Review Paper On Chromium Elimination using Banana Peel-Based Activated Carbon

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Abstract: Significant problems for the environment and human health arise when heavy metals like chromium contaminate water sources. This paper investigates the possibility of banana peel-derived activated carbon as an affordable and environmentally friendly chromium removal adsorbent. Adsorption mechanisms, affecting parameters like pH and contact time, case studies that illustrate practical uses, and preparation techniques for activated carbon derived from banana peels are all covered in this study. A comparison of this technique with alternative adsorbents highlights its effectiveness and financial feasibility. According to the research, activated carbon made from banana peels is a good way to remediate chromium while also encouraging trash vaporisation and environmental sustainability.

Keywords: Activated carbon, banana peels, chromium removal, heavy metals, adsorption, sustainable materials.

1.1 Introduction:

Chromium's toxicity, persistence, and capacity for bioaccumulation make its presence in industrial wastewater a serious environmental concern. Hexavalent chromium Cr (VI) is very dangerous since it can cause cancer and other serious health problems. [1] Conventional chromium removal techniques include membrane filtration, ion exchange, and chemical precipitation frequently have high operating costs and secondary contamination. [2] This calls for the creation of affordable, environmentally responsible, and alternative alternatives.

Banana peels, an agriculture byproduct, are a perfect starting point for the manufacture of activated carbon since they are high in cellulose, hemicellulose, and lignin. Heavy metals like chromium can be effectively removed thanks to the activation process, which improves their adsorption capabilities. [3] This review looks at the preparation, adsorption properties, and real-world uses of activated carbon derived from banana peels to determine how well it removes chromium.

1.2 Preparation of Activated Carbon from Banana Peels:

Carbonization and activation are the two primary processes that are usually involved in turning banana peels into activated carbon. Banana peels are burned in an inert atmosphere during the carbonization process, which breaks down organic material and creates a residue that is rich in carbon. [7] The surface area and pore structure can be improved by physical activation using steam or CO_2 or chemical activation using substances like KOH, $ZnCl_2$, or H_3PO_4.[8]

1.3 Key Parameters in Preparation: [1]

1.3.1 Carbonization Temperature: Optimal temperatures range between 400–600°C.

1.3.2 Activation Agent: KOH and $ZnCl_2$ are widely used due to their efficiency in creating microporous structures.

1.3.3 Activation Time: Prolonged activation increases surface area but may reduce yield.

1.4 Mechanisms of Chromium Adsorption: [6]

Activated carbon removes chromium primarily through:

1.4.1 Physical Adsorption: Interaction between chromium ions and the porous surface.

1.4.2 Chemical Adsorption: Formation of bonds between chromium ions and functional groups (e.g., hydroxyl, carboxyl) on the carbon surface.

1.4.3 Ion Exchange: Replacement of surface ions with chromium ions.

1.5 Detailed Case Studies:

Case Study 1:

Elimination of Chromium from Indian Industrial Effluent In a 2013 study, excessive levels of Cr (VI) in tannery effluent were treated using activated carbon derived from banana peels. The elimination efficiency under ideal conditions (pH 3, 45-minute contact period) was 92%, according to the results. [4]

Case Study 2:

Egyptian Laboratory-Scale Experiment In 2012, scientists used chemically activated banana peel carbon to study the adsorption of Cr (VI). The material's potential for high-efficiency removal was demonstrated by the study's stated maximum adsorption capacity of 45 mg/g. [8]

Case Study 3:

In 2014, a pilot project in South Africa used carbon produced from banana peels to remediate wastewater from an electroplating factory. The method demonstrated scalability by reducing chromium levels by 90%. [11]

Case Study 4:

Brazil's Municipal Wastewater Treatment Municipal wastewater was treated in 2010 using activated carbon made from banana peels. Its application in various effluent streams was validated by the results, which demonstrated an 87% chromium removal effectiveness. [9]

Case Study 5:

Malaysian Agricultural Runoff Treatment The effectiveness of carbon derived from banana peels in eliminating chromium from agricultural runoff was shown in a 2011 study, which achieved a 75% decrease under field conditions. [12]

1.6 Comparative Analysis

Research shows that activated carbon made from banana peels performs as well as or better than other adsorbents (such as commercial activated carbon, charcoal, and zeolites) at removing chromium. This is explained by the adsorbents made from banana peels' large surface area, availability of functional groups, and inexpensive cost of production.

Parameter	Optimal Range/Value	Conclusion
Carbonization Temperature	400–600°C	Higher temperature improves porosity.
Activation Agent	KOH, $ZnCl_2$	Enhances microporous structure.
pH for Adsorption	2–4	Maximum chromium removal at acidic pH.
Contact Time	30–60 minutes	Equilibrium reached within this range.
Adsorption Capacity	45 mg/g (approx.)	Dependent on preparation conditions.

Conclusion:

Activated carbon made from banana peels is a potential adsorbent for chromium removal because of its sustainability, affordability, and high efficiency. Adsorption capacity can be increased by optimizing the preparation process, which makes it appropriate for use in industrial settings. Regeneration methods, large-scale application, and the adsorption of additional heavy metals should be the main topics of future studies.

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