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Paper Mill Pollutants Reduction-*Azolla pinnata*

Sivakumar D[1*], Shankar D[2], Durai Arasu T[1] and Ragothaman VM[1]

[1]Department of Civil Engineering, Vel Tech High Tech Dr. Rangarajan Dr. Sakunthala Engineering College, India

[2]Department of Pharmaceutical Chemistry, K.M. College of Pharmacy, India

[*]**Corresponding author:** Sivakumar D, Department of Civil Engineering, Vel Tech High Tech Dr. Rangarajan Dr. Sakunthala Engineering College, Avadi 600 062, Chennai, Tamil Nadu, India, Tel: 919790973774; E-mail: shri.sivakumar1974@gmail.com

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Abstract

In this present study, *Azolla pinnata* an aquatic plant was used to remove pollutants from effluent of paper mill. The constructed wetland study was conducted against dilution ratio, pH, and biomass of Azolla pinnata. The maximum percentage removal was found at the optimum dilution ratio of 6, pH of 8 and biomass 400 g for various parameters from the effluent of paper mill. The maximum removal percentage of 84.3%, 90.6% and 82.6% respectively for TDS, BOD, and COD from the effluent of paper mill. This study concluded that *Azolla pinnata* was successfully used for eradicating all properties from the effluent of paper mill.

Keywords: Paper mill; Phytoremediation; Azolla pinnata; Industrial effluent

Introduction

The surface water and groundwater are contaminated due to various industrial effluent when it is not discharged properly [1,2], the paper mill effluents are highly affecting the environment, because of paper mill effluent containing organic matter, BOD, COD, TDS, TSS, phenols, sulphate, calcium, magnesium, sodium and colour in high level. The various processes in a paper mill contributes the large quantity of effluent, which stands 20th rank in the world. The paper mill effluent may not be disposed on any medium with proper treatment, leading to contamination on those medium. The soil medium particularly was affected more when compared to water medium and in turn affects the growth of plants [3,4]. Hence, various contaminants are to be controlled, before actually being discharged on land and in water bodies.

The various conventional methods used for removing pollutants from paper mill effluent are adsorption [5-12], ion exchange, chemical precipitation, electro-chemical methods [13,14], bioremediation [15-19], electro-dialysis and electro-coagulation etc. Presently phytoremediation method using aquatic and terrestrial plants is consider more for treating various industrial wastewater, because of more advantages include: less cost; more efficiency; minimization of chemical and biological sludge.

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There are several studies conducted on growth rate of the plants stated that the growth rate was diminished when used raw paper mill effluent, whereas growth was improved when used in diluted conditions.

The constructed wetland is nowadays highly used for removing more organic oriented industrial effluent than other conventional methods. Before implementing, the basic knowledge on processes used in constructed wetland for removing various pollutants is required [20,21]. Thus, the present study focused on usage of *Azolla pinnata* an aquatic plant to remove various contaminants in a paper mill effluent [22-24].

Materials and Methods

Collection of *Azolla pinnata*

The aquatic plant *Azolla pinnata* was collected from aquarium, Chennai, the collected *Azolla pinnata* were cleaned using distilled water and kept for stabilization. The similar local pond conditions were established in the experimental constructed wetland by filling gravel and sand.

Collection of waste water sample

The paper mill effluent from Karur was collected with the help of air tight sterilized bottles. Samples were kept in the Environmental Engineering Laboratory for further analyzing the pollutants from paper mill effluent. The pollutant concentration was determined by APHA, 2005 [25]. The Physico-Chemical characteristics of paper mill effluent are presented in TABLE 1. The various parameters in the effluent from a paper mill are varied in a wide range depending on process details and working behaviour in the production step of industry.

TABLE 1. **Physico-chemical characteristics of paper mill effluent.**

Sl. No.	Characteristics	Values
1	pH	8.4
2	EC	5.63 µS/cm
3	TDS	2384 mg/l
4	BOD	1840 mg/l
5	COD	4560 mg/l
6	Calcium	358 mg/l
7	Chloride	542 mg/l
8	Alkalinity	356 mg/l
9	Sulphate	473 mg/l

Sorption experiments

For the experiments, 1000 ml of paper mill effluent was filled in experimental constructed wetland tanks. The samples of triplicate were collected after treatment. The experimentation was conducted for a period of 7 days with an interval of 1 day using *Azolla pinnata* against various dilution ratio (2, 4, 6, 8, and 10), pH (3, 4, 5, 6, 7, 8 and 9) and biomass (100 g, 200 g, 300 g, 400 g, and 500 g).

The pH was adjusted by using 0.1 M of NaOH and 0.1 M of HCl. The various parameters concentration from the effluent of paper mill before treatment and after treatment with *Azolla pinnata* were determined [25]. The percentage reduction was calculated as:

$$Percentage\,\mathrm{Re}duction = \frac{(\mathrm{C}_{1-}\mathrm{C}_2)}{C_1} \times 100 \qquad (1)$$

in which C_1 and C_2 are the concentration of the various parameters before and after treatment with *Azolla pinnata*.

Results and Discussion

The dilution ratio, pH, biomass against the contact time were selected as process parameters to remove TDS, BOD, and COD in a paper mill effluent rather than other parameters using *Azolla pinnata*.

Effect of dilution ratio

FIG.1 indicates the effect on dilution ratio for removing TDS, BOD and COD from the effluent of paper mill using *Azolla pinnata* against the different dilution ratios (day 6 pollutants reduction value only presented, because maximum reduction was obtained on day 6 only) with the contact time of day 6, biomass of 200 g, and pH of 5.

The results revealed that the percentage removal for TDS, BOD and COD from the effluent of paper mill is low at the starting of the experiment and then increases with dilution ratio. This is because; ions are loosely bonded in less concentration than high concentration, as a result, more reduction was completed in maximum dilution ratio by the *Azolla pinnata.* Up to a dilution ratio of 6, the sorption of various parameters from the effluent of paper mill by *Azolla pinnata* increased steadily and the same results were observed for the dilution ratio of 8 and 10, as that of dilution ratio 6.

Thus, optimum dilution for which maximum sorption taken place is 6. Further, the maximum sorption removal percentage was found to be 74.9%, 78.6% and 72.5% respectively for TDS, BOD, and COD (FIG.1).

Effect of pH

FIG. 2 represents the effect of pH to remove TDS, BOD and COD in a paper mill effluent using *Azolla pinnata*. The selected pH ranges from 3 to 9 with an increment of 1 for this study. The percentage reduction of TDS, BOD and COD in a paper mill effluent using *Azolla pinnata* against pH with a contact time of 6 days, biomass of 200 g, and an optimum dilution ratio of 6 was presented in FIG. 2.

The results revealed that the percentage removal of TDS, BOD and COD in a paper mill effluent is low at less pH than in high pH value. At acidic condition, there was good bond between various ions present in the wastewater, thus, *Azolla pinnata* could not be sorbed effectively. As pH increases, some of the ions become neutral and that could be sorbed easily by *Azolla pinnata.*

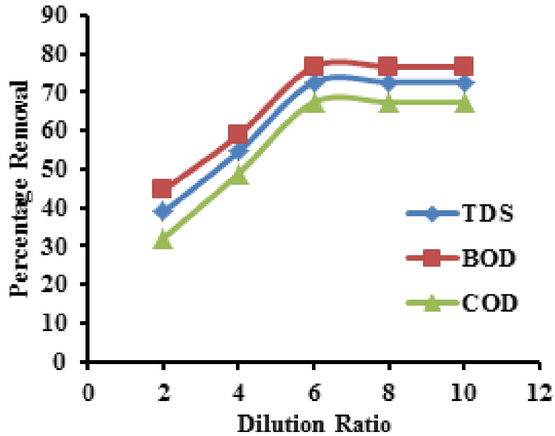

FIG.1. **Effect of dilution ratio on removal of TDS, BOD, and COD from paper mill effluent.**

Further, maximum reduction was found at pH of 8, beyond which (at pH 9 and 10), there was no further reduction as that of reduction in pH 8. Thus, optimum pH found in this study is 8 and the maximum sorption removal percentage of 79.8%, 86.3% and 77.2% respectively was observed for TDS, BOD and COD in a paper mill effluent by *Azolla pinnata* (FIG. 2).

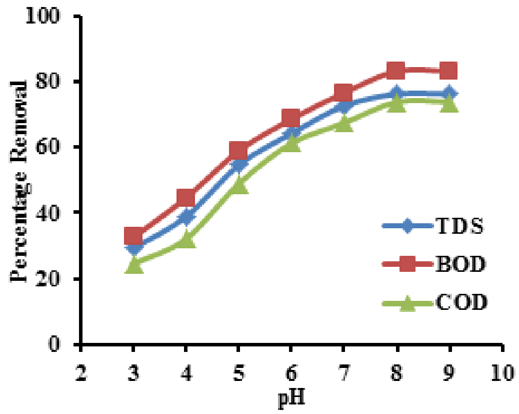

FIG. 2. **Effect of pH on removal of TDS, BOD, and COD from paper mill effluent.**

Effect of *Azolla pinnata* biomass

FIG. 3 indicates the effect of *Azolla pinnata* Biomass for removing TDS, BOD and COD from effluent of paper mill. The selected *Azolla pinnata* biomass ranges from 100 g to 500 g with an increment of 100 g. The percentage reduction of TDS, BOD, and COD from the effluent of paper mill using *Azolla pinnata* against biomass with a contact time of 6 days, optimum dilution ratio of 6, and optimum pH of 8.

The percentage reduction of TDS, BOD and COD in a paper mill effluent is low by *Azolla pinnata* at low biomass, and then increases with increased biomass.

The results indicated that at high biomass, the biomass is sufficient to remove the pollutants in a paper mill effluent than at low biomass, where biomass is not sufficient to sorb pollutants in a paper mill effluent.

For the biomass of 400 g, the maximum reduction was observed for all selected parameters, beyond which (for 500 g), there was no further reduction, as that of reduction observed for 400 g biomass. Hence, optimum biomass found in this study is 400 g and the maximum sorption removal percentage of 84.3%, 90.6% and 82.6% respectively was observed for TDS, BOD and COD from the effluent of paper mill by *Azolla pinnata* (FIG. 4).

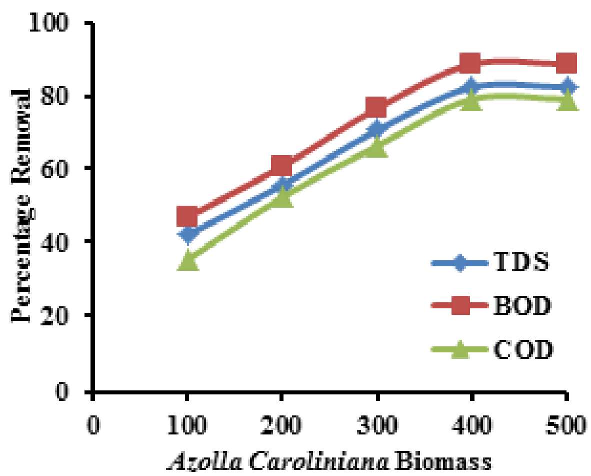

FIG. 3. **Effect of *Azolla pinnata* biomass on removal of TDS, BOD, and COD from paper mill effluent.**

From FIG. 1 to 3, it may be observed that the order of removal efficiency between TDS, BOD and COD in a paper mill effluent is BOD>TDS>COD against the selected process parameters of dilution ratio, pH, and biomass.

Conclusion

The constructed wetland experiments were done to know the aptness of *Azolla pinnata* for eradicating TDS, BOD and COD in paper mill effluent. The ability of *Azolla pinnata* was observed for removing TDS, BOD, and COD against the process parameters like dilution ratio, biomass, and pH. The results of this study indicated that the maximum removal percentage of TDS, BOD, and COD from the effluent of paper mill was found to be 84.3%, 90.6% and 82.6% respectively and it was identified at an optimum dilution ratio of 6, biomass of 400 g and pH of 8. Thus, this study concluded that the aquatic plant *Azolla pinnata* might be used as sorbents for removing TDS, BOD, and COD along with other parameters in paper mill effluent. Further, this study may extend to remove any pollutant from not only in a paper mill effluent, but also from any industrial wastewater.

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