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Full Length Research Paper

Phytoremediation of Textile Industry Effluent using free floating Macrophyte *Azolla pinnata*

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Abstract
The present study deals with laboratory experiment on the use of Azolla pinnata in the removal of some heavy metals from ETCO Denim Pvt Ltd, Bijapur Company. The experimental study showed that Azolla pinnata is a suitable plant for effective removal of heavy metals. Azolla showed highest percentage reduction of BOD (40.26% and 59.70%) and Sulphate (84.42% and 85.37%) in both 25% and 50% concentration of the effluent respectively.

Keywords: *Heavy metals, Phytoremediation, Azolla pinnata.*

Introduction

Water is an indispensable part for the sustenance of mankind and the increasing awareness about the environment; especially aquatic ecosystems have attracted the attention of researchers worldwide. A definite need exists to develop a low cost and eco-friendly technology to remove pollutants particularly heavy metals, thereby improving water quality. Phytoremediation offers an attractive alternative. Among these, *Azolla,* a free-floating, fast growing, and nitrogen fixing pteridophyte seems to be an excellent candidate for removal, disposal, and recovery of heavy metals from the polluted aquatic ecosystems (Arora et al. 2006; Umali et al. 2006; Anjuli sood et al., 2012).

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 (Mishra and Tripathi, 1993).

The main aim of the current study is to investigate the feasibility of using *Azolla pinnata* 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. Also, to analyze the percentage reduction of physico-chemical characteristics of the 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. *Azolla pinnata* was collected from paddy field near Santhekadur of Shivamogga district.

***Azolla pinnata* (Water velvet)**

Kingdom : Plantae
Division : Pteridophyta
Class : Polypodiopsida
Order : Salviniales
Family : Azollaceae
Genus : Azolla
Species : A. pinnata

Fig. 1 *Azolla pinnata*

A minute, floating fern up to 2.5 cm long, forming dull green or reddish blanket over the surface in shorelines and shallow ponds. Fronds 1 to 3 together, each with 3-5 pairs of alternate branches. Roots are very fine, plumose, hanging in water.

Plant acclimatization for phytoremediation

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 textile effluent revealed a high level BOD, COD, Total alkalinity (TA), Chloride, Iron and Nitrate. The aquatic macropohyte *Azolla pinnata* 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%. 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.
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. 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).

Azolla pinnata

Azolla was found to be a rather delicate plant and started to decompose, after being introduced into the effluent irrespective of its concentration. There was a slight change in the colour of effluent at the end of the study period. *Azolla* showed highest percentage reduction of BOD (40.26% and 59.70%) and Sulphate (84.42% and 85.37%) in both 25% and 50% concentration of the effluent respectively (Table 5,10,15,20).

Table 1- trail 1

Parameters	Raw effluent (mg/l)	Azolla (mg/l)
DO	0.0	42.0
BOD	310.0	124.0
COD	320.0	264.0
TH	4.784	2.520
TA	171.36	50.00
Chloride	274.71	101.80

Table 2- trail 2

Parameters	Raw effluent (mg/l)	Azolla (mg/l)
DO	0.0	43.5
BOD	317.4	128.6
COD	319.1	263.5
TH	5.85	3.65
TA	170.63	50.91
Chloride	273.75	100.74

Table 3-trail 3

Parameters	Raw effluent (mg/l)	Azolla (mg/l)
DO	0.0	43.1
BOD	319.9	129.1
COD	317.5	262.8
TH	5.69	3.25
TA	169.98	48.73
Chloride	274.51	101.35

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

Parameters	Raw effluent (mg/l)	Azolla (mg/l)	Stdev
DO	0	42.86667	±8.568048
BOD	315.7667	127.2333	±31.88118
COD	318.8667	263.4333	±26.03934
TH	5.441333	3.14	±0.900798
TA	170.6567	49.88	±12.02878
Chloride	274.3233	101.2967	±17.00764

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

Parameters	Azolla(%)
DO	–
BOD	59.706
COD	17.384
TH	49.293
TA	70.771
Chloride	63.073

Table 6- trail 1

Parameters	Raw effluent (mg/l)	Azolla (mg/l)
DO	0.0	28.0
BOD	200.0	152.0
COD	104.0	80.0
TH	1.88	1.52
TA	84.26	30.0
Chloride	141.16	63.62

Table 7-trail 2

Parameters	Raw effluent (mg/l)	Azolla (mg/l)
DO	0.0	30.5
BOD	199.1	102.5
COD	103.9	81.2
TH	3.25	1.70
TA	83.63	31.41
Chloride	141.16	63.11

Table 8- trail 3

Parameters	Raw effluent (mg/l)	Azolla (mg/l)
Do	0.0	31.7
Bod	199.7	103.2
Cod	104.6	80.8
Th	3.31	1.50
Ta	84.17	31.45
Chloride	140.69	63.03

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

Parameters	Raw effluent (mg/l)	Azolla (mg/l)	Stdev
DO	0	30.06667	±3.342706
BOD	199.6	119.2333	±26.59973
COD	104.1667	80.66667	±15.79096
TH	2.813333	1.573333	±0.539509
TA	84.02	30.95333	±7.587035

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

Parameters	Azolla (%)
Do	–
Bod	40.263
Cod	22.560
Th	44.075
Ta	63.159
Chloride	55.140

Table 11- trail 1

Heavy metals	Raw effluent (mg/l)	Azolla (mg/l)
Copper	0.0096	0.0
Manganese	4.5	3.6
Iron	10.78	9.60
Nitrate	46.74	20.37
Sulphate	4.00	0.54

Table 12- trail 2

Heavy metals	Raw effluent (mg/l)	Azolla (mg/l)
Copper	0.0098	0.0
Manganese	4.6	3.9
Iron	10.81	9.50
Nitrate	43.52	18.99
Sulphate	4.10	0.69

Table 13-trail 13

Heavy metals	Raw effluent (mg/l)	Azolla (mg/l)
Copper	0.0096	0.0
Manganese	4.3	3.5
Iron	10.66	9.35
Nitrate	42.70	9.35
Sulphate	4.07	0.55

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

Heavy metals	Raw effluent (mg/l)	Azolla (mg/l)	Stdev
Copper	0.009667	0	±0
Manganese	4.466667	3.666667	±0.841295
Iron	10.75	9.483333	±0.500934
Nitrate	44.32	16.23667	±2.009063
Sulphate	4.056667	0.593333	±0.395517

Table 15. Percentage reduction of effluent heavy metal in 50% concentration.

Heavy metals	Azolla (%)
Copper	100
Manganese	17.910
Iron	11.782
Nitrate	63.364
Sulphate	85.373

Table 16-trail 1

Heavy metals	Raw effluent (mg/l)	Azolla (mg/l)
Copper	0.0077	0.0
Manganese	2.9	2.5
Iron	5.93	3.84
Nitrate	18.79	10.26
Sulphate	2.10	0.35

Table 17-trail 2

Heavy metals	Raw effluent (mg/l)	Azolla (mg/l)
Copper	0.0078	0.0
Manganese	3.0	2.7
Iron	5.89	3.71
Nitrate	18.65	10.03
Sulphate	2.00	0.31

Table 18-trail 3

Heavy metals	Raw effluent (mg/l)	Azolla (mg/l)
Copper	0.0077	0.0
Manganese	3.1	2.3
Iron	5.90	3.91
Nitrate	18.772	10.17
Sulphate	2.00	0.29

Table 19: Av. & St. dev of effluent heavy metail at 25% conc.

Heavy metals	Raw effluent (mg/l)	Azolla (mg/l)	Stdev
Copper	0.007733	0	±0
Manganese	3	2.5	±1.276715
Iron	5.906667	3.82	±0.188336
Nitrate	18.73733	10.15333	±1.023035
Sulphate	2.033333	0.316667	±0.253888

Table 20: Percent reduction of effluent heavy metal in 25% conc

Heavy metals	Azolla (%)
Copper	100
Manganese	16.666
Iron	35.327
Nitrate	45.812
Sulphate	84.426

Conclusion

The textile industry effluent is one of the most important sources of pollution. The present study was undertaken with the prime objective to know the potential of selected aquatic macrophyte *Azolla* pinnata in reducing the pollutant concentration of textile industry effluent. This work revealed that the selected aquatic macrophytes are highly efficient in absorbing most the of pollutants from the effluent thereby reducing the pollution load. Heavy metals Copper, Manganese, Iron, Nitrate and Phosphates are the major contaminants in the textile effluent. *Azolla pinata* was found to play a key role in removal of heavy metals. These macrophytes showed different trend in their percentage removal of heavy metals. It was observed that *Azolla pinnata* was able to remove Sulphate from the effluent. From the foregoing observations it can be concluded that phytoremidiation is an, efficient , cost effective, alternate technology for treatment of recalcitrant industrial wastes. The study proves that Azolla is considerd as unwanted aquatic weeds can be successfully utilized for the degradation of textile industry waste. Therefore, this environment friendly system can be adopted in the field of phytoremediation.

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