



Investigation of *Lophira alata* Sawdust in Adsorption of Cadmium ions from Contaminated Water

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Abstract- The *Lophira alata* wood sawdust that was obtained was thoroughly washed with distilled water to remove impurities and then carefully dried under controlled conditions. After drying, it was used in its natural form as unmodified sawdust without any chemical treatment. This sample served as an adsorbent material for the removal of cadmium ions from aqueous solutions. Several experimental parameters were investigated to evaluate the adsorption efficiency, including contact time, sawdust dosage, and the pH of the solution. In addition, the physicochemical properties of the adsorbents used in the study were analyzed and computed to better understand their adsorption behavior. The results obtained from the study revealed that increasing the sawdust dosage significantly enhanced the adsorption capacity. Similarly, longer contact time improved the interaction between the adsorbent and the metal ions, leading to higher removal efficiency. The pH of the solution also played a crucial role, with higher pH values favoring increased adsorption of the metal ions. Based on these findings, it can be concluded that *Lophira alata* wood sawdust is an effective, low-cost, and environmentally friendly adsorbent for the removal of chromium ions from contaminated water systems.

Keywords- *Lophira alata* Sawdust, cadmium ions, Contaminated Water.

I. INTRODUCTION

Water is an indispensable resource for life, essential for human health, agriculture, and industrial processes. The quality of water, however, has been severely compromised in recent decades due to rapid industrialization, urbanization, and agricultural expansion (Obruche et al., 2025). One of the most pressing environmental challenges today is the contamination of water by heavy metals, which are non-biodegradable, persistent, and toxic even at low concentrations. Among these heavy metals, chromium, particularly in its trivalent (Cr^{3+}) and hexavalent (Cr^{6+}) forms, poses significant environmental and health risks. cadmium ions contamination originates from various sources including tanning industries, electroplating, dye production, and metal finishing operations (Umudi et al., 2025).

The presence of cadmium ions in water can lead to detrimental effects on aquatic life, soil quality, and human health, with chronic exposure potentially causing liver and kidney damage, respiratory problems, and carcinogenic effects (Ekpo et al., 2025). The treatment of heavy metal-contaminated water has attracted significant attention from researchers and environmental engineers. Conventional methods such as chemical precipitation, ion exchange, membrane filtration, and electrochemical treatment are commonly employed to remove heavy metals from aqueous solutions (Abeokuta et al., 2025). While these methods can be effective, they often come with limitations such as high operational costs, generation of secondary pollutants, complex instrumentation requirements, and inefficiencies at low metal concentrations. Consequently, there is a growing interest in developing sustainable, cost-



effective, and efficient alternatives for water purification (Erienu et al., 2022). Adsorption has emerged as one of the most promising techniques due to its simplicity, flexibility, and high removal efficiency.

Adsorption involves the accumulation of contaminants on the surface of solid materials, offering a practical approach to extract heavy metals from water without producing significant secondary waste (Itodo et al., 2021). The choice of adsorbent is critical in determining the efficiency and feasibility of the adsorption process. Activated carbon has historically been regarded as a benchmark adsorbent due to its large surface area and high adsorption capacity. However, commercial activated carbon is expensive and often inaccessible for widespread use in developing regions. This limitation has led researchers to explore low-cost and locally available materials that can serve as effective adsorbents. Biomass-derived materials, such as agricultural residues, fruit peels, and plant wastes, have garnered attention for their potential as sustainable adsorbents.

These materials are abundant, renewable, and often contain functional groups capable of binding heavy metal ions, including hydroxyl, carboxyl, and phenolic groups. Utilizing such materials not only provides a cost-effective solution for water treatment but also contributes to waste management and environmental conservation by valorizing agricultural by-products (Obruche et al., 2019). Among the various biomass-derived materials, sawdust has emerged as a particularly attractive candidate for heavy metal adsorption. Sawdust is a by-product of the wood processing industry and is often generated in large quantities. Its porous structure, high lignocellulosic content, and functional groups make it an effective adsorbent for a wide range of pollutants. Studies have demonstrated the ability of sawdust from different wood species to remove heavy metals such as lead, cadmium, nickel, and chromium from aqueous solutions (Umudi et al., 2025).

Additionally, sawdust can be chemically or physically modified to enhance its adsorption capacity and selectivity, making it a versatile material for water purification applications. *Lophira alata*, commonly known as African ironwood, is a tropical hardwood species renowned for its dense, durable timber and resistance to environmental stress. While its wood is highly valued for construction and furniture, the by-product sawdust is often underutilized and discarded as waste. *Lophira alata* sawdust (LAS), therefore, presents an untapped potential as a low-cost adsorbent. Preliminary investigations suggest that LAS possesses a significant amount of lignin, cellulose, and hemicellulose, which are rich in functional groups capable of binding metal ions. Moreover, the high surface area and porous nature of LAS enhance its ability to adsorb contaminants from water, making it a promising material for environmental remediation (Ekpo et al., 2025).

Cadmium ions, although less toxic than hexavalent chromium, can accumulate in water systems and pose long-term ecological and health risks. Efficient removal of cadmium ions from contaminated water is essential to meet environmental standards and protect public health. Adsorption using *Lophira alata* sawdust offers an innovative approach, combining the advantages of a low-cost, renewable adsorbent with the need for effective heavy metal remediation. The interaction between Cr^{3+} ions and LAS is influenced by various factors, including pH, contact time, adsorbent dosage, and initial metal concentration, which necessitates systematic investigation to optimize the adsorption process (Ugochukwu et al., 2025).

This study focuses on investigating the potential of *Lophira alata* sawdust as an adsorbent for the removal of cadmium ions from contaminated water. The research aims to evaluate the adsorption efficiency, determine the kinetics and isotherm behavior, and understand the underlying mechanisms involved in the binding of cadmium ions to the sawdust surface.



II. MATERIAL AND METHOD

Collection of Samples

The collection of samples was conducted following the procedures specified by Ugochukwu et al. (2025) and Umudi et al. (2025). The sawdust from Lophira Alata wood was sourced from a local sawmill situated in the Akpata area along Upper Siluko Road in the Egor local government area of Benin City, Edo State. A substantial quantity of fine particles from this sawdust was gathered. The salts of the heavy metals intended for adsorption were procured from the laboratory of the Chemistry Department. Nickel Sulphate (NiSO_4) and Cadmium Sulphate (CdSO_4) were collected.

Preparation of Samples

The preparation of samples was conducted in accordance with the methodologies established by Obruche et al. (2018). The sawdust was sun-dried until it was completely devoid of moisture. Subsequently, the sawdust sample was filtered using a sieve with a mesh size of $53\ \mu\text{m}$ to ensure that only the very fine particles were retained. The sawdust sample was then divided into two portions. The first portion served as the unmodified sawdust sample, while the second portion underwent carbonization, followed by activation, and was utilized as the activated-carbonized sawdust sample.

Characterization of the Unmodified Sawdust

Both the unmodified sawdust and the prepared activated carbon were characterized based on their physical and chemical properties. The physical properties of the unmodified sawdust and the activated carbon included moisture content, ash content, and bulk density, whereas the chemical properties encompassed pH, contact time, and sawdust dosage.

Moisture Content

Moisture content refers to the amount of water present in a material (Festus-Amadi et al., 2021). The moisture content of the unmodified sawdust is essential for defining and expressing its properties in relation to the net weight of the carbon. In this research project, the moisture content of the unmodified sawdust was determined using the oven drying method. A sample of 2 grams of the dried unmodified sawdust was weighed and placed into a pre-dried crucible, which was then placed in an oven at $110\ ^\circ\text{C}$ until a constant weight was achieved over duration of 2 hours. After drying, the crucible were removed, cooled in a dessicator and then weighed. The moisture content was calculated in by:

$$\% \text{ Moisture Content} = \frac{W_1 - W_2}{W_1} \times 100$$

Bulk Density

The bulk density of a powder is defined as the weight of the powder divided by the volume it occupies, typically expressed in g/ml . This measurement can serve as a general indicator of particle size and dispersion, which may influence the consistency of material flow and indicate packaging quantity. The bulk density of sandust is influenced by the shape, size, and density of the individual particles. In this research project, the bulk density of the samples was determined by filling a graduated cylinder (10ml) with dry, unmodified sawdust to the top graduation, achieved by gently tapping the cylinder on the table. The weight of the cylinder, along with the sample, was then measured, and the weight of the sample was divided by the volume of the cylinder to obtain the bulk density. The formula is provided as:

$$\text{Bulk density} = \frac{W_{\text{MAT}}}{V_{\text{MAT}}}$$



PH

The pH level of activated carbon serves as an indicator of its acidity or basicity. A pH that exceeds the optimal range suggests an excess of contaminants, while a pH that is too low, particularly in acid-washed activated carbon, indicates inadequate rinsing of the acid. Typically, activated carbons are designed to operate within a pH range of 6 to 8. In this study, 1 gram of the sample was accurately weighed and placed into a beaker. Subsequently, 100 ml of distilled water was added to the sample and stirred for one hour. The samples were permitted to stabilize prior to measuring the pH with a pH meter.

Contact Time

The influence of contact time on the adsorption of cadmium ions was examined. A total of 1.0 gram of each adsorbent (unmodified sawdust) was introduced into five beakers, each containing 100 ml of a metal solution with an initial concentration of 20 mg/L. The solutions were stirred at a constant speed of 180 rpm for varying durations, ranging from 20 to 120 minutes, while maintaining a fixed pH of 6. The final concentration of each solution was assessed using an Atomic Absorption Spectrophotometer (AAS), allowing for the determination of the percentage of Cd²⁺.

Sawdust Dosage

The impact of sawdust dosage on the percentage removal of metallic ions was analyzed by adjusting the adsorbent dosage between 0.1 and 0.4 grams. Distinct quantities of adsorbents (from 0.1 to 0.4 grams of both unmodified sawdust and activated-carbonized sawdust) were placed into four sample bottles, each containing 100 ml of a metal solution with an initial concentration of 20 ppm. The solutions were agitated at a consistent stirring speed of 180 rpm for a predetermined contact time of 120 minutes, while maintaining a fixed pH of 6.0. The final concentrations of the solutions were subsequently measured using an Atomic Absorption Spectrophotometer (AAS), enabling the calculation of the percentage removal of Cd²⁺.

Adsorption Experiment

The procedure for the adsorption experiment fundamentally entails the addition of a predetermined quantity of the prepared adsorbent, specifically the unmodified sawdust, to the already diluted solutions of heavy metals, such as Cadmium. The setups were organized in batches and subjected to different conditions, being agitated with a mechanical shaker at 120 rpm for a duration of 1 hour. Subsequently, the adsorbent was filtered from the solution. The concentration of the residual heavy metals in the various solutions was then assessed using an Atomic Adsorption Spectrophotometer (AAS), model AA500. The diverse conditions under which the batch experiments were conducted were meticulously recorded.

III. RESULTS AND DISCUSSION

Physiochemical Properties of Unmodified Sawdust

From the unmodified sawdust, the following physiochemical properties were obtained:

Table1: Physicochemical properties of Unmodified Sawdust

Parameter	Result Obtained
Moisture Content (%)	2.04
Ash Content (%)	1.28
Bulk Density (g.cm ⁻³)	1.00
PH	7.62

Adsorption of Cadmium Ion by Unmodified Sawdust

The tables presented below were derived from the results of the AAS analysis conducted on the different filtrates obtained from experiments utilizing both unmodified sawdust and activated-carbonized sawdust for the adsorption of Cadmium ions.



Table 2: Effect of Unmodified Sawdust Dosage Onadsorption of Cadmium ion

Sawdust Dosage (G)	Initial Concentration (Mg/L)	Equilibrium Concentration (Mg/L)	Amount Adsorbed (Mg/Kg)
0.1	100	1.04	98.96
0.2	100	0.51	99.49
0.3	100	0.32	99.68
0.4	100	0.26	99.74

Table 3: Effect Of PH of Unmodified Sawdust on Adsorption of Cadmium ion

PH	Initial Concentration (Mg/L)	Equilibrium Concentration (Mg/L)	Amount Adsorbed (Mg/Kg)
3	100	0.21	99.79
4	100	0.09	99.91
5	100	0.06	99.94
6	100	0.04	99.96

Table 4: Effect of Contact Time of Unmodified Sawdust on Adsorption of Cadmium ion

Contact Time (Min)	Initial Concentration (Mg/L)	Equilibrium Concentration (Mg/L)	Amount Adsorbed (Mg/Kg)
20	100	0.20	99.80
40	100	0.085	99.91
80	100	0.04	99.96
100	100	0.025	99.97
120	100	0.02	99.98

IV. DISCUSSION

The findings indicate that a greater dosage of sawdust correlates with an increased adsorption rate for Cadmium ions, particularly when compared to the data presented in the tables. A detailed analysis of the pH levels of the unmodified sawdust sample reveals that at pH 3, approximately 99.79 mg/kg was adsorbed. At pH 4, the adsorption increased to 99.91 mg/kg of Cadmium ions. At pH 5, the amount adsorbed rose to 99.94 mg/kg, and at pH 6, it reached 99.96 mg/kg of Cadmium ions. This suggests a trend where the quantity of toxic metals adsorbed by the adsorbent increases with rising pH levels.

Furthermore, the impact of contact time on the unmodified sawdust sample demonstrates that extending the time from around 20 minutes to 120 minutes also enhances the adsorption rate. Consequently, the results indicate that increases in sawdust dosage, contact time, and pH lead to a higher adsorption rate. Thus, it can be accurately concluded that the adsorption rate improves with greater adsorbent dosage, prolonged contact time, and elevated pH levels. These findings are consistent with the research conducted by Umudi et al. (2025), which was performed in a comparable setting.

V. CONCLUSION

The following conclusions can be drawn from the comparative study of heavy metal ion removal using *Lophira alata* wood sawdust as an adsorbent. First, *Lophira alata* sawdust proves to be a highly effective and economical material for the adsorption of heavy metals from wastewater. Its availability, low cost, and environmental friendliness make it a promising alternative to conventional treatment methods. The adsorption efficiency observed suggests that it possesses suitable physicochemical properties, such as surface area and functional groups, which enhance its binding capacity for metal ions. Secondly, the study demonstrates that sawdust, in general, is highly effective for removing heavy metals from aqueous



solutions. Its natural composition allows for significant interaction with contaminants, leading to improved purification outcomes. Overall, the findings highlight the potential of sawdust as a sustainable and efficient solution for wastewater treatment applications.

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