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Research Paper

Phytoremediation as an Alternative for Treatment of Paper Industry Effluents by Using Water Hyacinth (*Eichhornia crassipes*)-A Polishing Treatment

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Abstract: *Phytoremediation offers greater potentials to remediate contaminated water over conventional and costly methods. Phytoremediation potential of Eichhornia crassipes was studied in vitro for the period of 15 days to investigate the removal of pollutants in paper industry effluent with special reference to nutrients. Paper plant effluents were collected and stored in 5 L bottle for the culture of Eichhornia crassipes. Waste water was initially analyzed for physicochemical parameters i.e. pH, conductivity, TDS, DO, BOD, COD, turbidity, total phosphorous and TKN, NPP and heavy metal. After 15 days, of phytoremediation different physical, chemical, biological parameters were measured and Net primary productivity (NPP) was determined. This experiment was repeated several times and finally the mean value of data has been interpreted. Several studies shows plants such as the water hyacinth accumulate inorganic forms of nitrogen and phosphorus found in waste water and accumulate to a large extent in the roots, as well as different part of the plant. This quality signifies a second possible use for the water hyacinth as 'compost', or organic fertilizer. Water hyacinth has the capability to accumulate heavy metal as well, which was analyzed by Atomic Absorption Spectrophotometer (AAS).Water hyacinths absorb and digest waste water pollutants, converting effluents to relatively clean water. As well as due to its fiber nature it will also use as raw material for paper production.so it has been concluded that this plant emerged is a potential tool for treatment of paper mill effluent.*

Keywords: Phytoremediation, Eichhornia crassipes, Pollutants, Paper industry effluent.

Introduction

Phytoremediation is an emerging technology that uses various plants to degrade, extract and immobilize contaminants from soil and water. Pulp and paper industry has adverse environmental impact, due to generation of effluents with high concentrations of suspended solids, organic load, as well as high toxicity [1]. The deliberate discharge and release of harmful chemical compounds i.e.adsorbable organic halides (AOX) used for pulp bleaching, have the potential to disrupt the structure and functioning of the natural ecosystems [2].

Waste water consist of different dissolved organic contaminant. Plants take up those organic contaminants through the roots, transport them to the leaves, and accumulate in their body [3].Presence of enrichment amount of nitrogen and phosphorus in the paper industry effluent is the main cause of eutrophication in aquatic ecosystem[4].Aquatic plants have shown their efficiency in absorbing nutrients from various sources of polluted water [5]. Removal of nitrogen and phosphorus as well as wastewater purification has been recorded by using water hyacinth [6].Potential utility for removal of nutrients by some macrophysics like Eichhornia crassipes has been tested by different scientist [7, 8].The recent application in treatment of municipal waste, textile waste and different industrial waste by using water hyacinth is quite interesting and revealing [9, 10]. This technology has been receiving attention lately as an innovative, economic, cost-effective method at hazardous waste sites.

In light of above knowledge, presented work was planned to study the Phytoremediation potential of Water hyacinth (Eichhornia crassipes) in the removal of pollutants in paper industry effluent with special reference to nutrients in laboratory condition.

Material and Methods

In the present study, the young test plants (Eichhornia crassipes) which can double its size in two week were collected from Nagabali River Nearer To J.k pur. For my study I had collected waste water from J.k paper mill which creates a major problem to the nearest habitat. Phytoremediation potential of Water hyacinth (Eichhornia crassipes) in the removal of pollutants from Paper industry effluent was determined in the Laboratory by performing culture experiment.

Experimental set up: To access nutrient removal capacity of Eichhornia crassipes from Paper industry effluent, an off-site culture experiment was conducted in laboratory. The test plants (Initial weight taken after keeping them on a filter paper to remove excess water) were transferred to plastic troughs having capacity of five liters containing waste water of different concentrations. Before transferring plants into troughs, initial physical, chemical and biological parameters were analyzed. The experiment was divided into five sets.

Set 1: 25% Waste water+75% Tap water,

Set 2: 50% Waste water+50% Tap water

Set 3: 75% Waste water+25% Tap water,

Set 4: 100% Waste water

Set 5: Control (Tap water without dilution)

After 15 days, the analysis of treated water was taken for different physical, chemical, biological parameters and again the fresh biomass of plant after phytoremediation was noted for the determination of Net primary productivity (NPP). After 15 days Bioextraction occurred due to saturation of nutrient in plant so it was analyzed only for 15 days. This experiment was repeated three times and finally the mean value of data has been interpreted. All the analysis was done by following APHA-AWWA-WPCF-1980[16].

Net Primary Productivity (NPP) determination

Net Primary Productivity was determined by following Harvest method.

B_f - B_i/dt, Where Bf: Final biomass, B_i: Initial biomass in g/m-2/day, dt: No. of days of Culture

Procedure: Standard analytical methods are followed for determination of Physico-chemical and Biological parameter of wastewater according to Table 1.

Results and Discussion

Phytoremediation refers to the natural ability of certain plants called hyper accumulators to bioaccumulate, degrade or render harmless contaminants in water, air and soil. Contaminants such as metals, pesticides, organic waste, solvents, crude oil, and its derivative have been mitigated by phytoremediation. So it is considered as a clean, cost effective and ecofriendly technology as compared to mechanical cleanup method.

This weed is well known for its reproduction potential and as a plant that can double its population in twelve days [11]. The present work utilizes the response of a free floating aquatic weed (Eichhornia crassipes) to evaluate the remediation efficiency of paper industry waste.

Analysis of results:

The wastewater parameters were analyzed in labs as per the APHA (American public health administration) procedures.

The pH level was reduced significantly in all concentration as shown in figure 1 which clearly indicates Eichhornia crassipes can be used in area where acidity of soil is very high.

Table 1
Physico-chemical and Biological analysis of wastewater*

Parameters	Analytical method	References
pH	Glass electrode method(Potentiometer)	Jackson and Andrew(1996) [15]
Conductivity	Conductivity meter(conductometric)	Jackson and Andrew(1996) [15]
TDS	Filtration and Evaporation(103^{o}C) method	APHA(1992) [13]
DO	Modified Winkler's method	APHA(1976) [14]
BOD	Modified Winkler's method	APHA(1976) [14]
COD	Open reflux method	APHA(1992) [13]
Turbidity	Nephelometric turbidity units (NTU) method	USEPA(1993) [18]
TKN	Kjeldhal digestion and distillation method	APHA(1976) [14]
Total phosphorus	Stannous chloride method	APHA(1976) [14]
NPP	Harvest method.	Ripley et al.,(2006) [12],D.k Patel [4]
Heavy metals	By atomic absorption spectrophotometer (AAS)	USEPA(2007) [17]

*All The data of physicochemical parameter are mean values of three different experiments

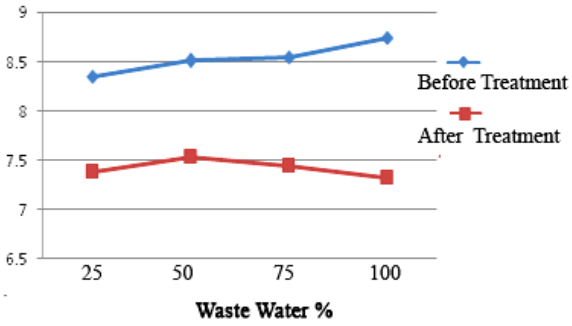

Figure 1: The values of pH before and after treatment

TDS was measured in Filtration and Evaporation (103^{o}C) method. The total dissolved solid removal by Eichhornia crassipes was good in almost all concentration as shown in figure 2. There occurred a maximum removal of 69.23% in 100% waste water and minimum i.e. 58.20% in 25% waste water.

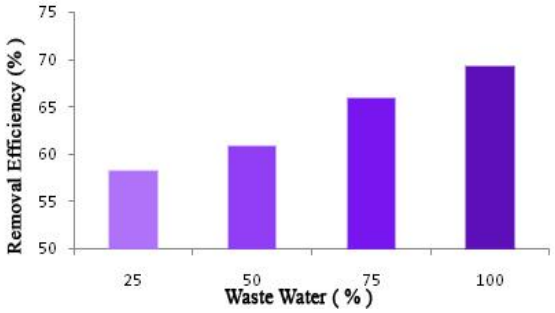

Figure 2: TDS removal efficiency of water hyacinth

Electrical conductivity (EC) estimates the total amount of Dissolved ions in the water. It is measured by "conductivity meter" and the unit is micro Siemens (1µS=1 µmho/cm). Water hyacinth decreased conductivity in all concentrations. But it was maximum in 100% waste water where it decreased from 1430 µmhos to 450 µmhos as shown in figure 3.

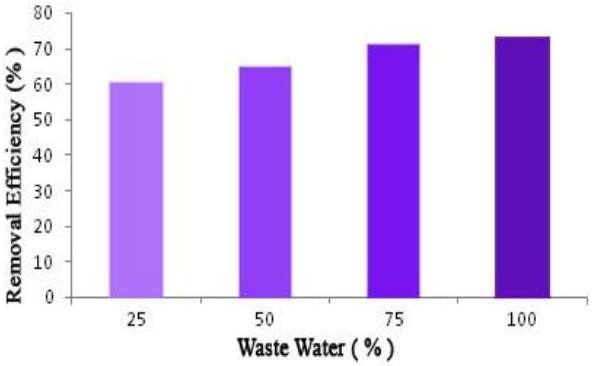

Figure 3: EC removal efficiency in %

In our study, water hyacinth increased the DO level in all wastewater samples. The highest increase of 72.5% in 100% waste water as shown in figure 4.

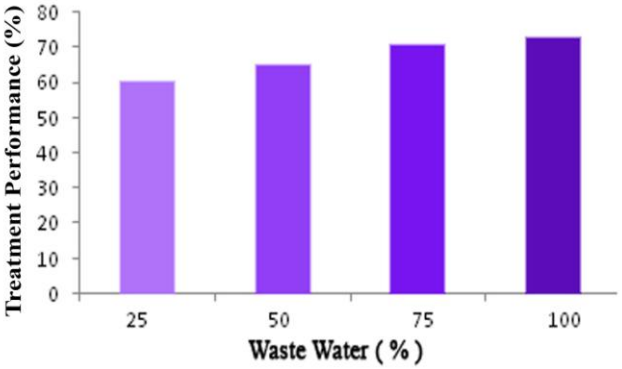

Figure 4: increasing level of DO by Water hyacinth

The BOD removal by water hyacinth in different concentration shows that it cannot perform well in 100% waste water having high BOD value. In our study we found that, it reduced maximum BOD level in 75% waste water and almost same in 25% and 50% waste waters as shown in figure 5.

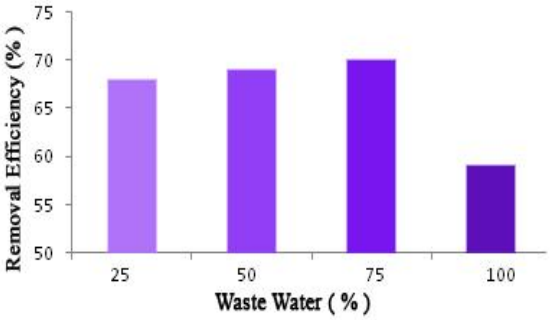

Figure 5: BOD removal efficiency (%) of Water hyacinth

In the present study, the test plant (Eichhornia crassipes) shows Maximum reduction of COD in 100% waste water while minimum in 25% waste water as shown in figure 6.

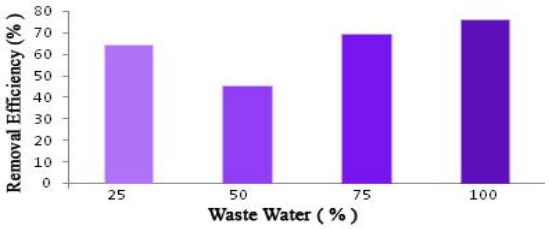

Figure 6: COD removal efficiency (%) by Water hyacinth

Turbidity can be measured using either an electronic turbidity meter or Nephelometric turbidity units (NTU).Turbidity was efficiently removed by water hyacinth in all its concentration shown in figure 7 but maximum removal was found in 75% waste water and almost same in 100% waste water.

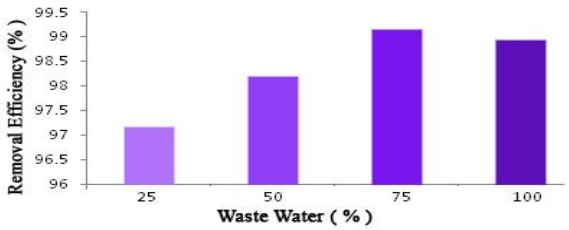

Figure 7: Turbidity removal efficiency by Water hyacinth

In the present study, Eichhornia crassipes removed nitrogen in all concentration. Maximum removal was found in 100% wastewater and almost same in 75% waste water, while minimum in 25% waste water as shown in figure 8.

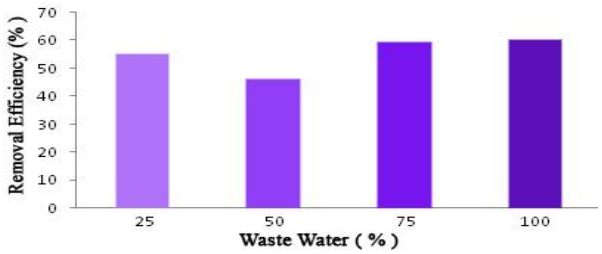

Figure 8: TKN removal efficiency in %

As far as phosphorus is concerned the test plant removed phosphorus in all concentration as shown in figure 9. Maximum removal was found in 100% wastewater.

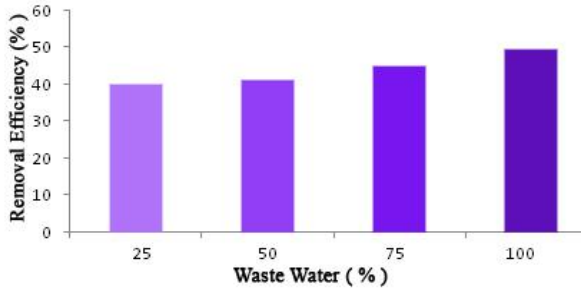

Figure 9: Total phosphorus removal efficiency in %

The results show that plants such as the water hyacinth accumulate appreciable amounts of the inorganic forms of nitrogen and phosphorus found in paper mill effluent. This quality signifies second possible use of water hyacinth as compost and organic fertilizer. A higher value of NPP was recorded in 100% waste water due to high concentration of nutrient as shown in figure 10.

The test plant (Eichhornia crassipes) reduced all the physico-chemical and biological parameters to a Significant level efficiently in 100% waste water. so the heavy metal was only analyzed for 100 % Waste water by Atomic Absorption Spectrophotometer (AAS). It was concluded that water hyacinth is more efficient for heavy metal phytoremediation.From different heavy metal Cu was efficiently accumulated by water hyacinth and its removal efficiency was 71.35% as shown in figure 11.

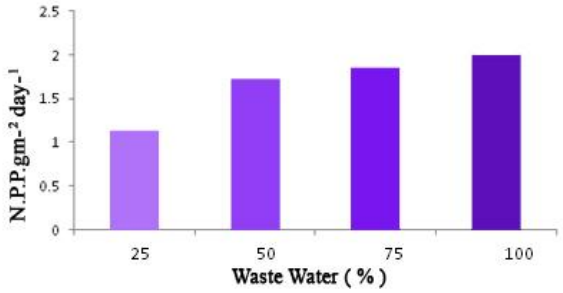

Figure 10: N.P.P in gm. m $^{-2}$.day^{-1} of Eichhornia crassipes after 15 days of culture in paper mill effluent

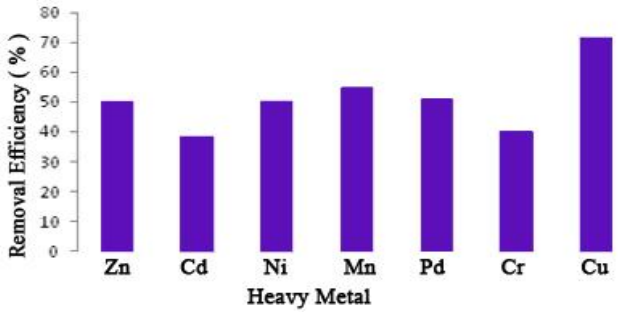

Figure 11: Heavy metal removal efficiency (%) by water hyacinth

Conclusion

The results indicate that, the test plant (Eichhornia crassipes) reduced all the physico-chemical and biological parameters to a significant level in all dilutions (i.e. 25, 50, 75, 100% waste waters) but the efficiency of removal is very high in 100% waste water. However, the dissolved oxygen (DO) and NPP showed an increasing trend to a significant level and it is highest in 100% waste water. It may be used for at least primary and secondary treatment, if aquatic systems are developed in a proper way. This plant might be utilized as an efficient, economical and ecological alternative to accelerate the removal and degradation of pollutant present in waste water.

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