

Treatment of Dairy Wastewater Using Mixed Adsorbents

Gujar Prashant D.¹, Dr. P.M. Patil², Ransing Shubham S.³, Gaikwad Aditya R.⁴, Adhav Sandesh V⁵
Dikonda Vishal S.⁶

¹*Guide, Professor, Civil Engineering, Adsul's Technical Campus*

²*Principal and Director, Adsul's Technical Campus*

^{3,4,5,6}*Students, Civil Engineering, Adsul's Technical Campus*

Abstract—The dairy industry is one of the major contributors to industrial wastewater generation. Dairy wastewater contains high concentrations of organic matter, suspended solids, dissolved solids, fats, oils, and nutrients that can adversely affect the environment if discharged without proper treatment. The present study investigates the treatment of dairy wastewater using mixed adsorbents prepared from tea waste and laterite. Batch adsorption experiments were conducted to evaluate the removal of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS), turbidity, and conductivity. The effects of contact time, adsorbent dosage, and pH on adsorption efficiency were studied. Adsorption equilibrium was analyzed using Langmuir and Freundlich isotherm models. Experimental results demonstrated significant reductions in COD, BOD, TDS, and turbidity, indicating that mixed adsorbents derived from low-cost waste materials can effectively treat dairy wastewater. The findings suggest that the adsorption process is economical, environmentally friendly, and suitable for industrial wastewater treatment applications.

Index Terms—Dairy Wastewater, Adsorption, Tea Waste, Laterite, COD Removal, BOD Reduction, Langmuir Isotherm, Freundlich Isotherm.

I. INTRODUCTION

Water is an essential natural resource for human survival, industrial development, and ecological sustainability. Rapid industrialization has led to increased generation of wastewater, which has become a major environmental concern. Among various industries, dairy processing industries consume large quantities of water and generate significant amounts of wastewater containing organic pollutants.

Dairy wastewater originates from milk processing operations such as washing, cleaning, pasteurization, packaging, and equipment maintenance. It contains milk residues, fats, proteins, carbohydrates, detergents, and cleaning chemicals. These contaminants contribute to high levels of BOD and COD, making dairy wastewater highly polluting if discharged untreated.

The Maharashtra Pollution Control Board specifies permissible discharge limits for dairy wastewater, including pH, suspended solids, COD, and BOD. However, untreated dairy effluent often exceeds these limits and requires treatment before disposal.

Adsorption is considered one of the most effective and economical methods for wastewater treatment. It offers simplicity, low operational cost, and high removal efficiency. The use of agricultural and industrial wastes as adsorbents further reduces treatment costs and promotes sustainable waste management.

The present research focuses on the treatment of dairy wastewater using mixed adsorbents prepared from tea waste and laterite.

II. NEED FOR THE STUDY

The increasing discharge of untreated industrial effluents into rivers and water bodies has resulted in severe environmental degradation. Dairy wastewater contains large amounts of biodegradable organic matter that can reduce dissolved oxygen levels in receiving water bodies.

Traditional treatment processes often involve high installation and operational costs. Therefore, there is a need for cost-effective treatment methods that can achieve high pollutant removal efficiencies while

utilizing locally available waste materials. Tea waste and laterite are abundantly available materials and possess adsorption properties that make them suitable for wastewater treatment.

III. OBJECTIVES OF THE STUDY

The major objectives of the present investigation are:

1. To prepare mixed activated carbon using tea waste and laterite.
2. To reduce COD, BOD, TDS, turbidity, and conductivity of dairy wastewater.
3. To study the effects of pH, adsorbent dosage, and contact time.
4. To evaluate adsorption efficiency using adsorption isotherms.
5. To analyze the applicability of Langmuir and Freundlich models.

IV. LITERATURE REVIEW

Adsorption has emerged as a promising wastewater treatment technology due to its effectiveness and simplicity.

Kushwaha et al. (2010) investigated COD removal from synthetic dairy wastewater using activated carbon and bagasse fly ash. Their study reported significant COD reduction under optimized conditions.

Bazrafshan et al. (2015) evaluated chemical coagulation and adsorption using modified activated sludge for dairy wastewater treatment. Freundlich isotherm successfully described the adsorption process.

Suman and Ahmad (2018) employed water treatment sludge as a coagulant and achieved substantial reductions in turbidity, COD, BOD, and TDS.

Pathak et al. (2016) used rice husk as an adsorbent and reported COD removal efficiency exceeding 90%.

Durairaj (2016) utilized eucalyptus wood sawdust activated carbon and achieved COD reduction of approximately 95%.

Several studies concluded that adsorption using low-cost adsorbents is a feasible and sustainable solution for dairy wastewater treatment.

V. THEORETICAL BACKGROUND OF ADSORPTION

Adsorption is a surface phenomenon in which molecules from a liquid or gas accumulate on the surface of a solid material. The substance being adsorbed is called the adsorbate, while the material on which adsorption occurs is known as the adsorbent.

Types of Adsorptions

Chemical Adsorption

Chemical adsorption involves strong chemical bonds between adsorbate molecules and the adsorbent surface. It is generally irreversible.

Physical Adsorption

Physical adsorption occurs due to weak Van der Waals forces and is usually reversible.

Exchange Adsorption

Exchange adsorption results from electrostatic attraction and ion exchange mechanisms.

VI. ADSORBENTS USED IN THE STUDY

The adsorbents selected for the study were:

Tea Waste



Tea waste is a readily available agricultural waste containing porous carbonaceous material capable of adsorbing pollutants.

Laterite



Laterite is a naturally occurring soil rich in iron and aluminum oxides. It exhibits adsorption characteristics suitable for wastewater treatment. The adsorbents were mixed in a homogeneous proportion of 1:1 to prepare mixed adsorbents.

VII. MATERIALS AND METHODOLOGY

The study was conducted using dairy wastewater samples collected from a dairy processing facility.

Preparation of Adsorbents

The adsorbents were crushed, sieved, and processed to obtain particle sizes of approximately 0.25 mm. Mixed activated carbon was prepared using tea waste and laterite.

Batch Adsorption Experiment

A 250 mL flask containing 100 mL wastewater sample was used. Predetermined quantities of adsorbent were added, and the mixture was agitated in an orbital shaker. After treatment, the solution was filtered and analyzed.

VIII. ANALYTICAL METHODS

The following standard methods were employed:

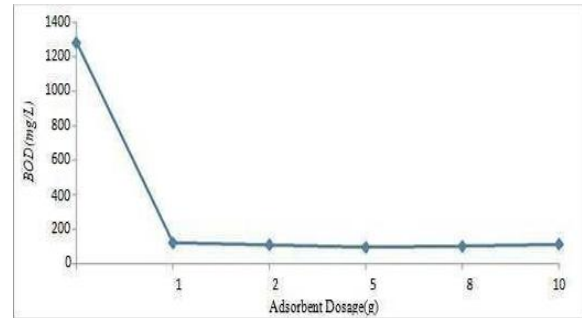
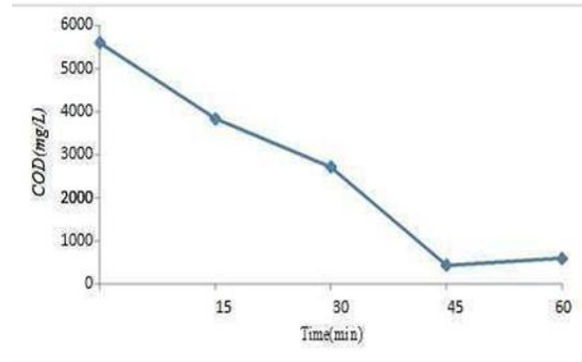
Parameter	Method
pH	pH Meter
COD	Open Reflux Method
BOD	Winkler Method
TDS	Gravimetric Method
Turbidity	Nephelometric Method

IX. CHARACTERISTICS OF RAW DAIRY WASTEWATER

The wastewater characteristics were determined before treatment.

Parameter	Value
pH	6.21
COD	5600 mg/L
BOD	1284 mg/L
TDS	520 mg/L
Suspended Solids	1180 mg/L
Turbidity	52.29 NTU

Effect of contact time on COD removal



Effect of Adsorbent Dosage on BOD removal

X. RESULTS AND DISCUSSION

The results demonstrated substantial reductions in pollutant concentrations after adsorption treatment.

COD Reduction

COD decreased from 5600 mg/L to 440 mg/L at optimum operating conditions.

BOD Reduction

BOD decreased from 1284 mg/L to 96.7 mg/L.

TDS Reduction

TDS decreased from 520 mg/L to 84 mg/L.

Turbidity Reduction

Turbidity decreased from 52.29 NTU to 12.96 NTU.

These results indicate that tea waste and laterite mixed adsorbents are highly effective in removing organic pollutants from dairy wastewater.

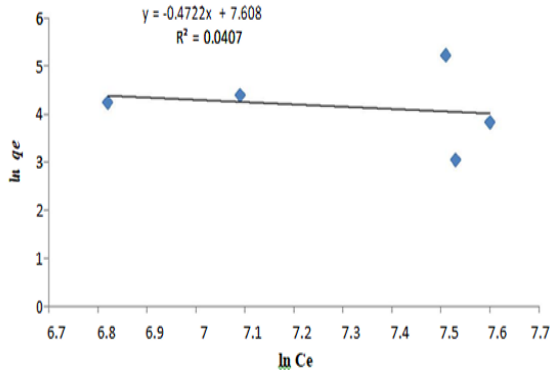
XI. ADSORPTION ISOTHERM STUDIES

Langmuir Isotherm

The Langmuir model assumes monolayer adsorption on a homogeneous surface. The separation factor (RL) was found to lie between 0 and 1, indicating favorable adsorption.

Freundlich Isotherm

The Freundlich model successfully described adsorption on heterogeneous surfaces. The value of $1/n$ was less than 1, confirming favorable adsorption conditions.



Freundlich Isotherm for Constant contact time of 45 min Tea Waste mixed adsorbent.

XII. SUMMARY

The present investigation successfully demonstrated the application of mixed adsorbents prepared from tea waste and laterite for dairy wastewater treatment. The study established optimum operating conditions and confirmed significant reductions in COD, BOD, TDS, and turbidity. Both Langmuir and Freundlich isotherm models adequately described the adsorption process.

XIII. CONCLUSIONS

1. Tea waste and laterite mixed adsorbents effectively treated dairy wastewater.
2. COD removal efficiency exceeded 90%.
3. Significant reductions in BOD, TDS, and turbidity were achieved.
4. Adsorption performance improved with increasing contact time.
5. Optimum dosage was found to be approximately 10 g/L.
6. The adsorption process followed both Langmuir and Freundlich isotherm models.
7. Mixed adsorbents provide a low-cost and eco-friendly wastewater treatment solution.
8. The process can be scaled for industrial applications.

REFERENCES

- [1] Kushwaha, J. P., Srivastava, V. C., and Mall, I. D., "An Overview of Various Technologies for the Treatment of Dairy Wastewaters", *Critical Reviews in Food Science and Nutrition*, Vol. 51, Issue 5, pp. 442–452, 2011.
- [2] Bazrafshan, E., Mostafapour, F. K., Alizadeh, M., and Farzadkia, M., "Treatment of Dairy Wastewater by Adsorption Process Using Modified Activated Sludge", *Desalination and Water Treatment*, Vol. 57, Issue 1, pp. 1–10, 2015.
- [3] Pathak, U., Das, P., Banerjee, P., and Datta, S., "Treatment of Wastewater by Adsorption Using Rice Husk", *Journal of Environmental Chemical Engineering*, Vol. 4, Issue 2, pp. 2096–2107, 2016.
- [4] Durairaj, S., "Removal of COD and TDS from Dairy Industry Wastewater Using Eucalyptus Wood Activated Carbon", *International Journal of Engineering Research and Applications*, Vol. 6, Issue 8, pp. 44–50, 2016.
- [5] Choi, Y., Jang, H. M., Kan, E., Wallace, A. R., and Sun, W., "Adsorption of Phosphate from Dairy Wastewater Using Calcium Hydroxide-Coated Biochar", *Journal of Environmental Management*, Vol. 248, pp. 109315, 2019.
- [6] Mohan, S. S., and Sheena, K. N., "Removal of COD and BOD from Dairy Wastewater Using Low-Cost Adsorbents", *International Journal of Civil Engineering and Technology*, Vol. 10, Issue 5, pp. 112–120, 2019.
- [7] Anjitha, A., and Kani, K. M., "Treatment of Dairy Wastewater Using Laterite Soil Grains", *International Journal of Innovative Research in Science and Engineering*, Vol. 6, Issue 4, pp. 78–86, 2017.
- [8] Bureau of Indian Standards, "IS 10500: Drinking Water Specifications", BIS, New Delhi, India, 2012.
- [9] APHA, "Standard Methods for the Examination of Water and Wastewater", 23rd Edition, American Public Health Association, Washington D.C., 2017.
- [10] Metcalf and Eddy, "Wastewater Engineering: Treatment and Resource Recovery", McGraw-Hill Education, New York, USA, 2014.