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Full Length Research Paper

Phytoremediation of Textile Industry Effluent using *Pistia stratiote*

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Abstract
The present study concerned a laboratory experiment on the use of Pistia stratiotes in the removal of some heavy metals from ECTO Denim Pvt Ltd, Bijapur Company. The experimental study showed that Pistia stratiotes is a suitable plant for effective removal of heavy metals and more nitrate. It was observed that the removal was more in 25% concentration than in 50% effluent concentration.

Keywords: *Heavy metals, Phytoremediation, Pistia stratiotes*

Introduction

Textiles are among the basic needs of human being. The textile industries have a great economic significance by virtue of its contribution to overall industrial output and employment generation. This sector has wide spectrum of industries ranging from small scale units that use traditional manufacturing process. The large integrated mills use modern machineries and equipments. There are 2324 textile industries in the country (Mishra *et al*., 1993).

Pistia strastiotes is a tropical duck weed. It is free floating, aquatic, stoloniferous herb with short stem found floating in stagnant shallow ponds and it has immense range throughout the tropics. Stem is short bearing a rosette of leaves. Root stalk touches the water column and produces long slender feathery numerous hairy roots, light yellow green leaves in the form of rosette is the main characteristics of water lettuce. Leaves are wedge shaped, spongy, inflated triangular in shape 5-10 cm long, flowers in the center of the plant. Buds, stolons are easily broken and multiplied.

Phytoremediation is a method to remove pollutants from the environment, heavy metals from soil, wastewater and sludge by using plants. Macrophytes are aquatic plants that grow in/or near water and can be classifed as emergent, submerged or floating plants. Studies have been done to investigating the capabilities of some macrophytes to remove different concentration of heavy metals, in the role as biomonitors of environmental metal levels (Mishra *et al.,* 2008) and in their ability as biological filters of the aquatic environment.

The aim of the present study is to investigate the feasibility of using Pistia stratiotes for treating textile industrial effluent and to know the physico chemical characteristics of raw textile industrial effluent before and after being treated with aquatic plant and also to analyze percentage of reduction of the physico-chemical characteristics of textile effluent.

Materials and methods

The methodology adopted for the present study is as follows:

- Sample collection
- Plant acclimatization for phytoremediation
- Effluent Analysis before and after the introduction of plants
- Comparative assessment for reduction of parameters

Sample collection:
The textile industry effluent was collected from the ETCO Denim Pvt Ltd, Bijapur before it reached the effluent collection tank and the aquatic macrophytes were collected from different water bodies around the University campus. *Pistia stratiotes was collected* from Lakkavalli pond.

Plant acclimatization for phytoremidiation:
The collected plants were acclimatized in the laboratory model in plastic tubs (3 L) containing tap water for about 7 days. The textile industry effluent was dark blue with pungent odour. This aquatic macropohyte was introduced after acclimatization into the different concentrations of the effluent and left for a period of 5 days after which the effluent was analyzed by removing the plants.

Effluent Analysis before and after the introduction of plants:
The Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Hardness (TH), Total Alkalinity (TA) and Chlorides (Cl) were determined by Titrimetric method. Copper (Cu), Manganese (Mn), Iron (Fe), Nitrate (NO_3^-) and Phosphates (SO_4^{2-}) were determined by Spectrophotometric method for textile effluent according to the Standard methods by APHA (2005) and N. Manivasakam (2008).

Statistical analysis involved the application of conventional statistics; mean value and standard deviations to check the precision of analytical results. The percentages were also established between the parameters and heavy metals of the textile effluent and the plants using SPSS 20 software.

Result and Discussion
The physico-chemical analysis of the raw effluent revealed a high concentration BOD, COD, Total alkalinity (TA), Chloride, Iron and Nitrate. The aquatic macropohyte *Pistia* was introduced into the effluent and left for a period of 5 days after which the effluent was analyzed by removing the plants. The analysis revealed that the concentration of the above mentioned parameters has decreased drastically.

Effluent Characteristics: The effluent from textile industry was collected and analyzed for DO, BOD, COD, Total Hardness, Total Alkalinity and Chloride. Results are shown in Tables 1,2,3,4,6,7,8 and 9. Raw textile effluent had alkaline pH as bleaching of fibers adds halogen. High concentration BOD could be explained by the fact that desiring 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 found to have a significant impact on aquatic life (Dos Santos *et al.,* 2006).

The concentration of DO is found to be nil in raw effluent. However, after the introduction of plant the concentration of DO was found to increase in both 50% and 25%. It was also observed that the concentration of DO in *Pistia* was 33.83 mg/l in 25% and 56.9 mg/l in 50% raw effluent. The concentration of BOD and COD decreased with increase in DO concentration (Mahdi Ahmed *et al*., 2007).

Heavy metal concentration: The overall characterization of the effluent revealed that the concentration of Nitrate and Iron was high in effluent. The concentration of Cu, Mn, Fe, NO_3^- and SO_4^{2-} are shown in Tables 11,12,13,14,16,17,18 and 19. It is almost several times higher than the permitted limits (Yasir *et al.,* 2005). Dyeing and printing processes produce effluent containing toxic organic compounds such as phenols, heavy metals like copper, chromium and also impart highly concentrated color. Heavy metals are considered as the most dangerous elemental pollutants and are of particular concern because of their toxicities to human health (Boran and Altinok, 2010).

Percentage reduction of heavy metals: The removal of different metals by the selected aquatic plants is shown in Table 15 and 20. *Pistia* was found to be the most efficient for the removal of selected heavy metals in both 50% and 25% concentration effluent. The present study is in accordance with the work done by Mishra and Tripathi (2008) while working on *Pistia stratiotes, Spirodela polyrrhiza* and *Eichhornia crassipes*. (Table 15), it is supposed to be the most difficult metal to remove from waste water because macrophytes do not require this for any physiological purposes. This 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).

There was 100% reduction in both 25% and 50% concentration of the effluent percentage pertaining to copper. The concentration of copper in effluent was negligible at the beginning and was nil after the treatment including that there was a complete uptake of copper by macrophytes. (Table 15, 20).

Standard deviation and mean was calculated for the precision of results and for the confirmation of variation of parameters and heavy metal concentration from the average. The fallowing parameters DO, BOD, COD, TH, TA & Chloride are 0±8.56, 315.76±31.88, 318.86±26.03, 5.44±0.90, 170.65±12.02 & 274.32±17.0 in 50% effluent and 0±3.34**,** 199.6±26.59, 104.16±15.79, 2.81±0.53, 84.02±7.56 & 141.0±8.32 in 25% effluent respectively (Table 4 and 9).

Similarly the variation of heavy metals Cu, Mn, Fe, NO_3^- & SO_4^{2-} are 0.0096±0, 4.46±0.84, 10.75±0.50, 44.32±2.00 & 4.05±0.39 in 50% effluent and 0.0077±0, 3±1.27, 5.90±0.18, 18.73±1.02 & 2.03±0.25 in 25 % effluent respectively (Table 14 and 19). 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).

Pistia stratiotes

Pistia was found to reduce the dark blue colour of the effluent to light colour. There was a considerable decline in COD, Total Hardness, Total Alkalinity and Chloride in 25% concentration of the effluent as compared to 50% (Table 4, 9). *Pistia* showed percentage reduction of the following parameters BOD, COD, TH, TA & Chloride are 13.62, 8.22, 17.06, 77.28 & 47.74 in 25% effluent, and in 50% effluent 40.18, 4.33, 32.24, 77.17 & 53.85 respectively.

There was a decreased in concentration of heavy metals Mn, Fe, NO_3^- & SO_4^{2-} are 100, 31.43, 56.64 & 59.83 in 25% effluent, then in 50% effluent 44.02, 14.04, 72.76 & 66.63 respectively (Table 5,10,15 and 20). A similar observation has been reported by Egbet Selvin Rose (1998) on *Lemna minor* and Jebansean (1997) on *Eichhornia crassipes. Pistia* has got the wonderful capacity of removal of heavy metals as well. Again it was observed that the removal was more in 25% concentration than in 50% (Table 14 and 19). Our observations had similarty with the work carried out on heavy metal removal from waste water by water lettuce (Selvapathy, 1997) and phytoremidiation on Zn using *Spirodela* (Rolli, 2007).

Parameters of textile effluent before and after treatment at 50% concentration

Table 1- trail 1

Parameters	Raw effluent (mg/l)	Pistia (mg/l)
DO	0.0	56.0
BOD	310.0	188.0
COD	320.0	304.0
TH	4.784	2.800
TA	171.36	38.60
Chloride	274.71	127.25

Table 2- trail 2

Parameters	Raw effluent (mg/l)	Pistia (mg/l)
DO	0.0	58.3
BOD	317.4	188.9
COD	319.1	307.4
TH	5.85	4.25
TA	170.63	37.69
Chloride	273.75	126.50

Table 3- trail 3

Parameters	Raw effluent (mg/l)	Pistia (mg/l)
DO	0.0	56.4
BOD	319.9	189.7
COD	317.5	303.7
TH	5.69	4.01
TA	169.98	37.80
Chloride	274.51	126.00

Table 4: Average and standard deviation of textile effluent parameters at 50% concentration

Parameters	Raw effluent (mg/l)	Pistia (mg/l)	Stdev
DO	0	56.9	±8.568048
BOD	315.7667	188.8667	±31.88118
COD	318.8667	305.0333	±26.03934
TH	5.441333	3.686667	±0.900798
TA	170.6567	38.03	±12.02878
Chloride	274.3233	126.5833	±17.00764

Table 5: Percentage reduction of textile effluent parameters in 50% concentration

Parameters	Pistia (%)
DO	_
BOD	40.187
COD	4.338
TH	32.246
TA	77.175
Chloride	53.856

DO- Dissolved oxygen, BOD- Biological Oxygen Demand, COD- Chemical Oxygen Demand, TH- Total Hardness, TA- Total Alkalinity, STDEV- Standard Deviation.

Parameters of textile effluent before and after treatment at 25% concentration

Table 6- trail 1

Parameters	Raw effluent (mg/l)	Pistia (mg/l)
DO	0.0	30.0
BOD	200.0	196.0
COD	104.0	96.0
TH	1.88	1.80
TA	84.26	19.6
Chloride	141.16	76.35

Table 7- trail 2

Parameters	Raw effluent (mg/l)	Pistia (mg/l)
DO	0.0	36.3
BOD	199.1	160.3
COD	103.9	95.7
TH	3.25	2.65
TA	83.63	18.70
Chloride	141.16	76.07

Table 8- trail 3

Parameters	Raw effluent (mg/l)	Pistia (mg/l)
DO	0.0	35.2
BOD	199.7	160.9
COD	104.6	95.1
TH	3.31	2.55
TA	84.17	18.96
Chloride	140.69	77.10

Table 9: Average and standard deviation of textile effluent parameters at 25% concentration

Parameters	Raw effluent (mg/l)	Pistia (mg/l)	Stdev
DO	0	33.83333	±3.342706
BOD	199.6	172.4	±26.59973
COD	104.1667	95.6	±15.79096
TH	2.813333	2.333333	±0.539509
TA	84.02	19.08667	±7.587035
Chloride	141.0033	76.50667	±8.32103

Table 10: Percentage reduction of textile effluent parameters in 25% concentration

Parameters	Pistia (%)
DO	_
BOD	13.627
COD	8.224
TH	17.061
TA	77.283
Chloride	45.741

Heavy metals of textile effluent before and after treatment at 50% concentration

Table 11- trail 1

Heavy metals	Raw effluent (mg/l)	Pistia (mg/l)
Copper	0.0096	0.0
Manganese	4.5	2.5
Iron	10.78	9.44
Nitrate	46.74	14.68
Sulphate	4.00	1.27

Table 12- trail 2

Heavy metals	Raw effluent (mg/l)	Pistia (mg/l)
Copper	0.0098	0.0
Manganese	4.6	2.7
Iron	10.81	9.37
Nitrate	43.52	13.28
Sulphate	4.10	1.47

Table 13- trail 3

Heavy metals	Raw effluent (mg/l)	Pistia (mg/l)
Copper	0.0096	0.0
Manganese	4.3	2.3
Iron	10.66	8.91
Nitrate	42.70	8.91
Sulphate	4.07	1.32

Table 14: Average and standard deviation of textile effluent heavy metals at 50% concentration

Heavy metals	Raw effluent (mg/l)	Pistia (mg/l)	Stdev
Copper	0.009667	0	±0
Manganese	4.466667	2.5	±0.841295
Iron	10.75	9.24	±0.500934
Nitrate	44.32	12.29	±2.009063
Sulphate	4.056667	1.353333	±0.395517

Table 15: Percentage reduction of textile effluent heavy metals in 50% concentration

Heavy metals	Pistia (%)
Copper	100
Manganese	44.029
Iron	14.046
Nitrate	72.269
Sulphate	66.639

Heavy metals of textile effluent before and after treatment at 25% concentration

Table 16- trail 1

Heavy metals	Raw effluent (mg/l)	Pistia (mg/l)
Copper	0.0077	0.0
Manganese	2.9	0.0
Iron	5.93	4.00
Nitrate	18.79	8.15
Sulphate	2.10	0.82

Table 17- trail 2

Heavy metals	Raw effluent (mg/l)	Pistia (mg/l)
Copper	0.0078	0.0
Manganese	3.0	0.0
Iron	5.89	4.05
Nitrate	18.65	8.19
Sulphate	2.00	0.80

Table 18- trail 3

Heavy metals	Raw effluent (mg/l)	Pistia (mg/l)
Copper	0.0077	0.0
Manganese	3.1	0.0
Iron	5.90	4.10
Nitrate	18.772	8.03
Sulphate	2.00	0.83

table 19: Average and standard deviation of textile effluent heavy metals at 25% concentration

Heavy metals	Raw effluent (mg/l)	Pistia (mg/l)	Stdev
Copper	0.007733	0	±0
Manganese	3	0	±1.276715
Iron	5.906667	4.05	±0.188336
Nitrate	18.73733	8.123333	±1.023035
Sulphate	2.033333	0.816667	±0.253888

Table 20: Percentage reduction of textile effluent heavy metals in 25% concentration

Heavy metals	Pistia (%)
Copper	100
Manganese	100
Iron	31.433
Nitrate	56.646
Sulphate	59.836

Conclusion

Heavy metals Copper, Manganese, Iron, Nitrate and Phosphates are the major contaminants in the textile effluent. The study explores the fact that textile industries discharged effluent having heavy metal used in various dyeing and printing processes that is toxic to the aquatic life. *Pistia stratiotes was* found to play a comparatively key role in removal of heavy metals. It was observed that *Pistia stratiotes* removed more percentage of Nitrate. From the foregoing observations it can be concluded that phytoremediation is an, efficient, cost effective, alternate technology for treatment of recalcitrant industrial wastes. The study proves that *Pistia,* which is considered as unwanted aquatic weeds can be successfully utilized for the degradation of textile industry waste.

Ethics

All the authors read and approved the manuscript and no ethical issues involved.

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