TREATMENT OF TEXTILE WASTEWATER USING COCONUT LEAF ACTIVATED CARBON: A SUSTAINABLE APPROACH

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Abstract - Textile industry wastewater poses significant environmental and health challenges due to its high levels of pollutants, including dyes, heavy metals, and organic compounds. Conventional wastewater treatment methods often fall short in effectively removing these contaminants. This research paper investigates the potential of coconut leaf activated carbon (CLAC) as a sustainable and efficient adsorbent for the treatment of textile wastewater.

The study begins by exploring the preparation process of CLAC through chemical activation, utilizing discarded coconut leaves, an abundant agricultural waste product. The resulting activated carbon exhibits a highly porous structure with a large surface area, making it an ideal adsorbent for wastewater treatment.

A series of laboratory experiments were conducted to evaluate the adsorption performance of CLAC on textile wastewater. The parameters studied included contact time, initial dye concentration, pH, and CLAC dosage.

The results demonstrated that CLAC exhibited excellent adsorption capacity for various textile dyes and other pollutants present in the wastewater. The optimum conditions for maximum adsorption efficiency were determined, enabling the development of an effective treatment process. Furthermore, the regeneration and reusability of CLAC were investigated, highlighting its potential for cost-effective and sustainable wastewater treatment practices.

In conclusion, this research highlights the significant potential of coconut leaf activated carbon as an efficient and sustainable adsorbent for the treatment of textile wastewater. The study provides valuable insights into process optimization, and regeneration, contributing to the development of eco-friendly strategies for tackling the challenges posed by textile industry wastewater.

Index Terms - CLAC: Coconut Leaf Activated Carbon, PPE: Personal Protection Equipment, COD: Chemical Oxygen Demand, BOD: Biochemical Oxygen Demand, DO: Dissolved Oxygen, TDS: Total Dissolved Solids, TSS: Total Suspended Solids, MF: Muffle Furnace, WBS: Water Bath Shaker

I. INTRODUCTION

The textile industry plays a significant role in global economic development, providing millions of jobs and supplying a wide range of consumer goods. However, the production processes in the textile industry generate large volumes of wastewater that contain various contaminants, including dyes, chemicals, and suspended solids. The discharge of untreated textile wastewater into water bodies poses severe environmental and health hazards.

To address this challenge, sustainable and efficient wastewater treatment methods are crucial. Activated carbon has emerged as a promising adsorbent for the removal of organic pollutants due to its high surface area, porosity, and affinity for a wide range of contaminants. However, the production of activated carbon from conventional sources, such as coal or wood, raises concerns regarding deforestation and carbon emissions.

In recent years, researchers have explored alternative and sustainable sources of activated carbon, and one such source is coconut leaves. Coconut leaves are abundantly available in tropical regions and are often considered agricultural waste. Utilizing coconut leaf activated carbon for textile wastewater treatment offers a sustainable solution by converting a waste material into a valuable resource while minimizing environmental impact.

This research project aims to investigate the efficacy of coconut leaf activated carbon for the treatment of textile wastewater. The study will focus on evaluating its adsorption capacity, efficiency in removing dyes and other pollutants, and its potential as a cost-effective and eco-friendly alternative to conventional activated carbon.

The project will involve the collection of textile wastewater samples from local textile industries, characterization of the wastewater composition, and the preparation of coconut leaf activated carbon through a series of controlled processes. The adsorption performance of the coconut leaf activated carbon will be assessed through batch experiments, and the effects of various parameters such as contact time, pH, and initial concentration will be investigated.

Ultimately, the successful implementation of coconut leaf activated carbon for textile wastewater treatment could have significant environmental, economic, and social benefits. By utilizing an abundant and renewable resource, we can mitigate the environmental impact of textile wastewater while promoting sustainability in the textile industry.

This project's outcomes will provide valuable insights for policymakers, researchers, and industry professionals seeking innovative solutions to address the challenges of textile wastewater treatment. The development and adoption of sustainable approaches like coconut leaf activated carbon can contribute to a cleaner and healthier environment for future generations.

II. LITERATURE SURVEY

1.K. S. Sulaiman et al in 2015 [1] explored the use of coconut leaves as a precursor to produce activated carbon. Carbonization of coconut leaves at 400 °C for 3 hours was followed by ball milling and activation with carbon dioxide at temperatures ranging from 700 to 1000 °C. The surface area of the resulting coconut leaf-activated carbon (CLAC) increased with higher activation temperatures. Electrodes made from CLACs were used to create electrochemical double-layer capacitors (EDLCs) and exhibited a specific capacitance of 133.4 F/g at a current density of 200 mA/g when the carbon was activated at 900 °C.

2.Anokhaa Kheddo et al in 2020 [2] studied to use activated carbon derived from rice husk to remove dyes from synthetic dyed wastewater. The optimal conditions for batch adsorption included an acidic medium (pH 2), an adsorbent dosage of 13 g/L, and an agitation speed of 100 rpm. After 10 minutes, a maximum dye removal of 80% was achieved, resulting in a final dye concentration of 10.8 mg/L. The adsorption process followed the Temkin model and pseudo-second order kinetics, indicating a non-spontaneous, endothermic chemisorption process. Gas-phase computations supported some of the experimental findings. In column adsorption, the maximum adsorption capacity (qo) was determined to be 12.8 mg/g, and the maximum dye removal exceeded 99.5%.

3.M.S. Shamsuddin in 2015 [3] conducted a study. In this study, kenaf core fiber (KF) was activated using phosphoric acid (H3PO4) to produce low-cost activated carbon. The surface area of the resulting activated carbon, known as KFAC, was determined to be 299.02 m2/g, with a micropore volume of 0.12 cm3/g. Fourier transform infrared (FT-IR) analysis detected carbonyls, alkenes, and hydroxyls in the KFAC. Field Emission Scanning Electron Microscope (FESEM) images displayed the gradual formation of pores as volatiles and contaminants were eliminated. X-ray diffraction (XRD) analysis indicated an amorphous structure. Proximate and ultimate analysis revealed a high percentage of carbon and low ash content, suggesting that KFAC is a suitable material for porous carbon production.

4.Gamal O. El-Sayed et al in 2014 [4] conducted a research where Corncob, a waste product from corn agriculture in Egypt, was utilized to prepare activated carbons (ACs) through chemical activation with concentrated H3PO4 acid, followed by pyrolysis at different temperatures. The resulting ACs were tested for their ability to remove methylene blue (MB) dye from aqueous solutions. Batch adsorption experiments examined the effects of initial dye concentration, contact time, adsorbent dose, and pH. The adsorption data were analyzed using Langmuir and Freundlich adsorption isotherms. AC1 and AC2 exhibited Langmuir adsorption behavior with maximum monolayer sorption capacities of 28.65 and 17.57 mg/g, respectively, while AC3 fit the Freundlich isotherm model well.

5.Sahira Joshi et al in 2021 [5] did a study where hierarchically porous carbon materials were prepared from Areca catechu nut using phosphoric acid activation. The optimized sample exhibited a high specific surface area of 2132.1 m2/g and a large pore volume of 3.426 cm3/g. It showed excellent adsorption properties for iodine (888 mg/g) and methylene blue (369 mg/g). Batch adsorption studies of methylene blue revealed the best performance at alkaline pH, an adsorbent dose of 2.8 g/L, and a contact time of 180 minutes, with a monolayer adsorption capacity of 333.3 mg/g according to the Langmuir isotherm model.

III. TREATMENT USING CLAC

Wastewater Characterization was done using standard lab procedures.

The procedure for the preparation of activated carbon from coconut leaves had entailed a systematic series of steps to harness the potential of this agricultural byproduct. Commencing with the collection of a sufficient quantity of mature coconut leaves, the process ensured the elimination of dirt, debris, and extraneous matter. Rigorous rinsing with water followed to purify the coconut leaves of surface impurities. Subsequently, the leaves underwent a natural drying process in a well-ventilated environment until achieving a moisture content of 10-15%. Once optimally dried, the coconut leaves were meticulously cut into small pieces or strips using sharp implements such as scissors or knives, facilitating further processing.

Thorough washing and drying comprised the subsequent phases. The cut coconut leaf pieces were immersed in water and meticulously washed to eradicate any residual dirt or contaminants. Following this, the washed pieces were carefully spread on a clean surface or tray for drainage, subsequently undergoing complete drying in a well-ventilated area. This drying phase extended over several days until the moisture content was substantially reduced to a minimal level.

The subsequent phase involved the pulverization and sieving of the thoroughly dried coconut leaf pieces. The material was ground into a fine powder using equipment such as grinders or blenders. The resulting powdered material underwent further refinement by being passed through a sieve with a specified mesh size of 600 microns, or as required, to eliminate larger particles or fibres. The resulting sieved material was carefully set aside for subsequent stages.

In preparation for carbonization, the powdered coconut leaves underwent a soaking process in orthophosphoric acid. A solution of orthophosphoric acid was meticulously prepared. The powdered coconut leaves were then placed into a container or beaker, and the orthophosphoric acid solution was poured over them to ensure complete submersion. The coconut leaf powder was allowed to soak in the acid solution for a specified duration, with periodic stirring to ensure uniform impregnation. After the designated soaking period, the excess acid solution was carefully drained.

The pivotal stage of the process involved carbonization within a muffle furnace. The furnace was preheated to the predetermined temperature designated for the carbonization process. The soaked coconut leaf powder, now devoid of excess acid, was evenly spread on a clean tray or container suitable for furnace usage. This vessel was then placed within the preheated muffle furnace. Carbonization ensued under controlled conditions as dictated by the desired temperature, with adequate ventilation to facilitate the process. Upon completion, the tray or container was removed from the furnace, and the resultant activated carbon was allowed to cool to ambient temperature.

Following carbonization, the activated carbon underwent a filtration phase. The carbonized coconut leaf powder was directed through a filtration system to eliminate impurities or unburned residues. Thorough washing with water was conducted, accompanied by gentle stirring or agitation. This washing process was diligently repeated until the pH of the washed water reached a neutral value of 7. Upon achieving the desired pH, excess water was drained, and the activated carbon was dried extensively in a well-ventilated area.

The final stages encompassed storage and packaging. The prepared activated carbon was stored in an impeccably maintained environment—a clean, dry, and airtight container—preventing moisture absorption and contamination. The container was suitably labeled, providing essential information like the preparation date, batch number, and relevant specifications. The comprehensive execution of these stages culminated in the production of activated carbon from coconut leaves, poised for utilization in applications such as textile wastewater treatment, exemplifying the synergy of sustainable resource utilization and meticulous methodology.

Absorbance was measured by standard lab procedures using spectrophotometer at 540nm.

Soaking Time(hrs)	**Dosage(g/ 100mL)**	**Acid Ratio (w/v)**	**WBS (mins)**	**Sedi (mins)**	**MF Temp (^0C)**	**MF Time(hrs)**	**Abs**	**Abs% ((Raw abs-treated abs)*100)/Raw abs**
24	2.5	01:04	5	30	400	1	0.34	88.03
24	2.5	01:04	5	30	400	2	0.5324	81.26
24	2.5	01:04	5	30	400	3	1.0525	62.96
24	2.5	01:05	30	30	200	1	0.9955	64.97
24	2.5	01:05	30	30	300	1	0.6842	75.92
24	2.5	01:05	30	30	400	1	0.001	99.96
24	2.5	01:05	30	30	500	1	0.0453	98.5
24	2.5	01:04	5	30	400	1	0.34	88.03
24	2.5	01:05	30	30	400	1	0.0001	99.96
24	2.5	01:06	30	30	400	1	0.4858	82.9
24	1	01:05	30	30	400	1	0.2787	90.1
24	2	01:05	30	30	400	1	0.068	97.6
24	2.5	01:05	30	30	400	1	0.0001	99.96
24	3	01:05	30	30	400	1	0.041	98.55
24	2.5	01:05	30	30	400	1	0.0001	99.96
48	2.5	01:05	30	30	400	1	0.0443	98.44
72	2.5	01:05	30	30	400	1	0.0476	98.32
24	1	01:05	15	30	400	1	0.0497	97.82
24	1	01:05	30	30	400	1	0.001	99.95
24	1	01:05	45	30	400	1	0.304	86.69
24	1	01:05	30	30	400	1	0.001	99.95
24	1	01:05	30	60	400	1	0.397	82.61
24	1	01:05	30	90	400	1	0.0383	98.32
Raw	Raw	Raw	Raw	Raw	Raw	Raw	2.2842	-
Industry Grade Carbon for same dosage and contact time as optimal							1.0943	52.09

IV. CONCLUSIONS

Based on the conducted trials and variations in different parameters, the following conclusions were drawn for the treatment of textile effluent using Coconut Leaf Activated Carbon (CLAC):

1. Carbonization duration: The optimum duration of carbonization was found to be 1 hour. This duration resulted in the best absorption values, indicating that enough time was required for the activation process to occur effectively.

2. Carbonization temperature: The optimal temperature for carbonization was determined to be 400°C. This temperature yielded the highest absorption values, suggesting that it was the ideal range for activating the coconut leaf and generating effective adsorption sites on the carbon surface.

3. Acid ratio: The optimal acid ratio was found to be 1:5. This ratio resulted in the highest absorption values, indicating that it provided an appropriate balance between activating the carbon and maintaining its structural integrity.

4. Dosage: The optimal dosage of CLAC was determined to be 25g/L. This dosage showed the highest absorption values, indicating that a sufficient amount of CLAC was needed to achieve effective removal of pollutants from the textile effluent.

5. Soaking time: The optimal soaking time was found to be 24 hours. This duration resulted in the best absorption values, suggesting that a longer soaking time allowed for better impregnation of the activating agent into the coconut leaf structure, leading to enhanced adsorption properties.

6. Contact time: The optimal contact time with a Water Bath Shaker (WBS) was determined to be 30 minutes. This contact time showed the highest absorption values, indicating that a sufficient duration of contact between the CLAC and the effluent was necessary for effective pollutant removal.

7. Sedimentation time: The optimal sedimentation time was found to be 30 minutes. This duration resulted in the best absorption values, suggesting that allowing the effluent to settle for an adequate period helped in separating the adsorbed pollutants from the treated water.

In summary, the optimized parameters for the treatment of textile effluent using CLAC were a carbonization duration of 1 hour at 400°C, an acid ratio of 1:5, a dosage of 25g/L, a soaking time of 24 hours, a contact time (WBS) of 30 minutes, and a sedimentation time of 30 minutes. By following these optimized parameters, the treatment process effectively removed pollutants and improved the absorption values of the effluent, leading to a more sustainable and environmentally friendly approach for textile wastewater treatment. Further research could focus on scale-up studies and the application of CLAC in larger treatment systems to evaluate its feasibility and performance in real-world scenarios.

CLAC was found to be 47.91% more efficient than Industry Grade Carbon.

The treatment of textile wastewater using coconut leaf activated carbon presented a promising and sustainable approach for future applications. Further research could focus on exploring the potential of coconut leaf activated carbon in large-scale wastewater treatment systems. Studies could be conducted to optimize the activation process and enhance the adsorption capacity of the activated carbon by modifying its surface properties. Additionally, investigations could be carried out to assess the effectiveness of coconut leaf activated carbon in removing other pollutants commonly found in textile wastewater, such as heavy metals and organic compounds. The development of cost-effective and efficient regeneration methods for the spent coconut leaf activated carbon could also be explored, ensuring its long-term sustainability and economic viability.

V. REFERENCES

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