Experiment Studies On The Adsorption Characteristics Of The Rice Husk And Apricot Stones As Adsorption As Natural Adsorbents For Dye Removal

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Abstract- *The increasing contamination of water bodies by synthetic dyes poses severe environmental and health hazards. Dye pollution, primarily from textile and dyeing industries, has become a critical environmental issue due to its significant impact on water bodies and ecosystems. The discharge of untreated dye-laden wastewater deteriorates water quality, disrupts aquatic life, and introduces toxic, non-biodegradable substances that persist in the environment. Many synthetic dyes are harmful to humans, causing allergies, organ damage, and even cancer. Addressing this problem is vital for sustainable water management. Water pollution due to industrial effluents containing synthetic dyes is a significant environmental challenge, affecting aquatic ecosystems and human health. This study investigates the adsorption potential of rice husk and apricot stones as cost-effective and sustainable adsorbents for the removal of Methylene Blue (MB) dye from wastewater. A systematic series of batch adsorption experiments were conducted to evaluate the impact of key parameters, including adsorbent dosage, contact time, pH, temperature, initial dye concentration, and agitation speed, on adsorption efficiency. Experimental results revealed that apricot stones demonstrated superior adsorption capacity, achieving a maximum removal efficiency of 95.2%, while rice husk reached 92.1% under optimal conditions. The adsorption process followed pseudo-second-order kinetics, confirming that chemisorption was the dominant mechanism. The equilibrium data were best described by the Langmuir isotherm model, indicating monolayer adsorption on a homogenous surface. Additionally, both adsorbents exhibited high regeneration potential, retaining over 80% of their initial adsorption capacity after five reuse cycles, making them viable for multiple uses in wastewater treatment. The study further demonstrated a significant reduction in key water quality parameters, including Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS), and turbidity, confirming the effectiveness of these natural adsorbents in improving wastewater quality. These findings establish that rice husk and apricot stones are efficient, environmentally friendly, and economically feasible alternatives to conventional wastewater treatment methods. Their application in large-scale water purification systems could contribute to sustainable water management and pollution control.*

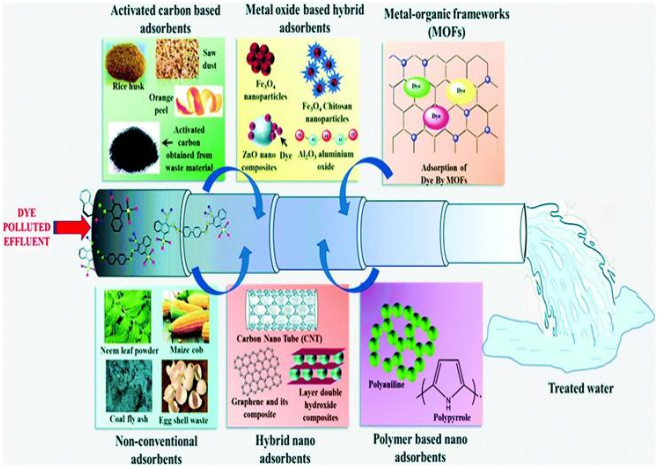
Keywords- Dye pollution, Industrial wastewater, Textile effluents, Rice husk, Apricot stones, Sustainable adsorbents, Methylene Blue removal, Environmental impact, Wastewater treatment, Eco-friendly solutions.

I. INTRODUCTION

Water pollution is a significant global challenge, adversely impacting aquatic ecosystems, human health, and economic activities. Industrialization and urbanization have resulted in the release of various pollutants, including synthetic dyes, into water bodies. Dyes are widely used in industries such as textiles, leather, paper, and plastics, and their discharge into natural water systems poses severe ecological and toxicological risks. The non-biodegradability, high solubility, and resistance of dyes to environmental conditions make them persistent pollutants. Their presence in water bodies not only alters the aesthetic quality of water but also reduces light penetration, affecting aquatic life. Moreover, some dyes and their degradation products are carcinogenic and mutagenic.

The removal of dyes from wastewater is a critical area of research due to the detrimental effects of untreated dye effluents on ecosystems and human health. Dyes are widely used in industries such as textiles, leather, cosmetics, and food processing, and their effluents are discharged into water systems, causing significant environmental issues. Conventional wastewater treatment methods, including chemical coagulation, oxidation, and membrane filtration,

have been extensively applied to tackle dye pollution. While these methods can achieve satisfactory removal rates, they often come with several challenges. Chemical coagulation requires large amounts of coagulants and results in the generation of sludge that demands further disposal. Similarly, oxidation methods, such as ozonation or Fenton's process, involve high operational costs and require sophisticated equipment, making them unsuitable for widespread use in low-resource settings. Membrane filtrationtechnologies, although effective, suffer from issues like membrane fouling and require regular maintenance, adding to their long-term costs.



NATURAL ADSORBENTS - The use of natural adsorbents for dye removal offers a sustainable and cost-effective solution. Agricultural and forestry by-products have garnered attention as potential adsorbents due to their abundance, low cost, and renewable nature. Materials such as rice husk, apricot stones, sawdust, and fruit peels have demonstrated promising adsorption capacities for various dyes. These materials are primarily composed of cellulose, hemicellulose, lignin, and other functional groups that facilitate dye binding.

Rice Husk as an Adsorbent - Rice husk, a readily available agricultural by-product from paddy processing, has gained attention as an effective adsorbent for dye removal due to its unique properties. Produced in large quantities globally, rice husk is both abundant and sustainable, making it a cost-effective option for wastewater treatment. Its high silica content and the presence of hydroxyl and carboxyl functional groups allow it to interact effectively with dye molecules, facilitating efficient adsorption. Theporous structure of rice husk further enhances its ability to trap and retain dye particles, making it highly suitable for treating dye-laden effluents. Additionally, surface modifications, such as chemical activation or treatment with acids and alkalis, have been shown to significantly improve its adsorption capacity. These modifications increase the surface area, introduce more active binding sites, and enhance the affinity of rice husk for various dye molecules. As a result, rice husk, in both its raw and modified forms, stands out as a promising, eco-friendly solution for addressing dye pollution in wastewater.

Apricot Stones as an Adsorbent - Apricot stones, an abundant agricultural waste product, are gaining recognition as an effective and sustainable adsorbent for dye removal from wastewater. Composed primarily of lignin and cellulose, these by-products possess inherent adsorptive properties that enable them to bind with dye molecules. The microporous structure of apricot stones enhances their ability to adsorb pollutants, making them suitable for treating dye-laden effluents. Additionally, apricot stones exhibit significant improvements in adsorption efficiency when subjected to thermal or chemical treatments. These treatments increase the surface area, create more active adsorption sites, and improve the material's overall porosity, making it highly effective for removing various dyes from aqueous solutions. As a low-cost, eco- friendly alternative, apricot stones hold great potential for addressing environmental challenges posed by dye pollution
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II. OBJECTIVES OF THE STUDY

The primary objective of this research is to evaluate and compare the adsorption characteristics of rice husk and apricot stones for dye removal. Specific objectives include:

1. Analyzing the physical and chemical properties of the adsorbents.
2. Investigating the impact of parameters such as pH, initial dye concentration, and contact time on adsorption efficiency.
3. Studying the adsorption isotherms, kinetics, and thermodynamics of the process.
4. Assessing the potential for regeneration and reuse of the adsorbents.

III. MATERIALS USED

This section details the materials used in the study, including adsorbents, dyes, and other supporting reagents essential for the experimental process.

Rice Husk

Rice husk, an agricultural by-product of paddy processing, was chosen as an adsorbent for its high silica content and the availability of functional groups suitable for adsorption. The preparation involved sourcing rice husk from a local rice mill, washing it thoroughly with distilled water to

remove dust and impurities, and drying it in an oven at 105°C for 24 hours

Sample of Rice husk

Apricot Stones

Apricot stones, a low-cost agricultural by-product, were selected due to their high lignin and cellulose content, which significantly enhance their adsorptive properties. The preparation process for using apricot stones as an adsorbent involved several key steps to optimize their surface area and adsorption capacity. Initially, the apricot stones werecollected from local fruit processing units where they are typically discarded as waste.

The stones were then crushed into smaller fragments and sieved to obtain a uniform particle size, typically in the range of 0.5–1.5 mm. To further improve their adsorptive characteristics, the crushed apricot stones were subjected to thermal treatment by heating them in a furnace at temperatures between 400–500°C. This process increased their porosity and surface area, making them more effective for dye adsorption. In addition, apricot stones underwent chemical activation by soaking them in solutions of activating agents such as sodium hydroxide (NaOH) or zinc chloride ($ZnCl_2$). This activation helped introduce functional groups onto the surface, improving the adsorption efficiency. After activation, the stones were thoroughly washed to remove any residual chemicals, neutralizing their pH, and then dried to prepare them for further use in the adsorption process. Figure 3.2 shows the sample of Apricot stones used in this study.

Sample of Apricot Stones

Dyes

Synthetic dyes representing industrial pollutants were used to study adsorption. The dyes were chosen based on their chemical properties and prevalence in industrial effluents

Methylene Blue

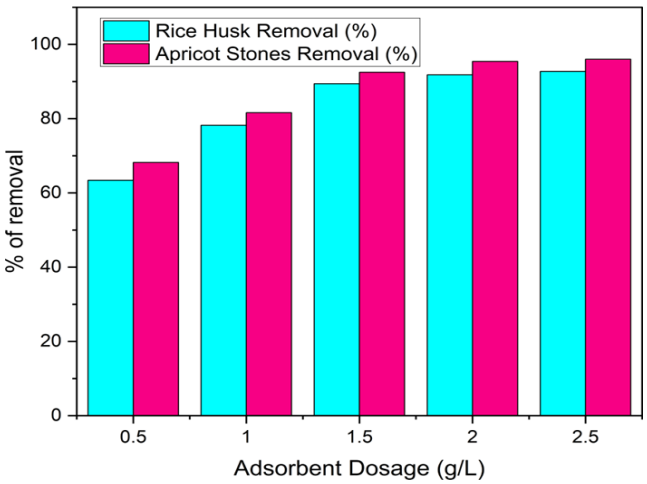
Methylene Blue is a basic dye commonly used in the textile industry due to its high solubility in water and intense colour, making it a widely recognized contaminant in industrial effluents. It is often employed in adsorption studies because of its stable structure and ease of detection in aqueous solutions. The dye is positively charged, and its high solubility and resistance to degradation make it an ideal candidate for assessing the efficiency of various adsorbents in dye removal. For this study, Methylene Blue was used to evaluate the adsorption potential of rice husk and apricot stones. Stock solutions of Methylene Blue were prepared by dissolving aknown amount of the dye in distilled water, and working concentrations were subsequently adjusted through serial dilution to achieve the required concentration for the adsorption experiments. Table 3.1 depicts the properties of Methylene Blue dye.

Properties of the Dye

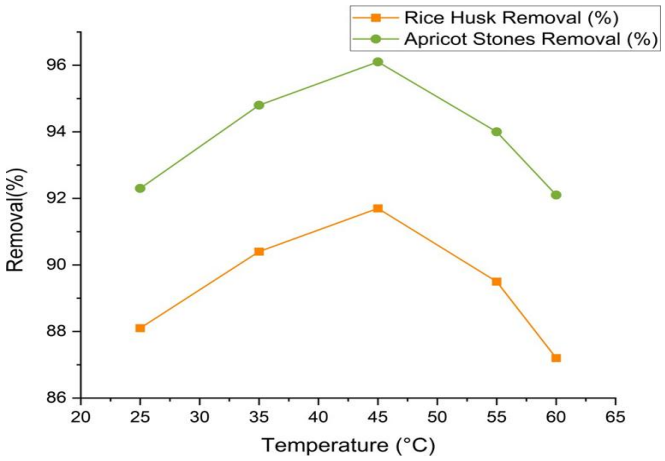
Dye	Molecular Weight	λmax (nm)	Dye Class	Charge type	Common Uses
Methylene Blue	319.85 g/mol	665	Basic	Cationic	Textile, paper

Parameter	Acceptable Limit	IS Code Reference
pH	6.5–8.5	IS10500:2012
Turbidity(NTU)	1	IS10500:2012
Total Dissolved Solids (TDS) (mg/L)	500	IS10500:2012
Total Suspended Solids (TSS) (mg/L)	100	IS3025(Part17)
Chemical Oxygen Demand (COD) (mg/L)	250	IS3025(Part58)
BiologicalOxygenDemand (BOD) (mg/L)	≤30(forindustrial effluents)	IS3025(Part44)
DissolvedOxygen(DO)(mg/L)	≥5	IS10500:2012
ElectricalConductivity(EC) (µS/cm)	500 - 1500	IS10500:2012
Color(Hazenunits)	5	IS10500:2012

Indian Standards (IS) for Water Quality Parameters



Effect of Adsorbent Dosage on MB Removal



Effect of Temperature on MB Removal

IV. CONCLUSIONS

Theexperimentalresultsconfirmthatbothricehuskanda pricotstonesare effective, low-cost, and environmentally friendly adsorbents for dye removal from wastewater. The following conclusions can be drawn:

- Apricot stones demonstrated superior adsorption performance due to their higher surface area and porosity.
- Rice husk also showed significant dye removal potential, making it a viable alternative for wastewater treatment.

- The adsorption process followed pseudo-second-order kinetics, indicating a chemisorption mechanism.
- Both adsorbents can be regenerated and reused for at least three cycles, enhancing their cost-effectiveness.
- The results suggest that these natural adsorbents can be used as sustainable alternatives to conventional treatment methods in industrial wastewater management.

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