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The Effect of Sugarcane bagasse on The Performance of Coffee Waste Membrane for Peat Water Purification

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ABSTRACT

This study investigates the potential of using sugarcane bagasse and coffee waste in membrane filtration for the purification of peat water. Peat water, known for its high organic content and challenging chemical properties, presents significant difficulties in traditional water treatment methods. Membrane technology has emerged as a promising solution, and this research aims to evaluate the effectiveness of membranes made from agricultural waste. Membranes were fabricated using different ratios of sugarcane bagasse and coffee waste, and their performance was tested based on parameters such as pH, turbidity, and Total Dissolved Solids (TDS). The results indicated that the 50:50 ratio of sugarcane bagasse to coffee waste provided the best outcomes in terms of pH neutralization and turbidity reduction, although the process still showed limitations in removing dissolved solids and addressing color and odor. This study demonstrates that while natural materials like sugarcane bagasse and coffee waste offer a sustainable alternative for water purification, further optimization and additional treatments are necessary for improving the removal of dissolved contaminants.

1. Introduction

Peat water, characterized by its high organic content and unique chemical properties, presents significant challenges for water treatment. The presence of humic substances and other organic materials in peat water can lead to color, odor, and potential toxicity issues. It makes effective treatment technologies to ensure safe usage necessary.

Membrane technology has emerged as a promising solution for treating peat water, leveraging various membrane processes to enhance water quality and facilitate reuse. (Li et al., 2013; Duan et al., 2013). The application of membrane

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technology in water treatment has seen substantial advancements, particularly in the context of municipal wastewater reclamation. Recent studies indicate that membrane processes can reduce contaminants in wastewater effectively, making them suitable for potable reuse (Warsinger et al., 2018).

These technologies are particularly advantageous due to their ability to operate with minimal chemical additives, thus reducing the environmental impact associated with traditional treatment methods (Mahmood et al., 2013). Furthermore, the integration of renewable energy sources, such as solar-driven processes, with membrane technology has been explored to enhance water treatment efficiency and sustainability (Song et al., 2022).

Innovative approaches to membrane fabrication have also gained attention, particularly the use of biomass-derived materials such as sugarcane sugarcane bagasse and coffee waste. These materials offer a sustainable alternative to conventional synthetic membranes, which often involve high production costs and environmental concerns. Researches demonstrated that cellulose-based membranes derived from agricultural waste can exhibit favorable filtration properties, including high permeability and selectivity for various contaminants (Colburn et al., 2019; Sharma et al., 2020).

The integration of sugarcane sugarcane bagasse and coffee waste into membrane technology for water filtration represents a sustainable approach to address water quality issues. Sugarcane sugarcane bagasse is rich in cellulose, hemicellulose, and lignin, making it a valuable resource for developing filtration membranes. The use of coffee waste adds the composite's effectiveness due to its porous structure and high surface area, which can enhance filtration performance.

Researches also showes that membranes fabricated from sugarcane sugarcane bagasse exhibit promising filtration characteristics. For instance, ceramic membranes created using sugarcane sugarcane bagasse ash as a pore-forming agent have shown effective microfiltration capabilities suitable for removing suspended solids and pathogens from water (Andrade et al., 2019). Additionally, the incorporation of activated carbon derived from sugarcane sugarcane bagasse has been shown to effectively reduce iron levels in wastewater, highlighting the potential of sugarcane bagasse- based materials in improving water quality (Maharani et al., 2019).

The combination of sugarcane sugarcane bagasse and coffee waste in membrane fabrication can leverage the unique properties of both materials. The cellulose content in sugarcane sugarcane bagasse contributes to the mechanical strength and structural integrity of the membrane, while the organic compounds in coffee waste may enhance the adsorption capacity for various contaminants. Furthermore, the development of biodegradable membranes from these materials aligns with the growing emphasis on sustainability in water treatment technologies, as they can reduce reliance on synthetic polymers and minimize environmental impact.

Recent studies have explored the potential of using sugarcane sugarcane bagasse and coffee waste in mixed matrix membranes, where the two materials are combined with a polymeric matrix to enhance filtration performance. Such membranes can exhibit improved mechanical properties and filtration efficiency, making them suitable for various water treatment applications (Elshabrawy, 2024). The utilization of such biomass not only contributes to waste reduction but also aligns with the principles of a circular economy by repurposing agricultural by- products for water treatment applications (Namdeti, 2023). The utilization of sugarcane sugarcane bagasse and coffee waste in membrane technology for water filtration presents a promising avenue for sustainable water treatment. The inherent properties of these materials, coupled with their availability as agricultural by-products, make them ideal candidates for developing efficient and eco-friendly filtration systems.

2. Research Method

2.1. Materials

This study uses sugarcane bagasse and coffee waste to produce membranes used in the peat water purification process. The tools used include a knife, blender, measuring cup, filter paper, oven, spatula, tray, desiccator, pH meter, turbidity and TDS meter, and pH paper. The materials used are sugarcane bagasse, coffee waste, distilled water (aquadest), and peat water.

2.2. Sugarcane bagasse Activation

The process begins with the activation of sugarcane bagasse, which is first peeled and washed with clean water to remove dirt. Afterward, it was dried under sunlight and then heated in an oven at 250°C for 1 hour to reduce its moisture content. Once dry, the sugarcane bagasse was cut and blended into a fine powder.

2.3. Coffee Waste Membrane Preparation

The membrane production process continues with the coffee waste, which was heated at 250°C for 2 hours to induce carbonization and enhance its porosity. After carbonization, the coffee waste washed with distilled water at 30°C until the pH of the water becomes neutral (pH = 7) to remove any remaining chemicals. The coffee waste is then heated at 120°C for 1 hour to remove excess water, ensuring that the material is dry and ready for use.

2.4. Hydrothermal Treatment

Once the materials are prepared, a hydrothermal process is carried out by mixing the finely waste sugarcane bagasse, cleaned coffee waste, and 250 ml of distilled water in an evaporation dish. The mixture is then heated in an oven at 250°C for 2 hours to produce the membrane. After heating, the produced membrane is cooled in a desiccator for 15 minutes. The cooled membrane is then used for the peat water clarification process. Peat water is passed through the membrane for filtration, and the filtrate is tested to measure parameters such as pH, turbidity, and TDS.

2.5. Analisys

To evaluate the effectiveness of the membrane, the experiment is conducted using three different material ratios. Each experiment is carried out by recording the filtration results and testing them according to the provided practical matrix. The data obtained from each experiment will be analyzed to determine the most effective material ratio for filtering peat water, with attention to changes in water quality parameters such as pH, turbidity, and TDS.

3. Result and Discussion

3.1. Result and Discussion

Table 1. Peat Water before Treatment

pH	4
TDS (ppm)	101
Turbidity	12,65
EC (µs/cm)	202
Temperature (ºC)	29,6
Color	Yellow
Odor	Pungent

The data describes the characteristics of peat water before treated using the membranes. The pH of 4 indicates the water is acidic, likely due to organic acids from the peat. The TDS concentration of 101 ppm suggests moderate levels of dissolved substances, which can affect the water quality and require treatment. With a turbidity of 12.65 NTU, the water is cloudy, indicating the presence of suspended particles that need to be removed. The EC value of 202 µS/cm shows moderate levels of dissolved ions, which can impact the filtration process. At 29.6°C, the water's temperature is warm, potentially influencing the efficiency of membrane filtration. The yellow color reflects the presence of dissolved organic compounds, such as tannins and humic acids. The pungent odor suggests the decomposition of organic matter, which should be addressed during purification.

Table 2. Filtration I (50:50) Ratio

Item	**Run 1**	**Run 2**
pH	7	7
TDS (ppm)	209	109
Turbidity	9,24	10,67
EC (µs/cm)	222	208
Temp. (ºC)	29,4	29
Color	Light Yellow	Light Yellow
Odor	Pungent	Less Pungent

The results obtained in this study regarding the filtration of peat water using various ratios of coffee waste and sugarcane bagasse show that the 50:50 ratio (Filtration I) yielded the most favorable results in terms of pH neutralization and turbidity reduction, although it still exhibited some limitations with TDS and EC. Filtration II (70:30 ratio) and Filtration III (90:10 ratio) were less effective, as they exhibited higher turbidity and increased TDS and EC, indicating that these filtration ratios were less efficient in removing suspended solids and dissolved ions. The color of the water remained light yellow, and the odor remained strong in most cases, which suggests that while the filtration process was able to reduce some suspended solids, it did not significantly address dissolved organic matter responsible for these characteristics.

In the 50:50 ratio of coffee waste to sugarcane bagasse (Filtration I), the pH of the water increased significantly from 4 to 7, indicating that this ratio is highly effective in neutralizing the acidity of the peat water. However, Total Dissolved Solids (TDS) experienced a sharp increase from 101 ppm to 209 ppm in Running 1, likely due to the release of organic compounds from the filtration medium. In Running 2, TDS decreased to 109 ppm, suggesting that the filtration medium began to stabilize after initial use. Turbidity decreased from 12.65 NTU to 9.24 NTU in Running 1, although it slightly increased in Running 2 to 10.67 NTU. These results demonstrate that the 50:50 ratio was effective at reducing turbidity but could not eliminate the dissolved solids completely. The increase in TDS may be attributed to the organic substances released during filtration, a phenomenon that is also noted in other studies involving natural adsorbents (Park et al., 2021; Tambaru, 2023).

Table 3. Filtration II (70:30) Ratio

Item	Run 1	Run 2
pH	6	6
TDS (ppm)	111	113
Tubidity	12,6	27,2
EC (µs/cm)	222	226
Temp (ºC)	29,4	29,6
Color	Light Yellow	Light Yellow
Odor	Pungent	Less Pungent

The 70:30 ratio (Filtration II) maintained a pH of 6, suggesting that this ratio was effective in stabilizing the acidity to a more neutral level compared to the initial peat water. The TDS in this ratio remained stable between 111-113 ppm, but turbidity increased significantly to 27.2 NTU in Running 2, indicating that the effectiveness of this filtration medium in reducing suspended particles was lower. The color of the water showed a shift to a golden yellow, and the odor was slightly reduced compared to the untreated water. This suggests that the 70:30 ratio performed better in some aspects but was less effective in turbidity reduction. The observed increase in turbidity with this ratio aligns with previous findings that suggested the ratio of organic material in a composite filtration medium impacts its efficiency (Zeng et al., 2019).

Table 4. Filtration III (90:10) Ratio

Item	Run 2	Run 2
pH	6	6
TDS (ppm)	112	116
Tubidity	24,96	22,38
EC (µs/cm)	226	232
Temp (ºC)	29,7	29,7
Color	Light Yellow	Light Yellow
Odor	Pungent	Less Pungent

In the 90:10 ratio (Filtration III), the pH remained at 6, similar to the 70:30 ratio. However, TDS increased slightly to 112–116 ppm, while turbidity decreased significantly to 22.38 NTU in Running 2. This decrease in turbidity suggests that a higher proportion of coffee waste in the filtration medium improved its ability to reduce suspended particles. The color of the water shifted to golden yellow, while the odor was slightly reduced but remained noticeable. These findings demonstrate that increasing the coffee waste proportion enhances the filtration medium's ability to reduce turbidity, as seen in previous studies that highlighted the effectiveness of coffee waste in adsorbing pollutants (Sulyman et al., 2020).

The findings of this study are consistent with prior research on the use of natural materials for water purification. Spent coffee waste (SCG) have been recognized for their high carbohydrate content and porous nature, contributing to their adsorption properties. SCG contains significant amounts of cellulose and other organic materials, making it an effective adsorbent for various contaminants (Park et al., 2021). Studies have shown that SCG can reduce turbidity and remove heavy metals from water, highlighting its dual functionality as both a filtration medium and an adsorbent (Tambaru, 2023; Nosek et al., 2020). The presence of lipids and other organic compounds in coffee waste further enhances their adsorption capacity, particularly for hydrophobic pollutants (Park et al., 2021). This supports the observation in our study that coffee waste effectively reduced turbidity, though their ability to address dissolved contaminants like TDS and EC was limited.

Similarly, sugarcane bagasse has been studied for its capacity to adsorb dyes and heavy metals from wastewater. The adsorption mechanism is primarily attributed to the physical and chemical interactions between pollutant molecules and the functional groups present in sugarcane bagasse, such as hydroxyl and carboxyl groups (Bhatnagar et al., 2015). This interaction facilitates the binding of contaminants to the surface of the sugarcane bagasse, enhancing its effectiveness as an adsorbent. Additionally, activation of the sugarcane bagasse through carbonization or chemical treatment increases its surface area and improves its adsorption capacity for various pollutants (Abbas et al., 2013). These findings are consistent with our study, which showed that while sugarcane bagasse helped reduce turbidity, it was less effective at reducing TDS and EC, particularly at higher pH levels.

Chavan and Patil (2016) investigated the use of agricultural residues, including sugarcane bagasse, as low-cost adsorbents for wastewater treatment. Their results indicated that sugarcane bagasse showed promise in removing particulate matter and some pollutants but was less effective at removing dissolved ions, especially under conditions such as high pH. This aligns with the results of our study, where the 50:50 ratio achieved better results than other ratios in terms of pH neutralization, but TDS and EC remained elevated, indicating the limitations of sugarcane bagasse and coffee waste in removing dissolved ions without further treatment or modification.

The results also align with studies on composite filtration media, where the performance varies with material composition. For example, Zeng et al. (2019) demonstrated that composite materials made from organic and inorganic waste can improve water filtration efficiency, but their effectiveness strongly depends on the ratio of components. Their study showed that the combination of organic materials with inorganic components performs better for removing suspended solids but may require a higher concentration of inorganic materials to improve the removal of dissolved solids. This reinforces our finding that the 50:50 ratio of coffee waste and sugarcane bagasse may be more effective for turbidity reduction but less efficient for addressing dissolved substances like TDS and EC.

The lack of significant changes in the color and odor of the filtered water highlights the need for additional treatments targeting dissolved organic materials, such as activated carbon or ion-exchange resins. Previous research has shown that while sugarcane bagasse can remove some organic compounds, its ability to reduce color and odor is limited by its structural properties and the nature of the contaminants (Elsakka, 2023). Similarly, coffee waste has been found to be less effective in addressing color and odor in wastewater treatment. Although coffee waste can adsorb certain pollutants, their capacity to reduce color and odor is limited, especially when compared to activated carbon, which is widely known for its superior adsorption capabilities (Kyzas, 2012).

4. Conclusion

This study has successfully demonstrated the potential of using sugarcane bagasse and coffee waste in membrane filtration for peat water purification. The results indicate that the 50:50 ratio of coffee waste and sugarcane bagasse provided the most effective results, significantly neutralizing the acidity of the peat water and reducing turbidity. However, while this ratio improved pH and turbidity, it showed limitations in removing dissolved solids, as reflected in the elevated Total Dissolved Solids (TDS) and Electrical Conductivity (EC) values. The 70:30 ratio and 90:10 ratio demonstrated less efficacy in reducing turbidity and exhibited higher TDS and EC levels, which highlights the inefficiency of these ratios in removing dissolved contaminants.

The findings of this study align with previous research that explored the effectiveness of natural materials, such as coffee waste and sugarcane bagasse, for water treatment. Coffee waste were found to effectively reduce turbidity and adsorb certain pollutants, though their capacity to remove dissolved solids was limited. Similarly, sugarcane bagasse, when used alone or in combination, was effective at removing suspended solids, but further treatment is needed to address dissolved ions and organic contaminants, such as color and odor.

While this study supports the use of agricultural waste for water purification, further optimization is required to improve the removal of dissolved contaminants. Potential strategies include the addition of activated carbon or ion-exchange resins to enhance the filtration process. Additionally, exploring other treatment technologies or combinations of materials could help address the limitations identified in this study, particularly with regard to the removal of color and odor in peat water.

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