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PHYTOREMEDIATION OF ZINC BY *SPIRODELA POLYRRHIZA* (L.) SCHLEIDEN

N. M. Rolli, M.G. Nadagouda, B.S. Giriyappanavar* and T.C. Taranath
Department of Botany, Karnataka University, Dharwad-580 003, Karnataka
*Department of Botany, Karnataka Science College, Dharwad, Karnataka

ABSTRACT

Industrial development coupled with population growth has resulted in the over-exploitation of natural resources. Life support systems *viz*, water, air and soil are, thus, getting exposed to an array of pollutants especially heavy metals released by anthropogenic activities. Tolerant species of aquatic plants are able to survive and withstand the pollution stress and serve as pollution indicators and as a tool for phytoremediation of heavy metals from the aquatic ecosystems. Phytoremediation is an environment cleanup strategy in which selected green plants are employed to remove toxic contaminants. This is an emerging biogeotechnological application based on "green liver concept" and operates on the principles of biogeochemical cycling. This paper focuses the relevance of phytoremediation technology for cleanup of metals in water by the use of floating aquatic macrophytes.

Laboratory experiments were conducted to assess the efficiency of aquatic macrophyte *Spirodela polyrrhiza*, as a phytotool for the remediation of zinc from synthetic effluent at the interval of 4 days for 12 days. Phytoremediation of zinc by *Spirodela* is significant with respect to exposure concentration, and maximum rate of removal is recorded at four days of exposure. *Spirodela* shows the symptoms of toxicity at the exposure concentration of 40 and 50 ppm after 12 days of exposure. However, the plants do not exhibit symptoms of toxicity at lower concentrations. Results confirm that *Spirodela* serves as a phytoremediation tool for the remediation of the zinc from synthetic effluent. Regular harvest of the plant at the interval of four days would help to cleanup aquatic environment. Harvested biomass may be used for composting.

INTRODUCTION

Industrialization and urbanization coupled with alarming rate of population growth have resulted in the large scale pollution of our aquatic ecosystems by industrial and domestic wastewater discharges. Sewage is rich in organic matter and contains appreciable amounts of macro and micronutrients (Feign et al. 1991, Pescod 1992, Gupta et al. 1998, Brar et al. 2000). Sewage effluents may contain variable amounts of heavy metals, which may limit its long term use for agriculture purpose. Natural erosion and anthropogenic activity are greatly responsible for water pollution, particularly heavy metals such as zinc, cadmium and lead etc. There is likelihood of phytotoxicity and environmental risks (de Filippis & Pallaghy 1994, Wei et al. 2003). Heavy metals, persisting in sediments, may be slowly released into the water and become available to organisms. Some heavy metals like zinc, copper, iron and manganese etc. are called micronutrients (Reeves & Baker 2000) and are only toxic when taken in excess amounts (Monni et al. 2000, Blaylock & Huang 2000).

The wastewater emanating from source contains metals which could be toxic to flora and fauna (Srivastava et al. 2000). Biological treatment of wastewater through aquatic macrophytes has a great potential for its purification, which effectively remove heavy metals such as zinc (Nasu et al. 1983, Wolverton et al. 1975, Brix & Schierup 1989, Rai et al. 1995, Srivastava & Pandey 1998). Aquatic macrophytes accumulate considerable amount of toxic metals and, thus, play a significant role in cleaning up of environment and make the environment free from metal pollutants. Many plants have been successfully utilized for removing toxic metals from aquatic environments. These plants include *Eichhornia crassipes, Ceratophyllum, Lemna, Pistia and Salvinia.* Recently, more data have been accumulated on the uptake of heavy metals by aquatic weeds (Satyakala & Kaiser Jamil 1992). Algae are also used to remove heavy metals from aquatic systems as they have capacity to accumulate dissolved metals (Wilde & Benemann 1993). *Eichhornia crassipes* has been used for the removal of copper, cadmium and lead, *Pistia* for the removal of mercury and chromium (VI), and *Salvinia* for the removal of mercury, chromium, copper, nickel, iron and lead. *Potamogeton pectinatus* accumulates high amounts of zinc and cadmium and showed tolerance to these toxic metals (Rai et al. 2003, Tripathi et al. 2003). In the present investigation *Spirodela polyrrhiza,* a common aquatic floating macrophyte in sewage polluted pond, is used for phytoremediation of zinc from synthetic effluent under laboratory conditions.

MATERIALS AND METHODS

Laboratory experiments were conducted for the phytoremediation of zinc by *Spirodela polyrrhiza* from the synthetic effluent. The young plants of *Spirodela polyrrhiza* were collected from Srinagar pond near Karnataka University, Dharwar and maintained in artificial pond as a stock. The plants were acclimatized for 7 days in 5% Hoagland solution before using for experiments. Plastic tubs of 30 litre capacity were filled with 10 L of tap water and used as control. Growth media was treated with different concentrations of zinc (5, 10, 20, 30, 40 and 50 ppm). 50 g of plants were washed with distilled water and introduced into the experimental tub. Experiments were run for 12 days. Estimation of zinc content of *Spirodela,* both in control and treated plants, was done by atomic absorption spectrophotometer at four days interval for twelve days for the evaluation of phytoremediation efficiency of *Spirodela.*

The harvested plants were washed thoroughly with distilled water to remove any zinc adsorbed on the plant surface and excess water was removed by using blotting paper. These plants were oven-dried at 80°C for 24 hours. The powdered plant material was digested by mixed acid digestion (Allen et al. 1974) using Gerhardt unit. Zinc content of digested samples was estimated by using atomic absorption spectrophotometer at the wavelength of 213.9nm using air acetylene flame. Data were statistically analysed using two factor ANOVA.

RESULTS AND DISCUSSION

Results of the experiments are presented in Table 1 and Fig. 1. The rate of phytoremediation of zinc by *Spirodela* is substantial at four days of exposure and is proportional to its concentration in the synthetic effluent. However, at subsequent exposure duration it is marginal.

The loss of zinc from the effluent may be attributed to phytoextraction by *Spirodela* and its interaction with physicochemical parameters of effluent leading to the formation of zinc salts which precipitate and settle down in the experimental tank. These observations conforms to Rai et al. (1993) with respect to copper uptake by *Eichhornia.* It is observed that the rate of phytoremediation is maximum up to 4 days exposure. There was most dramatic uptake of zinc in *Cladophora glomerata* within first 10 minutes as

Table 1: Zinc accumulation profile of *Spirodela polyrrhiza* (Two-way ANOVA)).

Exposure time	Mean	Variance	
4 days	0.0017	0.0022	8
days	2.937	5.187	12
days	5.212	7.425	

Between treatment concentration	F = 319.3847*
Between treatment period	F = 6.95259*

Significant at 5% level of significance

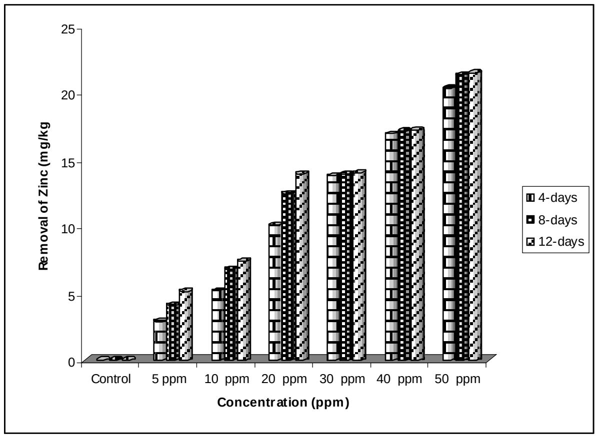

Fig-1. Accumulation of zinc by *Spirodela polyrrhiza*.

recorded by Brenda et al. (1990). Similar observations were reported in *Salvinia natans* with copper treatment at the concentration of 1.0µM to 20µM/mL (Asit et al. 1990). Metal uptake increased gradually with increase in concentration. Rate of zinc accumulation in *Potamogeton pectinatus* increases with increase in duration. Maximum accumulation of zinc by the plant was achieved when exposed to 10mM zinc for 96 hours. In the present investigation phytoextraction of zinc is linear and significantly correlated with zinc concentration in the effluent. Similar observation was made by Tripathi et al. (2003). *Spirodela polyrrhiza* accumulated significant amounts of zinc (ANOVA <0.05) in concentration.

The uptake studies of zinc and cadmium using *Eichhornia* show that the uptake of zinc and cadmium was rapid in all the concentrations and the absorption capacity gradually reduced by *Eichhornia* with increase in the number of days (Sridevi et al. 2003). Zinc and lead content in *Azolla pinnata* and *Lemna minor* increased with the increase in initial concentration in the feed solutions and exposure time (Jain. et al. 1990). Wang & Levis (1997) reported that metal accumulation by aquatic macrophytes under controlled laboratory conditions is dependent on metal concentration in the water.

CONCLUSION

Spirodela serves as a phytoremediation tool for the extraction of the zinc from synthetic effluent. Regular harvest of the plant at the interval of four days helps to clean up aquatic environment. Harvested biomass may be used for composting and may be used as to supplement the fertilizers.

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REFERENCES

Allen, S.E., Grimshaw, H.M., Parkinson, J.A. and Quarmby, C. 1974. Chemical Analysis of Ecological Materials. Blackwell Scientific Publications, Oxford.

Anita, S., Mahesh, V. and Sheela Sasikumar, C. 2005. Removal of heavy metals from electroplating industrial effluent by phytoremediation. Indian J. Environ. & Ecoplann. 10(1): 125-128.

Asit, K. Sen and Nitya, G. Mondal. 1990. Removal and uptake of copper (II) by *Salvinia natans* from waste water. Water, Air, and Soil Pollution, 49: 1-6.

Blaylock, M. J. and Huang, J.W. 2000. Phytoextraction of metals. In: Phytoremediation of toxic metals: Using plants to clean up the environment. (Ed: I. Raskin and B.D. Ensley), John Wiley & Sons, Torento, Canada. pp. 53-70.

Brar, M.S., Mahli, S.S., Singh, A.P., Arora, C.L. and Gill, K.S. 2000. Sewer water irrigation effects on some potentially toxic trace elements in soil and potato plants in northwestern India. Can. J. Soil Sci., 80: 465-71.

Brenda, M. McHardy and Jennifer J. George. 1990. Bioaccumulation and toxicity of zinc in the green alga, *Cladophora glomerata*. Environmental Pollution, 66: 55-66.

Brix, H., Schierup, H.H. 1989. The use of aquatic macrophytes in water pollution control. Ambio, 18: 100-107.

de Filippis, L.F. and Pallaghy, C.K. 1994. Heavy metals: sources and biological effects. In: Rai, L.C., Gaur, J.P. and Soeder, C.J. (eds), Algae and Water Pollution. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 31-77.

Feign, A., Ravina, I. and Shalhevet, J. 1991. Irrigation with treated sewage effluent: Management for environmental protection, Berlin, Springer Verlag.

Gupta, A.P., Narwal, R.P. and Antil, R.S. 1998. Sewer water composition and its effect on soil properties. Bioresour. Technol., 65: 171-173.

Jain, S.K., Vasudevan, P. and Jha, N.K. 1990. *Azolla pinnata* and *Lemna minor* L. for lead and zinc removal from polluted water. Water Res., 24(2): 177-183.

Monni, S., Salemaa, M. and Miller, N. 2000. The tolerance of *Empetrum nigrum* to copper and nickel. Environ. Pollu., 109: 221-229.

Nasu, Y., Kugimoto, M., Tanaka, O. and Takimoto, A. 1983. Comparative studies on the absorption of Cd and Cu in *Lemna paucicostata*. Environ Pollut., 32: 201-209.

Pescod, M.B. 1992. Waste water treatment and use in agriculture. Bull FAO, 47: 125, Rome.

Rai, S., Hasan, S.H., Joshi, V.C., Narayan swami, M.S. and Rupainwar, D.C. 1993. Removal of copper (II) from simulated water by water hyacinth (*Eichornia crassipes*). Indian J. Environ. Hlth., 35(3): 178-184.

Rai, U.N., Sinha, S., Tripathi, R.D., Chandra, P. 1995. Waste water treatability potential of some aquatic macrophytes. Removal of heavy metals. Ecol. Engg., 157-158.

Rai, U.N., Tripathi, R.D., Vajpayee, P., Pandey, N., Ali, M.B. and Gupta, D.K. 2003. Cadmium accumulation and its phytotoxicity in *Potamogeton pectinatus* L. (Potamogetonaceae). Bull Environ. Contam. Toxicol., 70: 566-575.

Reeves, R.D. and Baker, A.J.M. 2000. Metal accumulating plants, In: Phytoremediation of toxic metals: Using plants to clean up the environment, (Ed. I. Raskin and B.D. Ensely). John Wiley and Sons, Inc., Torento, Canada. pp. 193-229.

Satyakala, G. and Kaiser Jamil. 1992. Chromium-induced biochemical changes in *Eichhornea crassipes* (Mart) Solms and *Pistia stratiotes* L. Bull. Environ. Contam. Toxicol., 48: 921-928.

Sridevi, B.S., Dawood Sharif, Nausheen Dawood, Noorjahan, C.M., and Prabhakar, K. 2003. Bioabsorption of nickel and zinc by water hyacinth, *Eichhornia* sp. Eco. Env. & Cons., 9(3): 361-365.

Srivastava, P.K. and Pandey, G.C. 1998. Bioremediation of distillery effluent using selected aquatic plants. Res. J. Chem. Environ., 2: 43-45.

Srivastava, P.K., Pandey, G.C. and Neraliya, S. 2000. Bioaccumulation of distillery effluent metals by some aquatic macrophytes. Proc. Nat. Acad. Sci., 70: 311-317.

Tripathi, R.D., Rai, U.N., Vajpayee, P., Ali, M.B., Khan, E., Gupta, D.K., Shukla, M.K., Mishra, S. and Singh, S.N. 2003. Biochemical responses of *Potamogeton pectinatus* L. exposed to higher concentration of zinc. Bull. Environ. Contam. Toxicol., 71(2): 255-262.

Wang, W. and Lewis, M.A. 1997. Metal accumulation by aquatic macrophytes, In: Plants for Environmental Studies (Eds: W. Wang, J.W. Gorsuch and J.S. Hugkes). CRC Press, New York, pp. 367-416.

Wei, L., Donat, J.R., Fones, G. and Ahner, B.A. 2003. Interactions between Cd, Cu, and Zn influence particulate phytochelatin concentrations in marine phytoplankton: Laboratory results and preliminary field data. Environ. Sci. Technol., 37: 3609-3618.

Wilde, E.W. and Benemann, J.R. 1993. Bioremoval of heavy metals by the use of micro-algae. Biotech. Adv., 11: 781-812.

Wolverton, B.C., MacDonald, R.C. and Gorden, J. 1975. Waterhyacinth and alligator weeds for final filtration of sewage. NASA Tech. Memo., TM-X-72724, Washington DC, USA.