FACULTY OF CIVIL ENGINEERING & TECHNOLOGY FKTA
Universiti Malaysia Perlis (UniMAP)
FKTA Postgraduate Colloquium 2024
UNIVERSITI MALAYSIA PERLIS UniMAP

Banana Stem as An Adsorbent in Removing Pollutant in Wastewater: A Mini Review

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KEYWORDS

Adsorption
Adsorbent
Banana stem
Wastewater Treatment

ABSTRACT

Wastewater pollution is a critical environmental issue since it can affect the ecosystem. Discharging untreated wastewater into the waterways can introduce various pollutants which lead to severe ecological imbalances, risks to human and aquatic life. Nowadays, great attention has been paid to green adsorbent. to treat the wastewater before it is discharged. In this paper, the review focuses on the banana stem used as an adsorbent. This paper explores the factors affecting adsorption, the types of adsorption and the potential of banana stems to remove various pollutants from wastewater.

1. INTRODUCTION

The increasing pollution of the environment, particularly in rivers and lakes, is primarily due to industrial activities, which has needed the development of efficient and cost-effective water treatment methods. Adsorption is widely used technique for removing contaminants from wastewater, and agricultural waste has been seen as a good choice for adsorbent due to its abundance, low cost, and natural porous structure, which makes it highly effective at trapping and removing contaminants from air, water, and soil. Many types of agricultural waste used such as rice husks, coconut shells, banana stem and sugarcane bagasse.

Banana stems have emerged as a promising low-cost adsorbent for the removal of pollutants from wastewater, particularly heavy metals and dyes. Banana stems possess excellent adsorption properties, and utilizing them not only contributes to environmental sustainability by recycling agricultural waste but also offers an effective solution for improving water quality in polluted areas.

2. PROPERTIES OF BANANA STEM

Banana stem is a lignocellulosic material containing 48.0% cellulose, 21.1% hemicellulose and 15.7% lignin [1] that making it a lignocellulosic biomass with contain a high surface area and porosity. The fibrous structure allows the interaction between the pollutants in the solution. The ability of it to bind with different ions and molecules is enhanced by the presence of functional groups like hydroxyls and carboxyls.

3. APPLICATIONS IN WASTEWATER TREATMENT

Banana stems have been shown in numerous studies to be an efficient natural adsorbent for environmental treatment. Table 1 shows the applications of banana stems in wastewater treatment.

Table 1 Applications of Banana Stem

Banana Stem as	Applications	References
Activated carbon	Potential in dye adsorption by successfully removing methylene blue dye from wastewater.	[2]
Biochar	Potential in eliminating heavy metals from water, particularly lead (Pb^{2+}) and cadmium (Cd^{2+}) ions.	[2]

4. ADSORPTION MODELING

Models like pseudo-first-order and pseudo-second-order are commonly used in kinetics model to explain the adsorption behavior. Since it suggests that the rate of adsorption is proportional to the square of the number of unoccupied sites, the pseudo-second-order model is commonly used in adsorption studies involving banana stems, suggesting that chemisorption plays a significant role in the adsorption process [3]. Compared to the pseudo-first-order model, this model has been proven to provide a better fit for experimental data [4]. The equation for the pseudo-second-order model is given by:

$$\frac{1}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} t$$

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where q_t is the amount of adsorbate adsorbed at time t, k_2 is the rate constant for the pseudo-second-order model, and q_e is the amount adsorbed at equilibrium.

Furthermore, isotherm models such as Freundlich and Langmuir are frequently used to examine the connection between the amount of adsorbate adsorbed at equilibrium and its concentration. The Freundlich model explains heterogeneous adsorption on uneven surfaces, whereas the Langmuir model suggests monolayer adsorption on a surface with a limited number of identical sites [4]. Yet, the Langmuir model gave a better idea of maximum adsorption capacity when banana stem was used as the adsorbent [5] and is represented by:

$$\frac{q_e}{C_e} = \frac{Q_{max} b}{1 + bC_e}$$

whereQ_{max} is the maximum adsorption capacity and *b* is a constant related to the affinity of binding sites.

5. ADSORPTION FACTORS

Banana stems adsorption influenced by several factors, such as pH, contact time, initial concentration and adsorbent dosage. These parameters determine how efficiently pollutants are removed. They play an important role in this process.

pH: The optimum pH range for banana stem adsorption is between 6 and 11 [4]. Electrostatic interactions between the adsorbent's charged surface and the adsorbate are primarily responsible for the effectiveness of adsorption. The surface of the banana stem may become more positively charged at lower pH values, which could prevent positively charged contaminants from adhering. On the other hand, the availability of negatively charged sites increases with increasing pH, improving cationic adsorption [4].

Adsorbent Dosage: Increasing amounts of banana stem dosage lead to higher initial removal rates of multiple contaminants, including turbidity, and heavy metals [6]. It can be concluded that more adsorbent can improve water purification effectiveness. More surface area and active binding sites for adsorption are provided by a higher dosage, so it is more effective [7].

Initial Concentration: As the concentration of adsorbates like dyes or heavy metals increases, more banana stems can typically adsorb them. A greater concentration gradient increases mass transfer, making adsorption more efficient [7].

Contact time: An increase in contact time generally leads to higher adsorption rates initially, as more active sites on the adsorbent are occupied. However, after reaching equilibrium, the rate of adsorption slows down as fewer sites are available [8].

6. CONCLUSION

In conclusion, banana stems are a sustainable and efficient adsorbent for removing pollutants, especially dyes and heavy metals, from wastewater. The adsorption efficiency is influenced by factors such as pH, dosage, initial concentration of pollutants, and contact time, with optimal performance observed at pH levels between 6 and 11. Significant chemisorption processes are highlighted by the Langmuir isotherm and pseudo-second-order kinetic model, which both successfully explain the adsorption behavior. Banana stem have high cellulose content and functional groups, make it one of valuable resource for wastewater treatment because agricultural waste can be recycled and enhance water quality while also promoting environmental sustainability.

ACKNOWLEDGEMENT

The authors acknowledge the financial support provided by Ministry of Higher Education Malaysia through the Fundamental Research Grant Scheme (FRGS) under grant number of FRGS/1/2023/WAB02/UNIMAP/02/5.

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