Potential of *Eichhornia crassipes*, *Pistia stratiotes* and *Salvinia molesta* in Phytoremediation of Textile Waste Water (A Case Study)

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Abstract

Textile industry is one of the profitable industries in Sri Lanka. However, large volumes of wastewater arising from its operations may cause significant environmental problems and operational costs for the industry. Phytoremediation is an emerging low cost green technology which uses plants for treating contaminant in the environment. The present study focused on investigating the phytoremediation potential of locally available aquatic plants in the treatment process of textile wastewater.

Textile waste water was treated with *Eichhornia crassipes* (water hyacinth), *Pistia stratiotes* (water lettuce) and *Salvinia molesta* (water fern) for a period of 14 days and their effluent treatment efficiency was estimated by measuring the waste water quality over the experimental period. The reduction efficiencies of conductivity, Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Solids (TS), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), nitrates, phosphates, heavy metals (Cd, Ni and Zn) and total and fecal coliform from the waste water by each plant species were estimated. Bio Concentration Factors (BCF) and Translocation Factors (TF) of three plant species for Cd, Ni and Zn were also estimated in order to identify their heavy metal absorption capacity.

The results of the study indicated that greater than 50% reduction of BOD, COD, nitrates, phosphates, total coliform and Zn from the initial waste water by the three plant species. Comparison of reduction efficiencies of effluents by three plant varieties indicated that *E.crassipes* to be the most effective aquatic plant in reducing effluents in the textile waste water. Results of the study also suggested that the selected aquatic plants are hyperaccumulators of Cd, Ni and Zn metals and they are stored in their root systems. Findings of this study suggest that *E.crassipes*, *P.stratiotes* and *S.molesta* are potential aquatic plants for treating textile waste water.

Key words: Aquatic plants, *Eichhornia crassipes*, Phytoremediation, *Pistia stratiotes*, *Salvinia molesta*, Textile industry, Textile waste water

Introduction

Textile industry is one of the profitable industries in Sri Lanka. However, large volumes of wastewater arising from its operations may cause significant environmental problems and operational costs for the industry. Phytoremediation is an emerging low cost green technology which is adopted for treating contaminants in the environment using plants (Pivertz, 2001). Aquatic macrophytes are reported to be more effective in wastewater treatment in comparison to terrestrial plants because of their faster growth and larger biomass production, relative higher capability of pollutant uptake, and better purification effects due to direct contact with contaminated water. The potential of aquatic macrophytes for heavy metal removal has been investigated and reviewed extensively by many authors (Dhir et al., 2009a; Dhote and Dixit 2009).

Problem statement

Even though there is a considerable amount of literature available in the area of phytoremediation potential of aquatic plants in the global context a very few research has been carried out on the phytoremediation potential of aquatic plants in Sri Lanka. Many of these reported studies are limited to investigate the phytoremediation potential of aquatic plants such as reeds and sedges (Jayaweera et al., 2011; Pathiraja and Perera, 2011; Shasikala et al., 2010). However the literature on research work related to phytoremediation potential of floating aquatic plants are limited within the context of Sri Lanka.

Research objectives

The main objective of the present study is to evaluate the phytoremediation potential of floating aquatic plants, *Eichhornia crassipes*, *Pistia stratiotes* and *Salvinia molesta* to treat textile waste water.

Key theory and empirical evidence

The term "**phytoremediation**" comes from Greek and Latin (φυτο- 'phyto' means plant, "remedium" means restoring balance or remediation) is a generic term for the group of technologies that use plants for remediating soils, sludge, sediments and water contaminated with organic and inorganic contaminants (Flathman and Lanza, 1998). There is a scarcity of local literature on the implementation of phytoremediation in Sri Lanka implying that very limited research on the topic of phytoremediation has been carried out in Sri Lanka. A study conducted by Jayaweera et al., (2011) has demonstrated that *Typha angustifolia* is having potential of removing Zinc (Zn). Simultaneously, Gamage et al., (2001) carried out a study to evaluate the performance of water hyacinth which is grow in series of tanks inter connected with the waste water treatment plant to treat textile waste water and found more than 50% reduction of BOD, COD, TDS, TS, nitrates and phosphates from its initial level.

Methodology

The experimental setup was established using identical four plastic tanks that were filled with 20 liters of diluted raw textile effluent. Nearly equal weights of selected stabilized aquatic plants (300g fresh weight) were transferred to prepared tanks containing diluted textile effluent separately. One plastic tank with diluted textile waste water was kept as a controller. The treatments and control tanks were kept outdoor condition. Waste water samples were collected from tanks for analysis daily for 14 day period. The quality of the waste water samples were determined in three phases i.e before dilution, after dilution and after treating with aquatic plants. Three replicates of waste water samples were collected from the treatments. All analysis were conducted following APHA (2005) procedures.

BOD was determined after 5 days incubation period using wrinkles method and COD was measured by open reflux method. COD was estimated in the initial sample, 1st day, 7th day and 14th day only due to the constraints encountered in analysis of COD due to lack of facilities. Conductivity and TDS were measured using digital conductivity meter while pH was measured by digital pH meter. TS were measured by the gravimetric method and TSS was measured by subtracting the amount of TDS from the amount of TS. Total and fecal coliform colony counts were estimated by membrane filtration method. Nitrates and phosphates were measured by spectrophotometer whereas heavy metals (Cd, Ni and Zn) in waste water were measured by using Atomic Absorption Spectrophotometer. Percentage reductions of the effluent concentrations were calculated using following equation,

$$\text{Percentage Reduction} = \frac{(\text{Initial amount} - \text{Amount at time t})}{\text{Initial amount}} * 100$$

Where,

t = Day 14

The plants were removed from the tanks after 14 days and metal concentrations (Cd, Ni and Zn) in plant tissues were estimated after digesting the samples using the method adopted by Carvalho and Martin (2001). BCF and TF of each plant variety were calculated using following equations.

$$BCF = P/E$$

Where,

P = metal concentration in plant tissues (mg/kg dry wt)

E = metal concentration in the waste water (mg/L)

$$TF = As/Ar$$

Where,

As = amount of trace element accumulated in the shoots (mg/kg dry wt)

Ar = amount of trace element accumulated in the roots (mg/kg dry wt)

Findings

Percentage reductions of effluents after 14 days and BCFs and TFs for plant varieties are represented in the tables 1 and 2.

Table 1 Percentage reductions of treatments after 14 days period

Parameter	**Percentage reductions (%)**			
	E.crassipes	***P.stratiotes***	***S.molesta***	**Control**
BOD	90	95	50	0
COD	82	74	80	23
TS	62	42	35	11
TDS	61	51	41	2
TSS	67	17	17	44
Conductivity	4	5	7	2
Nitrates	64	82	80	55
Phosphates	81	69	69	35
Total coliform	93	96	89	71
Cd	37	47	37	8
Ni	45	44	60	2
Zn	94	87	99	42

Table 2 Measured BCFs and TFs for plant varieties at the end of 14 days

Metal	***E.crassipes***		***P.stratiotes***		***S.molesta***	
	BCF	TF	BCF	TF	BCF	TF
Cd	5.00	0.50	6.60	0.43	4.42	0.33
Ni	6.91	0.40	6.05	0.48	10.70	0.23
Zn	130.55	0.49	47.24	0.25	1072	0.34

The results of the study indicated that greater than 50% reduction of BOD_5, COD, nitrates, phosphates, total coliform and Zn from the initial waste water by the three plant species. Comparison

of reduction efficiencies of three plant varieties indicated that *E.crassipes* is to be the most effective aquatic plant in reducing effluents from waste water. The BCF values recorded for three aquatic plants were >1 indicates that these plants have higher phytoremediation potential for selected metals. This further indicates that three selected aquatic plants are hyperaccumulators for studied heavy metals. Measured TFs of *E.crassipes*, *P.stratiotes* and *S.molesta* for selected heavy metals are within the range of 0.23-0.49. TFs values recorded for *E.crassipes* , *P.stratiotes* and *S.molesta* were <1. This suggested that these plants do not effectively transfer these metals to shoots from their roots i.e the plants accumulates metals in the below ground parts (roots/ rhizosphere) than in the above ground parts (shoot/ leaves).

Conclusions

It could be concluded from the present study that *E.crassipes* being the most effective plant in terms of its phytoremediation potential of textile waste water among the three aquatic plants experimented. *P.stratiotes* and *S.molesta* are also having capabilities to treat textile waste water but their efficiency in reducing the effluents in the waste water are lesser than that of *E.crassipes*. The findings of the present study also indicated that selected aquatic plants are having the capability of removing heavy metals Cd, Ni and Zn from the waste water with higher removal efficiency of Zn. The results of the present study also indicated that *E.crassipes*, *P.stratiotes* and *S.molesta* are hyperaccumulators of the studied metals. The further findings of the present study suggest that *E.crassipes*, *P.stratiotes* and *S.molesta* having potential of treating effluents in the textile waste water.

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