Comparative study of Natural Coagulants and Natural Surfactants for treatment of Dairy Wastewater

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Abstract: In this study locally available natural coagulants i.e. cactus, chickpea, soya and surfactantslike ashwagandha, aloe vera and lemon were used to reduce COD of dairy wastewater. The tests were carried out by using variable dosage concentrations of coagulants with Magnetic stirrer test. Percentage reduction 82.8%, 83%, 42%, 60%, 17% and 17% in COD value was observed after dosing water-soluble extracts of cactus, chickpea, soya, ashwagandha, aloe vera and lemon respectively in dairy wastewater. Natural coagulants worked better than natural surfactants. Chickpea showed highest COD reduction efficiency i.e. 83%. In the present study suitable, easier, and environment friendly alternative for dairy wastewater treatment was observed by using locally available natural coagulants and surfactants.

Keywords: *Surfactants, Coagulants, Dairy wastewater, COD.*

I. INTRODUCTION

Fast growth of industries has not only increased the productivity but also resulted in release of toxic substances into the environment, creating health hazards. It has serious impact on normal operations of ecosystems, flora and fauna. In a last few years, considerable attention has been paid to the industrial wastes, which are usually discharged on land or into different water bodies. This is likely to result in the degradation of environment (Chhonkar*et al*., 2000). Dairy industry is one among the most polluting food industries because of its large water consumption. Due to the increased demand of milk and milk products in India, the dairy industry is expected to grow rapidly and thereby the dairy effluent is expected to pose environmental pollution problems in the near future (Nayana and Valsa, 2015).

Water management in dairy industry is well documented, but wastewater production and release in the environment remain a problematic issue. An efficient and cost-effective treatment technology has to be developed that enable dairy industry to contribute in water conservation (Porwal *et al*., 2015). Various physicochemical parameters have been studied for their applicability in treatment of wastewaters (Rodrigues*et al*., 2007). In 2016 drought effect many states in India and so does agriculture. India government now focusing on reusing treated wastewater for irrigation purposes. There are many physical (primary) and biological (secondary) methods to treat wastewater. Nowadays new approach like degradable or natural coagulants such chickpea, cactus etc. are used for coagulation. But in the present study natural surfactants were also used to treat dairy wastewater because many of the most persistent contaminants exhibit low water solubility and hence, bioavailability of contaminants can often be improved by addition of emulsifiers (Singh *et al*., 2005).

Work on getting efficient and more economical treatment process to treat dairy wastewater are still going on worldwide. The present investigation was carried out to see the COD reduction efficiency of various natural coagulants and surfactants. The study was conducted in two phases (1) treatment of dairy wastewater with natural coagulants (2) treatment of dairy wastewater with natural surfactants.

1. Material and Methods:

2.1. Procurement of dairy wastewater

Fresh dairy wastewater sample was obtained from a dairy wastewater treatment plant of verka located in Mohali of Punjab. The sample was collected in a sterilize 2 L plastic container.

2.2. Procurement of chemicals, media, reagents and instruments

All the chemicals and reagents used were of analytical grade with the sufficient purity and the chemicals were supplied by HIMEDIA®, Loba Chemie®, SRL®(Sisco Research Laboratories) and Qualigens®. The instruments were procured from Remi equipments Ltd, Esico, M.S. Electronics India Pvt Ltd and Bio-age.

2.3. Analysis of COD (Chemical Oxygen Demand) of dairy wastewater

COD of wastewater just after collection and treatement was determined using titermetric methods (Sawyer *et al.*,2003; Prasad and Manjunath, 2011).

2.4. Preparation of Natural coagulants and Natural surfactants

The size of seed powder was maintained approximately less than 75 micrometer to achieve solubilization of active ingredients in the seed. A mature seed of chickpea was used in the study. After sun drying, external shells were removed and seed kernels were obtained. Using grinder, fine powder was achieved from seed kernel. Distilled water was added to the powder to make 1% suspension of it. The suspension was vigorously shaken for 4 hr using a magnetic stirrer to promote water extraction of the coagulant proteins and this was then passed through filter paper (Whatman no.42). The filtrate portions were used for required dose of natural coagulants. Fresh solutions were prepared daily and kept refrigerated to prevent any ageing effects such as change in pH, viscosity and coagulation activity. Solutions were shaken vigorously before use (Rahane and Navale, 2015).

Cactus opuntia used in the study was collected from a nursery. The cactus was washed with tap water and subsequently sliced into small pieces to facilitate drying. The sliced cactus was then dried under direct sunlight and then kept in oven for 6 hours at 80 C. The dried cactus was ground into fine powders using pestle and mortar (Kannadasan *et al*., 2013).

Mature Aloe vera leaves, collected from a nursery were washed with water to remove dust and cut into small pieces [1 cm broader and 1 cm wide] were allowed to dry at room temperature in a shadow for two weeks. Then leaves were kept in an air oven at 50 to 60 0C for 3 hours till the leaves became crisp. The dried leaves were then converted into fine powder (Aloe vera leaf powder) by grinding in a mechanical grinder. The powder was sieved and the 53–74µm fraction was separated (Malik and Lata, 2015).

Juice of lemon extracted and filtered through filter paper (Whatman no.42). Ashwagandha powder was procured from market and then it was sieved.

2.5. Magnetic stirrer test of Dairy wastewater with Plant based coagulants

The coagulation and emulsification process is generally a surface phenomenon; therefore, coagulation or emulsification performance can be significantly affected by the surface charge due to the mass of the coagulant or surfactant. Thus, from an economic point of view, the optimization of the coagulant or surfactant dosage and the best-required mass of the coagulant or surfactant for the scale-up and design of large-scale equipment is necessary (Ramavandi, 2014).Hence, the influence of selected coagulants or surfactants quantity on COD reduction was considered at an optimum pH of 7. Magnetic Stirrer test was used to determine the effectiveness of selected coagulant or surfactant. The test was conducted using magnetic stirrer apparatus using 500 ml beakers. Untreated 100ml effluent sample were treated with coagulants or surfactants in the stirrer. Cactus powder, chickpea powder, soya powder, ashwagandha, aloe vera powder and lemon juice extract of dosages of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1 and 1.2gm/100ml respectively were added to the effluent samples respectively. This was the mixing stage. After a period of mixing stage coagulation process was carried out for 6hrs and the samples were allowed to stand for 30 minutes after which treatment was completed (settling stage). After settling COD of treated sample (supernatant) was compared with COD of untreated sample (Kannadasan *et al*., 2013).

Fig 1: Magnetic stirrer test

II. Result and Discussions

For efficient biological wastewater treatment there is also important an efficient primary wastewater treatment, especially the removal of fat because the fat breaks down slowly and with difficulty and removal of suspended particles (Posavac *et al*., 2010). In the present study three natural coagulants and surfactants respectively were used in primary treatment of dairy wastewater are shown in Table 1. Soya and lemon for the first time used in dairy wastewater treatment process. The untreated wastewater collected from treatment plant was milky but after primary treatment with coagulants or surfactants it was clear. The changes in color of dairy wastewater might be due to settling of organic matter after coagulation. The findings of this study were in accordance with the work of Ramavandi (2014).

Fig 2: Untreated Dairy wastewater with COD 840mg/l and treated Dairy wastewater with 140mg/l COD value

When the coagulation experiments were started, the first dramatic observations indicative of coagulation process were the visual observations. As soon as the low coagulants value, 0.1 mg/100ml, was dosed, the formation of large flocs was observed.

3.1 Reduction of COD Using Natural Coagulants

The Magnetic stirrer test operations using different coagulants were carried out in different dosage concentrations of natural coagulants. The efficiency of the extracts of cactus, chickpea and soya made them used as natural coagulants for the clarification of water. Doses started from 0.1g/100ml to 1.2g/100ml for corresponding three beakers. COD was measured before and after treatment.Table 1 shows the results of different doses of coagulant treatment in magnetic stirrer test. From Table 1, it is found that the untreated wastewater COD was 840mg/l. COD reduced to 145, 140 and 488mg/l corresponding to cactus, chick pea and soya natural coagulants respectively.

Table I: Treatment of dairy wastewater by using threenatural coagulants

Dosage Concentration g/100ml	COD of sample 840mg/l		
	Cactus	Chickpea	Soya
	COD mg/l after treatment		
0.1	480	320	840
0.2	432	300	840
0.3	361	280	840
0.4	348	280	840
0.5	300	260	781
0.6	240	260	722
0.7	145	240	684
0.8	160	180	684
0.9	168	160	664
1.0	168	160	588
1.1	176	140	488
1.2	193	140	684

In this study maximum reduction in COD value i.e. 83% was achieved with chickpea at 1.1 and 1.2% dosage concentration. Range of COD percentage reductions shown by chickpea were 61-83%, cactus 42.9-82.8% and soya 0-41.9%. Rate of reduction in COD value is as follows: chickpea (83%) > cactus (82.8%) > soya (41.9%).

A. COD Reduction Efficiency of Different Coagulants in Different Dosage Concentration Ranges

A comparative study of COD reduction efficiency of different coagulants in different dosage concentration ranges are presented in Figure 3 (0.1-0.6mg/100ml) and 4 (0.7-1.2mg/100ml). In every case 0.1 to 1.2 g/100ml doses were used. It was found that chickpea reduced maximum COD among all coagulants used. It reduced up to 83% COD which is almost as same as the reduction capacity of cactus (82.8%). So, it was found most efficient among the studied natural coagulants. Another study using Chickpea, showed COD reduction efficiency 83% at a dosage concentration 0.1g/500ml, Patil and Hugar (2015). Similar reduction in COD value was achieved in present study *i.e.* 83%.

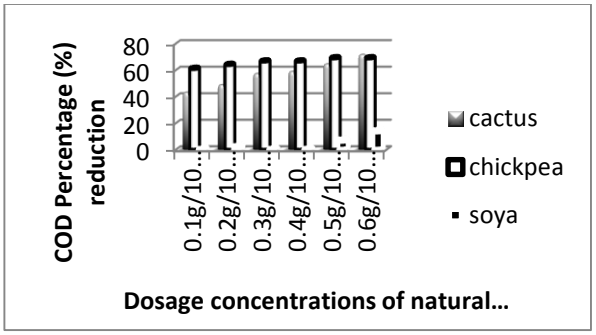

Fig 3: COD percentage reduction in dairy wastewater with variable dosage concentrations *i.e.* 0.1 to 0.6g/100ml of natural coagulants

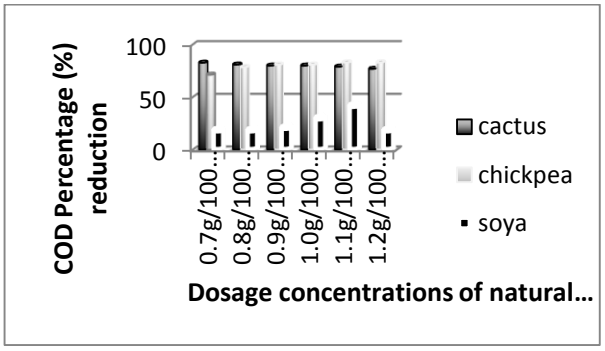

Fig 4: COD percentage reduction in dairy wastewater with variable dosage concentrations *i.e.* 0.7 to 1.2g/100ml of natural coagulants

The study also showed that lower dosages did not significantly increase COD reduction. The wastewater from dairy industry was treated with cactus powder for the reduction of COD. Mucilage in Cactus contains carbohydrates such as l-arabinose, d-galactose, l-rhamnose, dxylose, and

galacturonic acid. Galacturonic acid is possibly the active ingredient that affords the coagulation capability (Vijayaraghavan *et al*., 2011).A study was conducted using cactus as natural coagulant for reduction of COD by Kazi and Virupakshi (2013). Coagulation was the most effective at a dose of 0.2g/500 mL and maximum reduction in COD value was 75%. In the present study cactus reduced up to 82.8% COD.

In another research by Thakur and Choubey (2014)it has been stated that the coagulation efficiency of Acacia catechu depends considerably on the content of the tannin in it and because of tannin it removed wastewater turbidity up to 91%. Tannin is an excellent substitute to chemical coagulants. The presence of phenolic groups in tannin clearly indicates its anionic nature since it is a good hydrogen donor. The more phenolic groups are available in a tannin structure, the more effective its coagulation capability (Vijayaraghavan *et al*., 2011). Considering this in present study Soya use as coagulant because of it tannin content. Soya reduced COD of dairy wastewater upto 41.9% at 1.1g/100ml dosage concentration.

In another research by Nawashet al. (2014) three natural coagulants i.e. *Moringaoleifera*, *Vigna unguiculata*, *Calotropis procera* were used to treat dairy wastewater. COD percentage reduction shown by *Moringa oleifera*, *Vigna unguiculata*, *Calotropis procera* were 34%, 28% and 15% respectively. Similar study done by Parmar et al. (2012) to treat dairy wastewater by using *Moringa oleifera* as natural coagulant and observed only 40% reduction in COD value of dairy wastewater.

3.3 Reduction of COD Using Natural Surfactants

The Magnetic stirrer test operations using different surfactants were carried out in different dosage concentrations of natural surfactants. The efficiency of the extracts of ashwagandha, aloe vera and lemon made them used as natural surfactants for the clarification of water. Doses started from 0.1g/100ml to 1.2g/100ml for corresponding three beakers. COD was measured before and after treatment.Table 2shows the results of different doses of surfactant treatment in magnetic stirrer test. From Table 2, it is found that the untreated wastewater COD was 1160mg/l. COD reduced to 464, 960 and 976mg/l corresponding to ashwagandha, aloe vera and lemon natural surfactants respectively.

Table II: Treatment of dairy wastewater by using three natural surfactants

Dosage Concentration g/100ml	COD of sample 1160mg/l		
	Ashwagandha	Aloe vera	Lemon
	COD mg/l after treatment		
0.1	828.5	1080	1160
0.2	795.8	1060	1160
0.3	779.5	1060	1160
0.4	464	1000	1160
0.5	614.8	960	1160
0.6	513.9	1000	1160
0.7	629.9	1020	976
0.8	464	1060	976
0.9	530.4	1060	1600
1.0	530.4	1080	1600
1.1	568	1080	1160
1.2	629.9	1100	1160

In this study maximum reduction in COD value i.e. 60% was achieved with ashwagandha at 0.4 and 0.8% dosage concentration. Rate of reduction in COD value is as follows: ashwagandha (60%) >aloe vera (17.2%) >lemon (16.6%).

3.4 COD Reduction Efficiency of Different surfactants in Different Dosage Concentration Ranges

A comparative study of COD reduction efficiency of different surfactants in different dosage concentration ranges are presented in Figure 5 (0.1-0.6mg/100ml) and 6 (0.7-1.2mg/100ml). In every case 0.1 to 1.2 g/100ml doses were used. It was found that ashwagandha reduced maximum COD among all surfactants used and it reduced up to 60% COD load. So, it was found most efficient among the studied natural surfactants.

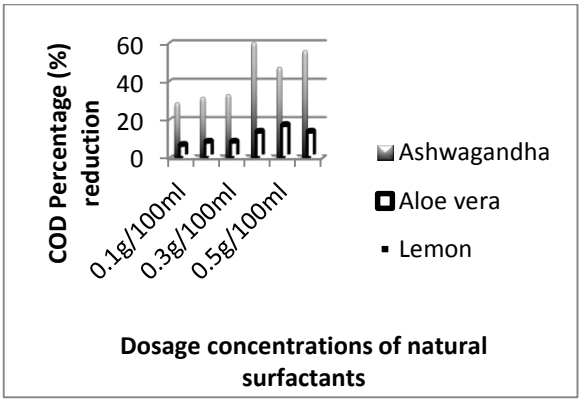

Fig 5: COD percentage reduction in dairy wastewater with variable dosage concentrations *i.e.* 0.1 to 0.6g/100ml of natural surfactants

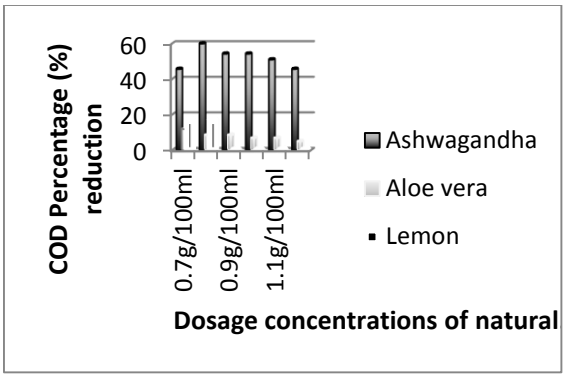

Fig 6: COD percentage reduction in dairy wastewater with variable dosage concentrations *i.e.* 0.7 to 1.2g/100ml of natural surfactants

Comparative results of natural coagulants and natural surfactants in reduction of COD value is shown in figure 8. Chickpea gave 83%, cactus 82.8%, soya 41.9%, ashwagandha 60%, aloe vera 17.24% and lemon 16.6% reduction in COD value. Out of six natural ingredients used in the present study only three had given high COD reduction value above 50%.

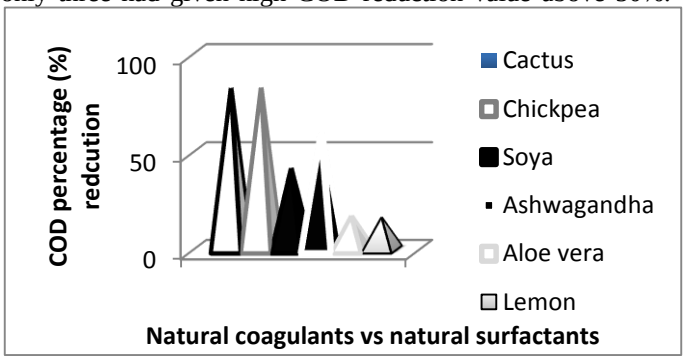

Fig 7: Maximum COD reduction percentage shown by natural coagulants and natural surfactants

So, these three efficient natural coagulants or surfactants (cactus, chickpea, ashwagandha) might be considered as excellent alternative of traditional chemicals and very efficient coagulants or surfactants for high-COD ranges. Natural coagulants or surfactants have been used to treat water for domestic household use for centuries in rural areas. Interest in the use of natural coagulants or surfactants has increased over time, especially to reduce water and wastewater treatment problems in developing countries to avoid health risks (Asrafuzzaman *et al*., 2011).

III. CONCLUSION

Significant improvement in removal of COD from dairy wastewater was observed by using some locally available natural coagulants or surfactants for example cactus, chickpea, soya, ashwagandha, aloe vera and lemon. Primary treatment using natural coagulants or surfactants were also performed earlier for the wastewater treatment but in the present study it was used for treatment of dairy wastewater. Soya and lemon were first time used as coagulant and surfactant and they reduced COD i.e. 41.9% and 16.6% respectively. Chickpea was found most effective among all natural coagulants and surfactants used, it reduced 83% COD from the dairy wastewater.

ACKNOWLEDGEMENT

This research was financially supported by the UGC under major research project grant.The authors are grateful to the Department of Biotechnology, SGGS College and Panjab University for providing infrastructure to carry out work over there.

REFERENCES

[1]. Chhonkar, P. K., Datta, S. P., Joshi, H. C. and Pathak, H. (2000). Impact of industrial effluents on soil health and agriculture-Indian experience: Part-II tannery and textile industrial effluents. *J. Sci. Ind. Res*., 59, 446-454.

[2]. Nayana, K. and Valsa, A. K. (2015). Biodegradation of Lipid Rich Dairy Effluent by Bacterial Consortium. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 9(9), 16-20.

[3]. Porwal, J. H., Mane, A. V. and Velhal, S. G. 2015. Biodegradation of dairy effluent by using microbial isolates obtained from activated sludge. *Water Resources and Industry*, 9, 1–15.

[4]. Rodrigues, M. A. S., Amado, F. D. R., Xavier, J. L. N., Streit, K. F., Bernardes, A. M. and Ferreira, J. Z. (2008). Application of photoelectrochemical–electrodialysis treatment for the recovery and reuse of water from tannery effluents. *Journal of Cleaner Production*, 16(5), 605-611.

[5]. Singh, A., Van Hamme, J.D. and Ward, O.P. (2007). Surfactants in microbiology and biotechnology: Part 2. Application aspects. *Biotechnology advances*, 25(1), 99-121.

[6]. Sawyer, C., McCarty, P. and Parkin, G. (2003). Chemistry for Environmental Engineering and Science 5th ed.McGraw- Hill, New York ISBN0072480661.

[7]. Prasad, M. P. and Manjunath, K. 2010. Comparative study on biodegradation of lipid-rich wastewater using lipase producing bacterial species. *Indian Journal of Biotechnology*, 10, 121-124.

[8]. Rahane, V. R. and Navale, V. B. 2015. Modelling and optimization of pH, dosage and settling time for reduction of turbidity. *International journal of advance foundation and research in science and engineering*,1, 1-8.

[9]. Kannadasan, T., Thirumarimurugan, M., Sowmya, K. S., Karuppannam, S. and Vijayashanthi, M. (2013). Dye industry effluent treatment using Cactus (opuntia) and water hyacinth (Eichhornia crassipes). *IOSR journal of environmental science, toxicology and food technology*, 3 (4), 41-43.

[10]. Malik, R., Lata, S. and Singhal, S. (2015). Removal of heavy metal from waste water by the use of modified aloe vera leaf powder. *International Journal of Basic and Applied Chemical Sciences*, 5 (2), 6-17.

[11]. Ramavandi, B. (2014). Treatment of water turbidity and bacteria by using a coagulant extracted from Plantago ovata. *Water Resources and Industry*, 6, 36-50.
[12]. Posavac, S., Landeka Dragičević, T. and Zanoški, Hren M. 2010. The improvement of dairy wastewater treatment efficiency by the addition of bioactivator. *Mljekarstvo*, 60(3), 198-206.
[13]. Patil, C. and Hugar, M. M. (2015). Treatment of dairy wastewater by natural coagulants. *IRJET*, 2(4), 1120-1125.
[14]. Vijayaraghavan, G., Sivakumar, T. and Kumar, A. V. (2011). Application of Plant based Coagulant for Waste Water Treatment. *International Journal of Advanced Engineering Research and Studies*, 1(1), 88- 92.
[15]. Kazi, T. and Virupakshi, A. (2013). Treatment of tannery wastewater using natural coagulants. *IJIRSET*, 2(8), 4061-4068.
[16]. Nawash. B., Vasudevan. G., Yogesh. S., Ramesh Babu. N. G. and HemakalaiRani. R. (2014). Comparative Study of Parameters for Treatment of Dairy Wastewater by Biomass of Various Plants. *International journal of engineering research and technology*, 3(1), 1-8.
[17]. Asrafuzzaman, M., Fakhruddin, A. N. M. and Hossain M. A. (2011). Reduction of turbidity of water using locally available natural coagulants. *ISRN microbiology*, 2011, 1-6.