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Assessment of Sawdust-Activated Carbon for Heavy Metal Removal from Domestic Wastewater

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Abstract

Heavy metal pollution in domestic wastewater poses a significant threat to environmental and human health. This study investigated the effectiveness of sawdust-activated carbon (SDAC), produced from three locally sourced sawdust, in removing heavy metals from domestic wastewater. Batch experiments were conducted at varying adsorbent dosages (5g/L, 10g/L, and 15g/L) to evaluate the adsorption capacities of the different SDAC samples for heavy metals, including copper (Cu), chromium (Cr), cadmium (Cd), iron (Fe), manganese (Mn), lead (Pb), and zinc (Zn). The SEM images of the SDAC samples revealed a porous, flaky structure with significant surface area, indicating their potential for effective adsorption. The results revealed that SDAC 2 achieved a 14% reduction in Cu concentration at the optimal 10g dosage, while SDAC 3 achieved a 16.7% reduction in Cr concentration at the same dosage. SDAC 1 and SDAC 2 both achieved 100% removal of Cd at the 5g and 15g dosages. SDAC 3 showed a 33.6% reduction in Fe concentration at 5g dosage, SDAC 1 reduced Mn concentration by 40.6% at 5g dosage, and SDAC 3 achieved a 9.2% reduction in Zn concentration at 10g dosage. The study demonstrated variations in heavy metal removal efficiencies across different SDAC types and dosages and emphasized the need for optimization and further research.

1. Introduction

Domestic wastewater contains various pollutants, including heavy metals, that can pose environmental and health risks if not properly treated [1, 2, 3]. Heavy metals, characterized by an atomic density exceeding 5 g/cm³ and a relative atomic mass ranging from 63.5 to 200.6, represent significant pollutants in freshwater reservoirs [4][5]. They present a direct hazard to both organisms and human well-being. The principal source of heavy metal contamination in the environment is attributed to the swift proliferation of the human population, widespread industrial advancements, and the expansion of agricultural activities [6]. As human life and industrial production advance, heavy metal pollution is increasingly severe and has emerged as a significant environmental issue that demands attention [7][8].

The presence of heavy metals in water can have diverse impacts on human health [9]. Heavy metals of environmental concern include copper (Cu), chromium (Cr), cadmium (Cd), iron (Fe), manganese (Mn), lead (Pb), and zinc (Zn). While Cu is essential in small amounts in drinking water, elevated levels can result in symptoms like nausea, vomiting, and stomach cramps, potentially causing harm to the liver and kidneys [10]. According to the World Health Organization (WHO), regulations or guidelines regarding Cu levels in drinking water have been established by 104 countries. The median allowable limit is 1.5 mg/L, with values ranging from 0.05 mg/L to 3 mg/L across different regions [11]. Untreated wastewater containing copper can adversely affect aquatic ecosystems, endangering fish and invertebrates and potentially contaminating drinking water sources, leading to gastrointestinal issues in humans [12]. Cr in water is highly hazardous, causing skin irritation, respiratory problems, and an elevated risk of cancer. Consequently, it's essential to monitor Cr levels in drinking water sources [11][14]. Of particular concern is hexavalent Cr (Cr VI), which can induce cancer, reproductive complications, and developmental issues in humans, and is also highly toxic to aquatic organisms [15][16]. Cd is extremely poisonous, resulting in harm to the kidneys, reduction in bone density and heightened susceptibility to cancer [17][18]. Cd poses significant toxicity to aquatic organisms and has the potential to accumulate in the food chain. This accumulation can result in adverse effects such as kidney impairment and the loss of bone minerals in humans [19][20]. Fe is essential for the production of blood, yet an abundance of Fe can result in gastrointestinal problems and burden internal organs, potentially causing harm to the liver and heart [21][22]. An overabundance of Fe can result in the discoloration of water, disrupt aquatic ecosystems by encouraging the growth of algae, and induce gastrointestinal discomfort in humans. Mn is vital in small quantities for bone development and metabolism, but excessive levels can lead to neurological problems, such as symptoms similar to Parkinson's disease [23]. Mn at elevated concentrations can prove harmful to aquatic organisms and potentially interfere with human neurological development when present in drinking water as a contaminant [24]. Pb poses significant toxicity to both aquatic life and humans, causing severe neurological and developmental problems, especially in children [25][26]. It is extremely toxic, leading to neurological damage, developmental delays, and harm to various organs [27]. Zn is vital in modest quantities, but an overabundance can be detrimental to aquatic ecosystems, causing disturbances in reproductive cycles and growth. In humans, excessive Zn intake may result in symptoms such as nausea and vomiting [28]. The significance of treating wastewater to eliminate heavy metals before releasing it into the environment is highlighted by these effects. Maintaining controlled levels of these metals in water is vital for ensuring public health safety.

Numerous strategies and methodologies have been devised and utilized for eliminating heavy metals from wastewater, encompassing physical, chemical, and biological techniques [3, 29, 30] Nonetheless, following the primary treatment, additional measures are required to further decrease the heavy metal concentration to acceptable levels. Physical methods, such as adsorption, ion exchange, and membrane technology, represent viable options. Chemical approaches, including electrokinetic technology, chemical precipitation, and coagulation, as well as biological methods like phytoremediation and biochar, are also employed for this purpose [31]. While activated carbon is commonly used for heavy metal removal, its high-cost limits widespread use. Activated carbon is a highly porous material with a large surface area, making it a powerful adsorbent for a wide variety of applications including water and air purification and environmental remediation [32][33].

Sawdust, a byproduct of the wood industry, can be transformed into activated carbon through chemical activation [34, 35, 36]. Sawdust comprises fine particles that can vary from very small, almost powdery grains to larger, coarser shavings. The precise size depends on the type of wood and the processing technique employed [37]. Many studies have explored the use of sawdust, a readily available and renewable biomass, as a precursor for activated carbon production [38]. Sawdust is favored due to its low cost, high carbon content, and porosity, which are essential for effective adsorption of contaminants from wastewater [39, 40, 41]. Researchers have assessed the adsorption capacity of sawdust-activated carbon (SDAC) for removing heavy metals, organic pollutants, and other contaminants from wastewater [42, 43, 44]. Studies often focus on determining optimal conditions such as pH, temperature, contact time, and dosage to maximize adsorption efficiency [45].

This study explores the possibility of using SDAC from different samples of sawdust as an alternative approach to eliminate heavy metals from domestic wastewater. The novelty of this research lies in the comparative performance assessment of the different SDAC samples.

2.0 Materials and Methods

In this study aimed at removing heavy metals from wastewater using SDAC, the following materials and methods were used:

2.1 Materials

Domestic wastewater was collected from a residential house within Akure metropolis in South Western Nigeria where wastewater was not properly managed. Three samples of sawdust were collected from three different wood industries in Akure, Nigeria and chemically activated using phosphoric acid. The three samples of sawdust are shown in Plate 1.

Plate 1: Samples of sawdust

2.2 Methods

2.2.1 Characterization of Wastewater

The concentration of heavy metals (Cu, Cr, Cd, Fe, Mn, Pb and Zn) in the wastewater sample was determined using Atomic Absorption Spectroscopy (AAS) which is a technique used to quantify the concentration of metals in a sample by measuring the absorption of characteristic wavelengths of light.

2.2.2 Characterization of Sawdust

Phosphoric acid was impregnated into sawdust using a 1:2 impregnation ratio for this experiment. For the impregnation, 8ml of phosphoric acid was used for every 30g of sawdust sample that was measured. For sixty minutes, the impregnated sawdust was subjected to temperatures above 500°C in an induction heat furnace. The activated carbon was allowed to cool before being kept in plastic bottles far from moisture. The resulting SDAC was characterized using Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) analysis. The methodology for Scanning Electron Microscopy (SEM) of sawdust activated carbon involved mounting the sample on a stub, coating it with a thin layer of gold alloy material, and then imaging the sample at various magnifications to analyze its surface morphology while EDS was conducted by preparing a sample using standard mounting and coating techniques, followed by examining the surface morphology and elemental composition using an EDS-equipped scanning electron microscope (SEM).

2.2.3 Batch Experiments

Batch experiments were conducted to evaluate the adsorption capacity of SDAC for Cu, Cr, Cd, Fe, Mn, Pb and Zn ions. At different adsorbent doses of 5g/l, 10g/l, and 15g/l, the batch adsorption was done. 5g, 10g, and 15g of each activated carbon sample were weighed on a weighing balance and then transferred into different beakers. The home wastewater was collected in a bucket, and each litre of wastewater was measured out of a 1000ml beaker and transferred to other beakers to be combined with activated carbon. To ensure that there was enough agitation to maximize the wastewater's interaction with the activated carbon, a magnetic stirrer was utilized. With the magnetic stirrer set to 200 rpm and the mixed sample on top, each sample was stirred for five minutes. In order to allow for optimal adsorption, the samples were allowed to come into contact for 24hours. After a 24-hour period of contact, the samples were filtered using filter papers into plastic bottles to extract the activated carbon from the treated wastewater and taken to the laboratory for testing.

2.3 Percentage Reduction

The effectiveness and heavy metal reduction of the treatment approach was determined using the formula presented in Equation 1.

$$\%\ Heavy\ metal\ reduction = \frac{H_1 - H_2}{H_1} x\ 100 \qquad (1)$$

Where H_1 represents the initial heavy metal content prior to treatment, while H_2 denotes the heavy metal's value after treatment.

3.0 Results and Discussion

3.1 SEM image of SDAC 1

The SEM image of SDAC 1 is presented in Figure 1. The image shows a rough, flaky, and irregular surface texture, which is typical of materials like activated carbon or similar porous substances. The flakes and layers suggest a high surface area, which is a desired characteristic for materials used in adsorption applications. The presence of various cracks, voids, and interstitial spaces between the flakes indicates high porosity. Such structural features enhance the material’s ability to adsorb gases or liquids, making it suitable for applications like water purification, air filtration, or as a catalyst support. this SEM image of SDAC 1 likely represents a highly porous, flaky material with significant surface area, typical of activated carbon or a similar adsorbent. According to [46], these characteristics make it suitable for applications requiring high adsorption capacity. Based on the SEM image alone, the material appears to have the necessary morphological characteristics (high surface area and porosity) for effective heavy metal adsorption from wastewater. From the EDS spectra, peaks corresponding to elements like carbon (C), oxygen (O), iron (Fe), and others indicate their presence in the sawdust. In wastewater treatment, C is crucial for microbial metabolism and the removal of organic pollutants, O is essential for aerobic biological processes that degrade contaminants, and Fe is important for chemical coagulation and precipitation processes that remove phosphates and heavy metals. The intensity of these peaks reflects the concentration of each element, with higher peaks indicating higher concentrations. By comparing the intensity of heavy metal peaks before and after treatment, the effectiveness of sawdust in adsorbing these metals can be assessed, with a decrease in peak intensity suggesting successful removal.

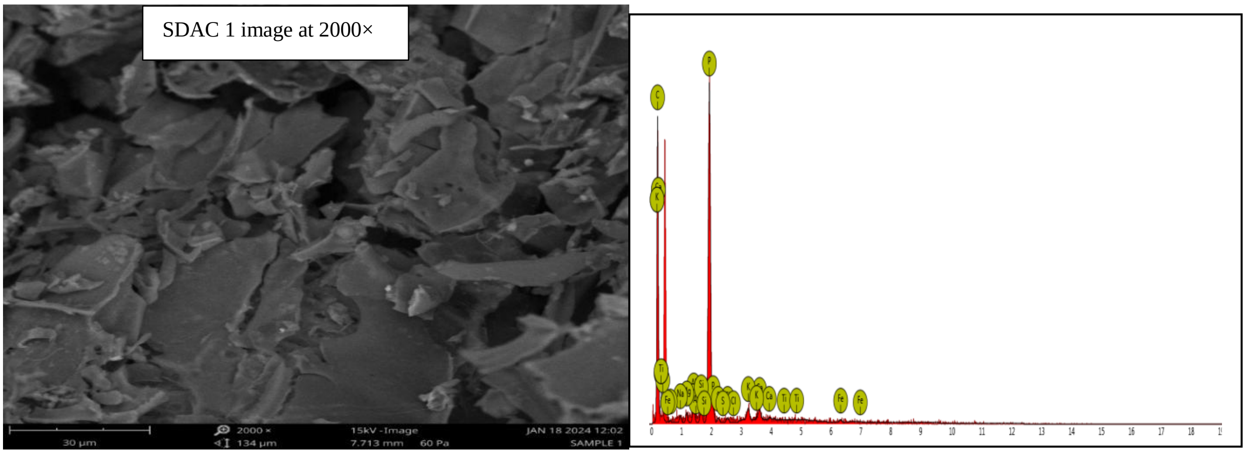

Figure 1 SEM image and EDS spectra of the surface of SDAC 1

3.2 SEM image of SDAC 2

The SEM image of SDAC 2 (Figure 2) reveals a material with a high surface area and significant porosity, both of which are critical characteristics for effective heavy metal adsorption from wastewater. These structural features suggest that the material could be highly effective in adsorbing heavy metals, The flaky and layered structure seen in the image suggests a large surface area. This is critical because a higher surface area provides more active sites for the adsorption of metal ions. The numerous voids and cracks indicate a porous structure, which is advantageous for adsorption as it allows for better contact between the metal ions in the wastewater and the adsorbent material. The porous nature ensures that metal ions can diffuse into the material, maximizing the contact area and interaction time, which are crucial for effective adsorption. Such materials can potentially adsorb a wide range of heavy metals (Cu, Cr, Cd, Fe, Mn, Pb, Zn). These facts were affirmed by [47].

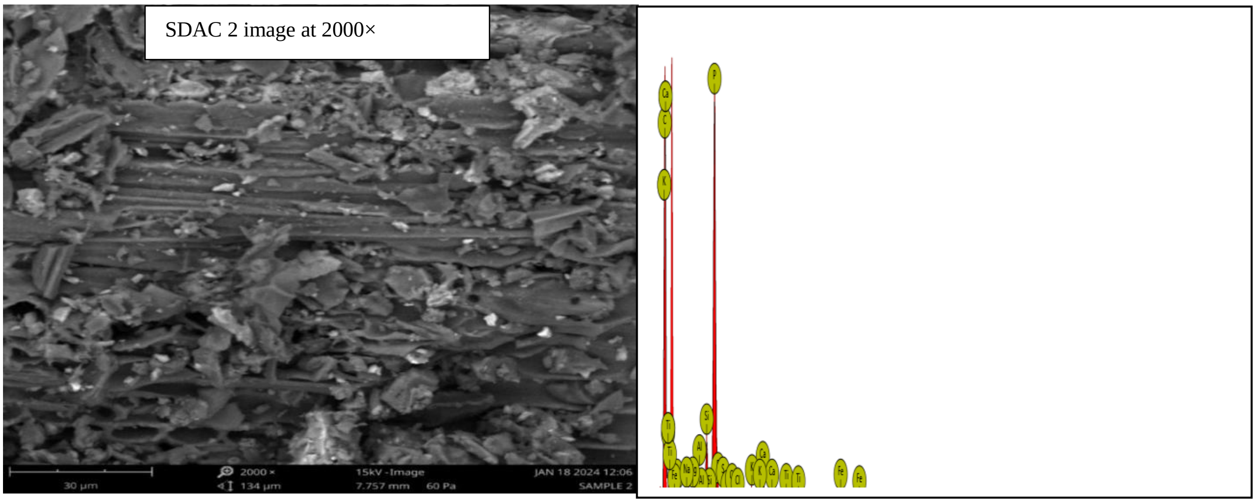

Figure 2: SEM image and EDS spectra of the surface of SDAC 2

3.3 SEM image of SDAC 3

The SEM image of SDAC 3 (Figure 3) reveals a structure highly suited for heavy metal removal, characterized by extensive porosity, high surface area, and a rough texture, all of which contribute to its effectiveness in wastewater treatment. The porous structure allows for physical adsorption where heavy metal ions could be trapped within the pores. The high surface area ensures that a large number of ions can be adsorbed. The particles are irregularly shaped (angular and flaky) which enhances the overall surface area. The irregular particle shapes would likely further increase the available adsorption sites thereby improving the efficiency of heavy metal removal from wastewater. [48] corroborated these findings.

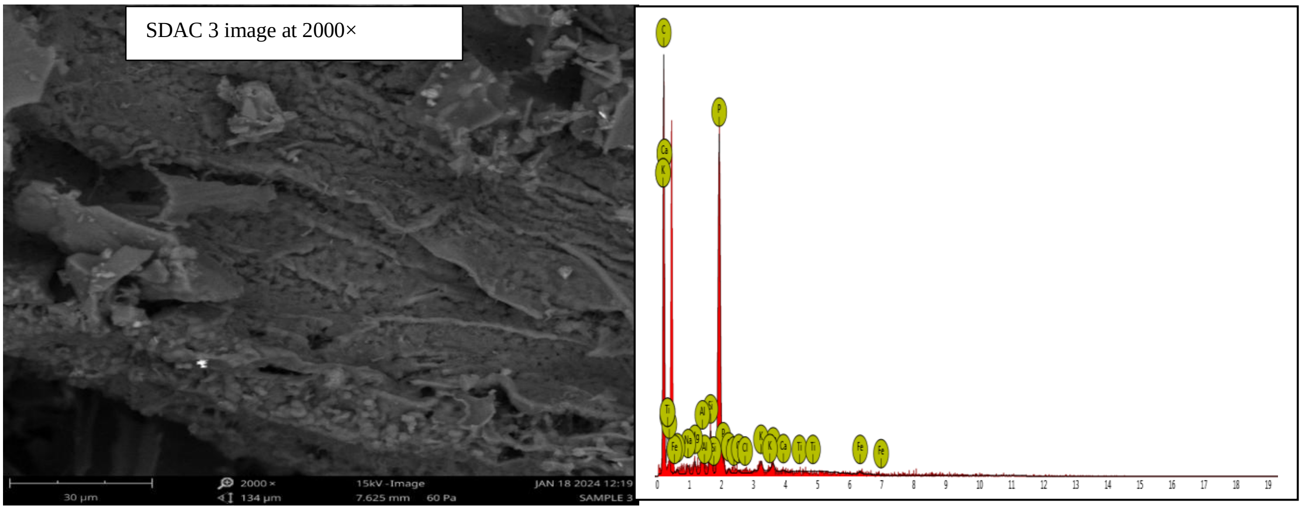

Figure 3: SEM image and EDS spectra of the surface of SDAC 3

3.4 Effect of different dosages of SDAC on Cu removal

Figure 4 shows the effect of SDAC dosage on Cu removal from domestic wastewater. The untreated wastewater had a Cu concentration of 0.1 mg/L. The Cu concentrations after treatment with SDAC 1 were 0.115 mg/L (5g), 0.1 mg/L (10g), and 0.113 mg/L (15g). These results indicate minimal change or even slight increases in Cu concentration compared to the untreated sample (0.1 mg/L), suggesting that SDAC 1 was not effective in removing Cu. The Cu concentrations after treatment with SDAC 2 were 0.143 mg/L (5g), 0.086 mg/L (10g), and 0.141 mg/L (15g). Among these, the 10g dosage showed a reduction in Cu concentration (0.086 mg/L), indicating some effectiveness. However, the 5g and 15g dosages resulted in higher Cu concentrations than the untreated sample, suggesting inconsistencies in performance. The Cu concentrations after treatment with SDAC 3 were 0.152 mg/L (5g), 0.118 mg/L (10g), and 0.17 mg/L (15g). These results indicate an increase in Cu concentration for all dosages, demonstrating that SDAC 3 was ineffective and possibly contributed to additional Cu contamination. SDAC 2 showed a notable decrease in Cu concentration at the 10g dosage, suggesting effective Cu removal at this level. However, the 5g and 15g dosages resulted in higher Cu concentrations than the untreated sample, indicating that either too little or too much SDAC 2 can reduce its effectiveness. The 10g dosage appears to be the optimal amount for this sample. In summary, SDAC 2 achieved a 14% reduction in Cu concentration at the optimal 10g dosage, while SDAC 1 and SDAC 3 were ineffective, with some dosages even increasing Cu levels. The presence of impurities in the sawdust may be responsible for SDAC 1 and SDAC 3 ineffectiveness and why SDAC 2 showed partial effectiveness in Cu removal from the wastewater. According to [46][49], choosing an adsorbent that demonstrates outstanding adsorption effectiveness is crucial for the adsorption procedure.

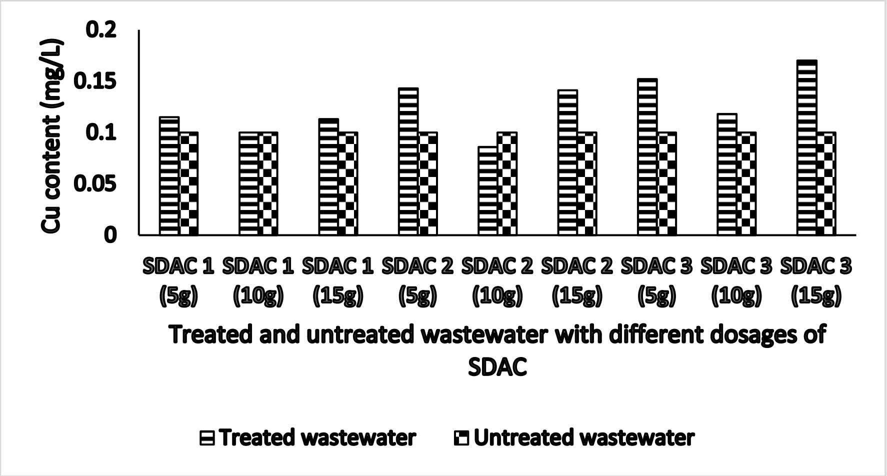

Figure 4: Effect of SDAC dosage on Cu removal from domestic wastewater

3.5 Effect of different dosages of SDAC on Cr removal

The untreated wastewater had a Cr content of 0.06 mg/L, and the World Health Organization (WHO) limit for Cr in drinking water is 0.05 mg/L. Wastewater polluted with chromium (Cr) presents a significant environmental issue, particularly in developing nations [50]. According to [51], current physico-chemical methods employed for the elimination of Cr are not environmentally sustainable and require significant quantities of chemicals. The effects of SDAC dosage on Cr removal from domestic wastewater are presented in Figure 5. The results for SDAC 1 indicate that the Cr content increased with higher dosages. This could imply that SDAC 1 is not effectively removing Cr at higher dosages, and there might be a saturation effect or even leaching of Cr from the activated carbon. SDAC 2 shows a similar trend to SDAC 1, where the 5g and 10g dosages are somewhat effective, but the 15g dosage reaches the untreated level of 0.1 mg/L. This suggests that SDAC 2 is also not very effective at higher dosages. SDAC 3 performs the best among the three samples. At the 10g dosage, the Cr content is reduced to 0.05 mg/L, which is below the untreated concentration and meets the WHO limit. Even at 5g and 15g, the results are better than SDAC 1 and SDAC 2. Both samples showed limited effectiveness in Cr removal, especially at higher dosages. The increase in Cr content at higher dosages suggests possible desorption or saturation effects. SDAC 3 demonstrated effective Cr removal, particularly at the 10g dosage. For SDAC 3, 10g appears to be the optimal dosage for Cr removal. In summary, for Cr removal, SDAC 3 demonstrated the highest efficiency, achieving a 16.7% reduction at 10g dosage, meeting the WHO limit of 0.05 mg/L. Further fine-tuning around this dosage could yield even better results.

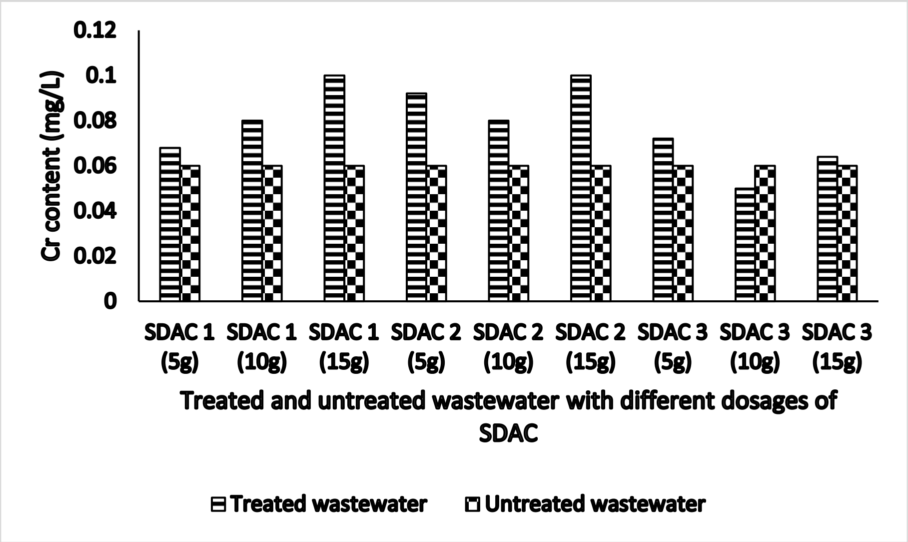

Figure 5: Effect of SDAC dosage on Cr removal from domestic wastewater

3.6 Effect of different dosages of SDAC on Cd removal

The untreated wastewater had a Cd concentration of 0.04 mg/L, and the World Health Organization (WHO) limit for Cd in drinking water is 0.003 mg/L. Figure 6 presents the effect of SDAC dosage on Cd removal from domestic wastewater. The results for SDAC 1 indicate that both the 5g and 15g dosages were highly effective, reducing the Cd content to 0 mg/L, well below the WHO limit. The 10g dosage reduced Cd to 0.02 mg/L, which, although not meeting the WHO limit, shows significant reduction. SDAC 2 shows effectiveness similar to SDAC 1. The 10g dosage completely removed Cd, while the 5g and 15g dosages brought it down to 0.02 mg/L, showing significant reduction but not meeting the WHO limit. SDAC 3 showed mixed results. The 15g dosage was completely effective, reducing Cd to 0 mg/L. The 5g dosage reduced Cd to 0.01 mg/L, which is below the initial concentration but still above the WHO limit. Interestingly, the 10g dosage showed no reduction at all, maintaining the Cd content at 0.04 mg/L. The experiment demonstrated that sawdust activated carbon has significant potential for removing Cd from domestic wastewater, with SDAC 1 and SDAC 2 showing the most promise. The results of this study corroborates the findings of [52] which affirmed that activated carbon has very good potential for the removal of Cd from aqueous solutions.

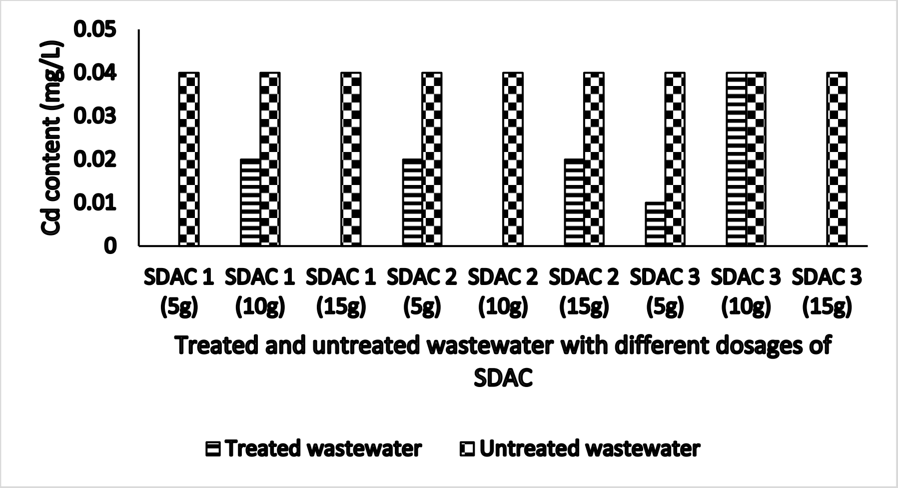

Figure 6: Effect of SDAC dosage on Cd removal from domestic wastewater

3.7 Effect of different dosages of SDAC on Fe removal

The untreated wastewater has an Fe concentration of 0.113 mg/L, and the World Health Organization (WHO) aesthetic limit for Fe in drinking water is 0.3 mg/L. Figure 7 shows the effect of SDAC dosage on Cd removal from domestic wastewater. The results for SDAC 1 indicate that the 5g dosage slightly reduces the Fe concentration below the untreated level. However, increasing the dosage to 10g and 15g shows a marginal reduction or even a slight increase in Fe concentration, suggesting that higher dosages are not more effective for SDAC 1. SDAC 2 shows similar results across all dosages, with the Fe concentration remaining relatively unchanged and slightly above the untreated level. This suggests that SDAC 2 is not effective in reducing Fe content in the wastewater. SDAC 3 shows better performance at the 5g dosage, significantly reducing the Fe concentration to 0.075 mg/L. The 10g and 15g dosages are less effective but still manage to reduce the Fe concentration below the untreated level. In summary, SDAC 3 showed the best Fe removal performance, achieving a 33.6% reduction at 5g dosage, whereas SDAC 1 and SDAC 2 were less effective. The experiment shows that sawdust activated carbon has potential for removing Fe from domestic wastewater, with SDAC 3 showing the most promise, particularly at the 5g dosage. The findings of this study align with those of [53], which demonstrated the effectiveness of sawdust in removing Fe from aqueous solutions.

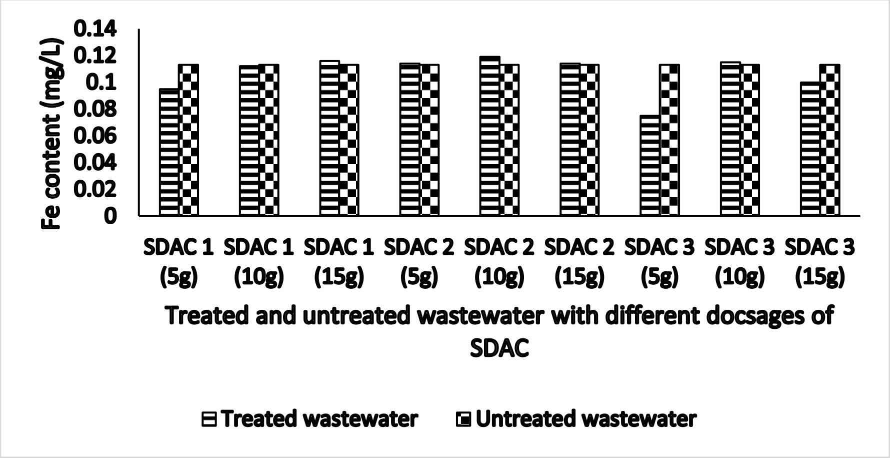

Figure 7: Effect of SDAC dosage on Fe removal from domestic wastewater

3.8 Effect of different dosages of SDAC on Mn removal

The effects of different dosages of SDAC on Mn removal from the wastewater are shown in Figure 8. The Mn content in the untreated wastewater is consistently 0.064 mg/L across all samples. This value is well below the WHO limit of 0.4 mg/L for Mn in drinking water. For SDAC 1 (5g), the Mn concentration in the treated wastewater is 0.038 mg/L, reflecting a significant decrease from its original level before treatment. In the case of SDAC 1 (10g), the Mn concentration rises to 0.092 mg/L, surpassing the initial level, indicating a potential flaw or contamination during the treatment process. For SDAC 1 (15g), the Mn concentration remains elevated at 0.085 mg/L, still above the untreated level, suggesting inconsistency in the effectiveness of removal. Moving to SDAC 2 (5g), there's a slight decrease in Mn concentration to 0.06 mg/L. However, with SDAC 2 (10g), the Mn content increases to 0.1 mg/L, exceeding the untreated level once more, hinting at inefficiency in treatment. In contrast, with SDAC 2 (15g), the Mn concentration drops to 0.052 mg/L, indicating an improvement in removal efficiency. For SDAC 3 (5g), the Mn concentration is 0.049 mg/L, demonstrating effective removal. For SDAC 3 (10g), the Mn content rises to 0.075 mg/L, higher than the untreated level. Lastly, for SDAC 3 (15g), the Mn content is 0.068 mg/L, slightly elevated but closer to the untreated level. The results show variability in the effectiveness of SDAC for removing Mn from wastewater. Some dosages of SDAC effectively reduce Mn levels below the untreated level, while others result in higher Mn concentrations in the treated wastewater. The inconsistency could be due to possible contamination during treatment. Despite these variations, all treated water samples remain well below the WHO limit of 0.4 mg/L thus indicating that the SDAC, in general, does not pose a risk of exceeding safe Mn levels. [54] showed that activated carbon is a cost-effective and efficient adsorbent for Mn removal from wastewater, with its performance enhanced through physical or chemical modifications that introduce active functional groups.

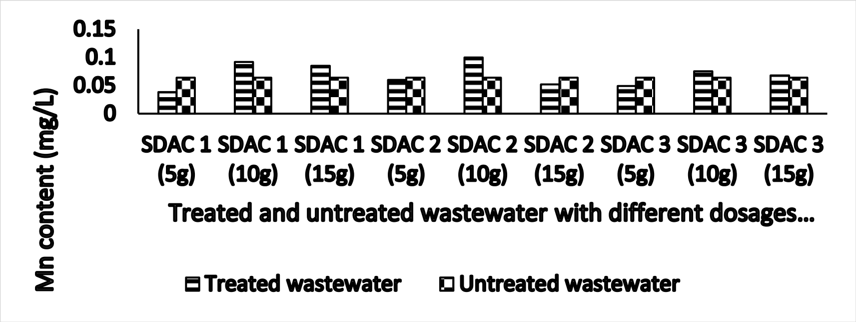

Figure 8: Effect of SDAC dosage on Mn removal from domestic wastewater

3.9 Effect of different dosages of SDAC on Pb removal

Figure 9 provides results for Pb removal from wastewater using different dosages of SDAC, comparing treated wastewater Pb concentrations to untreated wastewater, along with the WHO (World Health Organization) limit for Pb in drinking water, which is 0.01 mg/L. In untreated wastewater, the Pb concentration is consistently measured at 0.09 mg/L, indicating the initial level of Pb contamination in the samples. For SDAC 1, increasing the dosage from 5g to 15g results in treated wastewater Pb concentrations ranging from 0.01 mg/L to 0.06 mg/L. Despite variations in dosage, all treated wastewater Pb concentrations fall within the WHO limit of 0.01 mg/L, indicating effective Pb removal by SDAC treatment. For SDAC 2, at dosages of 5g and 15g, the treated wastewater Pb concentrations are 0.03 mg/L and 0.02 mg/L, respectively. Although these concentrations are slightly above the WHO limit, they still indicate significant Pb removal by SDAC treatment. Notably, at the 10g dosage, the treated wastewater Pb concentration drops to 0 mg/L, suggesting complete removal of Pb, which meets the WHO limit. Similarly, for SDAC 3, at dosages of 5g and 15g, the treated wastewater Pb concentrations are 0 mg/L, indicating complete Pb removal. At the 10g dosage, the concentration is 0.04 mg/L, slightly above the WHO limit but still relatively low compared to the untreated wastewater level. Overall, the results demonstrate that SDAC treatment effectively removes Pb from wastewater, with different dosages achieving Pb concentrations either within or slightly above the WHO limit. However, even at higher dosages, SDAC demonstrates efficacy in reducing Pb concentrations to levels considered safe for drinking water. [55] reviewed the removal of lead ions (Pb^{2+}) from water and wastewater using low-cost adsorbents and discovered that the removal efficiencies of these adsorbents ranged from 13.6% to 100%, with agricultural waste showing adsorption capacities between 0.7 and 2079 mg/g. Notably, some dosages resulted in complete Pb removal aligning with the higher removal efficiencies observed by [55] for other adsorbents. Both studies highlight the potential of low-cost, natural adsorbents for significant Pb removal from wastewater, emphasizing the effectiveness and variability in performance based on dosage and type of adsorbent used. [56, 57] affirmed the potential of sawdust as a major industrial byproduct for removing lead from wastewater corroborating the findings of this present study.

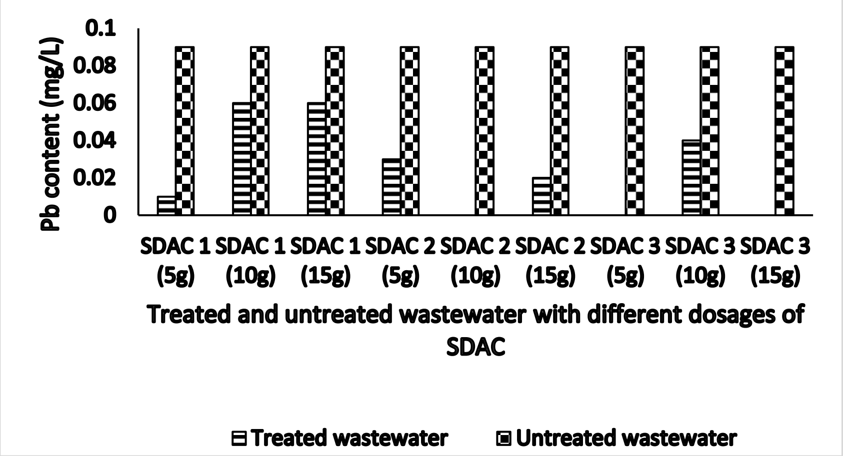

Figure 9: Effect of SDAC dosage on Pb removal from domestic wastewater

3.10 Effect of different dosages of SDAC on Zn removal

Figure 10 displays the results of Zn removal from wastewater using different dosages of SDAC comparing treated wastewater Zn concentrations to untreated wastewater. In untreated wastewater, the Zn concentration remains constant at 1.183 mg/L across all samples, indicating the initial level of Zn present in the samples. For SDAC 1, increasing the dosage from 5g to 15g shows a slight increase in treated wastewater Zn concentrations, ranging from 1.593 mg/L to 1.723 mg/L. Despite this increase, all concentrations still remain relatively close to the initial level of Zn in untreated wastewater. In the case of SDAC 2, the treated wastewater Zn concentrations also vary with dosage. At 5g and 10g dosages, the concentrations are 1.362 mg/L and 1.574 mg/L, respectively, while at 15g dosage, the concentration drops to 1.096 mg/L. This indicates a decrease in Zn concentration compared to untreated wastewater, especially notable at the 15g dosage. Similarly, for SDAC 3, the treated wastewater Zn concentrations fluctuate with dosage. At 5g and 15g dosages, the concentrations are 1.81 mg/L and 1.488 mg/L, respectively, while at 10g dosage, the concentration decreases to 1.074 mg/L, indicating a significant reduction in Zn concentration compared to untreated wastewater. Even though the results showed that both untreated and treated wastewater samples did not exceed the Zn WHO limit in drinking water, overall, the results suggest that higher dosages of SDAC tend to Pb to more effective removal of Zn from wastewater, with SDAC 3 (10g) showing the most significant reduction in Zn concentration. However, none of the dosages achieve a reduction below the initial concentration of Zn in untreated wastewater. Similar results for zinc removal from wastewater have been achieved in various studies using different methods such as commercial activated carbon, complexation–microfiltration process, adsorption on cork powder, polyaniline nanocomposite coated on rice husk, as well as treatments with ferric chloride and alum. [58] indicated that aluminium sludge is highly effective, achieving a zinc removal efficiency of up to 97.4% from wastewater. Further optimization of SDAC dosage and treatment methods may be necessary to achieve more substantial reductions in Zn concentration and meet regulatory standards.

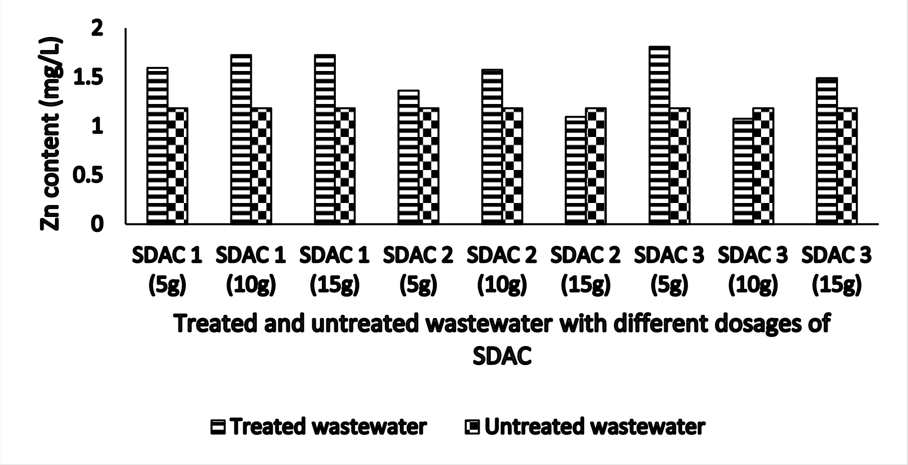

Figure 10: Effect of SDAC dosage on Zn removal from domestic wastewater

4.0 Conclusion

This study demonstrated the potential of SDAC as an adsorbent for heavy metal removal from domestic wastewater. SDAC 2 achieved a 14% reduction in Cu concentration at the optimal 10g dosage, while SDAC 3 showed a 16.7% reduction in Cr concentration at the same dosage. SDAC 1 and SDAC 2 both achieved 100% removal of Cd at the 5g and 15g dosages, SDAC 3 showed a 33.6% reduction in Fe concentration at 5g dosage. SDAC 1 reduced Mn concentration by 40.6% at 5g dosage, and SDAC 3 achieved a 9.2% reduction in Zn concentration at 10g dosage. The discrepancy between the promising structural features observed in the SEM images of the different SDAC samples and its practical effectiveness in heavy metals removal highlights the complexity of adsorption processes in real-world applications. Factors such as impurities in the sawdust used to produce SDAC may have contributed to its ineffectiveness. Additionally, variations in dosage levels and their impact on adsorption efficiency underscore the importance of optimizing dosage for each specific application. The findings of this study contribute to the body of knowledge by demonstrating the feasibility of using locally sourced sawdust as an effective adsorbent for wastewater treatment. Practical implications include potential applications in small-scale and decentralized wastewater treatment systems, particularly in resource-limited settings. Further studies are needed to investigate the scalability and long-term stability of SDAC for real-world applications.

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