Phytoremediation of Dairy Effluent Using Aquatic Macrophytes

Chinchu.S.Nair and K.Mophin Kani

Abstract— The paper describes the role of aquatic macrophytes in dairy wastewater treatment. Aquatic plants azolla and water hyacinth are selected for the present study because of its availability and it has a huge potential for the removal various pollutants from wastewater and especially it has the ability to grow even in severely polluted water. A laboratory scale experiment was conducted by taking waste water from MILCO dairy plant and which was treated with both the plants. Experiment proved that significant reduction in pH, Biological Oxygen Demand, Total Solids etc., while treating with selected aquatic macrophytes.The result showed excellent removal efficiency with BOD, Magnesium Hardness, Total Hardness and Electrical Conductivity as 93.33%, 99.29%, 97.39%, 84.52% respectively treating with azolla. High removal efficiencies by both the plants may be due to absorption of the contaminants with the help of its root system. Comparatively azolla based treatment showed most efficient in removing the pollutants from dairy wastewater than water hyacinth based treatment system.

Index Terms— Aquatic macrophytes, Azolla, Biological Oxygen Demand, Phytoremediation, Wastewater, Water Hyacinth

1 INTRODUCTION

Wastewater treatment is the process of treating wastewater from different industries and making it suitable for discharging it into the environment without any causative agents. Wastewater treatment may be of three types- physical, chemical and biological. Using living organisms and plants for treatment of wastewater is categorized as biological treatment process.

Phytoremediation is one of biological wastewater treatment methods and it is based on the concept of using plant based systems and microbiological processes to eliminate contaminants from natural system naturally. In the phytoremediation process, selective plant roots helps in breaking the contaminants present in the soil or in absorbing the contaminants and store it in the plant body. Application of phytoremediation process includes the agricultural field especially for removing the contaminants and land preparation for cultivation, or wasteland site remediation and environmental restoration. This process can be effectively used for the remediation of pesticides, heavy metals, chlorinated compounds, hydrocarbons, explosives, excess nutrients etc., (Stanley Rungwa,2013). Aquatic plants have drawn more attention because of its rapid growth even in the polluted water and its capability to remove varieties of pollutants from domestic and industrial effluents.

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They are also having capability to remove excessive nutrients and other organic and inorganic elements from domestic sewage and industrial effluents (Bhadresh R. Sudani, 2014).

2 EXPERIMENTAL LAYOUT

The experiment was conducted for dairy plant wastewater. Aquatic plants like azolla and water hyacinth are used for the experiment by aclamatize these plants in the laboratory conditions and introduce in the wastewater as pilot scale research. The experiment was planned to assess the removal efficiency of some physical and chemical characteristics of the diary wastewater and to compare which plant is more effective for the dairy wastewater treatment among selected plants. The pilot model executed with the interval of 5 days respectively for four cycles from zeroth day.

2.1 Experimental plants

Water hyacinth (*Eichhornia crassipus*) is included in the family Pontederiaceae, is listed as one of the most productive plants on the earth and is considered the world's worst aquatic weed. It is a free-floating perennial plant which can grow to a height of 3 feet. It has circular or elliptical dark green leave blades attached to a spongy, inflated petiole. Thick, heavily branched, dark fibrous root system is an important feature of this plant. The root helps in phytoremediation process. It has light blue to violet flowers located on a terminal spike. (Dipu Sukumaran, 2011)

Azolla (*Azolla pinnata*) is included in the family Salviniaceae; small (usually only a few cm across) and float, but can be very abundant and have the speciality to form large mats over the water surface. Azolla floats on the

surface of water by means of numerous, small, closely overlapping scale-like leaves, with their roots hanging in the water. (Dipu Sukumaran, 2011)

Fig 1 Water Hyacinth

Fig 2 Azolla

2.2 Experimental Setup

Approximately 40 liters of raw effluent was collected from MILCO dairy plant and was brought to the laboratory and stored in laboratory conditions. The aquatic plants selected for the study viz Azolla and Water Hyacinth were collected freshly from natural ponds and Akkulam Lake, Trivandrum and brought in plastic bags along with water. These plants were cleaned properly to remove dirt and dust and stabilized in laboratory conditions for 1 week to normalise their growth. The wastewater after necessary dilutions were poured into three rounded, transparent plastic trough at a volume of 15 litres. The capacity of each plastic trough was about 20 liters. The plants which maintained in the stock tanks were collected and introduced in the experimental tanks separately on the basis of 100g/1liter of wastewater. The laboratory conditions were maintained uniformly throughout the experimental period of 15 days.

Fig 3. Untreated sample

Fig 4. Treatment using Water Hyacinth

Fig 5. Treatment using Azolla

2.3 Estimation of physico-chemical parameters of the effluents

Physicochemical characterization of wastewater samples (pre and post treatments) such as pH, EC,Turbidity, TDS, TSS, TS, BOD, Hardness etc., were determined by standard methods.

3 RESULTS AND DISCUSSIONS

In the present study, an attempt has been made to make comparative assessment of the efficiency of aquatic weeds like *Eichhornia sp*. and *Azolla sp*. on treating the dairy wastewater under laboratory conditions. The samples collected from the treatment setup were analysed periodically with a view to find out the periodical changes in its physicochemical properties brought by the growth of the respective weeds. The physicochemical properties of samples analysed includes the changes in pH, turbidity, conductivity, total solids, TDS, TSS, TS, BOD and Hardness. The percentage change (increase/decrease) in the physicochemical characteristics of control and effluent samples treated with aquatic macrophytes in retention time of 15 days were also assessed. The variation of physicochemical characteristics of dairy wastewater treated with water hyacinth and azolla is given on table 1.

3.1 Effluent treated with Water Hyacinth

A decrease in pH value was observed when the dairy effluent was treated with Water Hyacinth. In the initial stage the pH was 8.26 in this study whereas it was decreased to 7.56 after 15 days on treating with water hyacinth with the removal efficiency of 8.47%. The conductivity decreased during the treatment process. Turbidity showed a decreasing efficiency after 15 days of treatment as 51.85%.

The total hardness was initially measured as 61200 mg/l and it was decreased upto 2400mg/l on treating with water hyacinth after 15 days. Calcium hardness was decreased upto 58.33% during the study whereas calcium level was reduced from 1923.84mg/l to 801.6mg/l.

On treating with water hyacinth the TSS was reduced upto 6000mg/l after 15 days of the treatment. Total solids and total dissolved solids levels also showed considerable variation during the study period respectively as 86.92% and 85.89%.

3.2 Effluent treated with Azolla

When treated with Azolla, the pH of the diary effluent was found to decrease from the 8.26 to 7.8. The electrical conductivity at final stage was reduced when compared to initial stage in the treatments. The turbidity of dairy wastewater in the initial stage was 324 NTU. It was decreased upto 156 NTU on treating with azolla. The percentage decrease of turbidity was high in the case of azolla.

The total hardness was initially at the level of 61200 mg/l in the dairy wastewater effluent.It was decreased to 1600mg/l on treating with azolla on the 15th day. The calcium hardness was initially at the level of 4800mg/l in the untreated dairy effluent. It was decreased upto 1200mg/l on treating with azolla at the end of experiment period.

The calcium was initially at the range of 1923.84mg/l in the dairy wastewater. It was reduced to 480.96mg/l after treating with azolla at 15th day of the experiment.

Initially total solid concentration was about 130000mg/l. During treatment it was reduced to about 80.15%. Total suspended solids is present initially in the wastewater at the rate of 52000mg/l. On treating with azolla it was reduced to 13800mg/l after 15th day of the experiment with 73.46% reduction efficiency with azolla.

Initial BOD level was 1215.19mg/l and it was reduced upto 81.012mg/l while treating with azolla.

3.3 Discussion

The pH range during phytoremediation is an important factor to be considered. It should be essential to maintain a condition for the growth of plants (Mesania Rizwana, 2014). The results of present investigation indicated that aquatic plants and dilution of wastewater have caused significant reduction in pH value as compare to initial stage. The reduction in pH favors microbial action to decrease biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in the wastewater (Dipu Sukumaran, 2011). Intial pH level shows that raw effluent is alkaline in nature. In this treatment pH was reduced from the alkaline nature to neutral pH level. Dipu Sukumaran (2011) earlierly reported similar results. Highest EC was recorded in absence of aquatic plants as compare to the presence of Azolla and water hyacinth. The results clearly revealed reduction in EC in presence of plants as well as with dilution of wastewater. The range of EC mostly depends on the concentration of various types of soluble salts in wastewater. The decrease in EC during phytoremediation indicated the heavy uptake of these salts by root system. From the result azolla can be better used for reducing the turbidity of dairy wastewater compared to water hyacinth. The roots of most aquatic plants are capable of retaining both coarse and fine particulate organic materials present in the water on which they are growing. This was mainly achieved through the electrical charges associated with the root hairs, which reacts with the opposite charges on colloidal particles (Dipu sukumaran, 2013).

Table1 Variation in physico-chemical characteristics of dairy effluent

Parameters analysed	Retention time	Treated with Water hyacinth	Treated with Azolla
pH	Initial	8.26	8.26
	5 days	8.18	8.22
	10 days	8.0	8.14
	15 days	7.56	7.8
	% increase/decrease	8.47	5.56
Electrical Conductivity (µS/cm)	Initial	8200	8200
	5 days	3655	2613
	10 days	2840	1568
	15 days	1860	1269
	% increase/decrease	77.32	84.52
Turbidity (NTU)	Initial	324	324
	5 days	268	128
	10 days	178	78
	15 days	156	54
	% increase/decrease	51.85	83.33
Total hardness (mg/l)	Initial	61200	61200
	5 days	27000	30000
	10 days	22000	22200
	15 days	2400	1600
	% increase/decrease	96.07	97.39
Calcium Hardness (mg/l)	Initial	4800	4800
	5 days	3000	4000
	10 days	2600	2800
	15 days	2000	1200
	% increase/decrease	58.33	75
Calcium (mg/l)	Initial	1923.84	1923.84
	5 days	1202.4	1603.2
	10 days	1042.08	1122.24
	15 days	801.6	480.96
	% increase/decrease	58	75
Magnesium Hardness (mg/l)	Initial	13705.2	13705.2
	5 days	5832	6318
	10 days	4714.2	4714.2
	15 days	97.2	97.2
	% increase/decrease	99.29	99.29

Parameters analysed	Retention time	Treated with Water hyacinth	Treated with Azolla
Total dissolved Solids (mg/l)	Initial	78000	78000
	5 days	50000	62000
	10 days	40000	20000
	15 days	11000	12000
	% increase/decrease	85.89	84.61
Total suspended solids (mg/l)	Initial	52000	52000
	5 days	31000	30000
	10 days	27000	29000
	15 days	6000	13800
	% increase/decrease	88.46	73.46
Total solids (mg/l)	Initial	130000	130000
	5 days	88000	92000
	10 days	67400	49000
	15 days	17000	25800
	% increase/decrease	86.92	80.15
BOD (mg/l)	Initial	1215.19	1215.19
	5 days	810.13	810.13
	10 days	445.48	405.011
	15 days	324.05	81.012
	% increase/decrease	73.51	93.33

The percentage decrease of total hardness was high in the case of azolla compared to water hyacinth. Highest percentage decrease of calcium hardness was observed at treating with azolla. Degree of contaminations or amount of impurities present in the wastewater was often expressed with the help of the level of total dissolved solids present in it. The total dissolved solids at final stage were decreased significantly in presence of Azolla and Eichhornia as compare to their initial stage. About 85 percentage reduction of TDS occurred on treating with water hyacinth. Decrease in TDS reflects improvement in quality of wastewater due to phytoremediation. The reduction of TS was due to the retaining of coarse and fine particulate organic materials present in water bodies supporting their growth by the root systemThe reduction in TSS in the present study agrees with the study of Dipu Sukumaran (2011).

The presence of plants in wastewater can deplete dissolved CO_2 during the period of high photosynthetic activity (Ugay A Y, 2015). This photosynthetic activity increases the dissolved oxygen of water, thus creating aerobic conditions in wastewater which favor the aerobic bacterial activity to reduce the BOD and COD (Mesania Rizwana, 2014). In the study the lowest value of BOD was observed in the presence of Azolla. So the BOD value can be reduced a lot by treating the dairy wastewater with azolla. However, the growth and nutrient removal potential are affected by many factors such as temperature, water salinity, and physiological limitations of the plant (Mesania Rizwana, 2014).

4 FUTURE SCOPES

Different plants can be use for same study (Dipu Sukumaran, 2011). This can also developed for reducing the destructions imposed on environment by mining and rising industries throughout our country (Stanley Rungwa, 2013 and K.P.Sharma, 2005). Other pollutant such as Phophates, Nitrates, Nonmetals and metals can also be removed by this method. Phytoremidiation system can use for Domestic Wastewater Treatment (Hossein Azarpira, 2013)

5 CONCLUSIONS

From the results of present study it can be concluded that Azolla and Water hyacinth will serve the purpose of dairy wastewater treatment. Amongst both them *Azolla* was more efficient for reducing almost all the parameters studied. It has been observed that phytoremediation of wastewater using the floating plant system is a predominant method which is economic to construct, requires little maintenance and increase the biodiversity. Many researchers have used water Hyacinth, water lettuce, azolla etc for the removal of water contaminants but their treatment capabilities depend on different factors like climate, contaminants of different concentrations, temperature, etc. The removal efficiency of contaminants like TSS, TDS, BOD, COD, EC, hardness, heavy metals, etc varies from plant to plant. Plant growth rate and hydraulic retention time can influence the reduction of contaminants. But the removal efficiency of the plant may vary with the type of plant selected, temperature, treatment method, properties of the contaminants present in the wastewater etc. Therefore, an available knowledge and techniques for removal of water contaminants and advances in waste water treatment can be integrated to assess and control water pollution.

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