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BRIEF COMMUNICATION

Effects of copper, lead and zinc on phytoplankton growth

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Abstract

Impact of Cu, Pb and Zn on the growth of *Closterium acerosum, Pediastrum simplex, Chlorella vulgaris* and *Scenedesmus quadricauda* was studied *in vitro*. At concentration 0.1 g m^{-3} these metals were not toxic, however, at concentration 10.0 g m^{-3} the growth of phytoplankton was inhibited. Cu was the most toxic followed by Pb and Zn. *S. quadricauda* expressed highest tolerance to these metals, and least tolerance was exhibited by *C. acerosum*.

Additional key words: Chlorella, Closterium, heavy metals, *Pediastrum, Scenedesmus.*

Regular discharge of toxic materials from the industries, urban settlements as well as surface run-off from agricultural fields results in considerable degradation of water quality of rivers. Heavy metals (Cu, Zn, Mn, Pb, Fe, Cd, Cr, Hg, Ni, *etc.*) are a serious threat to the aquatic environment because of their toxicity, long persistence, bioaccumulation and biomagnification in the food chain (Whitton 1970) and their concentration in Indian rivers is gradually increasing (Bilgrami 1993). Only fragmentary data are available on the impact of heavy metals on freshwater biota of river Ganga. We studied their effects on some common phytoplankton species of this river.

Closterium acerosum (Schrank) Ehr., *Pediastrum simplex* Meyen, *Chlorella vulgaris* Beijerinck, and *Scenedesmus quadricauda* (Turp.) Breb. (all chlorophytes) were used for toxicity test of Cu, Pb and Zn. Phytoplankton species were isolated with a capillary pipette into Bold basal liquid medium and subsequently transferred to agar plate by a streaking technique (Hoshaw and Rosowski 1973). The stock cultures of the algae were maintained in Bold medium. One week old stock culture

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(1.0 cm^3, approximately 1000 cells per cm^3) of selected algae were introduced into 250 cm^3 Bold basal liquid medium (pH 8.0) in flasks containing 0.1, 1.0 or 10.0 g m^{-3} of either $CuSO_4 . 5 H_2O$, $Pb(NO_3)_2$ or $ZnSO_4 . 7 H_2O$. Three replicates were prepared for each concentration along with a blank (control). The flasks were incubated at 26.0 ± 2.0 °C, irradiance of 9 W m^{-2} and 12-h photoperiod. The flasks were shaken 4 - 5 times daily. Density of phytoplankton was recorded after 7 d of incubation.

Low concentration (0.1 g m^{-3}) of Cu, Pb and Zn was almost non-toxic to phytoplankton (growth upto 80 - 95 % of the control after 7 d of cultivation; Table 1). However, 10.0 g m^{-3} of Cu was highly inhibitory. Growth of the algae was 0 - 21.6 % of the control. The same concentrations of Pb and Zn were only moderately toxic. Least toxic was Zn. The tolerance of phytoplankton to heavy metals was increasing in order *C. acerosum* < *P. simplex* < *C. vulgaris* < *S. quadricauda.*

Table 1. Effects of different concetrations (0.1, 1.0 and 10.0 g m^{-3}) of Cu, Pb and Zn on phytoplankton growth [× 1000 cells cm^{-3}] *in vitro* for 7 d (values in parentheses are % of control).

Species	Control	Cu			Pb			Zn		
		0.1	1.0	10.0	0.1	1.0	10.0	0.1	1.0	10.0
Chlorella vulgaris	38.0	32.4 (85.3)	22.6 (59.5)	3.2 (8.4)	32.8 (86.3)	24.8 (65.3)	18.5 (48.7)	35.2 (92.6)	29.8 (78.4)	21.3 (56.1)
Closterium acerosum	31.0	24.7 (79.7)	8.8 (28.4)	0 (0)	26.5 (85.5)	16.3 (52.6)	5.4 (17.4)	28.5 (91.9)	17.4 (56.1)	7.7 (24.8)
Pediastrum simplex	22.0	18.6 (84.5)	13.4 (60.9)	1.2 (5.5)	19.2 (87.3)	14.2 (64.5)	9.4 (42.7)	19.6 (89.1)	14.8 (67.3)	11.8 (53.6)
Scenedesmus quadricauda	25.0	22.0 (88.0)	18.4 (73.6)	5.4 (21.6)	22.5 (90.4)	19.4 (77.6)	15.8 (63.2)	23.8 (95.2)	21.2 (84.8)	16.6 (66.4)

The found toxicity order of metals to phytoplankton confirmed the earlier findings of Rzewuska and Werinkowska-Ukleja (1974) and Sorentino (1979). However, Hannan and Patouillet (1972) recorded higher toxicity of Pb than Cu in *Chlorella* sp. The differences in tolerance to heavy metals in the tested species are in conformity with the findings of Monahan (1976), Palmer (1980) and Jindal and Verma (1989). Rachlin and Farran (1974) as well as Agrawal and Kumar (1978) reported significant reduction in growth of phytoplankton at 20 and 2.4 g(Zn) m^{-3}, respectively. The toxic effect of these heavy metals on phytoplankton growth is attributed to the inhibitory effect at multiple sites of electron transport in photosynthetic system (Clijster and Van Assche *1985*, Murthy and Mohanty *1995*). Besides this Zn, Pb and Cu may also damage the plasma membrane permeability leading to uncontrolled leakage of electrolytes (Passow *et al.* 1961, O'Kelly 1974, Mierle and Stokes 1976). Zn also disrupts phosphate metabolism (Kuwabara 1985) and induces a decline in cell division and number (Moore 1991).

References

Agrawal, M., Kumar, H.D.: Physico-chemical and phycological assessment of two mercury polluted effluents. - Indian J. Environ. Health **20**: 141-155, 1978.

Bilgrami, K.S.: Bioconservation and biomonitoring of river Ganga in Bihar (Munger to Kahalgaon). - Final Technical Report. Pp. 1-89. Ganga Project Directorate, New Delhi 1993.

Clijsters, H., Van Assche, F.: Inhibition of photosynthesis by heavy metals. - Photosynth. Res. **7**: 31-40, 1985.

Hannan, P.J., Patouillet, C.: Effects of mercury on algal growth rates. - Biotechnol. Bioeng. **14**: 93-101, 1972.

Hoshaw, R.W., Rosowski, J.R.: Methods for microscopic algae. - In: Stein, J.R. (ed.): Handbook of Phycological Methods (Culture Methods and Growth Measurements). Pp. 53-68. Cambridge University Press, Cambridge 1973.

Jindal, R., Verma, A.: Copper toxicity to plankton. - Pollution Res. **8**: 123-128, 1989.

Kuwabara, L.S.: Phosphorus-zinc interactive effects on growth by *Selenastrum capricornatum* (Chlorophyta). - Environ. Sci. Technol. **19**: 417-421, 1985.

Mierle, G., Stokes, P.M.: Heavy metal tolerance and metal accumulation by planktonic algae. - In: Hemphill, D.D. (ed.): Trace Substances in Environmental Health. Vol. 10. Pp. 113-122. University of Missouri, Columbia 1976.

Monahan, T.H.: Lead inhibition of chlorophycean microalgae. - Phycology **12**: 358-362, 1976.

Moore, J.W.: Inorganic Contaminants of Surface Water. - Springer-Verlag, New York 1991.

Murthy, S.D.S., Mohanty, P.: Action of selected heavy metal ions on the photosystem 2 activity of the cyanobacterium *Spirulina platensis*. - Biol. Plant. **37**: 79-84, 1995.

O'Kelly, J.C.: Inorganic nutrients. - In: Stewart, W.D.P. (ed.): Algal Physiology and Biochemistry. Pp. 610-635. Blackwell Scientific Publications, Oxford 1974.

Palmer, C.M.: Algae and Water Pollution. - Castle House Publ., England 1980.

Passow, H., Rothstein, A., Clarkson, T.W.: The general pharmacology of heavy metals. - Pharmacol. Rev. **13**: 185-223, 1961.

Rachlin, J., Farran, M.: Growth response of the green alga *Chlorella vulgaris* to selected concentration of zinc. - Water Resour. **8**: 105-109, 1974.

Rzewuska, E., Werinkowska-Ukleja, E.: Research on the influence of heavy metals on the development of *Scenedesmus quadricauda* (Furp) Breb. I. Mercury. - Arch. Hydrobiol. **21**: 109-117, 1974.

Sorentino, C.: The effect of heavy metals on phytoplankton - a review. - Phykos **18**: 149-161, 1979.

Whitton, B.A.: Toxicity of heavy metals to freshwater algae: a review. - Phykos **9**: 116-125, 1970.