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PERCENTAGE UPTAKE OF HEAVY METALS OF DIFFERENT MACROPHYTES IN STAGNANT AND FLOWING TEXTILE EFFLUENT

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ABSTRACT

Concentration of different heavy metals in various plant species was analyzed in two different drains having Stagnant and Flowing water. *Pistia stratiotes* Cu(0.33ppm), Pb (1.48 ppm), *Typha angustifolia* Cu (0.21ppm), Pb (1.58ppm), *Eichornia crassipes* Cr (0.24ppm), Pb (1.48ppm) and *Phragmites karka* Cu (0.20ppm) and Pb (1.37ppm) in Flowing water where as in Stagnant water metal concentration is *Schenoplectus litoralis* Cd (0.18ppm), Pb (3.19ppm) and *Dichanthium annulatum* Cd (0.19 ppm), Pb (3.25ppm). Bioconcentration factor of certain heavy metals was also calculated and different plant species showed varied uptake at different metal concentrations in textile effluent. Bioconcentration factor of *Pistia stratiotes* for Cu and Ni was 140.72 and 377.36 at concentration in flowing textile effluent 0.23 ppm and 0.063ppm respectively. *Eichornia crassipes* showed maximum bio concentration factor for Cr 176.63 at 0.36 ppm concentration in flowing water. In Stagnant water *Dichanthium annulatum* and *Schoenoplectus litoralis* showed bioconcentration factor for Pb 264.23ppm and 259.23ppm respectively. Over all *Pistia stratiotes* appeared to be best the accumulator with high bioconcentration factor (>100) for different heavy metals.

Key words: Phytoremediation, Aquatic macrophytes, Bioaccumulation, Heavy metals.

INTRODUCTION

The textile sector plays vital role in exports of Pakistan, but environmental pollution is one of the most important consequences of this industry. It is one of the main polluters in industrial sectors in the scope of volume and the chemical composition of the discharged effluent. Inefficient dyeing processes often result in considerable residuals of dyes. The presence of these dyes in effluent is considered to be very problematic because of the persistent and recalcitrant nature. The byproducts of these dyes are also very toxic and mutagenic to life (Pavan *et al.,* 2007). Higher amount of heavy metals are also present in textile effluent. Heavy metals are non biodegradable and many of them have harmful effects on living organisms up to certain concentration (Mansouri *et al.,* 2012). Results revealed that Heavy metal accumulation has negative effects on the growth of silkworm larvae (Ashfaq *et al*., 2012). Contaminations of fruits with heavy metals pose a serious threat to food safety. Lead and cadmium are very harmful elements for human body especially in high concentration (Pehluvan *et al.,* 2012).

The toxicity of textile effluent renders it difficult to be treated through modifications in activated sludge process or combinations of this process with other chemical or physical processes. This situation emphasizes the need to find out more environmental friendly and cost effective treatment methods. Phytoremediation could be a viable option because of their ability to detoxify the effluent and it is an environmental friendly approach. In this the principal method is adsorption of metals through roots (Eapen and D'Souza, 2005).

Results presented by different researchers demonstrate that there are various plant species *Pistia stratiotes* L., *Eichhornia crassipes* (Mart.) Solms, *Typha angustifolia* L. and *Spirodela polyrrhiza* (W. Koch) growing within waste stream exhibit elevated levels of heavy metals in their tissues (Chandra and Yadava, 2010; Rahman and Hasegawa, 2011). For the waste water remediation purpose *Lemna minor*, *Elodea canadensis*, and *Leptodictyum riparium* were also considered as good candidates (Basile *et al.,* 2012).In addition, levels of heavy metals in various species of plants growing in the same habitats may vary considerably (Mari *et al.*,2011). Different techniques were also used to determine the effect of metal accumulating plants on the chemical properties and dynamics of metals in bio solids (Trang *et al.,* 2012). Results have proved that heavy metal pollution is one of the largest threats to human health and marine environment (Özkan, 2012). In this study an attempt has been made to study the population of indigenous plants grown in textile Stagnant and Flowing water. Percentage uptake of heavy metals in plant species was also carried out to find out the best bio remediator.

MATERIALS AND METHODS

Sample Collection: Plant and Water samples were taken from Stagnant and Flowing waters. Identification of plants was done from Dr. Sultan Ahmad herbarium. Plants which were identified; *Pistia stratiotes* L., *Eichornia crassipes* (Mart.) Solms., *Typha angustifolia* L. *Phragmites karka* (Retz.) Steud., *Digitaria longiflora* (Retz.) Pers., *Dichanthium annulatum* (Forssk.) Stapf. and *Schoenoplectus litoralis* (Schrad.) Palla.

Plant Digestion: For the plant digestion process, In 1 gm of dried plant sample 10 ml 65% conc. Nitric acid was added. After that plant samples were heated for 4 hour at 140 °C, until 1ml acid remained. Furthermore, added distilled water into it and filter the suspension in the volumetric flask and diluted up to the mark (Fatih Duman *et al.,* 2006). In water samples concentrated HCl was added drop wise and maintained the pH of the sample less than 4. Analysis was performed on Atomic Absorption Spectrophotometer "FAAS Shimadzu AA-7000F".

Analytical Tests: Dissolved Oxygen and pH were determined according to the APHA methods for wastewater. Nitrates, Phosphates and Sulphates were analyzed by using spectrophotometer. APHA standard methods, 4500-SO_4^{-2} turbidimetric method for Sulphates, 4500-$NO_3^{-2.}$ Spectrophotometric method and 4500-P Ascorbic acid method for phosphates were used. BOD was determined according to the standard method (5210B- 5days BOD test).

Statistical analysis: Statistical analysis involved the application of conventional statistics; mean value and standard deviations to check the precision of analytical results. The Pearson correlation coefficients were also established between the parameters pair of the textile effluent and the plants using Microsoft Excel 2007.

RESULTS AND DISCUSSION

Waste Water Characteristic: The effluent from Flowing and Stagnant textile water was collected and analyzed for DO mg/l, pH, Phosphates mg/l, Sulphates mg/l, Nitrates mg/l, Chlorides mg/l and BOD mg/l. Results were shown in Table 1.Textile waste water has alkaline pH and it is because bleaching of fibers adds halogen and it makes the waste water alkaline. High level BOD can best be explained by the fact that desizing step in textile process contributes 50 % increase of BOD load. Biodegradable organic compounds like synthetic and natural polymers in water bodies cause deficiency of dissolved oxygen and it has a significant impact on aquatic life. (Dos Santos *et al.,*2006).

Heavy metal concentration in Textile Effluent: The overall characterization of the Flowing and Stagnant water revealed that the concentration of Cr and Pb was high in flowing water and it was 0.36ppm and 1.32ppm, where as in Stagnant water concentration of Cu, Cd and Pb was high and it was 0.18ppm, 0.18ppm and 1.23ppm.(Table 2) and it is almost several times higher than the permitted limits (Yasir *et al.,* 2005). Dyeing and printing processes produce waste water-containing toxic organic compound such as phenols and also impart highly concentrated color and copper, chromium metals. Heavy metals are considered as the most dangerous elemental pollutants and are of particular concern because of their toxicities to human health (Boran and Altınok, 2010).

Cr and Cd are considered to be very toxic even at low concentration (Shukla *et al.,* 2007). Similarly, Cd has proven to be highly toxic to aquatic plants. The interactions of Cd and metal nutrients can change nutrient concentration and composition in some plant species (Scebba *et al.,* 2006). Pb in waste water also cause serious health hazards if it is exposed to human. High level concentration of lead can cause central nervous system damage (Naseem and Tahir, 2001).

Heavy metal concentration in Plant species: High metal concentration accumulation was observed in *Pistia stratiotes and Eichhornia crassipes* (Table 3). Successful removal of five heavy metals (Fe, Zn, Cu, Cr and Cd) was done by *P. stratiotes* and *E. Crassipes* (Mishra and Tripathi, 2008). *E. Crassipes* showed a very promising ability to remove and accumulate (Cd, Cr, Cu, Pb and Ni), metals from the leachate 24% to 80% removal of total heavy metals (Ahmed and El-Gendy, 2008). The highest concentration of Cu was observed in *Pistia stratiotes* 0.33ppm and lowest was observed in *Schoenoplectus litoralis* 0.14ppm. Nirmal Kumar *et al.,* (2012) also determined high accumulation of Cu in different macrophytes. Results from analysis confirmed the accumulation of different metals within the plant and a corresponding decrease of metals in the water (Mishra and Tripathi, 2008). Selected plants shown a wide range of tolerance to all of the selected metals and therefore can be used for large scale uptake of heavy metals from textile effluent. These macrophytes have high biomass, fibrous root and broad leaves due to which they absorb higher concentrations of heavy metal. Higher removal of heavy metals by *P. stratiotes* may be attributed to their luxuriant growth in heavy metal and nutrient rich media, greater biomass accumulation (Mant *et al.,* 2007) increased diversity and absorption of metals from medium. Accumulation of Ni and Cd in *Pistia stratiotes* was 0.24ppm and 0.19ppm and it was find out that it decreased the chlorophyll content with decrease in the activities of the Fe enzymes catalase and peroxidase (Pandey and Sharma, 2002).

Percentage Uptake of heavy metals: Results revealed high removal of different metals by these plants species as shown in Table 4. In flowing water *P. stratiotes* the most efficient for the removal of selected heavy metals followed by *E. crassipes* (>100%). Significant correlations between metal concentration in water and macrophytes were also obtained (Mishra and Tripathi, 2008). It was observed that there is less uptake of Cr by

Phragmites karka (Table 4) it is supposed to be the most difficult metal to remove from waste water because macrophytes do not require this for any physiological purposes. Cr phytotoxicity can result in the inhibition of seed germination, pigment degradation, disturbances in the nutrient balance and the generation of reactive oxygen species (ROS), which induces oxidative stress and alterations in antioxidant enzyme activities (Sharmin *et al.*, 2012). Many studies revealed that heavy metals are not only retained in the roots but transferred to the shoots and deposited in the leaves, at concentrations 100–1000-fold higher than those found in non-hyper accumulating species (Rascio and Izzo, 2012).

Table 1. Textile waste water characteristic

Parameters		Flowing water	Stagnant water
DO	mg/l	0.51[a] (0.02)[b]	0.59 [a] (0.01)[b]
pH		7.14[a] (0.01)[b]	7.77[a] (0.01)[b]
Phosphates	mg/l	7.67[a] (0.005)[b]	2.48 [a] (0.01)[b]
Sulphates	mg/l	9.34 [a] (0.01)[b]	1.88 [a] (0.01)[b]
Nitrates	mg/l	3.70 [a] (0.01)[b]	0.59[a] (0.01)[b]
Chlorides	mg/l	10.20 [a] (0.10)[b]	3.97[a] (0.06)[b]
BOD	mg/l	168.00[a] (1.00)[b]	88.67 [a] (1.15)[b]

[a] Mean of 5 ()[b] shows standard deviation.

Table 2. Heavy metal concentration (ppm) in Textile Effluent

	Cu	Cd	Cr	Pb	Ni
Flowing water	0.23	0.21	0.36	1.32	0.063
Stagnant water	0.18	0.18	0.11	1.23	0.053

Detection limits Ni= 0.05 ppm, Pb=1.0 ppm, Cd, Cr, Cu = 0.1 ppm

Table 3. Concentration of Heavy metals (ppm) in different macrophytes

	Flowing water			Stagnant water			
Heavy Metals	***Pistia stratiotes***	***Eichhornia crassipes***	***Typha angustifolia***	***Phragmites karka***	***Digitaria longiflora***	***Dichanthium annulatum***	***Schoenoplectus litoralis***
Cu	0.33	0.24	0.21	0.20	0.15	0.18	0.14
Cd	0.19	0.15	0.13	0.18	0.12	0.19	0.18
Cr	0.35	0.65	0.65	0.21	0.11	0.14	0.14
Pb	1.48	1.58	1.58	1.37	2.34	3.25	3.19
Ni	0.24	0.16	0.06	0.08	0.05	0.06	0.07

Table 4. Percentage uptake of heavy metals in different macrophytes

Heavy metals	Flowing water			Stagnant water			
	Pistia stratiotes	***Eichhornia crassipes***	***Typha angustifolia***	***Phragmites karka***	***Digitaria longiflora***	***Dichanthium annulatum***	***Schoenoplectus litoralis***
Cu	140.72	102.35	89.55	85.29	83.33	100.00	77.78
Cd	88.58	69.93	60.61	83.92	66.67	105.56	100.00
Cr	95.11	176.63	176.63	57.07	100.00	127.27	127.27
Pb	112.04	119.61	119.61	103.71	190.24	264.23	259.35
Ni	377.36	251.57	94.34	125.79	92.94	113.21	132.08

Standard deviation and mean was calculated for the precision of results. For the confirmation that plant uptake heavy metal from the textile effluent correlation is established. It was observed that coefficient of correlation between macrophytes and flowing water is 0.99, 0.98, 0.98 and 0.99 for *Pistia stratiotes, Eichhornia crassipes, Typha angustifolia* and *Phragmites karka* respectively (Table 5), where as coefficient of correlation between macrophytes and stagnant textile effluent is 1 which is very strong, reason is that in stagnant water time to uptake heavy metals from water by macrophytes is more where as in the flowing water flowrate and concentration of metal varries time to time. A study has also shown that uptake of metals by plants depends upon the bioavailability of metal in the water phase which is depending upon the retention time of metal (Tangahu *et al*., 2011).

Table 5. Correlation coefficient between macrophytes and Textile effluent

	Flowing water			Stagnant water			
	Pistia stratiotes	***Eichhornia crassipes***	***Typha angustifolia***	***Phragmites karka***	***Digitaria longiflora***	***Dichanthium annulatum***	***Schoenoplectus litoralis***
Correlation coefficient	0.99	0.98	0.98	0.99	1	1	1

0.99 strong Correlation 1 Very Strong Correlation

Conclusion: Heavy metals Cr, Cu and Pb are the major contaminants in the textile effluent. It explores the fact that textile industries discharged effluent having heavy metal dyes used in various dyeing and printing processes that is toxic to the aquatic life. *Pistia stratiotes*, *Eichornia crassipes* and *Dichanthium annulatum* were found to play comparatively key role in uptaking of heavy metals. These macrophytes showed different trend in their %age uptake of heavy metals. It was observed that in Copper accumulation *Pistia stratiotes* showed 1.4 times more uptake than water. *Eichornia crassipes* exhibited maximum %age uptake for chromium 1.8 times more than water. Lead was highly accumulated in *Dichanthium annulatum* and its value was very significant i.e. 2.6 times more.

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