WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Study on the Efficiency of Biochar for Textile Dye Removal

Jaisyreena J, Juby T R*

Department of Microbiology Sree Narayana Guru College, K G Chavadi, Coimbatore, Tamil Nadu, India

A B S T R A C T

With growing environmental concerns over synthetic dye pollution, innovative approaches are necessary to mitigate these challenges. This research investigates the use of immobilized biochar in a distinct application: the reduction of methylene blue dye in wastewater. Biochar, a carbon-rich material derived from fish waste through pyrolysis, has gained attention due to its adsorption capabilities and potential to remove pollutants from wastewater. In this study, biochar is used for textile dye reduction. Immobilized biochar's large surface area enhances dye adsorption. The efficacy immobilized biochar for the removal of artificial textile dye, Methylene blue was tested in a controlled setting. The outcomes of this research will provide insights into the potential of immobilized biochar systems for environmental remediation. Dye removal efficacy study results contribute to the development of eco-friendly solutions to pressing global challenges.

Keywords: *Biochar, Immobilized Biochar beads, synthetic dye, dye reduction*

1. Introduction

In recent years, pollution from textile industries has raised major environmental concerns due to the discharge of synthetic dyes into water bodies, leading to reduced sunlight penetration, lower oxygen levels, and adverse effects on aquatic ecosystems and human health [1]. Synthetic dyes such as methylene blue (MB) are toxic, carcinogenic, and resistant to conventional wastewater treatments like coagulation and chemical oxidation, which are costly and may produce secondary pollutants [2]. As a result, there is growing interest in developing sustainable, cost-effective, and eco-friendly alternatives for dye removal from industrial effluents.

Biochar, a carbon-rich material produced by pyrolyzing agricultural biomass, has shown high potential as an adsorbent for dye-laden wastewater due to its porous structure, large surface area, and abundant surface functional groups [3]. Research studies demonstrated that biochar derived from cattle manure and rice husk achieved methylene blue removal efficiencies of up to 99%, with adsorption following Langmuir isotherms and pseudo-second-order kinetics. To improve practicality and reusability, biochar can be immobilized into beads using binders like sodium alginate or polyvinyl alcohol, which enhances mechanical strength and facilitates separation from water systems.

This study aims to evaluate the performance of immobilized biochar beads for methylene blue reduction, contributing to the development of a sustainable bioremediation system aligned with circular economy practices.

2. Materials and Methods

2.1 Collection and preparation of biochar sample

Collected fish waste from aquaculture in IRTC, Mundur, Palakkad, Kerala.

2.2 Preparation of biochar

Biochar was prepared using the Fish waste by pyrolysis method using Matte furnace. The collected raw material was pyrolyzed in lid-covered porcelain crucibles (Haldenwanger 79MF) in a muffle furnace, preheated at 100 °C, to a highest heating temperature of 900°C with a holding time of 1 hour. The crucibles were then moved with the lids and cooled at room Temperature to prevent any loss in homogeneity due to accidental combustion. Ground and sieved biochar samples were used for chemical analysis.

2.3 Analysis the micronutrients and trace elements present in the prepared fish biochar

Composition of the prepared biochar was analyzed at the Integrated Rural Technology Centre (IRTC) Mundur Palakkad to determine its elemental content, focusing on carbon, hydrogen, Nitrogen and oxygen levels. These elements are essential for understanding biochar's capacity for pollutant adsorption and nutrient retention.

2.4 Preparation synthetic dye solution

100 ppm Methylene Blue solution was prepared by dissolving 0.1 gram of methylene blue powder in 1000 ml of sterile distilled water. 5 ml of main solution was taken and diluted in 100 ml distilled water to obtain 5 ppm of standard solution [4].

2.5 Preparation of Immobilized Biochar bead

1 gram of biochar was added to 10ml of distilled water and added the biochar solution to 4% sodium alginate solution and stirred to make a homogenous biochar alginate suspension. Using a syringe dropped the alginate-Biochar mixture into a 1.5% $CaCl_2$ solution. The drops formed beads upon contact with $CaCl_2$. After 30 mins, the beads were washed with distilled water 3-4 times and stored at 4°C.

2.6 Methylene blue dye reduction using immobilized Bacillus Sp. And biochar beads.

To evaluate the dye reduction potential of immobilized biochar for the prepared synthetic dye reduction. The initial absorbance was measured at 660nm using a colorimeter. The experiment was set up adding 2g of immobilized biochar beads to the conical flask containing 100 ml of the dye solution and a control were incubated at room temperature on a rotary shaker to ensure proper mixing, Periodic samples were taken over every 24 hours to monitor the reduction of methylene blue dye by measuring the absorbance at 660nm. The reduction in absorbance over time was used to calculate the percentage of dye removal.

3. Result

3.1 Biochar, produced from fish scales and other waste biomass, shows promise in aquaculture for water purification, fish health management, and potentially as a feed additive, offering a sustainable and cost-effective approach to improving aquaculture practices.

3.2 Preparation of Fish biochar

The collected Fish wastes were dried through thermal Decomposition and converted to biochar using pyrolysis method. The samples were pyrolyzed in the muffle furnace at high temperature to form the biochar, which was then sieved to get fine particles of biochar.

3.3 Analysis of micronutrients and trace minerals of fish biochar

Analysis for macro and trace minerals using Acid-digested Sample (3 ml) of biochar was performed by Inductively Coupled Plasma Mass Spectrometry (ICPMS). ICP-MS-Perkin ElmerNexION 300X (PerkinElmer, Inc. Waltham,USA) armed with nickel Sampler, quartz torch and cross-flow nebulizer with normal resolution n triplicates (Melaku et al., 2005) was used. Biochar composition was analyzed and the result are tabulated (Table 1)

Table 1: Micronutrients in Fish Biochar

SI.No	Parameters detected	Concentration (mg/kg)
1	Organic carbon(C)	59
2	Nitrogen (N)	4.8
3	Sulphur(S)	2.5
4	Beryllium(Be)	0.0048
5	Sodium(Na)	45
6	Aluminum (Al)	2.01
7	Potassium(Cr)	4.48
8	Manganese(Mn)	1.88
9	Iron(Fe)	5.01

10	Nickel(Ni)	1.14
11	Copper(Cu)	2.33
12	Zinc(Zn)	2.98
13	Arsenic(Se)	0.0002
14	Selenium(Se)	0.11
15	Molybdenum(Mo)	1.57

3.4 Methylene blue dye reduction using immobilized biochar beads

Immobilized biochar beads demonstrated significant methylene blue dye reduction. Over a period of 24 hours, a marked decrease in absorbance at 660 nm was observed, indicating the removal of the dye. The reduction was increasing with increase in the incubation time. The results demonstrate the biochar beads have the capacity to adsorb the artificial dye (figure 1)

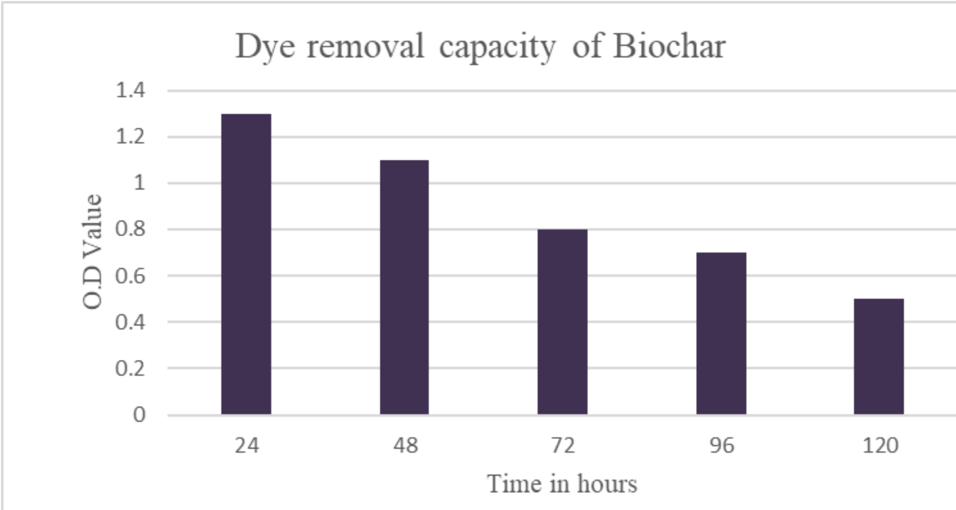

Fig1: Removal of synthetic textile dye by immobilized biochar beads

4. Discussion

The biochar was characterized and the elemental composition was analysed. The nutrient found in the fish biochar were organic carbon- 54%, nitrogen-3.8% and sulphur 2.1%. According to llango, & lefebvre, O (2016) [5] the study on human faeces biochar, the average elemental composition determined were 47.3% of carbon and 3.9% nitrogen. The carbon content in the fish waste derived biochar was comparatively high and organic carbon and nitrogen content was also high; organic carbon 59%, Nitrogen 4.8%, and Sulphur 2.5 in fish biochar.

The application of Immobilized biochar in alginate beads for methylene blue dye reduction showed significant results in this study. The immobilized system enhanced the efficiency of dye reduction compared to using biochar alone. Study conducted by Sahu *et al* (2017) [6] demonstrated the efficacy of biochar in adsorbing organic dyes due to its high surface area and porosity, supporting the findings in this research that biochar beads aid in adsorption while the bacteria degrade the dye.

The enhanced dye reduction observed in this study aligns with findings from Chen *et al*. (2020) [7], where biochar, combined with microbial treatments, showed improved remediation of dyes in wastewater. In this research, the biochar served as an adsorbent to reduce methylene blue concentrations over the time. Comparing these results with available literature, this study aligns with and extends existing knowledge on the use of biochar-based systems for both dye reduction. Zhang *et al*. (2019)[8] highlighted the efficiency of biochar in adsorbing dyes and heavy metals from contaminated water systems, further supporting the role of biochar in the removal of methylene blue in this study.

REFERENCES

1. Forgacs, E., Cserháti, T., & Oros, G. (2004). Removal of synthetic dyes from wastewaters: a review. *Environment International*, 30(7), 953–971.
2. Robinson, T., McMullan, G., Marchant, R., & Nigam, P. (2001). Remediation of dyes in textile effluent: a critical review on current treatment technologies with a proposed alternative. *Bioresource Technology*, 77(3), 247–255.
3. Lehmann, J., & Joseph, S. (Eds.). (2009). *Biochar for environmental management: Science and technology*. Earthscan.

4. Rahmawati, L., Azis, M. M., & Rochmadi, R. (2021). Methylene blue removal from waste water using sodium lignosulfonate and polyaluminium chloride: Optimization with RSM. *AIP Conference Proceedings, 2349*(1), 020035.

5. Ilango, K. and Lefebvre, O. (2016). Human feces-derived biochar for heavy metal adsorption. Environmental Science and Pollution Research, 23(8), 7645-7658.

6. Sahu, O., Mazumdar, B., & Chaudhari, P. K. (2017). Treatment of wastewater by natural and synthetic coagulants: A review. Journal of Water Process Engineering, 16, 212-227.

7. Chen, W., Meng, J., Han, X., Lan, Y., Zhang, W., & Yang, X. (2020). Adsorption of dyes by biochar derived from pyrolysis of herb-residue. *Journal of Environmental Management, 270*, 110853.

8. Zhang, Q., Chang, C. J., Wang, L., & Shi, J. (2020). Biochar–microbe synergy for enhanced degradation of synthetic dyes in wastewater. *Journal of Hazardous Materials, 387*, 121676.