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Bioabsorption of heavy metals of sewage waste water using *Eichhornia* sp. and anatomical study of affected plant parts

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Abstract

Degradations of 100% untreated and treated sewage waste water using water hyacinth - *Eichhornia sp* were investigated. All the physico-chemical parameters of the sewage waters reached permissible levels after treatment with the water hyacinth. Anatomical studies revealed physical changes in different parts of *Eichhornia* sp. after bioabsorption. The bioabsorption of zinc is more than copper and accumulation of heavy metals in leaves is more followed by petiole and roots.

Keywords: bioabsorption, *Eichhornia* sp., heavy metals, sewage waste water, water hyacinth

INTRODUCTION

Water is one of the most important commodities which man exploited. Any undesirable change in the physical, chemical or biological characteristics of our air, land and water will harmfully affect human life. The pollution of water courses are due to discharge of waste from different industries such as tanneries, pulp, paper, sago mills, distilleries, sugar factories, dyeing industries, textile mills, fertilizers, petroleum and chemical industries, sewage waste water etc. Sewage is the collection of domestic waste, especially from the houses, offices and hospital waste present in the urban. Domestic sewage contains a wide variety of dissolved and suspended impurities such as organic materials and plant nutrients that tend to rot. Plant nutrients come from chemical soaps, washing powder etc. Sewage-contaminated water causes eutrophication, which is the increase in concentration of chemical elements required for life. Heavy metal content in the sewage water is one of the most hazardous environmental pollutants. Industrial effluents are discharged in the sewage canals of cities causing serious pollution and health hazards (Baddesha and Rao, 1986) and toxic heavy metals, like Cu, Zn, Cr, Pb and Cd are mostly absorbed and get accumulated in various plant parts as free metals which may adversely affect the plant growth and metabolism (Barman and Lal, 1994). Heavy metals having toxic effects on man and his ecological environment include As, Sb, Cr, Cd, Cu, Pb, Hg, Ni and Zn. Hence, sewage treatment is a very important consideration before its disposal. The World Health Organization (WHO, 1984) and other environmental protection agencies have stipulated tolerance limits with a view to protect the environment from these metals (Selvapathy *et al.*, 1997).

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Sewage treatment or domestic waste water treatment is the process of removing contaminants from waste water, both runoff and domestic. It includes physical, chemical and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge also suitable for discharge or reuse back in to the environment. Mechanical treatment includes influx, (influent), removal of large objects, removal of sand and grit and pre-precipitation. Chemical treatment is usually combined with settling and other processes to remove solids, such as filtration (Wikipedia, 2007). It involves, primary, secondary and tertiary treatments. Biological treatment includes oxidation bed (Oxidising bed) and post precipitation processes. All these techniques are expensive and if the sewage water could be treated with an aquatic plant such as water hyacinth - *Eichhornia* sp., for its purification it might be a cost effective method and this paper details information in this regard.

Water hyacinth, *Eichhornia* sp. is a dark green, broad-leaved plant, floating freely in water. Earlier, pollutant removal from sewage waste water using water hyacinth was tested in laboratory condition by Tripathi and Shukla (1989) to evaluate its role in waste water treatment. This sustainable technology, occasionally referred to as “Phytoremediation” has several merits such as low energy consumption, low operation cost, fast growth rates and simple growth requirements (Sajwan and Ornes, 1994). Taking a lead from such studies, it was thought worthwhile to use the local plant *Eichhornia* sp. to bioabsorb a few metals from a local sewage waste water with special reference to copper and zinc and to ascertain the extent of absorption. Anatomical studies of different plant parts such as leaf, petiole and roots of *Eichhornia* sp. after degradation (96 hrs) of both untreated and treated sewage waste water and estimation of the amount of accumulation of heavy metals in different parts of the plant were also assessed.

MATERIALS AND METHODS

Untreated and treated sewage waste water were collected from a sewage treatment plant, Nesapakkam, Chennai, Tamil Nadu, India. The untreated sample was collected from the primary tank and treated sample was collected from the tertiary tank of the sewage treatment plant in polythene containers (5 litres capacity). They were brought to the laboratory with due care and stored at 25°C for further analysis. The samples were collected once in a month for a period of 3 months for the analysis of physico-chemical parameters.

Untreated and treated sewage waste water of about 2 litres each were collected using polythene containers from the same sites, brought to the laboratory and degradation process of the sewage using *Eichhornia* sp. was carried out. Healthy water hyacinth, *Eichhornia* sp. of similar size were harvested from the Red Hills Pond, Chennai. They were washed and introduced into large tubs containing tap water and maintained for 10 days to acclimatize them to the laboratory conditions.

The physico-chemical parameters of the sewage water such as colour, odour, pH, Electrical conductivity (EC), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Copper and zinc of untreated and treated sewage before and after introduction of the water hyacinth plants were determined by following the Standard Methods outlined by APHA (1995).

Experiments were conducted in plastic tubs to carry out degradation of 100% untreated and treated sewage waste water using *Eichhornia sp* for a period of 96 hours in the laboratory condition. The outer surface of the tubs were covered with black polythene papers to prevent excessive light entering from the sides. The water hyacinth plants of similar size and weight were introduced into the tubs containing 100% untreated and treated sewage waste water and the tubs with sewage and without plants were used as control. This setup was carried out for degradation by following the procedure of Kannagi (2007). Both the untreated and treated sewage water were analysed for physico-chemical parameters before and after degradation process. At the end of the experiment, the accumulation of the copper and zinc in different parts of water hyacinth plants such as leaf, petiole and roots were estimated using Atomic Absorption Spectrophotometer (AAS) following the procedure of Hussain and Jamil (1989). Anatomy of various plant parts like leaves, petiole and roots of *Eichhornia* sp. were carried out as per the procedure of Sass (1940) and O'Brien *et al.* (1964).

RESULTS AND DISCUSSION

Physico-chemical Parameters

The physico-chemical characteristics of 100% untreated and treated sewage water were carried out before and after degradation using water hyacinth (Table 1). The results of analysis of physico-chemical parameters of untreated and treated sewage before treatment revealed that Colour of the 100% untreated and treated sewage were grayish black and brown. Odour of 100% untreated and treated sewage were offensive and earthy, respectively. pH values were found to be acidic, whereas the values for EC 2517 µmhos / cm (untreated) and 1147µmhos / cm (treated), TSS 180 mg / l (untreated) and 110 mg / l (treated), TDS 2492 mg / l (untreated) and 2216mg / l (treated), BOD 180 mg / l (untreated) and 50 mg / l (treated) and COD 497 mg / l (untreated) and 300 mg / l (treated) in the sewage and they were found to be higher than the permissible limits of CPCB (1995) for disposal. After degradation, colour and odour changed to colourless and odourless, respectively and EC to 984 µmhos / cm (60.90%) in the (untreated) and 396 µmhos / cm (65.47%) in the treated TSS to 7 mg / l in the untreated (96.11%) and 4 mg / l (96.36%) in the treated, TDS to 546 mg / l (78.08%) in the untreated and 362 mg / l (83.66%) in the treated, BOD to 45mg / l (75%) in the untreated and 7mg / l (86%) in the treated and COD to 126mg / l (74.64%) in the untreated and 17 mg / l (94.33%) in the treated sewage samples, which were below the permissible limit of CPCB (1995). Physical changes such as dryness indicated the toxicity of the metals to the plant *Eichhornia* sp. after 96 hrs of degradation of sewage water.

Copper levels were 0.01998 mg / l and 0.00138 mg / l, and Zinc levels of 0.024 mg / l, 0.00141 mg / l for 100% untreated and treated sewage waste water, respectively, before treatment and they were within the permissible limits of CPCB (1995). But after degradation by 96 hrs. *Eichhornia* sp. showed complete removal of Cu [0.0092 mg / l (95.395%) (untreated), Nil (100%) (treated)] and few traces of Zn [0.00118 mg / l (95.082%) (untreated), 0.00039 mg / l (72.34%) (treated)]. Thus *Eichhornia* sp. has the capacity to remove completely the heavy metals from the sewage water. These results are in agreement with earlier observations made by Selvapathy *et al.* (1997).

The absorption of heavy metals depends not only on the plants but also on the number of roots. During the study, it was noticed that *Eichhornia* sp. when introduced in 100% of untreated and treated sewage water, the leaves were shrunken with leaf injury and chlorosis which can be used as indicators of toxic symptoms. In spite of the plant injury, the plants were normal for the initial 2 days. Then, the colour of leaves changed from green to yellow and finally started to wilt (Selvapathy *et al.*, 1997). This toxicity of the waste water on the *Eichhornia* sp. may be due to the synergistic effect of the inorganic ions present in the sewage waste water. Water hyacinth is probably a better sink for metals due to its air pockets and parenchymatous tissue which are more permeable to foreign substances.

Table 1. Analysis of physico-chemical parameters of 100% untreated and 100% treated sewage waste water before (control) and after degradation using *Eichhornia* sp. (96 hours)

S. No.	Parameters	CPCB (1995) Standards	Control (Untreated)	Bio-untreated (*Eichhornia* sp.)	Control (Treated)	Bio-treated (*Eichhornia* sp.)
1.	Colour	Colourless	Grayishblack	Colourless	Brown	Colourless
2.	Odour	Odourless	Offensive	Odourless	Earthy	Odourless
3.	pH	5.5 - 9.0	6.7 ± 0.08	7.1 ± 0.08	5.7 ± 0.08	7.0 ± 0.82
4.	Electrical Conductivity (µmhos/cm)	400	2517.0 ± 0.81	984 ± 0.816 (60.90%)	1147.0 ± 0.81	396.0 ± 0.82 (65.48%)
5.	Total Suspended Solids (mg/l)	100	180.0 ± 0.82	7 ± 0.81 (96.11%)	110.0 ± 0.82	4 ± 0.81 (96.36%)
6.	Total Dissolved Solids (mg/l)	2100	2492.0 ± 0.82	546 ± 0.816 (78.09%)	2216.0 ± 0.82	362 ± 0.82 (83.66%)
7.	Biochemical Oxygen Demand (mg/l)	30	180.0 ± 0.82	45 ± 0.82 (75.0%)	50.0 ± 0.81	7 ± 0.82 (86.0%)
8.	Chemical Oxygen Demand (mg/l)	250	497.0 ± 0.82	126 ± 0.81 (74.647%)	300.0 ± 0.83	17 ± 0.81 (94.33%)
9.	Copper (mg/l)	3	0.01998 ± 0.0006	0.00092 ± 0.0816 (95.40%)	0.00138 ± 0.008	Nil (100%)
10.	Zinc (mg/l)	1.5	0.024 ± 0.000816	0.00118 ± 0.022 (95.08%)	0.00141 ± 0.052	0.00039 ± 0.018 (72.34%)

Values are $\overline{X} \pm$ Standard Deviation; % = Percentage Change

Table 2. Bioabsorption of heavy metals, Copper and Zinc, on leaves, petiole and roots of water hyacinth *Eichhornia* sp. before (control) and after degradation of 100% untreated and 100% treated sewage waste water for 96 hrs.

S. No.	Metals	Control			Untreated			Treated		
		Leaf	Petiole	Root	Leaf	Petiole	Root	Leaf	Petiole	Root
1.	Copper (mg/l)	0.00011 ± 0.027	0.00008 ± 0.025	0.00004 ± 0.024	0.00016 ± 0.022	0.00014 ± 0.021	0.00004 ± 0.020	0.00010 ± 0.019	0.00011 ± 0.018	0.00004 ± 0.017
2.	Zinc (mg/l)	0.00069 ± 0.026	0.00028 ± 0.024	0.00024 ± 0.023	0.00118 ± 0.022	0.00104 ± 0.021	0.00048 ± 0.020	0.00067 ± 0.019	0.00039 ± 0.018	0.00022 ± 0.017

Values are $\overline{X} \pm$ Standard Deviation

The results of the present study indicate that the removal efficiencies were higher in the sample in which *Eichhornia* sp. was introduced as compared to those sample without the plants (control). The reason is that in the sample, without the plants, the removal of metal was due to adsorption on the walls of the tub and sedimentation, while in sample with the plants absorbed the heavy metals.

Anatomical Studies of *Eichhornia* sp.

The research work was further extended to study the anatomical features of different plant parts such as leaf, petiole and roots of *Eichhornia* sp. The changes in the lamina, adaxial epidermis (upper epidermis), abaxial epidermis (lower epidermis), mesophyll tissue, air chamber, vascular bundles, cell inclusions and insect infections of leaf, epidermal cells, air chambers and vascular bundles of petiole, rhizodemis, cortex and vascular cylinder of roots of the control (normal *Eichhornia* sp.) and water hyacinth after degradation of sewage waste water were observed in accordance with Mohammed (2002).

The comparative anatomical features of various plant parts revealed that, the ingredients of the sewage waste water not only affected the biomass but also brought about lesser development and tissue differentiation. The effect could be due to synergistic impact of chemicals or may be due to certain other environmental factors. In the present investigation it was recorded that the total physiology of the plant was drastically affected. The affected plants became pale in colour (chlorosis), stunted in growth (dwarfing), lean in size, the leaves become smaller in size (little leaf) and the number of leaves were reduced. The biomass of the stem and roots also decreased.

Bioabsorption of Cu & Zn by different parts of *Eichhornia* sp.

The study was extended for bioabsorption of Cu and Zn by the different parts such as leaf, petiole and roots of the water hyacinth after degradation. Among the three parts of plants, maximum level of Copper i.e., 0.00016mg/l and Zinc 0.00118 mg/l were absorbed in leaves of plants exposed to 100% untreated and treated sewage samples followed by petiole (Cu 0.00014 mg/l, Zn 0.00104 mg/l, respectively) and roots (Cu 0.00004 mg/l, 0.00048 mg/l, respectively) (Table 2). Among the two heavy metals Cu and Zn, absorption of zinc was absorbed more by different parts of *Eichhornia* sp., compared to copper. Among the three parts-leaves, petiole and roots-maximum absorption of heavy metals was recorded in the leaves than petiole and roots. Due to solubilization and accumulation of the trace elements in the sewage, the plant absorb the trace elements through their roots. The absorbed trace elements are then translocated to the other parts of the plants and finally reach and accumulate in the leaves. Due to the above reason the leaves showed maximum content of trace-elements. This inference is in accordance with that of Sridevi (2000).

Hence from the above investigation it can be concluded that water hyacinth *Eichhornia* sp. has a tremendous capacity of absorbing metals (Panda, 1996). Many of the methods used for scavenging heavy metal ions from waste water are either uneconomical or they are unable to meet effectively the stringent water quality limits. Thus the commonly available Indian aquatic plants like *Eichhornia* sp seems to be an alternative for retrieval of toxic pollutants. The sewage water after treatment could be utilized for washing floors, toilets *etc.*, Furthermore, it can be recommended that properly diluted and nutrient enriched water could be used for growing crops and ornamental plants.

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