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Performance Study of Municipal Wastewater Treatment Using Activated Sludge Process

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Abstract - Rapid urbanization and population growth have significantly increased the generation of municipal wastewater, necessitating efficient treatment before discharge into natural water bodies. The activated sludge process (ASP) remains one of the most widely applied biological treatment technologies for municipal wastewater due to its flexibility and high removal efficiency of biodegradable organic matter. This study investigates the performance of a laboratory-scale activated sludge reactor operated in batch mode for the treatment of real municipal wastewater collected from Kolkata, India. The reactor was operated with an initial mixed liquor suspended solids (MLSS) concentration of 2000–2500 mg/L and influent biochemical oxygen demand (BOD_5) ranging from 220–230 mg/L. Treatment performance was evaluated over multiple batch cycles by monitoring BOD removal efficiency and biomass behavior. Results indicate a progressive improvement in treatment efficiency, achieving approximately 70% BOD removal under optimized operating conditions. The findings demonstrate the technical feasibility of ASP for municipal wastewater treatment at laboratory scale and provide insight into its applicability for small- to medium-scale wastewater treatment systems.

Keywords: Activated sludge process, municipal wastewater, BOD removal, batch reactor, biological treatment

1. INTRODUCTION

The continuous increase in urban population, industrial activity, and improved living standards has led to the generation of large volumes of municipal wastewater containing biodegradable organic matter, suspended solids, and nutrients. Untreated or inadequately treated wastewater poses serious risks to aquatic ecosystems and public health. Biological treatment processes play a vital role in the removal of organic pollutants from wastewater, among which the activated sludge process (ASP) is the most widely used suspended-growth aerobic treatment method.

The ASP offers operational flexibility, high treatment efficiency, and adaptability to varying influent characteristics. It is capable of simultaneous carbon oxidation and nitrification under controlled conditions. Given the increasing pressure on wastewater treatment infrastructure in developing countries like India, performance evaluation of ASP under controlled laboratory conditions provides valuable data for optimizing full-scale systems.

This study focuses on evaluating the performance of a laboratory-scale ASP operated in batch mode for the treatment of real municipal wastewater collected from an urban drainage system.

2. OBJECTIVES AND SCOPE OF THE STUDY

The primary objectives of the study are:

- To evaluate the treatment efficiency of a laboratory-scale activated sludge process for municipal wastewater.
- To study the removal of biodegradable organic matter in terms of BOD reduction.
- To assess the behavior of biomass under batch operational conditions.

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The scope of the study includes characterization of raw municipal wastewater, acclimation of activated sludge biomass, and batch performance evaluation under controlled laboratory conditions.

3. MATERIALS AND METHODS

3.1 Wastewater Collection and Characterization

Raw municipal wastewater was collected from an open drain (NALA) located within the Techno India University campus, Salt Lake Sector V, Kolkata, India. Grab samples were collected and characterized following Standard Methods (1998).

Key characteristics of the raw wastewater are summarized in Table 1.

Table 1. Characteristics of Municipal Wastewater

Parameter	Value
pH	7.21
Total Alkalinity (mg/L)	400
BOD_5 (mg/L)	230
Total Solids (mg/L)	550
Total Dissolved Solids (mg/L)	418

3.2 Reactor Setup

A laboratory-scale activated sludge reactor was fabricated using a 10 L PVC container. Aeration was provided using an aquarium air pump to maintain aerobic conditions. The reactor was connected to a secondary clarifier for solid–liquid separation. The system was operated in batch mode with real municipal wastewater.

3.3 Biomass Acclimation

Activated sludge was acclimated to municipal wastewater over a period of 21 days under batch feeding conditions. Gradual increase in wastewater strength was applied to ensure microbial adaptation. MLSS concentration, pH, and BOD were monitored periodically to confirm stable biomass development.

3.4 Analytical Methods

The following parameters were analyzed:

- **BOD_5:** Measured using standard incubation and titration methods.
- **MLSS and MLVSS:** Determined gravimetrically.
- **Dissolved Oxygen (DO):** Measured using Azide-modified Winkler's method.
- **Total Solids and Suspended Solids:** Determined by oven-drying methods.

All analyses were conducted following Standard Methods for the Examination of Water and Wastewater.

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4. RESULTS AND DISCUSSION

4.1 Treatability Performance

The performance of the activated sludge reactor was evaluated based on BOD removal efficiency over successive batch runs. A gradual improvement in treatment efficiency was observed with increasing acclimation and stabilization of biomass.

Table 2. Performance of Activated Sludge Reactor

Batch No.	Influent BOD (mg/L)	Effluent BOD (mg/L)	Removal Efficiency (%)
1	220	220	–
5	175	130	40.9
7	110	55	50.0
9	65	19	70.5

The maximum BOD removal efficiency of approximately 70% indicates effective biodegradation of organic matter. The improvement in efficiency can be attributed to stable MLSS concentration and adequate aeration.

4.2 Process Stability

The reactor demonstrated stable operation under batch conditions with no significant sludge bulking or foaming observed. The acclimated biomass showed good settling characteristics, supporting efficient solid–liquid separation.

5. CONCLUSIONS

The laboratory-scale activated sludge process demonstrated effective treatment of municipal wastewater under batch operation. The system achieved up to 70% BOD removal, confirming the suitability of ASP for treating low- to medium-strength municipal wastewater. The study highlights the importance of biomass acclimation and operational control for achieving stable performance. The findings support the applicability of ASP as a cost-effective and reliable biological treatment method for municipal wastewater, particularly in small- and medium-scale applications.

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REFERENCES

[1] *(Condensed journal-style reference list derived from the project report)*
Ardern, E., & Lockett, W.T. (1914). Experiments on the oxidation of sewage. *Journal of the Society of Chemical Industry*.
[2] Eckenfelder, W.W. (2000). *Industrial Water Pollution Control*. McGraw-Hill.
[3] Hait, S., & Mazumder, D. (2008). Scope of improvement of treatment capacity of ASP by hybrid modification. *Journal of Environmental Engineering Science*, 7, 147–158.
[4] Ødegaard, H., Rusten, B., & Westrum, T. (1994). A new moving bed biofilm reactor. *Water Science and Technology*, 29, 157–165.
[5] Wanner, J., Grau, P., & Kucman, K. (1988). Activated sludge process combined with biofilm cultivation. *Water Research*, 22, 207–215.