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Original Research Paper

Bioremediation of Molasses Effluent Using Aquatic Plants

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ABSTRACT

Molasses is a thick syrup produced as a byproduct of sugar industries. It is used in industries like food, beverages, lactic acid and acetic acid manufacturing units. For the present study, the effluent samples were collected from lactic acid manufacturing company using molasses as a raw material. The physico-chemical parameters such as colour, odour, pH, EC, salinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), hardness, bicarbonates, alkalinity, chloride, nitrites, calcium, sulphate, sodium, potassium, magnesium and total free sugars (glucose) of both the effluents (untreated and industry treated) were studied to ascertain the role of aquatic plants (*Eichhornia crassipes*, *Pistia stratiotes*, *Ludwigia adscendens*) in bioremediation of molasses effluent. Among the plants used in the study, *Eichhornia* seems to be best in treating the industrial waste. The efficiency of treatment of the molasses effluent by the plants was *Eichhornia crassipes* > *Pistia stratiotes* > *Ludwigia adscendens.*

INTRODUCTION

There is an increasing concern about environmental pollution in India and the world over. Pollution is the unfavourable alteration of our environment, largely as a result of human activities (Southwick 1976). Among the contributing factors for water pollution, industrial wastes have the greatest potential for polluting the water bodies. The untreated effluents are discharged into low level areas, streams and lands, and affect the environment as well as the groundwater quality through seeping. Plants and microbes play an important role in cleaning up of the environment.

Bioremediation is the stimulation of microorganisms or macroorganisms to rapidly degrade hazardous organic contaminants to environmentally safe levels in soils, waters, sludges and residues (Jogdand 1995). But recently phytoremediation is an emerging technology that uses the plants to remove contaminants from soil and water. The technology of phytoremediation is relatively new, which uses green plants and their associate microbes and microbiota for the *in-situ* treatment of contaminated soil and water (Sadowsky 1999). It is the ability of rooted aquatic plants to perform the treatment functions. Conversely, aquatic macrophytes modify the aquatic environment through their development and metabolic activity (Madsen et al. 2001), have curative effect resulting in reduction some chemicals (Ratushnyak 2008), and can directly mobilize nutrients through root uptake.

MATERIALS AND METHODS

Effluent was collected from a lactic acid manufacturing unit using molasses as a raw material. Thirty litres of untreated and industry treated effluent was collected for bioremediation study. The water plants *Eichhornia crassipes*, *Pistia stratiotes*, and *Ludwigia adscendens* were harvested from the local ponds carefully without damaging the roots. Care was taken to have same size in each species. The physico-chemical parameters such as colour, odour, pH, electrical conductivity (EC), salinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), hardness, bicarbonates, alkalinity, chloride, nitrites, calcium, sulphate, sodium, potassium, magnesium and total free sugars (glucose) of both the effluents (untreated and industry treated) were studied following standard methods (APHA 2005).

For the phytoremediation water plants were introduced in the effluent (untreated and industrially treated) for 96 hours, and the physico-chemical parameters of both untreated and treated effluent was studied.

RESULTS AND DISCUSSION

Analysis of physico-chemical characteristics of both, untreated and industry treated molasses effluents, after biotreatment with the three aquatic plants is shown in Fig. 1.

The untreated molasses effluent was chocolate brown colour and industry treated effluent was pale yellow. Odour of the untreated effluent was burnt sugar, and industry treated effluent was slightly burnt sugar smell. Even after biotreatment with aquatic plants, there was no change in colour and odour both in untreated and industry treated effluents, which may be due to the presence of organic compounds present in the effluent.

The pH of untreated (8.90) and industry treated (7.5) effluent after biotreatment with *Eichhornia crassipes* was 7.81 and 7.2, with *Pistia stratiotes* 7.91 and 7.2 and with *Ludwigia adscendens* 8.1 and 6.9 respectively indicating that the plants bring about a reduction in pH.

Dissolved oxygen in the untreated molasses effluent was totally absent, while in industry treated effluent it was 4.14 mL/L. Dissolved oxygen level was found to be increased after phytoremediation to 4.28, 4.16 and 4.19 mL/L respectively by three plants *Eichhornia crassipes*, *Pistia stratiotes* and *Ludwigia adscendens*. It may be noted that permissible limit of DO is 4-6 mL/L, hence the results indicate that the increase of DO level was more efficiently carried out by *Eichhornia crassipes* than the other two plants, and this is due to thick and long roots of the plant.

Salinity of the untreated and industry treated effluent was 1.83 and 0.91 ppt (before biotreatment). The salinity reduced after biotreatment in the effluent treated with *Eichhornia crassipes* (1.27 and 0.21 ppt), *Pistia stratiotes* (1.31 and 0.62 ppt) and *Ludwigia adscendens* (1.36 and 0.23 ppt) respectively.

Total suspended solids (TSS) in the untreated and industry treated molasses effluent was 630 and 582 mg/L. After biotreatment with *Eichhornia crassipes* it reduced to 376 and 263 mg/L, with *Pistia stratiotes* 419 and 325 mg/L and with *Ludwigia adscendens* 448 and 334 mg/L. Results indicate that maximum level of TSS reduction in molasses effluent was done by *Eichhornia crassipes*. The BIS has specified maximum permissible limit for TSS as 100 mg/L in effluent dischargeable into water courses.

BOD of the molasses effluent (untreated and industry treated) was 1314 and 908 mg/L respectively, but when biotreated with *Eichhornia crassipes*, *Pistia stratiotes* and *Ludwigia adscendens* it showed reduction to a level of 870 and 516 mg/L, 967 and 720 mg/L, and 888 and 694 mg/L respectively, which is still higher than permissible limit of 30 mg/L prescribed by CPCB indicating that high organic load may be factor. Results indicate that the reduction of BOD in molasses effluent was more efficiently carried out by the *Eichhornia crassipes.*

The COD of untreated and industry treated molasses effluent was 4102 and 3898 mg/L. The biotreated waste with *Eichhornia crassipes* decreased COD to 3210 and 3007 mg/L, *Pistia stratiotes* to 3620 and 3214 mg/L, and *Ludwigia adscendens* to 3840 and 3220 mg/L respectively, which do not meet the standards (250 mg/L) prescribed by CPCB for effluent discharge into inland surface water. The maximum reduction of COD was achieved by *Eichhornia crassipes.* The difference in the reduction may be due to degrading/absorbing capacity of water hyacinth (*Eichhornia crassipes*). Probably the treatment requires more time for degrading/absorbing so as to reach CPCB norms. It may be pointed out that though *Eichhornia crassipes* seems to be more efficient, still it is unable to meet the CPCB norms for either BOD and COD, which are the prime pollutants of any industrial effluent.

Calcium in the untreated and industry treated molasses effluent before biotreatment was 80 and 116 mg/L. The calcium was reduced in the effluents treated with *Eichhornia crassipes* to 56 and 79 mg/L, *Pistia stratiotes* and *Ludwigia adscendens* to 54, 83 mg/L and 60, 76 mg/L respectively. In the same way magnesium, sodium and potassium levels of the untreated and treated effluent decreased considerably after biotreatment with the three aquatic plants. The reduction of magnesium, sodium and potassium in molasses effluent was more efficiently carried out by the *Eichhornia crassipes.* Aquatic plants are important components of lakes, ponds, rivers and stream ecosystems. In spite of their nuisance characteristic, the ecological and environmental significance of these plants, especially their capability to improve water quality, has created substantial interest in utilizing them for beneficial purposes. Plants contain a complete harmony of enzymes, which ensure the oxidation of essential intermediates. The importance of water hyacinth (*Eichhornia crassipes*) and its biodegradation capacity in the purification of wastewaters has already been reported by Wolverton (1987) and Adnan Abubakr (2010), and it is confirmed in the present study.

Eichhornia crassipes is commonly used in wastewater treatment, while *Pistia stratiotes* is rarely used, but *Ludwigia adscendens* is used for the first time in this study. From this study it may be noted that *Ludwigia adscendens* and *Pistia stratiotes* were able to clean up the molasses effluent for an extent, but the efficiency of *Eichhornia crassipes* is considered to be the best among all the three aquatic plants studied. *Eichhornia crassipes* was able to survive for more than 96 hrs, both in untreated and industry treated molasses effluent.

Pistia stratiotes could not survive in the effluent after 96 hrs. The plant is soft, small in size with short roots, and may be vulnerable to the toxic compounds present in the effluent. Further, the roots of the plant are small and the time to absorb the effluent is fast, whereas in *Eichhornia crassipes,* it takes time for the absorbing because of long roots, indicating that roots have a role in biodegradation. Histological studies of the roots of these plants may throw some light on the capacity of the plants for bioremediation. Similarly, *Ludwigia adscendens* was able to survive in treated effluent after 96 hrs because of the coiled nature, which is a surface

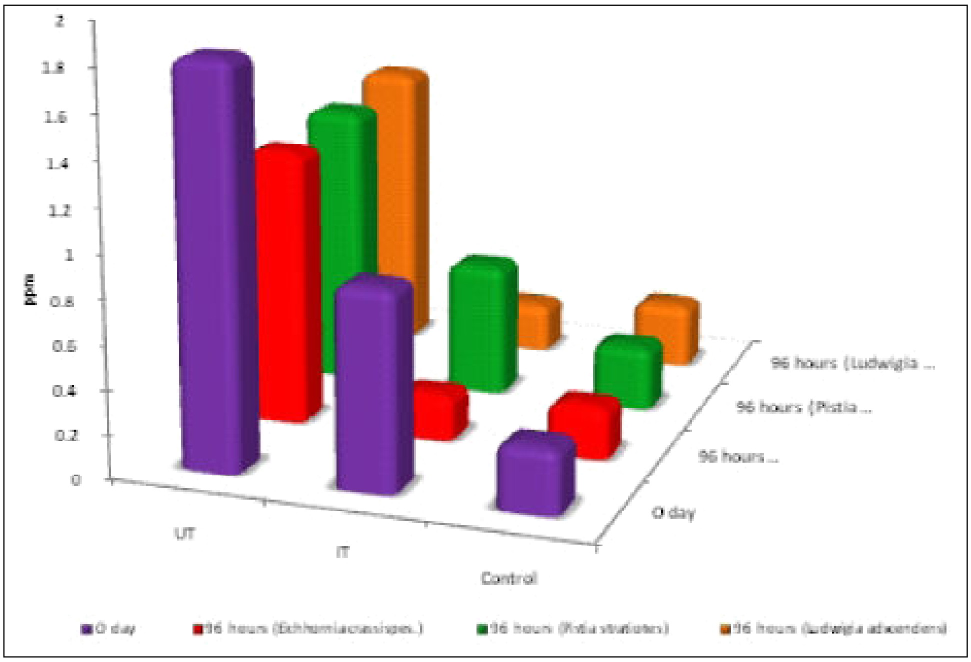

Fig .1: Salinity (ppt) of molases effluent after bioremediation using *Eichhornia crassipes, Pistia stratiotes* and *Ludwigia adscendens.*

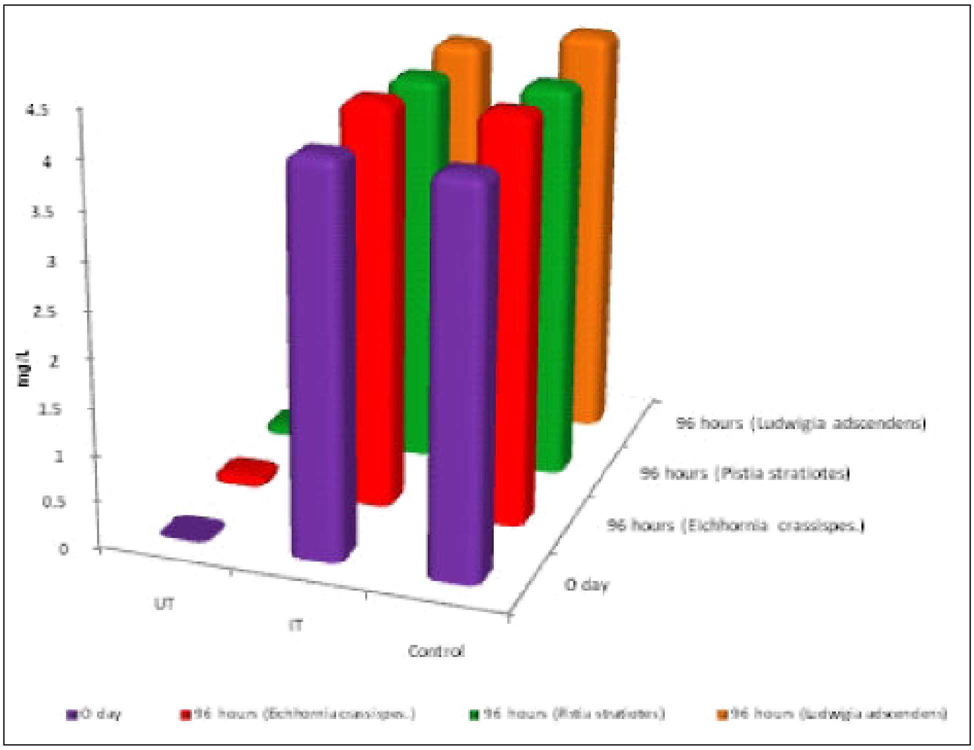

Fig. 2: Dissolved oxygen (mg/L) of molases effluent after bioremediation using *Eichhornia crassipes, Pistia stratiotes* and *Ludwigia adscendens.*

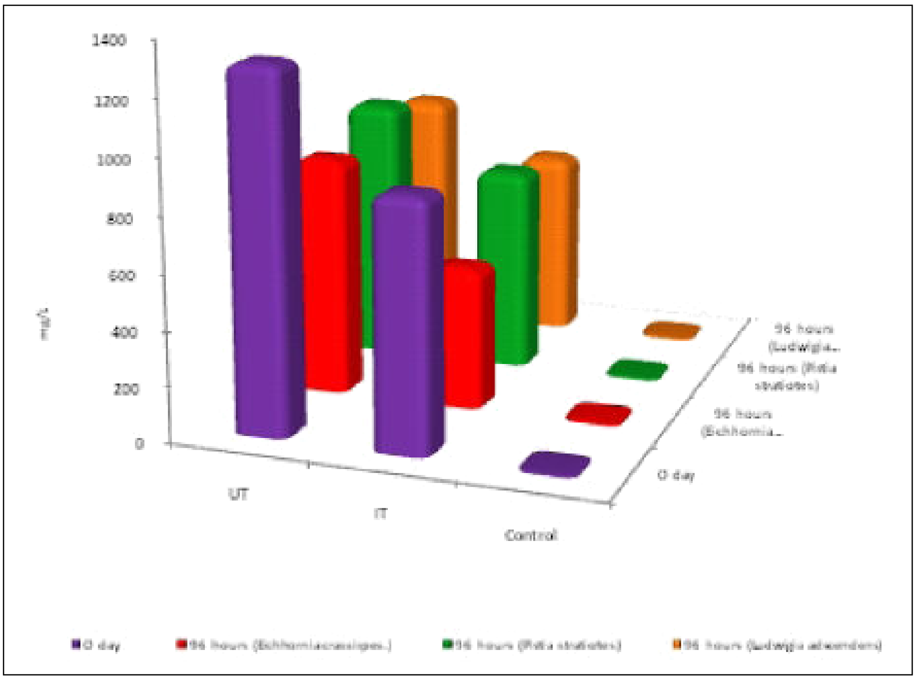

Fig. 3: Biochemical oxygen demand (mg/L) of molases effluent after bioremediation using *Eichhornia crassipes, Pistia stratiotes* and *Ludwigia adscendens.*

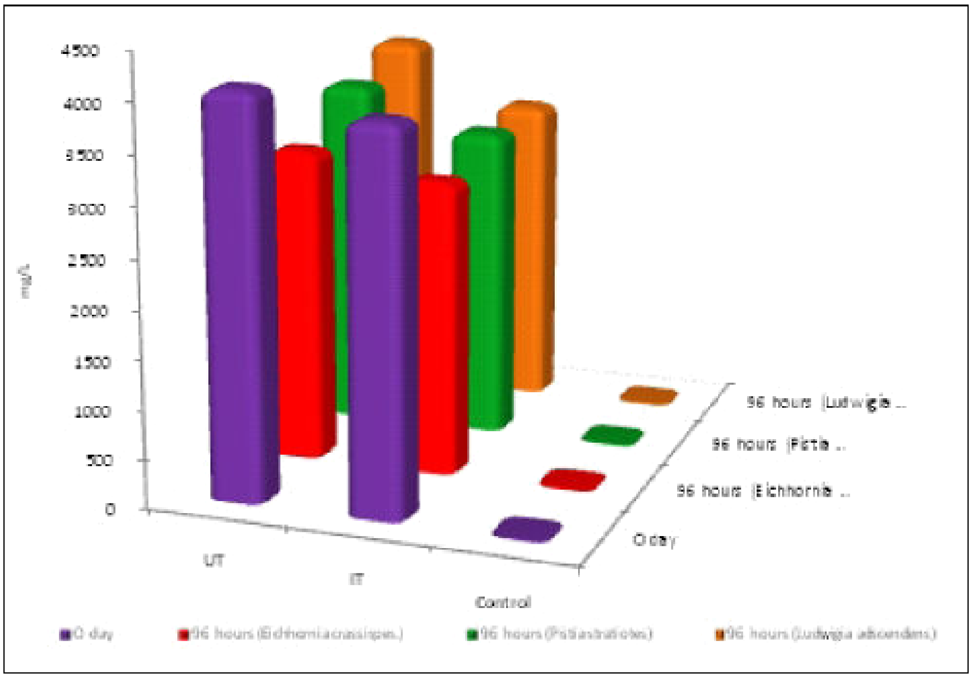

Fig. 4: Chemical oxygen demand (mg/L) of molases effluent after bioremediation using *Eichhornia crassipes, Pistia stratiotes* and *Ludwigia adscendens.*

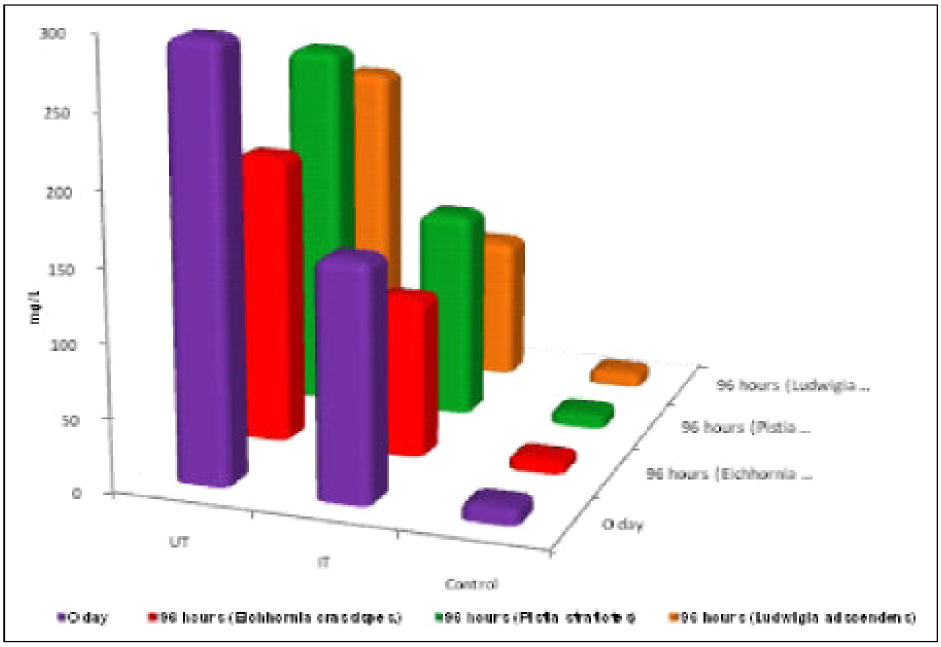

Fig. 5: Bicarbonates (mg/L) of molases effluent after bioremediation using *Eichhornia crassipes, Pistia stratiotes* and *Ludwigia adscendens.*

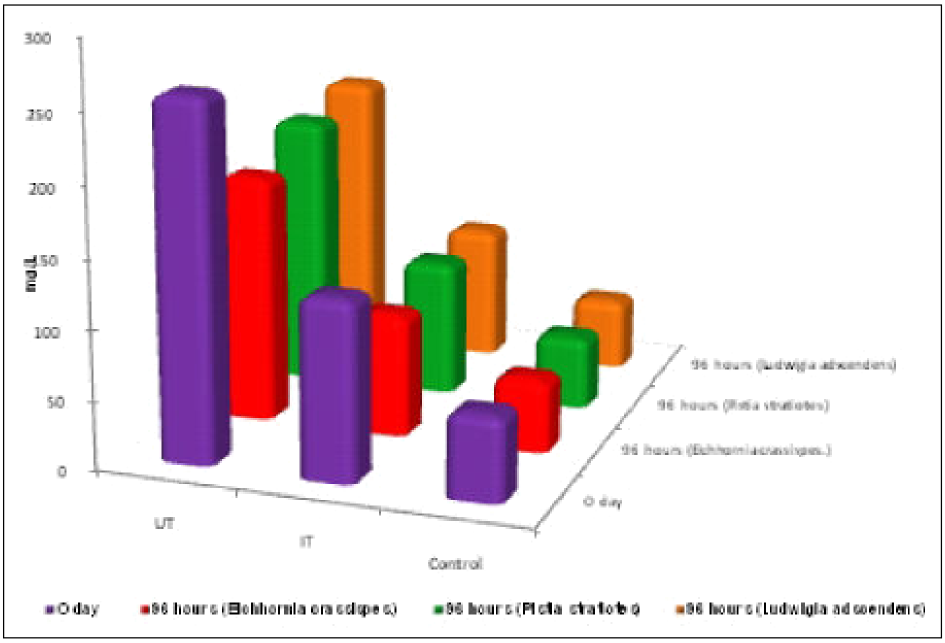

Fig. 6: Nitrites (mg/L) of molases effluent after bioremediation using *Eichhornia crassipes, Pistia stratiotes* and *Ludwigia adscendens.*

mover and survive with air pockets at the junctions. Among the plants used in this experiment, *Eichhornia crassipes* seems to be best in cleaning up of the industrial waste. It is noticed that superiority of water plants is *Eichhornia crassipes* > *Pistia stratiotes* > *Ludwigia adscendens* in cleaning up of the molasses effluent.

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