Performance Evaluation of Pellet and Powdered Activated carbon-biochar in a Gravity-Driven Filter for Municipal Wastewater Treatment

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ABSTRACT

Municipal wastewater treatment is essential for reducing water pollution and promoting sustainable water resource management. This study evaluates the performance of pellet activated carbon and powdered activated carbon–biochar in a gravity-driven filter for municipal wastewater treatment. The system utilizes gravity to pass wastewater through filtration media, potentially reducing energy requirements and operational complexity. The treatment performance is assessed by comparing selected water quality parameters, including pH, turbidity, total dissolved solids (TDS), dissolved oxygen (DO), and chemical oxygen demand (COD), before and after filtration. The study focuses on comparing the effectiveness of both filtration configurations and understanding their suitability for improving wastewater quality. The results are intended to identify differences in treatment performance and the potential of carbon-based filtration media as supplementary treatment options. This research may contribute to the development of simple, resource-efficient approaches for wastewater treatment and potential reuse, subject to applicable water quality requirements.

Keywords: Municipal wastewater treatment, Pellet activated carbon, Powdered activated carbon–biochar, Gravity-driven filtration, Water quality assessment, Chemical oxygen demand (COD), Turbidity removal

INTRODUCTION

Municipal wastewater is generated from domestic, commercial, and other urban activities and contains suspended solids, dissolved substances, and organic pollutants. If discharged without adequate treatment, it can cause water pollution, harm aquatic ecosystems, and pose risks to public health. Therefore, effective wastewater treatment is essential for environmental protection and sustainable water resource management. Gravity-driven filtration offers a potential supplementary treatment approach that uses gravitational force to pass wastewater through filter media, reducing the need for continuous mechanical pumping.

Activated carbon and biochar are promising filtration materials because of their adsorption properties. Pellet activated carbon offers ease of handling, while powdered activated carbon provides a larger external surface area per unit mass. Biochar, derived from biomass, also has potential as a low-cost adsorbent. However, the comparative performance of pellet activated carbon and powdered activated carbon–biochar in gravity-driven filtration requires further evaluation. This study aims to compare both filtration configurations by assessing changes in pH, turbidity, total dissolved solids (TDS), dissolved oxygen (DO), and chemical oxygen demand (COD) before and after filtration. The findings may help identify the relative effectiveness of these materials for improving municipal wastewater quality and their potential application in supplementary wastewater treatment.

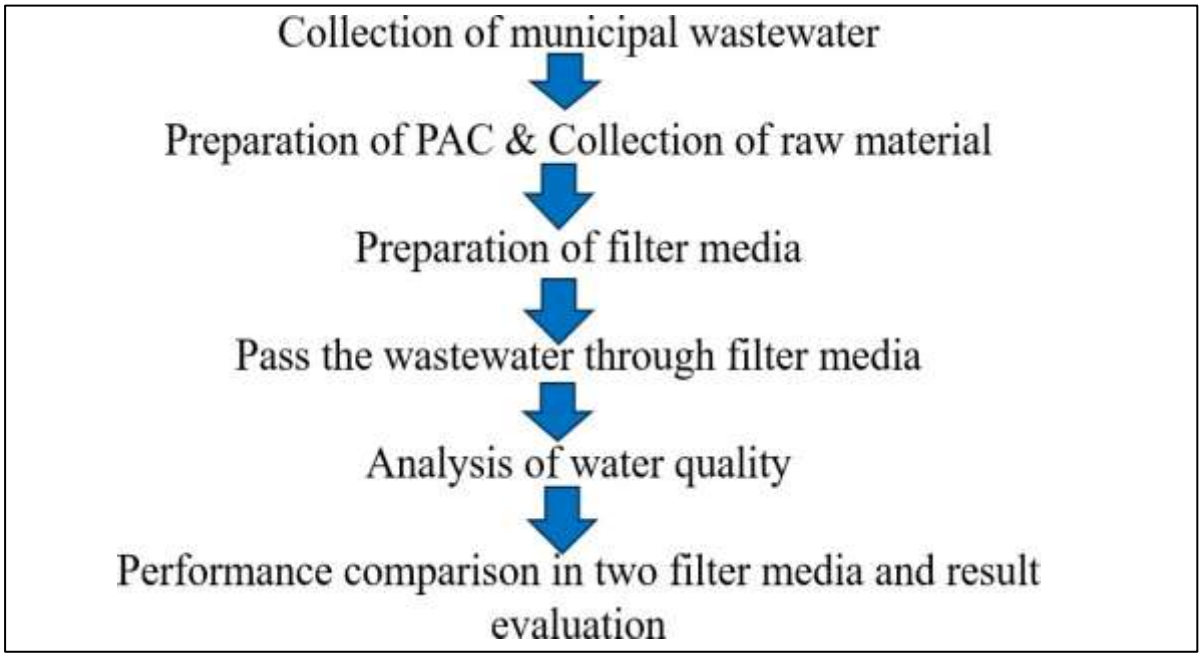
LITERATURE REVIEW

The reviewed literature indicates that activated carbon and biochar are effective materials for wastewater treatment due to their adsorption capacity and ability to remove various pollutants. Studies have demonstrated the effectiveness of granular activated carbon (GAC) and powdered activated carbon (PAC) in removing micropollutants, organic matter, and turbidity from wastewater. Biochar has also shown promising pollutant-removal performance and offers environmental benefits due to its potential for production from waste materials. Research comparing biochar and activated carbon has highlighted their suitability as adsorbents, while studies on activated carbon filtration have

demonstrated improvements in wastewater quality and the potential for water reuse.

Recent studies have explored gravity-driven filtration, biochar-based fixed-bed filters, and membrane filtration as energy-efficient approaches to water and wastewater treatment. Research has also shown that lower filtration flow rates can improve pollutant removal by increasing the contact time between wastewater and filter media. However, limited comparative research is available on the performance of pellet activated carbon and powdered activated carbon–biochar in gravity-driven filters for municipal wastewater treatment. Therefore, the present study aims to compare these two-filter media by evaluating changes in pH, turbidity, total dissolved solids (TDS), dissolved oxygen (DO), and chemical oxygen demand (COD) to assess their effectiveness and suitability for sustainable wastewater treatment.

METHODOLOGY



TEST PERFORMED

- **On Untreated water**:

Sr. No.	Test	Result	IS Code
1.	pH	4.85	IS 3025 (Part-11) 1983
2.	Turbidity (NTU)	250	IS 3025 (Part-10)
3.	Total dissolved solid (mg/l)	809	IS 3025 (Part-16) 2023
4.	Dissolved oxygen (mg/l)	2.5	IS 3025 (Part-38) 1989
5.	Chemical Oxygen Demand (mg/l)	568	IS 3025 (Part-58) 2006

- On treated water by:

1. **Pellet activated carbon**

Sr. No.	Test	Flow rate(ml/min)			IS Standard limit	IS Code
		17.966	16.064	14.864		
1.	pH	6.40	6.44	6.47	5.5 to 9.0	IS 3025 (Part-11) 1983
2.	Turbidity (NTU)	41	38	31	0 to 40 NTU.	IS 3025 (Part-10)
3.	Total dissolved solid (mg/l)	243	233	221	200-2,100 mg/L	IS 3025 (Part-16)
4.	Dissolved oxygen (mg/l)	3.46	4.5	5	4-6 mg/l	IS 3025 (Part-38) 1989
5.	Chemical oxygen demand	120	109	95	50-125 mg/l	L IS 3025 (Part-58)

2. Powdered activated carbon- biochar

Sr. No.	Test	Flow rate(ml/min)			IS Standard limit	IS Code
		17.966	16.064	14.864		
1.	pH	6.8	6.9	7.0	5.5 to 9.0	IS 3025 (Part-11) 1983
2.	Turbidity (NTU)	25	22	20	0 to 40 NTU.	IS 3025 (Part-10)
3.	Total dissolved solid (mg/l)	210	205	200	200-2,100 mg/L	IS 3025 (Part-16)
4.	Dissolved oxygen (mg/l)	4.8	5.2	5.5	4-6 mg/l	IS 3025 (Part-38) 1989
5.	Chemical oxygen demand (mg/l)	85	80	78	50-125 mg/L	IS 3025 (Part-58) 2006

RESULT & DISCUSSION

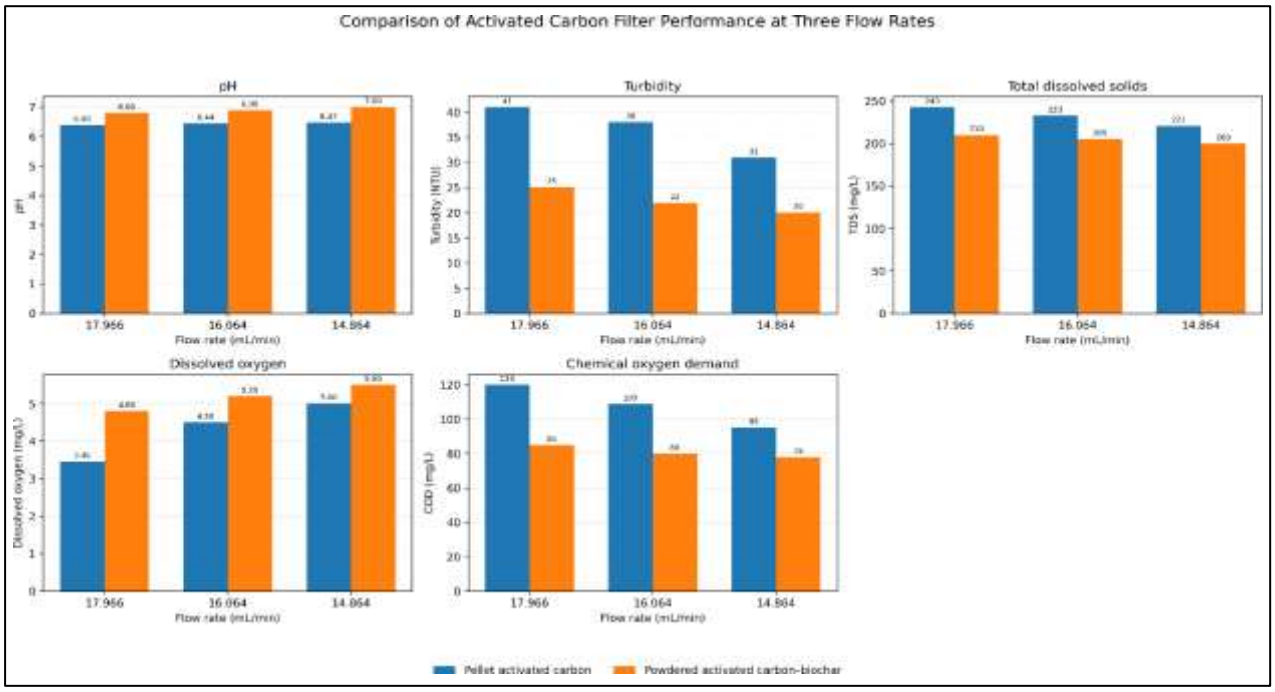


Fig. Comparison of Activated Carbon Filter Performance at Three Flow Rates

The experimental results showed that powdered activated carbon–biochar performed better than pellet activated carbon for most of the measured water quality parameters. The pH values ranged from 6.40–6.47 for pellet activated carbon and 6.8–7.0 for powdered activated carbon–biochar, remaining within the specified range of 5.5–9.0.

Turbidity decreased from 41 to 31 NTU for pellet activated carbon and from 25 to 20 NTU for powdered activated carbon–biochar. Similarly, TDS decreased from 243 to 221 mg/L and from 210 to 200 mg/L, respectively. Dissolved oxygen increased with decreasing flow rate, reaching
5.0 mg/L for pellet activated carbon and 5.5 mg/L for powdered activated carbon–biochar. COD decreased to 95 mg/L and 78 mg/L, respectively, indicating better observed removal of oxidizable substances by the powdered activated carbon–biochar filter.

Overall, both filtration media improved selected wastewater quality parameters, with powdered activated carbon–biochar showing more favourable results. The improvements observed at lower flow rates(14.864 mL/min) may be associated with increased contact time between wastewater and filtration media.

CONCLUSION

This study evaluated the performance of pellet activated carbon and powdered activated carbon–biochar in a gravity-driven filter for municipal wastewater treatment. Based on the experimental readings, the powdered activated carbon–biochar filter showed more favourable results for turbidity, TDS, and DO, while both filters exhibited pH values within the reported range. The COD values recorded for the two filters ranged approximately from 50 to 125 mg/L, indicating variations in treatment performance. Overall, the findings suggest that powdered activated carbon–biochar has potential for improving selected wastewater quality parameters. However, further testing under comparable flow conditions and verification of initial wastewater characteristics are required to establish the relative treatment efficiency of both filtration media.

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