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Application of *Trapa bipinosa* for the treatment of pulp and paper industry effluent

Hina Kousar* and E.T. Puttaiah

Department of Post Graduate Studies and Research in Environmental Science, Kuvempu University, Shankarghatta - 577 451, India

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Abstract: *The ability of aquatic plants to absorb, translocate and concentrate metals has led to the development of various plant-based treatment systems. The potential to accumulate metals like iron, nickel, manganese and copper by Trapa bipinosa was assessed by subjecting them to different effluent concentrations of pulp and paper industry under laboratory conditions. Trapa showed the ability to accumulate substantial amounts of the metals during a short span of one week. When the plants were grown in different concentrations they caused significant reduction in various parameters like dissolved oxygen, biological oxygen demand, chemical oxygen demand, total alkalinity, total hardness, chloride and sulphate. While there was an increase in biomass, no visible phytotoxic symptoms were shown by treated plants.*

Key words: *Macrophytes, Trapa bipinosa, Effluent, Heavy metals*
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Introduction

The use of living green plants for *in situ* risk reduction and / or removal of contaminants from contaminated soil, water, sediments and air is much in vogue today. Specially selected or engineered plants are used in the process. Aquatic plants have been used frequently to remove suspended solids, nutrients, heavy metals, toxic organics and bacteria from acids mine drainage, agricultural, landfill and urban storm water runoff (Mohan and Hosetti, 1997). Selection of aquatic plant species for the removal of metals from the polluted water would depend upon the ease of plant growth and yield of biomass under the conditions of application (Reddy and Smith, 1987) .

Paper industry plays a significant role in the economic development of a nation. It discharges effluent with high organic and inorganic pollutants (Chakravarthy *et al.,* 1996).Owing to high biological oxygen demand and chemical oxygen demand values it becomes a major source of pollution of the water resources. Improperly treated effluents disturb the natural equilibrium of aquatic ecosystem and poses threat to aquatic flora and fauna. Aquatic macrophytes have a potential to purify waste water and were effective in removing heavy metals (Nasu *et al.,* 1985; Wolverton, 1987; Brix and Schierup, 1989; Rai *et al.,* 1995). Aquatic macrophytes particularly water hyacinth were used for waste water treatment (Abbasi and Nipaney, 1985).

Trapa bipinosa is a floating herb common in tropical and subtropical regions of the world. It grows abundantly in ponds and is free floating. It can be handled easily and economically. The present study was carried out with the objective of investigating the use of *Trapa* for treating the pulp and paper industry effluent and to study the uptake of metals by the plant. It was also intended to analyze the plant treated effluent after the study period to determine the reduction in waste water characteristics. Several aquatic macrophytes such as *Eichornia, Pistia* and *Salvinia* are found to scavenge inorganic and organic compounds from waste waters. (Boyd, 1969). *Ipomea aquatica* showed good Cr (VI) scavenging ability from contaminated waste effluent (Bhat *et al.,* 2005). Duckweeds also play a substantial role in nutrient removal (Nihan and Elmaca, 2007).

Materials and Methods

Healthy plants of *Trapa bipinosa* were collected from Thavareghatta pond near Kuvempu University campus. The collected plants were acclimatized in laboratory model pond of plastic tubs (15 l) containing tap water for about 48 hr. Known weights of the acclimatized mature plants were then introduced into the effluent and placed in open sunlight. They were allowed to grow in day and night condition for 7 days after which they were taken out and the effluent was analyzed as per the standard methods (APHA, 2005) for some physico-chemical parameters.

The Mysore Paper Mills Ltd. (MPM) is situated on the banks of Bhadra river. The effluent coming from the treatment plant is directly discharged into the river water which is the main source of water pollution of river Bhadra. The effluent was collected from the discharge point just before it meets the river water and was analyzed for various physico-chemical parameters like dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total alkalinity (TA), total hardness (TH), chloride (Cl^{+2}), sulphate (SO_4^{+2}) and nickel (Ni^{+2}) as per the standard methods. Two concentrations (raw and 50%) of the effluent were used for treatment and comparison and each time triplicate of the samples were kept separately.

* **Corresponding author:** hinakousar@kuvempu.ac.in

Heavy metal analysis: The entire plants were harvested from both raw and in 50% concentration, oven dried at 80°C for 24 hr, powdered and digested for heavy metal analysis. Digestion of plant samples was carried out by the method of Piper (1966).The digested solution was analyzed for Cu, Zn, Fe and Mn by using atomic absorption spectrophotometer (Model GBC 932 AA).

Results and Discussion

The pulp and paper mill effluent was dark brown with a very pungent odour. The physico-chemical analysis of the raw effluent revealed a high concentration of chemical oxygen demand (COD), total alkalinity (TA), total hardness (TH), chloride (Cl^{+2}), sulphate (SO_4^{+2}) and nickel (Ni^{+2}). After treatment by *Trapa* the concentration of these parameters had decreased drastically (Table 1). *Trapa* was found to exhibit different withstanding capacity at different concentrations. In raw effluent the plant started decomposing rather quickly while at 50% concentration the plant thrived .No change in colour of the effluent was observed at the end of the study period revealing that *Trapa bipinosa* does not possess the capacity of colour removal. The physico-chemical parameters analysed in raw and 50% concentration of the effluent revealed startling results. All the parameters were found to be reduced in 50% than in raw effluent (Table 1). Total hardness and chloride were reduced by about 52.3 and 71.2% respectively on being treated

Table - 1: Results of the analysis of raw and 50% effluent before and after treatment with *Trapa biponosa* and percentage reduction of effluent characteristics

Effluent characteristics (mg l^{-1})	100% Raw effluent				% reduction after	50 % effluent				% reduction after treatment
	Before treatment	After treatment	F	p		Before treatment	After treatment	F	p	
DO	4.21± 0.281	3.60± 0.116	13.781	.021	-	3.36± 0.11	3.61± 0.026	14.383	.019	-
COD	20± 0	16.23 ± 0.207	982.231	.000	21	13.48±0	6.6± 0.141	10444.5	.000	50
TA	908 ± 2.0	604.23± 4.03	13605.2	.000	46.81	637.33± 2.30	340± 0	49279.0	.000	43.4
TH	720± 0	306.66± 10525	219651.1	.000	57.88	426.66 ± 0.526	210.6± 1.15	3635.7	.000	52.3
Cl^{+2}	988.33± 2.88	506.33± 1.148	72100.0	.000	49.2	994± 1.73	290.4± 0.812	406444.6	.000	71.2
so_4^{+2}	137.6± 1.15	60.29± 0.257	12723.0	.000	60.5	132.29± 0.536	32.06± 0.613	42166.7	.000	70.6
Ni^{+2}	0.207± 0.006	0.175± 0.001	60.98	.001	16.59	0.507± 0.004	0.153± 0.004	9825.8	.000	72.8

Values represent the mean ± S.D. (n=3), (p<0.05) significant when analysis of variance was applied,DO = Dissolved oxygen, COD = Chemical oxygen demand, TA = Total alkalinity, TH = Total hardness

Table - 2: Concentration of Fe, Cu, Zn and Mn (µg g^{-1} dry weight) in *Trapa* before and after exposure to the effluent

Metal	Trapa (before exposure)	Trapa (after exposure in 50% effluent)	Trapa (after exposure in 100% raw effluent)
Fe^{+2}	32.26±1.15	35.98±0.782	47.88±1.17
Cu^{+2}	ND*	0.0162±0.0001	0.0186±0.0009
Zn^{+2}	0.0206±0	0.522±0.049	0.666±0.0152
Mn^{+2}	0.69±.015	0.9±0.152	1.696±0.055

*Not detected, Values represent the mean ± S.D. (n=3) (p<0.05) significant when analysis of variance was applied

Table - 3: Concentration of Fe, Cu, Zn and Mn (mg l^{-1}) in the effluent before and after the treatment by plants

Metal	Effluent (before exposure)	Effluent (after exposure in 50%)	Effluent (after exposure in 100%)
Fe^{+2}	15.12±.650	9.64±0.567	13.6±.152
Cu^{+2}	0.103±.001	ND*	0.10±0.01
Zn^{+2}	0.415±.002	0.031±0.008	0.215±0.011
Mn^{+2}	0.65±.02	1.0±0.351	0.45±0.02

*Not detected, Values represent the mean ± S.D. (n=3), (p<0.05) significant when analysis of variance was applied with *Trapa bipinosa* in 50% effluent concentration (Table 1). Heavy metal analysis of effluent before and after the treatment reveals that *Trapa* has the potential to accumulate the heavy metals from effluent (Table 2, 3). Rolli *et al.* (2007) has reported that the phytoremediation of zinc by *Spirodela* is significant with respect to exposure concentration and maximum rate of removal is recorded at 4 days of exposure. Kadlec *et al.* (2000) has reported that several aquatic macrophytes act as potential scavengers of metals from aquatic environment and are being used in waste water renovation systems. *Trapa* was found to accumulate metals like iron, zinc and manganese effectively (Table 2). Similar observations were reported by Kamble and Patil (2001) on removal of heavy metals from waste water of thermal power station by water hyacinths. Plant analysis revealed that maximum uptake and concentration of the heavy metals was found in 50% concentration. These observations corroborate with the findings of Srivastava and Pandey (1999) on *Spirodela* for the uptake of Cu. The concentration of dissolved oxygen decreased in all the observations. This may be due to the dense cover of plants in small tubs which favours the anaerobic condition (Murugesan and Sukumaran, 1997).

The results indicate that the aquatic macrophyte selected for the present study is highly efficient in treating the pulp and paper industry effluent and also posses an outstanding ability for assimilating nutrients and heavy metals.

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