Comparative Study of Parameters for Treatment of Dairy Wastewater by Biomass of Various Plants

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Abstract

Need for treatment of waste water arises due to the demand for fresh water for irrigational and drinking purposes. Plants were subjected to use in water purification techniques because of the coagulation and flocculation property. The biomasses of Moringa oleifera, Vigna unguiculata, Calotropis procera were prepared using water as a solvent. These biomasses were treated with dairy waste water with measured parameters such as pH, hardness, turbidity, BOD and COD. The biomasses were effective in the clarification, sedimentation of total solids and also reduction of various parameters in the Dairy waste water sample. In those plants biomass, M. oleifera showed maximum efficiency in reduction in parameters. It reduced pH from 8.26 to 7.42, the efficiency of hardness removed was 25%, reduction of turbidity was 1.75NTU from 3.5NTU, reduction of COD was 450mg/l from 685.5mg/l and reduction of BOD was 104.5mg/l from 127mg/l. Other two plants also have considerable effect in the reduction in parameter as comparatively with M. oleifera.

Key words: Moringa oleifera, Vigna unguiculata, Calotropis procera, Coagulation, Parameters

1. Introduction

Disposal of wastewater is a major problem. Waste water discharged from industries is released into water bodies. The problem is not only due to lack of sufficient treatment capacity but also due to the inefficient methodology for the treatment of industrial effluent. Globally, the discharge of effluent is regulated by national environment agencies. Despite widespread recognition of the importance of improved water and sanitation, there was heavy investment by international and governmental organizations in developing countries in extending water treatment systems to improve water quality. Need for treatment of waste water arises due to demand for fresh water for irrigational and drinking purposes.

Wastewater comes from two major sources: as human sewage and as process waste from manufacturing industries. Discharge of untreated dairy waste water is the single most important concern of watershed management. Almost all the legislation is concerned with the prevention of pollution, and therefore sets concentration limits on dissolved organic carbon (as BOD or COD), nitrogen and phosphates – which cause eutrophication in receiving waters. It also attempts to limit the discharge of known toxic chemicals by setting allowable concentration limits in the effluent. Marobhe *et al*., (2013) investigated the activities of chemical coagulant and natural coagulant and thereby they reported that used seed proteins for purification is easily scalable. Crapper *et al*. (1973) and Miller et al. (1984) showed that the chemicals used for water purification can cause serious health hazards if an error occurs in their administration during the treatment process.

In many developing countries, industrial effluents are treated and used for agricultural purposes. In traditional methods, extracts of plants were subjected to water purification techniques because of the coagulation and flocculation property of plant extracts. Application of this method for treatment of industrial effluent is bound to draw more interest, since it reduces the need for chemical purifiers. In this study *M. oleifera*, *V. unguiculata* and *C. procera* were used in the treatment of dairy industry effluent. Coagulant ability of those plant extracts were compared along with the effect on various parameters like pH, hardness, turbidity, COD and BOD.

2. MATERIALS AND METHODS

2.1 Collection of sample

The dairy industry waste water was collected from the one of the dairy industry in Krishnagiri, Tamil Nadu, India in a sterile polyethylene bottle. *M. oleifera* seeds and other local plants such as *V. unguiculata* and *C. procera* were also collected from the surrounding area of effluent collection.

2.2 Seed preparation and treatment

For water treatment purposes, the seedpods of *M. oleifera*, *V. unguiculata*, and leaves of *C. procera* were allowed to dry naturally in the shade. After complete drying, it was homogenized to fine powder and stored. For each treatment, a mixture of powder with water was prepared at the rate of 50 g/l and was stirred for 10-15 minutes to release the active components of seed in water. The dairy waste water sample was treated with the plant

extracts and was stirred in a magnetic stirrer at 300 rpm for 60 sec and 50 rpm for 2 hrs. The samples were kept undisturbed for 24 hrs at room temperature. Finally, it was filtered and the filtrate was then analyzed for the reduction in parameters such as BOD, COD, turbidity, hardness and pH.

2.3 Measurement of pH

The pH of the dairy waste water was read from the supernatants obtained from the raw and treated samples (Esico model-1010).

2.4Analysis of total hardness (calcium + magnesium) of water

For 50 ml of dairy wastewater sample, 4 ml of buffer solution and 6 drop of mordant black solution was added to the sample and titrated against EDTA solution and the end point was observed to be blue in colour.

The hardness is calculated by the following equation:

$$CaCO_3 \text{ content (in mg/ml)} = \frac{V \times E\ (CaCO_3) \times 1000}{50}$$

where,

V = Volume of sample and E = Equivalent weight

2.5 Analysis of turbidity of water

The turbidity of the samples was expressed in Nephelometric Turbidity Units (NTU). Supernatants obtained after treatment of dairy waste water was analyzed for turbidity using a spectrophotometer (Systronics 4704).

2.6 Analysis of COD of water

50 ml of dairy waste water was taken in a refluxing flask and several boiling stones and 0.1 g $HgSO_4$ were added. 5ml of concentrated H_2SO_4 was also added to the solution. To ensure that $HgSO_4$ dissolved completely, the solution was swirled slowly while adding H_2SO_4. 0.1 g of Ag_2SO_4 was added to this solution. Finally, $K_2Cr_2O_7$ was added. Thorough mixing of the solution was ensured by swirling the flask in a water bath to recover any volatile substances that may have escaped from the liquid state. The flask was then attached to the condenser and further cooling was done. 20 ml of sulphuric acid was added to the solution in the flask continuing cooling and swirling to mix the solution. The solution was refluxed for 1 hour. A blank run (using 50 ml distilled water instead of sample) was simultaneously conducted, the solution was transferred to an Erlenmeyer flask. The reflux flask was rinsed thrice, pouring the rinsing water to the Erlenmeyer flask. The solution was diluted to about 300 ml and about 8 drops of Phenanthroline ferrous sulphate was added to the solution as an indicator. The solution was titrated against Mohr's salt and the titrate volume required for the color change from blue-green to reddish blue was noted. The procedure was repeated for the blank run.

The COD is calculated by

$$COD = 8000 * (V_{bl} - V_s) * M / \text{original volume of sample taken mg/l}$$

V_{bl} –Volume of Blank, V_s – Volume of Sample

2.7 Analysis of BOD of water

BOD of samples were tested by the procedure of IS: 3025 (Part 44) - Reaffirmed 2003. Briefly 10 ml of the sample was added to each of the two BOD bottles and the remaining quantity filled with diluted water. The remaining two BOD bottles were for blank, to these bottles and dilution water alone. After the addition, the glass stopper was immediately placed over the BOD bottles and bottles were identified. One blank solution bottle and one sample solution bottle were preserved in a BOD incubator at 20°C for 5 days. The other two bottles (one blank and one sample) were analyzed immediately. 2 ml of manganese sulfate was added to the BOD bottle by inserting the calibrated pipette just below the surface of the liquid. Then 2ml alkali- iodide-azide reagent was added in the same manner. It was then allowed to settle for sufficient time in order for it to react completely with oxygen.

The titration was continued until the blue color disappears to colorless, and the volume of sodium thiosulphate solution added was noted down, which gives the D.O. in mg/ml. The titration was repeated for concordant values. After five days, the bottles were taken out from the BOD incubator and the sample were analyzed and the blank for OD. 2ml of manganese sulfate was added to the BOD bottle by inserting the calibrated pipette just below the surface of the liquid. 2ml of alkali – iodide – azide reagent was added in the same manner. Brownish – orange cloud of precipitate or floc indicate the presence of oxygen. It was allowed to settle for sufficient time in order for it to react completely with oxygen.

When this floc had settled to the bottom, the contents were shaken thoroughly by turning it upside down. Then 2ml of concentrated sulphuric acid was added via a pipette held just above the surface of the sample, and inverted several times to dissolve the floc. Titration was started immediately after the transfer of the contents to an Erlenmeyer flask. The burette was rinsed with sodium thiosulphate and then filled it with sodium thiosulphate. Later 203ml of solution was measured from the bottle and transferred to an Erlenmeyer flask. Then the solution was titrated with standard sodium thiosulphate solution until the yellow colour of liberated iodine was almost faded out (pale yellow color) and 1ml of starch solution was added.

The amount of BOD is calculated by

$$\text{Biochemical oxygen Demand (mg/ml)} = \frac{(DO - D5 - BC) \times \text{volume of diluted samples}}{\text{Volume of sample taken}}$$

3. Results and Discussion

The investigation on coagulation of various plants species such as *M. oleifera, C. procera, V. unguiculata* were carried out. Jahn (1998) has shown that water clarification by *Moringa* seeds is primarily due to the action of seed proteins. In this study, water clarification of *M. oleifera* was compared with that of *C. procera, V. unguiculata* and the results showed that plant biomass *C. procera* and *V. unguiculata* have significant effect in the coagulation as in *M. oleifera*. Ndabigengesere *et al*., (1995) reported that the water soluble cationic proteins in the seeds of *M. oleifera* made it a natural coagulant. The similar coagulation ability was found in both *C. procera* and *V. unguiculata.* This suggests that in water, the basic amino acids present in the protein of *M. oleifera* would accept a proton from water resulting in the release of a hydroxyl group making the solution basic. This accounted for basic pH values observed for *M. oleifera* treatments compared with other local plants biomass in treatments that have decisive result of reducing the pH. New design for purification strategy based on charge was suggested by Garcia-fayo *et al*., (2010). According to their report, Cationic protein of molecular weight 17-26 kDa was purified and the coagulant activity was proven in such kind of local plants.As shown in Table 1 these natural coagulants not only reduce the pH and also it have the ability to reduce the hardness of the dairy wastewater. This shows the ability of these natural coagulants that can be used in heavy metal remediation. Locally, the coagulation attributes of *M. oleifera* have been found effective in clarifying turbidity of raw water (Oluwalana, *et a1.*, 1997). In dairy wastewater also turbidity due unwanted suspension are clarified effective by *M. oleifera* and moderately clarified by *V. unguiculata* and followed by *C. procera.* Rather than the clarifying property, these plants have the mild considerable effect on the reduction of BOD and COD as shown in the Table 2.

3.1 pH

The results of pH in water treated by dosages of different plant extracts are shown in Table 1. The pH of water treated by different plant extracts ranged from 6.65 to 7.74. Unlike *C. procera, V. unguiculata* the pH of water treated with *M. oleifera* was remarkably reduced from 8.26 to 7.42. Since the recommended acceptable range of pH for drinking water specified by WHO is between 6.0 and 8.0, this treated dairy wastewater can be used for domestic purpose.

3.2 Hardness

Hardness is a measurement of the concentration of divalent metal ions such as calcium, magnesium, iron, zinc etc. The U.S. Environmental Protection Agency (EPA) has classified hardness into four categories namely, soft (0-50mg/l), moderately hard (50-150), hard (150-300), very hard (>300). Most water consists mainly of calcium and magnesium salts, with trace amounts of other metals. If the hardness is more than 300, it will not lather with soap (Sharmila *et. al., 2013*). Hardness of the samples treated with various plant extracts was calculated (Table 1). Maximum amount of hardness removal was observed in the extract of *M. oleifera.*

This made suggestion for the further investigation on the specified removal of such metal ions from the various industrial effluents before they allowed to flow in domestic water sources.

3.3 Turbidity

Turbidity is a measure of cloudiness due to the presence of suspended solids and colloidal particles, such as clay, finely divided organic and inorganic matter, plankton and other microscope organisms in water. Clarification of dairy waste water by *M. oleifera* gives significant reduction in turbidity(Table 1). The suspended solid settles along with proteins of the plants biomass by the coagulation. This is due to the cationic property of proteins present in the biomass that ultimately coagulate the suspension to clarify the water.

3.4 COD and BOD

Organic compounds that are generally unstable will be oxidized biologically or chemically. An indication of organic content present in water can be determined by measuring the amount of oxygen required for stabilization(Tebbutt, 1983). The quantity of oxygen needed to chemically oxidize the organic compound converted to CO_2 and water can be expressed in terms of chemical oxygen demands where as the quantity of oxygen utilized by microorganisms to biologically degrade the organic matter can be expressed as biochemical oxygen demand. The results show the effective methodology for the treatment of wastewater (Table 2). This treatment technology that removes BOD was designed specifically to enhance disposal of effluents in domestic water resources.

Table 1: Effects of plant biomass on pH, hardness removal and turbidity

Plant extracts	pH (Initial value is 8.26)	% of hardness removal	Turbidity (NTU) (Initial value is 3.5)
Calotropis procera	7.74	19	3.1
Vigna unguiculata	6.65	24	2.8
Moringa oleifera	7.42	25	1.75

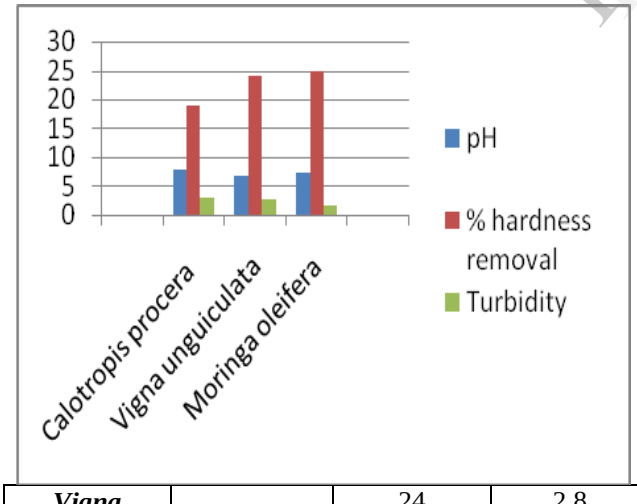

Figure 1: Effects of plant extract on pH, hardness removal and turbidity

Table 2: Effects of various plant biomass on COD and BOD

Plant extracts	COD(mg/l) (Initial value is 685.4)	BOD (Initial value is 127)
Calotropis procera	581	118.7
Vigna unguiculata	491	109.5
Moringa oleifera	450	104.5

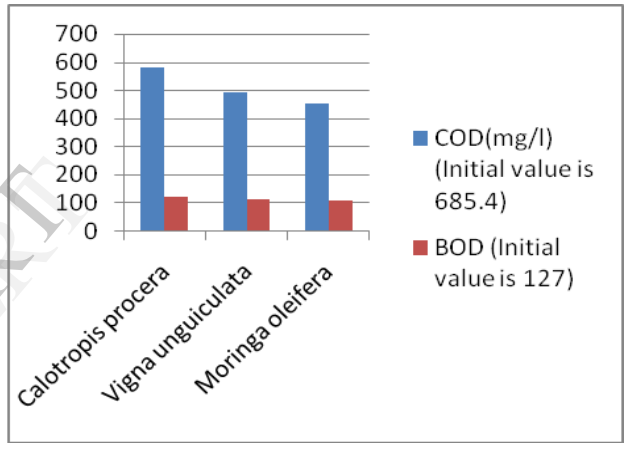

Figure 2: Effects of plant extracts on COD and BOD

4. Conclusion

The present study suggested that natural coagulants such as *Moringa oleifera*, *Vigna unguiculata*, and *Calotropis procera* can be used as an effective clarifying agent. It is suggested that *Moringa oleifera* has better coagulant property than that of other local plants. At this suggested dosage, the percent of reduction in parameter such as pH, hardness, turbidity, BOD and COD removal will increase the water quality. Also using natural coagulants reduces uses of chemical agents to almost 50%, which can help to reduce the detrimental effects of chemical based coagulants. Further, it has been suggested that *Moringa oleifera* is a sustainable and economical way of treating dairy waste water.

5. References

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