-1
BIOACCUMULATION OF METALS DETERMINED SPECTROSCOPICALLY

S.No.	Aquatic Plants	Bioaccumulation of Pb in presence of Cd and Cu	Bioaccumulation of Cd in presence of Pb and Cu	Bioaccumulation of Cu in presence of Pb and Cd
1.	*C. papyrus*	0.0493	0.2489	0.1414
2.	*H. verticillata*	0.0245	0.0980	0.0326
3.	*A. pinnata*	0.0475	0.0830	0.0766

Values are in μg/mg dry weight.

TABLE-2
BIOACCUMULATION OF METALS DETERMINED POLAROGRAPHICALLY

S.No.	Aquatic Plants	Bioaccumulation of Pb in presence of Cd and Cu	Bioaccumulation of Cd in presence of Pb and Cu	Bioaccumulation of Cu in presence of Pb and Cd
1.	*C. papyrus*	0.0482	0.2493	0.0487
2.	*H. verticillata*	0.0247	0.0910	0.0246
3.	*A. pinnata*	0.0474	0.0910	0.0474

Values are in μg/mg dry weight.

TABLE-3
BIOACCUMULATION OF Cd BY AQUATIC PLANTS IN PRESENCE OF Pb AND Cu

Sl. No.	Aquatic Plants	Bioaccumulation of (μg/mg dry weight spectrophotometric	Bioaccumulation (μg/mg dry weight polarographic)	Average (μg/mg dry weight)
1.	*C. papyrus*	0.2489	0.2493	0.2491
2.	*H. verticillata*	0.0980	0.0910	0.0945
3.	*A. pinnata*	0.0830	0.0910	0.0870

Table-4 presents the data of competitive bioaccumulation of lead, cadmium and copper by the aquatic plants. In these experiments, the plants were exposed to the three metals for eight days.

TABLE-4
COMPETITIVE BIOACCUMULATION OF METALS BY AQUATIC PLANTS

S.No.	Aquatic Plants	Bioaccumulation of Pb in presence of Cd and Cu (μg/mg dry wt)	Bioaccumulation of Cd in presence of Pb and Cu (μg/mg dry wt)	Bioaccumulation of Cu in presence of Cd and Pb (μg/mg dry wt)
1.	*C. papyrus*	0.0487	0.2491	0.0591
2.	*H. verticillata*	0.0246	0.0945	0.0301
3.	*A. pinnata*	0.0474	0.0870	0.0260

Cadmium is similar to zinc in chemical behaviour. It also exhibits mimicry effect since it can deceive biological molecules and get involved in place of zinc inside the plant cell. Cadmium, unlike zinc, is toxic both to plants and animals. Its toxicity probably lies in much higher affinity for thiol groupings present in enzymes and proteins. The presence of cadmium, therefore, disturbs enzyme activity.

Cadmium differs markedly from lead in that it can be transported readily from the soil through plant roots to the upper parts of the plant. Its availability to the plants mainly depends upon the soil pH and the presence of other cation species.

When the three elements lead, cadmium and copper are present together, they may compete for the binding sites on protein molecules of biological membranes responsible for uptake of cations. Cadmium has more affinity towards —SH groups present in protein. Metallothionein and inducible protein can sequester large quantities of cadmium following exposure. It is also possible that cadmium may divert Pb^{2+} and Hg^{2+} ions from the target to less important binding sites leading to decreased accumulation in case of lead and decreased toxicity of copper.

The possibility of the formation of a complex of any two metals has also been suggested by some workers as a mechanism of detoxification. In such cases, the inhibitory effect of one element is decreased in the presence of other.

REFERENCES

1. A. Sharma, A. Mukherjee and G. Talukdar, *Curr. Sci. (India)*, **54**, 540 (1985).
2. G.F. Nordberg, Effeets and Dose-response Relationships of Toxic Metals, Elsevier, Amsterdom (1976).
3. G.F. Nordberg, and O. Anderson, *Environ. Health Perspect*, **40**, 65 (1981).
4. T.L. Blunbell., and I.A. Jenkins, *Chem. Soc. Rev.*, **6**, 139 (1977).
5. U.S. Badge and A.K. Verma, *Curr. Sci (India).*, **51**, 830 (1982).

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