Statistical Analysis of COD and BOD Removal from Dairy Waste Water

Suman Mishra [1]*, Dr. Santosh Kumar Bindhani [2], Dr. Haramohan Jena [3]

[1] *Chemical Engineering, GIET University, Gunupur, Odisha, India.* sumanmishra@giet.edu

[2] *Chemical Engineering, GIET University, Gunupur, Odisha, India*

[3] *Chemical Engineering, NIT, Rourkela, Odisha, India*

Abstract: One of most water polluted industry is Dairy industry. It produces various milk products like milk powder, butter milk, curd, cheese, pasteurized milk etc. More amount of fresh water is used for different purposes i.e., cooling/heating, sanitary, processing, utilities and service section during milk processing and production of different milk products. It is observed from a report that for processing 1L of milk, the Dairy industries produce 2.5 to 10L of waste water. Major pollutants found in dairy waste water are Organic components like dissolved sugars, carbohydrates, proteins and fat are found as the major pollutants in the Dairy waste water. Apart from organic compound some inorganic compounds like Sulfur, Phosphorous and Nitrogen are also found. Hence, the dairy wastewater is having large amount of organic matter that can be measured in term of BOD and COD. As it is having pungent odor and is responsible for fly generation, it should be treated properly before disposal. In this present work, the synthetic dairy waste water was prepared and was treated with activated carbon prepared from coconut shell collected from temple side. The activated carbon prepared from Coconut shell CGAC could be able to remove COD and BOD of the used water up to satisfactory level at different bed height and contact time. This paper shows the statistical analysis of COD and BOD using the activated carbon. In the experiment, the standard deviation of maximum removal efficiency of COD and BOD from the dairy wastewater was found as 0.59 and 0.49, respectively.

Keywords: Synthetic Dairy Waste water, statistical analysis, COD, Coconut shell prepared Activated Carbon, BOD.

1. INTRODUCTION

For economic growth of country, Industrialization is one of the major parts. Because of the industrialization, pollution is gradually increasing day by day. The dairy industry is one of them. India is the largest producer of milk and dairy products in world. The growth rate of dairy industry is expected to increase 4-5% in each year. In dairy industries, more quantity of fresh water is used from milk receiving station to packaging station, [1]. It is observed from a report that for processing 1L of milk, the Dairy industries produce 2.5 to 10L of waste water, [2]. The dairy waste water contains varieties of components i.e., lactose, casein, inorganic salt, fat, detergents and sanitizers, [3]. Dairy waste water is having large quantity of organic contents, and TDS, TSS contents. Due to the presence of high quantity pollutants in dairy wastewater, the industries disposing the untreated/partially treated wastewater cause serious effects to the environment, [4]. Table 1 indicates the acceptable level of effluent present in the Dairy waste water by the Central Pollution Control Board and World Health Organization.

Table 1: Acceptable level of effluents from the dairy industry

Parameter	Maximum Value (mg/L)	World Bank Report CPCB, India
pH	6-9	6.5-8.5
BOD5	50	100
COD	250	-
TSS	50	150
Oil & Grease	10	10
Total Nitrogen	10	-

Parameter	Maximum Value (mg/L)	World Bank Report CPCB, India
Total Phosphorus	2	-
Temperature Increase	< = 30 C	-
Coliform Bacteria	400 Most Probable Number / 100 ml	-

Hence, Proper disposal of the waste water is a major challenge for the industry in India. In this work, the adsorption method is used for effluent removal from the dairy waste water. The adsorbent produced from Coconut shell is designed to reduce the tastes, odors and dissolved organic chemicals from the waste water, [5].

2. EXPERIMENTAL METHODS

2.1 Materials.

Synthetic dairy waste water Preparation:

The waste water was prepared in lab synthetically adding different ratios of chemicals in normal tap water. The details are provided in table 2. For whole experimental work, 10 L of waste water was prepared. Figure 1 shows the prepared dairy waste water in lab.

Table 2: Quantity of chemicals added in 1L tap water

Sl No.	Name of Chemicals	Quantity (gm)
1	Milk powder	5
2	glucose	2
3	Sodium Nitrate	1
4	Potassium Phosphate	1
5	Calcium Chloride	1

Figure 1: Synthetic Dairy waste water preparation

Coconut Shell Granular Activated Carbon (CGAC) preparation:

The granular activated carbon was prepared from coconut shell. Coconut shell was collected from temple. Then it was dried in sunlight for 15 days. It was heated at 400^0C for 2hours in furnace. After that, it was allowed to cool, ground and sieved to get a particle size of 1mm. Then Hydrochloric acid was used to wash it for activating the surface. Its activated characteristic was checked. This activated carbon has the highest hardness compared to other activated carbons that makes it the ideal carbon for water purification.

2.2 Methods.

2.2.1 Experimental Set up:

The set up was done in the laboratory. The fig.2 shows the experimental set up.

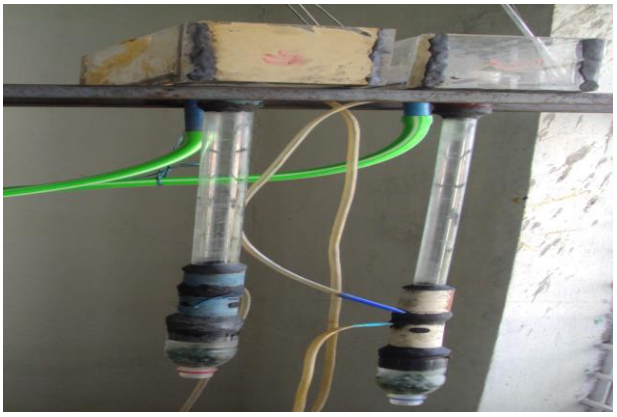

Figure 2: Experimental Set up

The freshly prepared activated carbon was used in this experiment. Five different bed heights 2cm, 4cm, 6cm, 8cm and 10cm of adsorbent CGAC maintained in five cylindrical beds of diameter 3cm. Dairy waste water was allowed to flow through the beds from the top. The particle size for CGAC was taken as 1mm. The contact time was maintained for 30minutes, 60minutes, and 90minutes, respectively. The dairy waste water at inlet and water after passing through the bed was collected from different bed height and taken for COD and BOD analysis.

2.2.2 Analytical method for COD:

The COD test was carried out using a standard procedure. 50ml of samples were carried out in six flasks, out of which one flask having the untreated water and rest five flasks having treated water by CGAC. Potassium dichromate solution was added to each flask with stirring gently. Solutions were heated in water bath at 100^0C for 1hour. Then samples were removed and cooled. Then potassium iodide & sulphuric acid were added to samples. The samples were titrated with sodium thiosulphate. The COD values were determined.

2.2.3 Analytical method for BOD:

The BOD tests were done using BOD bottles and BOD incubator. The samples were taken in six BOD bottles, out of which one bottle was filled with untreated water and rest five bottles with treated water by CGAC. The bottles were kept in the incubator maintaining temperature 20^0C for 5 days. After 5days, BOD values were observed.

3. RESULTS AND DISCUSSION

3.1 Analysis:

The initial COD and BOD of the Dairy waste water were obtained as 735.33mg/L and 438.67 mg/L, respectively. Experimental results obtained for different bed height of cylindrical beds using freshly prepared CGAC were reported in table 3.

Table 3: COD & BOD Analysis

Bed Height, cm	Contact Time, min	COD, mg/L	COD Removal %	BOD, mg/L	BOD Removal %
2	30	547	30.28	339	22.54
	60	532	32.17	320	26.95
	90	514	34.55	315	28.11
4	30	430	45.15	299	31.76
	60	399	49.11	275	37.16
	90	375	51.8	268	38.87
6	30	387	50.61	197	54.99

Bed Height, cm	Contact Time, min	COD, mg/L	COD Removal %	BOD, mg/L	BOD Removal %
	60	354	54.92	183	58.24
	90	340	56.69	173	60.46
8	30	302	61.49	167	61.83
	60	285	63.66	148	66.14
	90	267	65.88	139	68.25
10	30	266	66.03	100	77.12
	60	208	73.46	82	81.18
	90	197	74.88	76	82.59

3.1.1 Statistical Analysis:

The design wizard of the Design Expert software gave central composite design (CCD) as the most appropriate design for optimization, RSM and numeric factors criteria. The effects and interactions of the two factors were studied on two responses: %COD removal, %BOD removal. The effect of contact time and bed height on COD removal is represented in Fig. 3. The effect of contact time and bed height on BOD removal is represented in Fig. 4.

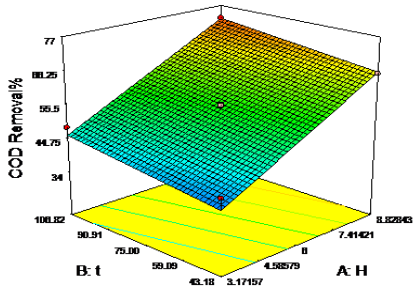

Figure 3: Combined Effect of bed height and time on % removal of COD (H represents bed height in cm, t represents contact time in min)

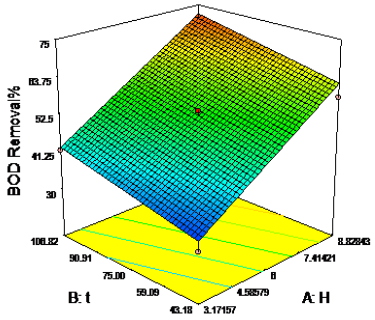

Figure 4: Combined Effect of bed height and time on % removal of BOD (H represents bed height in cm, t represents contact time in min)

The software suggested quadratic models to obtain regression equations for all the two responses. The regression model equation for % COD removal, % BOD removal, in terms of actual factors is given by Equations.

$$(COD)=+11.02509+6.96645*H+0.18985*t+0.010212*H*t-0.22535*H^2-1.18099E-003*t^2 \quad (3)$$

From the above equation, it is found that COD removal percentage highly depends on bed height and time individually, but the combined effect of bed height and time is less. From the Analysis of variance table, it is observed that, the Model F-value of 1018.23 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise. The Standard Deviation and R^2 are found as 0.59 and 0.9986, respectively.

$$(BOD) \quad =+2.69650+8.55431*H+0.14719*t+0.012364*H*t-0.18986*H^2-1.06281E-003*t^2 \quad (4)$$

From the above equation, it is found that BOD removal percentage highly depends on bed height and time individually, but the combined effect of bed height and time is less. From the Analysis of variance table, it is observed that, the Model F-value of 2948.72 implies the model is significant. There is only a 0.01% chance that a "Model F-Value" this large could occur due to noise. The Standard Deviation and R^2 are found as 0.49 and 0.9995, respectively.

Table 4: Analysis of variance table for COD

Source	Sum of Squares	df	Mean Square	F-Value	P-value (Prob>F)
Model Significant	1789.80	5	357.96	1018.23	<0.0001
H-Bed Height	1657.79	1	1657.79	4715.65	<0.0001
t-Time	97.76	1	97.76	278.08	<0.0001
Ht	2.84	1	2.84	8.08	0.025
H^2	28.61	1	28.61	81.39	<0.0001
t^2	5.55	1	5.55	15.78	0.0054

Table 5: Analysis of variance table for BOD

Source	Sum of Squares	df	Mean Square	F-Value	P-value (Prob>F)
Model Significant	3552.64	5	710.53	2948.72	<0.0001
H-Bed Height	3452.88	1	3452.88	14329.53	<0.0001
t-Time	72.91	1	72.91	302.57	<0.0001
Ht	4.16	1	4.16	17.27	0.0043
H^2	20.31	1	20.31	84.29	<0.0001
t^2	4.49	1	4.49	18.65	0.0035

The COD removal was observed more in 10cm bed height and for 90minute residence time. The BOD removal was observed more in 10 cm bed height and for 90-minute residence time.

4. CONCLUSION

CGAC has the highest hardness compared to other types of activated carbons, which makes it the ideal carbon for water purification.

It is observed from the experiment that by increasing the bed height of adsorbent in the bed and the contact time, the removal efficiency of BOD and COD is gradually increasing. CGAC has the highest hardness compared to other types of activated carbons, which makes it the ideal carbon for water purification.

The experiment can be carried out in continuous manner for industrial application with slight change in the experimental setup.

5. REFERENCES

[1] Baisali Sarkar, P.P. Chakrabarti, A. Vijay Kumar, Vijay Kale, Wastewater treatment in dairy industries — possibility of reuse, Desalination 195 (2006) 141–152

[2] Jai Prakash Kushwaha, Vimal Chandra Srivastava, Indra Deo Mall, An Overview of Various Technologies for the Treatment of Dairy Wastewaters, Critical Reviews in Food Science and Nutrition, 51:442–452 (2011)

[3] Aashika Patel, Vishakha Patel, Jyoti Singh, Mohit Ahir, Urvij B Dave, Comparative Study of Dairy Wastewater Treatment & Its Optimization"- A Review, IJSRD - International Journal for Scientific Research & Development| Vol. 5, Issue 12, 2018 | ISSN (online): 2321-0613

[4] A. S. Kolhe, S. R. Ingale and R. V. Bhole, Effluents of Diary Technology, Int. Res. Jr. Sodh, Samiksha and Mulyankan, 5 (II), 459-461 (2009).

[5] Bharati S. Shete and N. P. Shinkar, Dairy Industry Wastewater Sources, Characteristics & its Effects on Environment, International Journal of Current Engineering and Technology, ISSN 2277 - 4106, 2013.

[6] Samiksha Gaikwad, S. J. Mane, Reduction of Chemical Oxygen Demand by using Coconut Shell Activated Carbon and Sugarcane Bagasse Fly Ash International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438.
[7] Shuokr Qarani Aziz and Sazan Mohammed Ali, “Treatment of Synthetic Dairy Wastewater Using Disposed Plastic Materials as Trickling Filter Media: Optimization and Statistical Analysis by RSM”, Advances in Environmental Biology, 13(10), 1-16, October 2019.
[8] Kaajal Purushothaman and Hara Mohan Jena, “Biological treatment of synthetic dairy wastewater in FBBR ”, J. Indian Chem. Soc., Vol. 97, No. 12b, 2847-2853, December 2020.
[9] Ramjeawon T., “Cleaner Production in Mauritian Cane-Sugar Factories”, Journal of Cleaner Production, 2000.
[10] Tripathi, B.D. and A.R. Upadhyay, “Dairy Effluent Polishing by Aquatic Macrophytes”, Water Air Soil Pollut. 143: 127-133, 2003.
[11] Braio V.B. and C.R. Granhem, “Effluent Generation by the Dairy Industry: Preventive Attitude and Opportunities”, Journal of Chemical Engineering, 24 (4), 2007.
[12] Bhumesh Singh Bhadouria, Sai.V.S, “Utilization and Treatment of Dairy Effluent through Biogas Generation –A Case Study”, International Journal of Environmental Sciences, Volume 1, No 7, 2011
[13] Bharati S. Shete, Dr. N. P. Shinkar, “Comparative Study of Various Treatments for Dairy Industry Wastewater”, IOSR Journal of Engineering (IOSRJEN), Vol. 3, Issue 8, August. 2013.
[14] M. Rodgers, L. W. Xiao and J. Mulqueen, Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering, 2006, 41(5), 751.
[15] T. Yonar, O. Sivrioglu and N. Ozengin, “Physico Chemical Treatment of Dairy Industry Waste water: A Review”, in: Technological Approaches for Novel Applications in Dairy Processing, 2018.
[16] S.M. Ashekuzzaman, Patrick Forrestal, Karl Richards, Owen Fenton, Dairy industry derived wastewater treatment sludge: Generation, type and characterization of nutrients and metals for agricultural reuse, Journal of Cleaner Production, 230 (2019), 1266-1275.
[17] Saidat Olanipekun GIWA, Musa ADAMU, Abdulwahab GIWA, Treatment of Synthetic Dairy Waste Water Using Tamarind Tree Branch as Coagulant, 2, ABUAD Journal of Engineering Research and Development (AJERD), 2020.
[18] Harush D. P., Hampannavar U. S., Mallikarjunaswami M. E., Treatment of dairy wastewater using aerobic bio degradation and coagulation, International Journal of Environmental Sciences and Research, Vol. 1, No. 1, 2011, pp. 23-26
[19] Raed S. Al-Wasify, et al., 2017. Biodegradation of dairy wastewater using bacterial and fungal local isolates, Water Sci. Tech. 76(11): 3094-3100
[20] Patil, C. and Manika Hugar, 2015. Treatment of dairy wastewater by natural coagulants. Int. Res. J. Eng. Tech. 2(4): 1120-1125.
[21] Neethu, P., et al., 2017. Treatment of dairy waste water by moringa oleifera as natural coagulant. Int. J. advance res. innovative ideas Educ. 3(4):1448-1453.

DOI: https://doi.org/10.15379/ijmst.v10i2.3150