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Phytoremediation of Tannery Effluent by Water Hyacinth (*Eichhornia crassipes*)

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ABSTRACT

Increasing of urbanization, industrialization and over population are leading causatives of environmental pollution. Small and medium scale industries in Tamil Nadu playing a major role in polluting water bodies and key among pollutants are suspended solids, biological oxygen demand and heavy metals contamination. Conventional methods of treatment such as chemical precipitation does not provide sustainable solutions as the pollutants are merely transferred from the waste water to a sludge residue which is disposed of by land-filling. The pollutants eventually find their way to contaminating freshwater supplies. Phytoremediation, an eco-friendly technology which is ecologically sound and economically viable; it is also an attractive alternative to the current cleanup methods that are very expensive. This technology involves efficient use of aquatic plants to remove, detoxify or immobilize heavy metals from waste water.

KEYWORDS : Tannery effluent, heavy metals, physico-chemical parameters, phyto remediation

INTRODUCTION

Industrial discharges, effluents or wastewater produce high levels of pollutants that can subsequently contaminate the soil, sediments and surface water systems (Forstner and Salomons, 1991; Dekov, 1997; Evangelou, 1998).

Wastewater is considered one of the most important resources which could be a precious one if treated and managed well to be reused. However, in practice most of this domestic and industrial wastewater is discharged untreated or partially treated contains a wide range of toxic chemicals and pathogens, causing serious health issues for human health and environment (Scott *et al*., 2004).

Complete removals of heavy metals from effluents by conventional methods are insufficient. An alternative, naturally occurring biological tool called bioremediation, includes the use of microorganisms, plants and their products to remove contaminants is being substituted in pollution control process globally. The development of cost effective and environmental friendly technologies for the remediation of heavy metals from polluted soils and wastewaters is a topic of global interest.

Particularly, phytoremediation is complementary technology that can be used along with or, in some cases in place of mechanical conventional cleanup treatments that often require high capital inputs, more labor and energy intensive (Cunningham *et al.,* 1996). It is a less destructive to the environment, cost effective, aesthetically environmental pollutants removal approach most suitable for developing countries.

The value of metal-accumulating plants to wetland remediation has been recently realized and can be used as *in-situ* or *ex-situ* technique (Cheng *et al*., 2002 and Rai *et al*., 1995). Worldwide, there are around 400 plant species known to accumulate heavy metals in large amounts (Baker *et al*., 2000). The floating aquatic flowering plant water hyacinth, *Eichhornia crassipes* is known as a invasion plant. It is capable of rapid reproduction in shallow water and able to tolerate a wide range of environmental conditions (Toft *et al.,* 2003).

Hyacinth has been known to assist in the purification of wastewater because of its settlement action and absorption capacity. Its ability to reduce organic matter (Mangkoedihardjo, 2006), fecal coli forms (Mayo and Kalibbala, 2007) and heavy metals (Malik, 2007) has been reported. Many studies reported that water hyacinth was an excellent accumulator for Cd, Se, and Cu (Soltan and Rashed, 2003). While more than 93% of arsenate and 95% of arsenate were removed from a solution containing 200µg/l arsenic within 60 min of exposure to the powder of non-living dried roots of water hyacinth (Ranalli *et al.,* 2005).

Keeping the above facts in mind, the present study was planned to assign water hyacinth, *Eichhornia crassipes* as phytoremediator for heavy metals present in industrial wastewater, using the plant's root in different forms (whole fresh roots, whole dry roots, coarse grinded dry roots, and fine grinded dry roots) under controlled experimental conditions. The quality of treated wastewater was compared to FAO guidelines to evaluate its suitability for reuse in irrigation.

MATERIALS AND METHODS

Sample Collection

The tannery effluent sample was collected in sterile screw capped container from tannery industry located at Thiruvalarchipatti, Tiruchirappalli Dt., Tamil Nadu, South India during January 2015. The samples were brought to the laboratory and stored in refrigerator for further use.

Estimation of physico-chemical parameters of tannery effluent (APHA, 1998)

Physico-chemical parameters of the tannery effluent including pH, turbidity, conductivity, total solids, total dissolved solids (TDS), TSS, sodium, potassium, nitrate-nitrogen, salinity, biological oxygen demand (BOD) and chemical oxygen demand (COD) were analysed by the standard methods recommended by APHA, (1998).

Effluent treatment using *Eichhornia crassipes*

Approximately 20 L of raw effluent from tannery was brought to the laboratory in plastic containers and the experiments were set up in plastic tubs in triplicate. Ten L of the 50% effluent were prepared and

transferred to plastic tubs 40cm diameter in bottom and 60 cm diameter in top. The plant used for the effluent treatment study was an emergent floating wetland macrophyte *Eichhornia crassipes* collected from Punnai Lake, Thanjavur District. It was identified by the local flora (Gamble, 1935: Mathew, 1983) The *Eichhornia crassipes* was introduced in to the experimental tubs, it consist tannery effluent and maintained in open place for 12-13 h of photo period. After 20 days, the plant was removed from the experimental setup and the treated effluent was analyzed for the physico-chemical parameters.

resultS and Discussion

The effluent water contain excessive, alkalinity may cause eye irritation in humans and chlorosis in plants. A raise in temperature may increase the odour of a water body by changing the evaporation of volatile odorous compounds. Insufficient dissolved oxygen in water leads to the onset of anaerobic condition and subsequent to the release of odorous / anoxious gases such as H_2S. On the other hand, when the dissolved oxygen is limited or in sufficient to facilitate microbial activity, CH_4 is released from carbon, odorous amines results from N_2 and the foul smelling H_2 and the foul smelling H_2S gas from sulphur (Avasan Maruthi, 2001). The untreated tannery effluent is very rich in organic carbon, potassium, sulphate, phosphate, chloride, magnesium and moderate levels of nitrogen but decrease 10-15 times after proper treatment and dilution. Some macro-and micro- nutrients, which are important for plant growth and yield, becomes toxic, beyond tolerance limit and cause adverse effect on plant growth and yield was discussed by Om *et al*. (1994).

In the present study, the physico-chemical parameters of untreated tannery effluent and *Eichhornia* plant treated effluent sample were analysed and compared. The following physico-chemical properties were analysed such as pH, turbidity, conductivity, total solids, TDS TSS, sodium, potassium, nitrate-nitrogen, salinity, BOD and COD. The pH 10, alkalinity 200 mg/L, DO 21.70 mg/L, BOD 200 mg/L, COD 500 mg/L, TDS 4500 mg/L, organic carbon 1.468 mg/L and nitrate 0.34 mg/L were recorded. This physico-chemical data denotes highly polluted nature. The absence of dissolved oxygen, free CO_2, high biological oxygen demand (BOD), chemical oxygen demand (COD), and total nitrogen values are the main indicators of its being heavily polluted due to industrial effluents. This indicates high organic pollution at this site (Table-1, Fig. 1, 2)

In the present investigation, colour of tannery effluent was changed from pale yellow to light dirty colour and the change of foul odour to clay soil odour after treatment. After the treatment of effluent with *Eichhornia* plant the physico-chemical parameters were changed viz., pH 8, alkalinity 98 mg/L, BOD 4 mg/L, COD 268 mg/L, TDS 2600 mg/L, organic carbon 0.950 mg/L and nitrate 0.09 mg/L. On other hand, pH of the tannery effluent was 11 and the concentration was 920 mg/L for BOD and 3980 mg/L for COD (Table-1, Fig. 1, 2). These are beyond the tolerance limit of the water causing shifting of the bacterial forms towards more tolerant zone leading to biodiversity. Total solids, total dissolved solids and suspended solids were also considerably high discussed by GOB, (1997) and ECR, (1997).

The pH seems to be the most important parameter in the biosorptive process; it affects the solution chemistry of the metals, the activity of the functional groups in the biomass and the competition of metallic ions (Galun, 1987). The pH of the water sample of the treatment sets was reached the neutral range after they treated with *Eichhornia* sp. The pH of raw effluents used for the present study was found to be alkaline. Correspondingly, the pH was reduced from alkaline to nearly neutral by treatment with aquatic macrophytes (Abioye, 2005; Mahmood *et al.,* 2005). It can be interpreted that the reduction in pH and electrical conductivity is due to absorption of pollutants by plant. Briefly, floating macrophytes were the efficient candidates for sodium removal. Water hyacinth (*Eichhornia crassipes)*, is a floating macrophytes whose appetite for nutrients and explosive growth rate has been put to use in cleaning up municipal and agriculture wastewater (Gupta, 1980).

Several plant species of north east India, both terrestrial and aquatic, possess substantial hyper accumulating power that can be used for Cu phytoremediation from soil and water. Only the need of the hour is rapid research and development in this emerging field. Generally, the root type as well as contact time during treatment were the main key factors governing the process. The type of heavy metal removed also played an important role. The absorption capacity for water hyacinth was estimated at 0.24 kg/ha for Cd, 5.42 kg/ha for Pb, 21.62 kg/ha for Cu, 26.17 kg/ha for Zn, and 13.46 kg/ha for Ni. This study reported that water hyacinth to be a promising candidate for Phytoremediation of wastewater (effluent) polluted with Cu, Pb, Ni, Zn, and Cd (Liao Shao *et al.,* 2007). The plants accumulated Cu, Cr, and Cd up to 0.96, 0.83, and 0.50% respectively, of their dry root mass. However, lead and nickel were poorly accumulated in water hyacinth. Also, nonliving biomass of water hyacinth dry roots showed ability to accumulate all metals (El-Gendy *et al.,* 2006).

Table.1: Physico - chemical parameters of tannery effluent before and after treatment of *Eichhornia crassipes.*

S.No	Parameter	Before Treatment	After Treatment
1	Colour	Pale yellow colour	Light dirty colour
2	Odour	Foul	Clay soil
3	pH	10	8.0
4	Alkalinity mg/l	200	98
5	Free CO2 mg/l	90	98
6	Chloride mg/l	53.12	41.4
7	DO mg/l	21.70	Nil
8	BOD mg/l	200	4.0
9	COD mg/l	568	268
10	Ammonia mg/l	5.3	4.1
11	Nitrate mg/l	0.34	0.09
12	Nitrite mg/l	0.13	0.03
13	In organic PO4 mg/l	1	0.9
14	Organic Carbon mg/l	1.468	0.950
15	TDS(Total Dissolved Solid) mg/l	4500	2600

Fig. 1: Physico-chemical parameters of tannery effluent before and after treatment

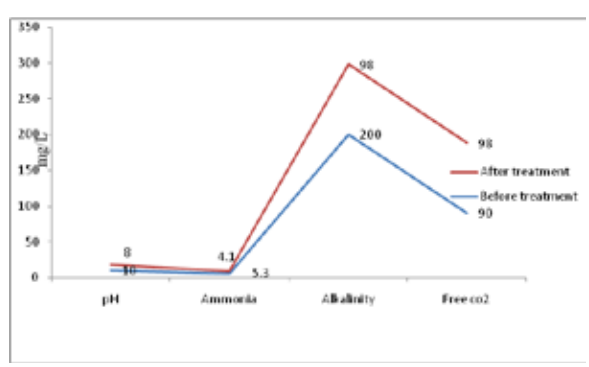
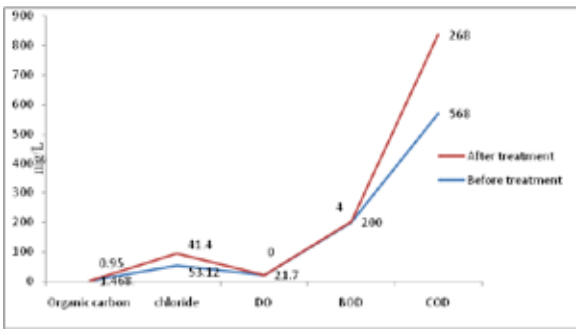


Fig. 2: Physico-chemical parameters of tannery effluent before and after treatment



SUMMARY AND CONCLUSION

Industrial waste water discharged was contaminated with a wide range of toxic chemicals and pathogens causing serious health problems in human health and environment. Aquatic plants are very effective in removing heavy metals from polluted water. Plant assimilation of nutrients and its subsequent harvesting are another mechanism for pollutant removal. Low cost and easy maintenance make the aquatic plant system attractive to use. *Eichhornia crassipes* can also remove other toxins, such as cyanide, which is environmentally beneficial in areas that have endured gold mining operations. The *Eichhornia* plant reduce pH 10 to 8, TDS 4500 mg/L to 2600 mg/L and other parameters also reduced 17-28%. So, the present investigation concluded that phytoremediation is suitable and low cost technology to remove or degrade the pollution from industrial effluent like tannery effluent. The *Eichhornia.crassipes* is an extraordinary tool for effluent treatment if it is properly concentrated on phytoremediation technology and it could be utilized the benefits and safe of our environment.

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