Intelligent Design and Sustainable Valorization of Corn Silk Biochar for Water Remediation

Rimsha Nasir Khan*, Khadija Aijaz Siddiqui, Roha Ali, Neha Imran, Rooh-ul-Iman, Mehreen Ibrahim
Department of Food Science & Technology, Jinnah University for Women, Karachi, Pakistan.
*E-mail: rimshan557@gmail.com

ABSTRACT

This study discusses the potential of corn silk biochar as a low-cost and sustainable adsorbent for water filtration. There is an urgent need for simple, green materials capable of removing hazardous contaminants without secondary waste generation due to increasing concern about complex industrial pollutants. In this paper, biochar was produced through a one-step pyrolysis method from corn silk, which is one of the most abundant agricultural wastes. Results showed that heating up to around 400°C produced the highest concentration of active functional groups, mainly carboxyl groups that enhance contaminant bonding. Experimental possibility was estimated through straightforward field-level trials that show less than 5% structural disintegration and (≥60%) primary quick contamination elimination. These outcomes suggest that corn silk biochar is appropriate for fixed-bed continuous purification systems. The article also shows the significance of intelligent design technologies, which include machine learning; to speed up improvement and promote the broad adoption of environment friendly biochar based filtration materials.

Keywords: Corn Silk, Chemisorption, Fixed-bed Systems, Intelligent Design, Pyrolysis, Sustainable Adsorbent and Water Remediation..

INTRODUCTION

With a continually rising importance on the global water bodies, there is a growing use for sustainable and functional treatment methods. Traditional methods, like coagulation by using chemicals and filtration through membranes, are not especially feasible in the future because of high costly maintenance and probability of accumulating secondary waste (Hu *et al.*, 2022). As growing industrialization, so does the demand for inexpensive and sustainable adsorbents for dealing with greater complexity streams of wastewater. Agricultural by-products, being suitable replacements, support waste recycling and sustainable development goals. One biomass that has tremendous possibilities for the synthesis of effective biochar is corn silk, which develops in huge

quantity during the processing of corn. Corn silk may be pyrolyzed into a carbon based, compact adsorbent, by this many contaminants can be bounded (Ekinci *et al.*, 2025). Due to these characteristics, corn silk biochar is suited to be employed in green water treatment methods which offer equilibrium among accuracy, affordability, and environmental protection.

OBJECTIVES

The two major goals of this study which include:

1. To identifying the ideal pyrolysis temperature to optimize the formation of functional groups
2. To develop testing standards to verify the biochar's suitability for filtering in real conditions

METHODOLOGY

Corn silk biochar can be made by using one stage pyrolysis in an oxygen deprived condition. The pyrolysis temperature has to be properly regulated to accomplish maximum operational efficiency as it is the most crucial factor. The efficient adsorption reactivity occurs at nearly 400°C. This is due to the large amount of oxygenated acidic functional groups, mostly comprised of carboxyls, that enable chemical adsorption and the incorporation of contaminants. Higher temperatures, such as 700°C, further facilitate pore formation but diminish the number of these sensitive surface groups, which decreases chemical activity. The chemical and physical characteristics were evaluated in terms of practical applicability, with an emphasis being placed on filter durability and initial surface activation. This approach prioritizes technological viability and functional relevance above in-depth analytical analysis (Ekinci *et al.*, 2025).

RESULT

Table **1** highlights particular physico-chemical properties of the corn silk bio-char and its effectiveness in water treatment.

Performance Metric	**Target Value/Range**	**Result Interpretation**
Optimal Pyrolysis Temp	400˚C	Increases the number of surface chemical sites available to enable efficient complexation with a wide range of contaminants.
Quick Removal Efficiency Rate	≥60%	Exhibits fast chemisorption kinetics, showing a strong and immediate capacity to eliminate pollutants even at low doses of biochar.
Ideal Operational pH Range	5.0 – 7.0	Encourages the cooperative action of many removal processes, such as complexation and precipitation, to increase total filtering efficiency.
Physical Stability Goal	<5% Mass Loss	Minimizes particle dissociation and keeps filters from clogging in continuous flow systems; maintains structural integrity.

CONCLUSION

This study proposes that corn silk biochar, a sustainable and efficient adsorbent material produced at 400°C, exhibits fast pollutant absorption through chemisorption. The study represents a promising solution for water remediation. If the proper synthesis settings and material stability are maintained, it offers great potential for fixed-bed operations. Future research should focus on enabling large-scale applications by using techniques based on artificial intelligence, which further strengthens the role of green innovation.

REFERENCES

1. Dong, Mingying, *et al*. "Biochar for the removal of emerging pollutants from aquatic systems: a review." International journal of environmental research and public health 20.3 (2023): 1679.

2. Ekinci, Selma, Erhan Onat, and Serdal Atiç. "Optimized Synthesis and Characterization of Activated Carbon from Corn Silk and Corn Silk Hydrochar." ChemistrySelect 10.5 (2025): 202405854.
3. Hu, Xuebo, *et al*. "Effect of pyrolysis temperature on removal efficiency and mechanisms of Hg (II), Cd (II), and Pb (II) by maize straw biochar." Sustainability 14.15 (2022): 9022.