Removal of Impurities from Waste Water Using Biochar

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ABSTRACT - The need for sustainable and affordable water treatment methods arises because of the growing contamination of water sources by industrial effluents, especially those that contain organic contaminants and synthetic dyes. In order to treat synthetic wastewater, this study investigates the utilization of biochar made from green coconut shell by slow pyrolysis and to replicate actual industrial effluent, the study concentrated on eliminating wastewater constituents such as methyl orange, methyl red, starch, and dairy waste. Further their ability to lower pH, turbidity, total solids (TS), total dissolved solids (TDS), chemical oxygen demand (COD), was evaluated for the prepared biochar. When analysied the results showed significant improvement in water quality. The study highlights the potential of coconut waste-derived biochar as an efficient, economical, and eco-friendly adsorbent for wastewater treatment applications.

Keywords: Green coconut, pyrolysis, biomass, biochar preparation, waste water, waste water treatment, pH, turbidity, total solids, total dissolved solids, chemical oxygen demand, economic, environmental impact

INTRODUCTION: -

Water contamination from industrial sources, particularly those in the food processing, pharmaceutical, and textile industries, is one of the largest environmental issues the world is currently facing. Hazardous substances commonly detected in untreated or inadequately treated industrial effluent include synthetic colors, heavy metals, microorganisms, and organic waste. Because these pollutants have the potential to significantly damage the environment and reduce the oxygen content of water bodies, they pose a direct threat to human health by contaminating fresh water. For this reason, effective and sustainable wastewater treatment solutions are desperately needed, particularly in areas with high population densities or industrial activity.

Despite the effectiveness of conventional wastewater treatment techniques like advanced oxidation, reverse osmosis, coagulation- flocculation, and membrane filtration, these methods are not very flexible in rural or low- resource environments, have high initial and operating costs, and require complex maintenance. Secondary pollution is also a result of many of these processes requiring a lot of energy or extra chemicals. And to overcome this problem there is a sustainable, low-cost water treatment known as biomass waste treatment in which biochar is prepared using biomass, it has drawn a lot of interest as an effective adsorbent for water purification.

Biochar is a carbon-rich, porous material obtained from the thermal decomposition of organic biomass under oxygen-limited conditions a process known as pyrolysis. Pyrolysis is a thermal breakdown process that breaks down organic compounds without the presence of oxygen at high temperatures usually 300– 700°C or even higher. It is extensively employed in material production, energy recovery, and waste management pyrolysis not only converts agricultural and forestry residues into a stable carbon product but also produces useful byproducts such as syngas and bio-oil, contributing to a circular economy.

Using agricultural waste to produce biochar turns an abundant, low-value leftover into a profitable commodity, which has further positive effects on the environment and the economy. For decentralized, economical wastewater treatment systems in both urban and rural areas, this makes biochar a particularly a perfect choice.

METHODOLOGY

Flow Chart: Figure 1 depicts the different stages of removal of impurity from wastewater using biochar which involves collection, processing, preparation of Biochar and its chemical activation, preparation of wastewater, testing of prepared wastewater, batch adsorption process, testing of treated wastewater and analysis of result.

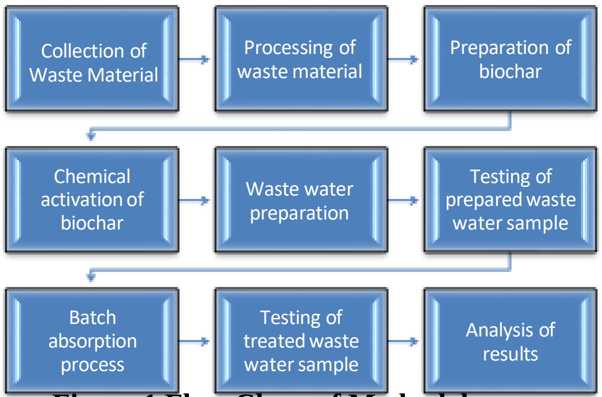

Figure 1 Flow Chart of Methodology

Collection and Preparation of Raw Material: Green coconut was sourced from local vendors in Nagpur. The material was washed, sun-dried for one week, and cut into smaller pieces for ease of processing.

Biochar Production via Pyrolysis: The dried biomass was oven-dried at 110°C and then subjected to pyrolysis in a muffle furnace at 650°C for 3 hours.

Chemical Activation: The prepared biochar was chemically activated by soaking in NaOH solution to enhance porosity and surface area. The activated biochar was dried again at 100°C for 1 hour.

Synthetic Wastewater Preparation: Three types of wastewater samples were prepared using combinations of methyl orange, methyl red, dairy wastewater, starch, universal indicator and tap water. Each sample had a total volume of 50 mL.

Batch Adsorption Testing: Prepared waste water samples was passed through to biochar.

Analytical Techniques: Different parameters where check such as pH it was measured using a digital pH meter. Turbidity was assessed using a nephelometer. Total Solids (TS) and Total Dissolved Solids (TDS) were determined gravimetrically. Chemical oxygen demand (COD) was measured using the open reflux method with potassium dichromate as the oxidizing agent.

MATERIALS AND EQUIPMENTS

Material:

Green coconut: The primary raw material utilized for biochar synthesis in this study was green coconut shell.

Chemicals:

Sodium Hydroxide (NaOH): It was used in experiment for chemical activation of the biochar to enhance its surface area and porosity.

To simulate real-world industrial wastewater conditions, three types of synthetic wastewater samples were prepared using the following reagents: **Methyl Orange** and **Methyl Red**: It helped representing textile industry effluents.

Universal Indicator: Used to visualize and simulate pH fluctuation.

Starch: It was added to representing biodegradable organic content.

Dairy Wastewater: Sourced from local dairy units to introduce proteins and organic load.

Each synthetic wastewater solution had a total volume of 50 mL, prepared by combining the above components in different ratios to evaluate treatment under varied pollutant loads.

Equipment's:

In the experiment work the following equipment were used:

Hot Air Oven: A hot air oven is a common laboratory equipment used for drying, sterilizing, and heat- treating various materials under controlled temperature conditions. It was used in the project for drying raw biomass and treated biochar at controlled temperatures.

Desiccator: Desiccator is used in lab for shielding materials that are susceptible to moisture from humidity. In these processes of finding TS and TDS samples must be cooled down before being weighed after being dried at particular temperatures to eliminate moisture and volatile materials. These heated samples may quickly acquire moisture from the surrounding air if they are left out in the open, which could result in measurement inaccuracies. In order to avoid this, the desiccator a sealed container that uses a desiccant substance like silica gel to maintain a low-humidity environment is used to hold the dried samples.

Muffle Furnace: Muffle furnace was used to carry out slow pyrolysis of green coconut shell in the project. Typically operating at temperatures between 300°C to 1200°C, basically it is a high-temperature laboratory apparatus used for sample burning, ashing, and heat treatment.

Glassware: Standard laboratory glassware including beakers, volumetric flasks, and graduated cylinders were used for solution preparation, mixing, and measurement of reagents and wastewater samples.

pH Meter: A digital pH meter was utilized for accurate measurement of the acidity or alkalinity of wastewater before and after treatment with biochar. Basically, a pH meter is a single probe that is submerged in the sample to know its pH.

Nephelometer: A nephelometer is a scientific device that measures a liquid sample's turbidity, or cloudiness which is due to the suspended particles present in the water. In the examination of water and wastewater, turbidity is a crucial physical measure because it shows the presence of silt, clay, organic matter, algae, and microorganisms.

Gravimetric Setup: For determination of Total Solids (TS) and Total Dissolved Solids (TDS), pre-weighed evaporating dishes were used. Samples were dried in an oven and the increase in weight was used to compute the concentration of solids. **Open Reflux Apparatus**: Was used for measuring Chemical Oxygen Demand (COD**)** using potassium dichromate as the oxidizing agent of the waste water. The Chemical Oxygen Demand (COD) test measures the oxygen equivalent needed to chemically oxidize organic molecules, which is one way to determine the amount of organic matter in wastewater. When evaluating the strength and effectiveness of wastewater treatment especially industry waste water, this is a crucial parameter.

Filter Papers and Storage Containers: Filter papers were used to separate biochar from treated wastewater, and plastic or glass jars were used for sample storage and handling.

EXPERIMENTAL WORK

The experimental work involved a series of steps to prepare, characterize, and evaluate the performance of biochar derived from green coconut shells in treating synthetic industrial wastewater.

Biochar Synthesis via Slow Pyrolysis: Pyrolysis was performed in a muffle furnace preheated to 100°C. The dried coconut shell was heated to 650°C for 3 hours in the furnace under limited oxygen supply and biochar is prepared as shown in figure 2.

Chemical Activation: Biochar was soaked in 1M NaOH solution for 12 hours to enhance surface porosity and functional groups. The activated biochar was then rinsed with distilled water and oven-dried at 100°C for 1 hour for complete drying.

Figure 2 Green Coconut Shell Biochar

Preparation of Synthetic Wastewater Samples: Three wastewater samples were created to represent industrial effluent: Solution I: Methyl orange, starch dairy wastewater and water. Solution II: Methyl red, starch, dairy wastewater, and water. Solution III: Methyl orange, methyl red, universal indicator, starch, dairy wastewater, and water.

Adsorption Experiment Setup: 50 mL wastewater sample was passed through biochar and left to interact for 1 hour at room temperature.

Parameter Measurement and Analysis: Waste water sample was analyzed for the parameters such as

pH: Measured using a calibrated digital pH meter before and after treatment.

Turbidity: Analyzed using a nephelometer and recorded in NTU.

Total Solids (TS): Determined by evaporating a volume of sample in a pre- weighed dish, cooling in a desiccator, and reweighing to know the total solids in the water sample.

Total Dissolved Solids (TDS): Measured after filtering the sample and evaporating the filtrate and reweighting to know the total dissolved solids in the same .

Chemical Oxygen Demand (COD): Determined by the open reflux method using potassium dichromate and titration with ferrous ammonium sulphate.

RESULTS AND DISCUSSION

The results from the experimental work highlighted the performance of shell biochar with three types of synthetic wastewater samples. The key findings are as follows:

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Solution I (Methyl Orange, Starch, Dairy Wastewater and water)

Table 1 Before and after treatment of solution I by shell biochar

Parameter	Before Treatment	After Treatment
pH	5.3	8.2
Turbidity	250 NTU	100 NTU
Total Solids (TS)	5775 mg/L	2390 mg/L
TDS	2170 mg/L	1370 mg/L
COD	601.6 mg/L	432 mg/L

Solution II (Methyl Red, Starch, Dairy Wastewater and water)

Table 2 Before and after treatment of solution II by shell biochar

Parameter	Before Treatment	After Treatment
pH	5.4	8.5
Turbidity	280 NTU	120 NTU
Total Solids (TS)	5570 mg/L	2190 mg/L
TDS	2130 mg/L	1070 mg/L
COD	672 mg/L	432mg/L

Solution III (Methyl Orange, Methyl Red, Universal Indicator, Starch, Dairy Wastewater and water)

Table 3 Before and after treatment of solution III by shell biochar

Parameter	Before Treatment	After Treatment
pH	5.1	8.2
Turbidity	310 NTU	190 NTU
Total Solids (TS)	6870mg/L	4170 mg/L
TDS	2970 mg/L	1770 mg/L
COD	720 mg/L	448 mg/L

Graphs Representing changes in parameters:

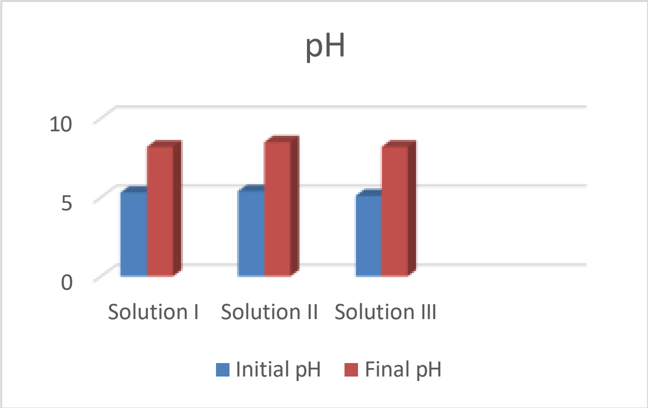


Figure 6 Variation in pH

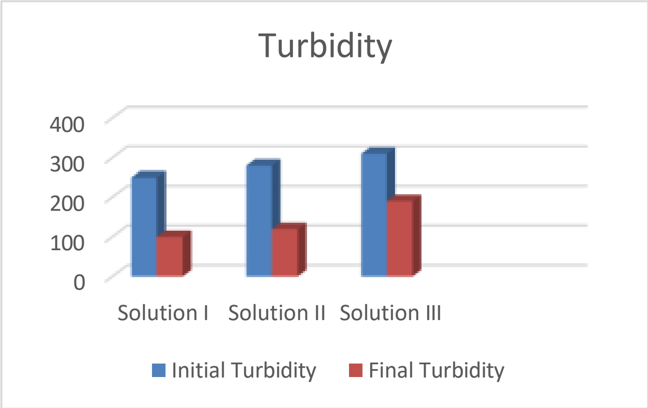


Figure 3 Variation in Turbidity

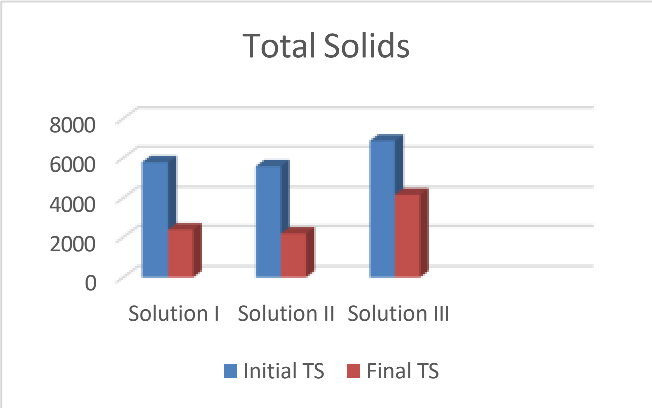
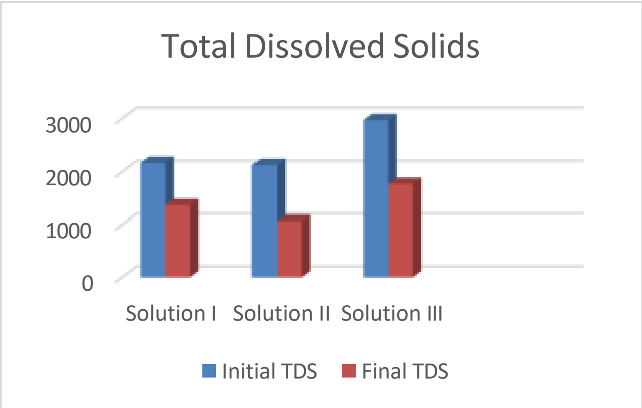


Figure 4 Variation in Total Solids

Figure 5 Variation in Total Dissolved Solids



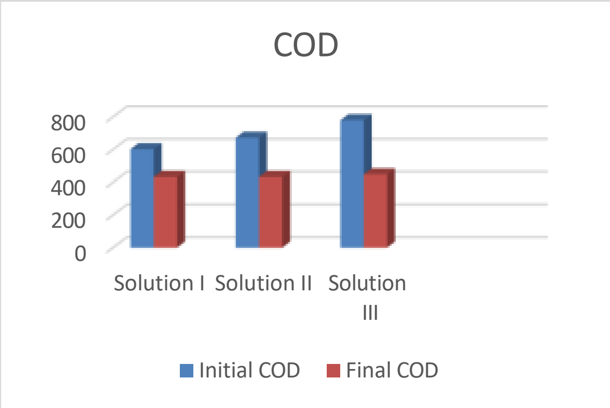


Figure 7 Variation in COD CONCLUSION

In conclusion it shows that biochar obtained from green coconut shells can effectively treat industrial wastewaters. Biochar made from shells showed ability to clear turbidity from water while decreasing COD measurements and enhancing pH values also seen a reduction in TS and TDS. NaOH activation transforms biochar into an effective water purifying agent through the combined effect of high mineral content and structural density. The research establishes two key benefits by carrying out waste management with biochar made from agricultural waste while providing affordable pollution control to developing countries.

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