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Potential of cellulose extracted from sweet corn stalks (*Zea mays saccharata* Sturt) as a microplastic filter membrane

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ABSTRACT

This study investigates the extraction and application of cellulose derived from sweet corn stalks (*Zea mays saccharata* Sturt) as a membrane material for the effective removal of microplastics from wastewater. The extraction process yielded a cellulose recovery of 43% from 100 grams of corn stalk powder, indicating the efficiency of the employed methodology and demonstrating the potential of corn stalks as a viable cellulose source. The extracted cellulose fibers exhibited desirable physical properties, including a rough and porous surface, which are conducive to trapping larger particles, while the pure cellulose displayed a smoother texture that facilitates the filtration of finer microplastics. The performance of the membranes constructed from both corn stalks cellulose and pure cellulose was evaluated through filtration experiments, revealing high efficiencies of 90% and 92.5%, respectively, in removing microplastics from contaminated water. The slight difference in efficiency suggests that the more uniform structure of pure cellulose may provide a more consistent filtration process. Scanning electron microscopy (SEM) analysis confirmed the structural integrity of the membranes, revealing an amorphous structure that is critical for effective filtration. Fourier transform infrared spectroscopy (FTIR) and energy dispersive spectroscopy (EDS) analyses indicated a higher purity of cellulose in the pure sample, with increased oxygen content correlating with the removal of lignin and hemicellulose. Furthermore, the corn stalks cellulose membrane demonstrated superior operational characteristics, including a higher average flow rate (55 mL/min) and better clogging resistance compared to pure cellulose. These findings highlight the potential of utilizing agricultural waste, such as corn stalks, in the development of sustainable membranes for microplastic pollution mitigation. The study underscores the importance of innovative approaches in environmental remediation and offers valuable insights into the use of renewable materials in wastewater treatment applications. Future research should focus on optimizing processing methods and evaluating long-term performance in real-world scenarios.

Keywords: corn stalks cellulose, membrane filtration, microplastic pollution.

INTRODUCTION

The production of synthetic fiber clothing, made from plastic polymers such as polypropylene, polyethylene, polyvinyl chloride, and polystirena, has increased significantly with global population growth and the rise of the fast fashion industry (Koszewska, 2018; Silva et al., 2018). As a result, there has been a substantial increase in both the frequency and volume of laundry activities, either through conventional hand washing or the use of washing machines. This leads to a significant release of microplastics into the environment, particularly into aquatic ecosystems such as oceans and rivers (Browne et al., 2011). Microplastics can originate not only from the direct breakdown of synthetic fibers during washing but also from the degradation of larger plastic waste, further polluting the environment (Andrady, 2011). Another sources of microplastics pollution can be found at drinking water and wastewater treatment plants (Sultan et al., 2023, Kamani et al., 2024)

Fast fashion's rapid growth has become a dominant contributor to the production and release of microplastics, with studies estimating that washing synthetic textiles accounts for approximately 35% of the primary microplastic pollution in oceans (Cobbing and Vicaire, 2016). Additionally, microplastics have been found in marine sediments, accelerating the degradation of polymer building blocks into CO_2, contributing to global warming (Royer et al., 2018). Microplastics thus pose a serious environmental threat, affecting air, soil, and water, as well as the organisms within these ecosystems (Prata et al., 2020), and also the sampling time has no significant different effect on the amount of the microplastics released to the environment (Petroody et al., 2021). This issue is exacerbated by the fact that no current wastewater treatment methods effectively filter out microplastics, due to their small size, often in the nano to micrometer range (Talvitie et al., 2017).

A study by the Norwegian Environment Agency estimates that laundry and household waste release between 100 to 600 tons of microplastics annually into Norway's waterways (Sundt et al., 2014). Similar studies show that synthetic textile fibers are one of the primary sources of microplastics released during laundry activities (Zubris and Richards, 2005). Addressing the increasing threat posed by microplastics requires innovative, cost-effective filtration methods, such as fiber membranes from cellulose (Zhao et al., 2022) and natural fiber composites (Chen & Wang, 2022; Li & Zhang, 2022) . One method is the use of cellulose-based membranes derived from agricultural waste, such as corn stalks (Kumar et al., 2023; Mohamad & Jai, 2022; Van, 2022). Corn stalks contain high levels of cellulose (up to 83.3%) and lignin, making them a suitable raw material for membranes capable of capturing microplastics from laundry wastewater (Mohapatra et al., 2010).

The exploration of sweet corn stalks as a natural cellulose source for the pollutant filtration membranes represents a promising intersection of agricultural sustainability and environmental protection. By leveraging agricultural waste, this approach not only addresses waste management issues but also contributes to the development of eco-friendly technologies aimed at mitigating water pollution. Further research and innovation in this field could pave the way for more sustainable practices in both agriculture and environmental engineering. The objective of this study is to explore and analyze the potential application of cellulose membranes derived from corn stalks in microplastic filtration. This research will also assess the advantages and benefits that this material offers in comparison to pure cellulose membranes. A key focus will be on how the physical structure of the membranes influences their filtration capacity in trapping microplastics.

MATERIALS AND METHODS

Preparation and extraction of cellulose from corn stalks

The samples consisted of corn stalks obtained from cornfields in Belumbang Village, Tabanan Regency, Bali Province, Indonesia. The samples were cleaned of dust, dirt, and adhering soil, followed by drying. The cleaned and dried samples were cut into pieces measuring 1–2 cm and then blended until a fine powder of corn stalk was obtained. Subsequently, a maceration process was conducted using 100 grams of the corn stalk powder, which was mixed with a solvent of 96% toluene and 98% alcohol in a 2:1 (v/v) ratio. The mixture was stirred and then subjected to maceration for three periods of 24 hours each. After this, the mixture was filtered and washed with distilled water until neutral. The resulting residue was dried using an oven.

The obtained residue was treated with 25% NaOH and heated at 70 °C for 2 hours. Following this, it was filtered and washed with distilled water until neutral, and the residue was again dried in an oven. The residue was then treated with 5% H_2O_2 at pH 12 and heated at 70 °C for 3 hours. This mixture was subsequently filtered and washed with distilled water until neutral. Finally, the residue was dried in an oven, yielding cellulose as the final product extracted from the corn stalks.

Fabrication of membranes utilizing cellulose yield reinforced with polyethylene glycol (PEG)

The cellulose extracted cut into the sheets of size 15 × 10 cm can be utilized and weigh the cellulose accurately. In a beaker, dissolve PEG in distilled water, the concentration should 15% w/v.

Heat the solution gently on a hot plate or in a water bath (not exceeding 60 °C) while stirring continuously until the PEG is completely dissolved. Submerge the cut pieces of cellulose in the PEG solution, ensuring complete saturation. Allow the cellulose to soak for a period of 1–2 hours to ensure thorough impregnation. Remove the saturated cellulose from the PEG solution and gently squeeze to eliminate excess liquid. Place the saturated cellulose sheets into molds specifically designed to achieve a thickness of 0.2 cm. Ensure that the molds are clean and free from contaminants that could affect the final product. Dry the composite for 4–6 hours, or until a constant weight and solidify the structure are achieved. After Cooling remove the membrane from the molds, ensuring that the structure remains intact. The membranes were characterized using FTIR analysis to determine the functional groups present. Scanning electron microscopy (SEM) was employed to assess the topology and morphology of the cellulose. Energy dispersive spectroscopy (EDS) analysis was conducted to map the distribution of elements in the obtained cellulose.

The membrane was utilized to filter out microplastics, specifically polyethylene (PE) and polyester, as well as laundry waste. Water samples were preparing by adding known concentrations of microplastics (e.g., 1-5 microns in size) into deionized water. The mixture was homogenized to ensure even distribution of microplastics. Filtration system was setup, where each type of membrane (corn stalks cellulose and pure cellulose) was placed in a membrane holder. The microplastic-contaminated water was poured through the membranes under controlled pressure and flow rate. The filtrate (filtered water) and the retained microplastic particles were collected. The quantity of microplastics in the water before and after filtration were measured using particle counters, microscopy, or spectrophotometry methods, and the concentration of microplastics in the filtered water was compared to determine the filtration efficiency of each membrane. Multiple trials for each type of membrane were conducted to ensure reliability and consistency.

The percentage of microplastics retained by each membrane was calculated to determine the efficiency of filtration (Talvitie et al., 2017), and the structural integrity of each membrane after multiple filtration cycles was tested. Membrane permeability was determine by measured the rate of water flow through each membrane to assess permeability and clogging tendency. The filtration efficiency and permeability of cellulose from corn stalks were compared with pure cellulose membrane.

RESULTS AND DISCUSSION

Cellulosa yield from corn staks extraction

The extraction process of cellulose from 100 grams of corn stalk powder yielding a 43% cellulose recovery is noteworthy. This high yield indicates the efficiency of the extraction method employed and highlights the potential of corn stalks as a viable source of cellulose. The resulting fine white fibers not only possess desirable physical properties but also demonstrate significant potential for application in membrane technology. The cellulose extracted from corn stalks shown in Figure 1.

To provide a detailed analysis of the FTIR graphs of cellulose yield, and pure cellulose, the following key differences and similarities would typically be showed in Figure 2. A broad peak around 3300–3500 cm^{-1} would be indicative of the hydroxyl group, which is common in all forms of cellulose and other plant materials. Peaks representing cellulose, such as the β-glycosidic linkages (around 897 cm^{-1}), would become more prominent in this spectrum. The stretching of the -OH group and the C-H bonds would still be visible, but the spectrum would reflect more purified cellulose compared to the raw material. Peaks around 1000–1100 cm^{-1} indicate the C-O-C stretching vibrations of the pyranose ring in cellulose.

The peaks associated with lignin and hemicellulose (1510 cm^{-1}, 1600 cm^{-1}, and 1730 cm^{-1}) would be nearly absent, indicating their complete

Figure 1. Cellulose yield from delignification, bleaching, and hydrolysis process of corn stalks

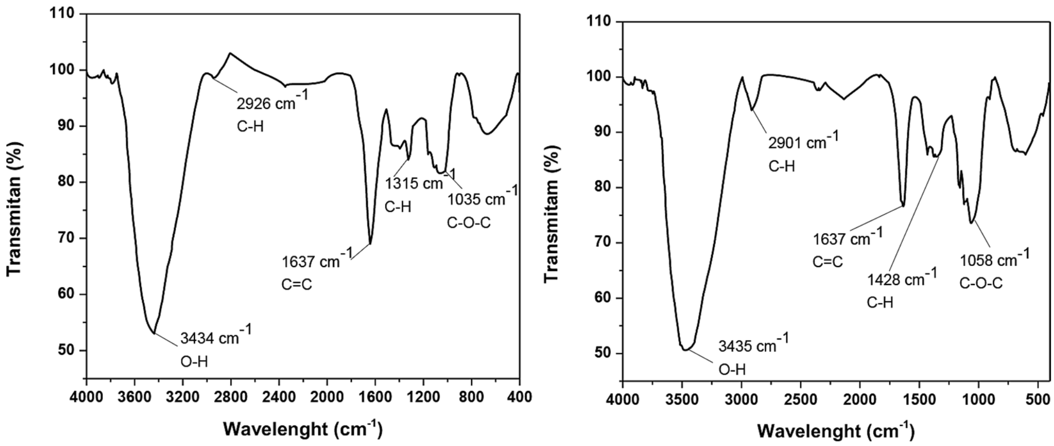

Figure 2. The comparison of FTIR spectra of (a) corn stalks cellulose (b) pure cellulose

removal. The FTIR spectrum would predominantly show signals from the cellulose itself. A more defined broad peak around 3300–3500 cm^{-1}, indicative of the -OH groups, would be stronger and clearer due to the pure cellulose structure. This reflects the abundance of hydroxyl groups in the cellulose chains. Peaks in the range of 1000–1100 cm^{-1} would dominate, showcasing the C-O-C bonds and β-glycosidic linkages typical of the cellulose structure. This region would be more intense and well-defined compared to the cellulose yield sample.

The extraction of cellulose from corn stalks presents an opportunity to utilize these materials sustainably while contributing to environmental remediation efforts. The properties of cellulose derived from corn stalks are influenced by the source material, extraction methods, and subsequent processing. This detailed examination focuses on the key properties of cellulose extracted from agricultural waste, highlighting its physical, chemical, and mechanical characteristics (Browne et al., 2011).

The physical, chemical, and mechanical characteristics of this cellulose are influenced by the source material and extraction processes, highlighting the importance of optimizing these factors to enhance performance. As the demand for sustainable materials continues to rise, the utilization of cellulose from agricultural waste presents a promising avenue for addressing environmental challenges while promoting resource efficiency. Future research should focus on further refining extraction methods, enhancing the properties of cellulose, and exploring novel applications that leverage its unique characteristics. (Talvitie et al., 2017).

Manufacture of cellulose-based membranes

Membranes are engineered systems designed to remove microplastics from wastewater through biological processes. The use of cellulose, a natural polymer, as a substrate for membranes offers several advantages, including biodegradability, abundance, and favorable adsorption properties. The reinforcement of cellulose with PEG, a hydrophilic polymer, aims to enhance the structural integrity and functional capabilities of the membrane, thereby improving its overall performance.

Figure 3 show the membranes reinforced with PEG can be precisely engineered to specific thicknesses, such as 0.2 cm, allowing for tailored applications depending on the intended use and required filtration capacity. The incorporation of PEG affects the density of the membrane. Typically, the density increases due to the additional mass of PEG, which contributes to the overall weight of the composite material. This density variation can influence the flow dynamics of the medium during filtration. The addition of PEG significantly enhances the tensile strength of the cellulose matrix. This improvement is attributed to the plasticizing effect of PEG, which increases the flexibility and resistance of the membrane to mechanical stress. The flexural modulus is also positively impacted by PEG reinforcement, resulting in a material that can withstand bending forces without permanent deformation. This characteristic is crucial for maintaining the structural integrity of the membrane during operation. PEG modifies the pore structure, potentially leading to an optimal balance between porosity and mechanical stability. High porosity facilitates greater surface area for microbial colonization and pollutant adsorption. The permeability of the membrane is

Figure 3. Membrane of cellulose corn stalks

critical for fluid flow through the material. PEG reinforcement can enhance permeability by maintaining pore structure while providing strength to the matrix. This characteristic is vital for ensuring adequate flow rates during filtration.

The primary components of the membrane are cellulose and PEG. The cellulose provides a natural substrate for microbial growth, while PEG serves as a plasticizer and stabilizer. The chemical interactions between cellulose and PEG can lead to improved compatibility and functionality. PEG is a hydrophilic polymer, which enhances the water retention capacity of the membrane. This property is beneficial for maintaining moisture levels necessary for microbial activity, thus promoting effective biodegradation of contaminants. Both cellulose and PEG are biodegradable materials, making the membrane environmentally friendly. The biodegradability of the membrane is an important characteristic, as it aligns with sustainable practices in environmental remediation.

Corn stalks cellulosa membrane characteristics

The characteristics of corn stalks cellulose membranes are compared with pure cellulose membranes using the same manufacturing method that reinforced with PEG. The structural integrity of both membrane material as evidenced by SEM analysis, reveals an amorphous structure that is relatively consistent with the morphology and topology of cellulose yield and pure cellulose. This finding underscores the importance of maintaining the physical and structural properties of cellulose during processing, which is essential for its functionality in filtration applications (Hubbe et al., 2008).

The surface structure of corn stalks cellulose membrane (Figure 4a) is characterized by rough and porous textures, with an uneven distribution fibers. The presence of lignin and other non-cellulose components gives the material its coarse

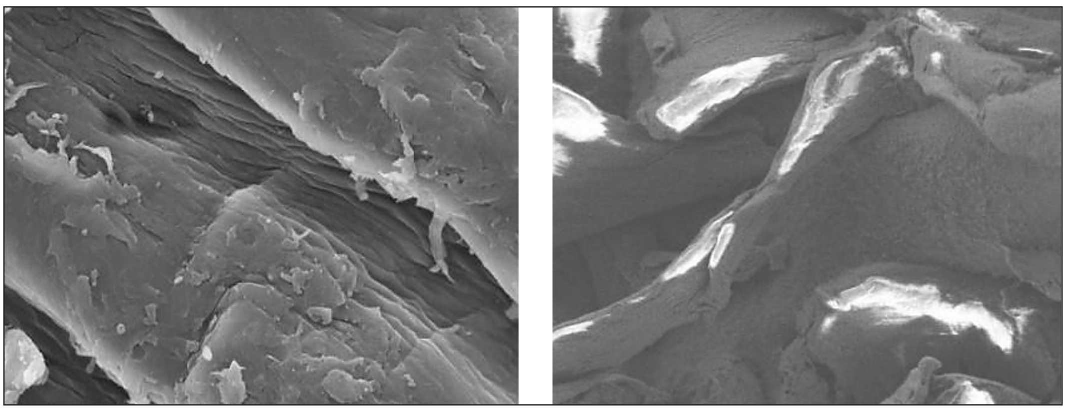

Figure 4. SEM images of (a) corn stalks cellulose membrane (b) pure cellulose membrane

appearance. This porous structure is beneficial for filtration, as it allows for the physical trapping of larger particles, such as microplastics. The cellulose extracted from corn stalks has defined fibrous structure, removing lignin and other impurities during the isolation process results in a cleaner surface with clearer fiber alignment. However, some residual non-cellulosic materials may still be present, as indicated by the rough surface areas in the SEM image. This structure enhances the material's ability to adsorb smaller particles, making it more efficient for filtering fine microplastics (membrane cellulose) .

The pure cellulose membrane (Figure 4b) shows a highly organized, smooth fiber structure, with minimal presence of non-cellulosic substances. The fibers are tightly packed, and the surface is cleaner and more homogeneous compared to the cellulose yield. This uniformity is critical for efficient filtration, as it allows for the adsorption of very fine particles, such as microplastics at the nano-scale. Pure cellulose, due to its organized structure and high surface area, is typically more effective in capturing contaminants compared to less refined materials (membrane cellulose) .

The cellulose yield membrane represents an intermediate stage, where much of the lignin has been removed, and the fibers are more aligned. This material is more effective in filtering smaller particles. Pure cellulose, with its smooth and organized fibers, provides the most efficient filtration due to its high adsorption capacity and surface area. These structural differences directly influence the membrane performance in removing microplastics from wastewater. Pure cellulose offers superior filtration for small particles, whereas cellulose yield can be more effective in capturing larger particles due to its rough texture.

The EDS analysis provides insight into the elemental composition of corn stalks cellulose and pure cellulose, as shown in Figure 5. The graph highlights the relative percentages of key elements, particularly carbon and oxygen, across the three samples.

The presence of various organic compounds, including lignin, hemicellulose, and cellulose. Lignin is particularly rich in carbon, contributing to this percentage. Oxygen is also present in substantial amounts, associated with functional groups such as hydroxyl (-OH) and carbonyl (C=O) in cellulose, hemicellulose, and lignin. Trace elements such as magnesium, calcium and cuprum from the plant material may also be present but in minor amounts, potentially undetectable in significant proportions by the EDS analysis shown here. Cellulose yield contain carbon 44.5% and oxygen 52.5% content. Pure cellulose have carbon 37.5% and oxygen 62. This indicates that most non-cellulosic components, particularly lignin and hemicellulose, have been removed, leaving behind highly oxygenated cellulose chains. The high oxygen content is associated with the hydroxyl (-OH) groups present in the cellulose polymer, which are more prevalent in the absence of other plant constituents. The increased oxygen percentage in pure cellulose indicates that the

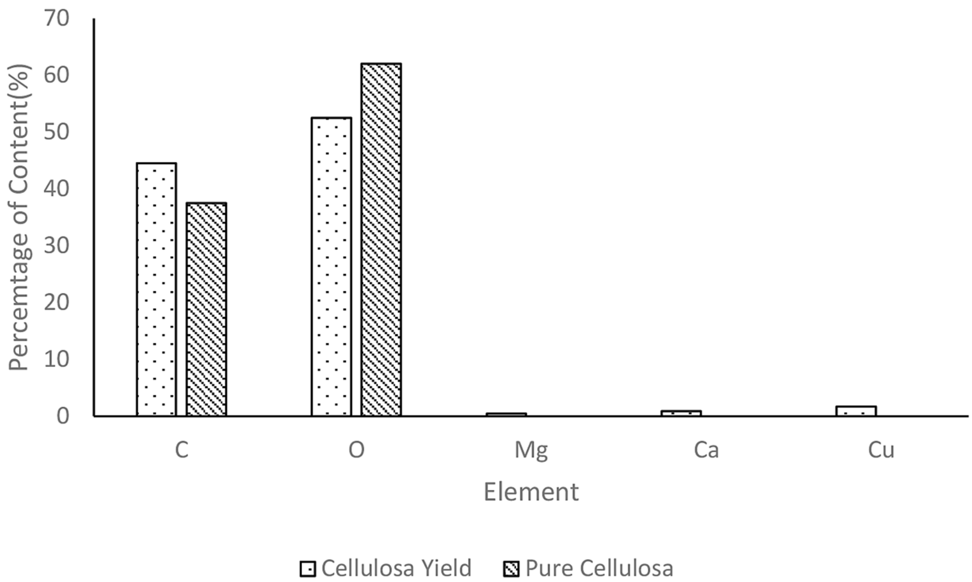

Figure 5. The concentration of elements in corn stalks cellulose and pure cellulose by EDS analysis

contains more hydroxyl groups due to the higher purity of cellulose compared to the yield material. The reduction in carbon is a result of the cellulose purification process, where the complex, carbon-rich components of lignin and hemicellulose are eliminated, leading to the dominance of oxygenated cellulose. This trend is expected, as pure cellulose has a higher oxygen concentration due to the abundant hydroxyl groups in its structure, which bond with oxygen atoms. The removal of non-cellulosic materials results in an increase in oxygen concentration. This change is critical for applications where high-purity cellulose is required, such as in membranes or other materials where the chemical properties of cellulose, particularly its oxygen-rich groups, are leveraged for adsorption and filtration.

The EDS analysis confirms the increasing purity of cellulose as reflected by the rising oxygen content and declining carbon content from yield cellulose to pure cellulose. This trend directly correlates with the removal of lignin and hemicellulose during the extraction and purification processes, leaving behind a more oxygenated and chemically homogeneous material. This increase in oxygen content in pure cellulose enhances its utility for biofiltration applications, where its chemical properties, such as hydrophilicity, play a crucial role.

The peformances of corns stalks membrane

The cellulose yield from corn stalks was approximately 25% of the initial mass. The resulting cellulose was successfully processed into membrane sheets with a thickness of 0.2 mm, consistent with the pure cellulose membranes used for comparison. Commercial pure cellulose membrane were readily available and maintained a similar thickness of 0.2 mm for uniformity in the experiment. The concentration of microplastics in the contaminated water before filtration was 100,000 particles per liter (polystyrene, 1–5 microns). The result efficiency of microplastic calculation after filtration using corn stalks cellulose membrane and pure cellulose membrane can be seen in Table 1.

Both membrane types demonstrate high filtration efficiencies, with pure cellulose slightly outperforming cellulose from corn stalks. The pure cellulose membrane shows a filtration efficiency of 92.5%, while the corn stalks cellulose membrane achieves 90% efficiency. These results are consistent with previous studies on cellulose-based filtration systems for microplastics (Ma et al., 2019). The high efficiency of both membranes in removing microplastics from water (90% and above) indicates their potential as effective solutions for addressing microplastic pollution. This level of performance is particularly significant given the growing concern over microplastic contamination in aquatic environments (Prata et al., 2020). The slight difference in filtration efficiency (2.5%) between the two membranes could be attributed to various factors. Pure cellulose may have a more uniform and controlled structure, potentially allowing for more consistent filtration (Karim et al., 2016). In contrast, corn stalks cellulose membrane might have a more varied structure due to the presence of other plant components, which could affect its filtration properties (Mohapatra et al., 2010). The pore size and distribution in pure cellulose membranes might be more optimized for capturing microplastics in the size range tested (Hubbe et al., 2009). The surface chemistry of pure cellulose could be more favorable for attracting and retaining microplastic particles (Talvitie et al., 2017). However, it's important to note that the corn stalks cellulose despite its slightly lower efficiency, still demonstrates excellent filtration capabilities.

The use of corn stalks cellulose membrane presents several advantages such as sustainability, utilizing agricultural waste products like corn stalks aligns with circular economy principles and offers an eco-friendly alternative to synthetic materials (Koszewska, 2018). Cost-effectiveness, corn stalks cellulose membrane can be sourced from agricultural waste, potentially reducing production costs compared to pure cellulose (Pelissari et al., 2014). Additional benefits, corn stalks cellulose membrane may offer other advantages not captured in this data, such

Table 1. Microplastic filtration efficiency

Membrane type	Initial concentration (particles/L)	Final concentration (particles/L)	Filtration efficiency (%)
Corn stalks cellulose	100,000	10,000	90
Pure cellulose	100,000	7,500	92.5

as improved durability or resistance to clogging, which could be beneficial in long-term applications (Zhao et al., 2022).

The corn stalks cellulose membrane demonstrates a higher average flow rate (55 mL/min) compared to pure cellulose (50 mL/min). This 10% increase in flow rate is significant in filtration applications, as it can lead to higher throughput and potentially more efficient water treatment processes (Hubbe et al., 2009). The superior flow rate of corn stalks cellulose could be attributed to its unique structural properties. Corn stalks fibers often have a more porous and less compact structure compared to pure cellulose, which might facilitate faster water passage (Mohapatra et al., 2010). This aligns with findings from Pelissari et al. (2014), who noted the distinctive fibrous structure of banana-derived cellulose. The average water flow rate for each membrane was measured to determine permeability and potential clogging after 3 cycles, as shown in Table 2.

After three filtration cycles, the corn stalks cellulose membrane shows only minor clogging, while pure cellulose membrane exhibits moderate clogging. This improved clogging resistance is a crucial factor in maintaining long-term filtration efficiency and reducing maintenance requirements (Zhao et al., 2022). The enhanced clogging resistance of corn stalks cellulose could be due to several factors are fiber structure. The natural fiber structure of corn stalks cellulose might create more tortuous paths for water flow, reducing the likelihood of particles becoming trapped and causing clogs (Mohapatra et al., 2010). Corn stalks cellulose may have surface characteristics that minimize particle adhesion, thus reducing clogging (Karim et al., 2016). Some studies have suggested that banana plant extracts possess antimicrobial properties, which could help prevent biofilm formation and associated clogging (Padam et al., 2014).

The combination of higher flow rate and better clogging resistance makes corn stalks cellulose membrane an attractive option for microplastic filtration. These properties can translate to several practical advantages such as increasing efficiency. Higher flow rates allow for more water to be treated in a given time period, potentially reducing energy costs and increasing overall system efficiency (Ma et al., 2019). Better resistance to clogging suggests that membranes made from corn stalks cellulose might maintain their performance for longer periods, reducing the frequency of filter replacements (Talvitie et al., 2017). Less clogging typically means less frequent backwashing or cleaning of the filtration system, leading to lower maintenance costs and reduced downtime (Zhao et al., 2022). Utilizing agricultural waste like corn stalks for filtration aligns with circular economy principles, offering an eco-friendly alternative to synthetic materials while potentially reducing waste (Koszewska, 2018). Membrane durability after conducting 10 filtration cycles, the integrity of the corn stalks cellulose membrane can retain structural integrity with no significant breakdown. Pure cellulose membrane showed slight wear and minor degradation at the edges.

The pure cellulose membrane shows a slightly higher filtration efficiency (92.5%) compared to the cellulose from corn stalks (90%). This small difference suggests that both materials are highly effective in removing microplastics from water. The high efficiency of cellulose-based filters aligns with findings from Ma et al. (2019), who reported significant microplastic removal using cellulose-based materials. The corn stalks cellulose membrane exhibits a faster water flow rate compared to pure cellulose membrane. This characteristic is advantageous in practical applications, as it allows for more rapid water treatment. The difference in flow rates may be attributed to the unique structural properties of corn stalks cellulose, which could create more favorable pathways for water passage (Mohapatra et al., 2010). Data in Table 3 showed the comparison properties of corn stalks cellulose and pure cellulose membranes.

The corn stalks cellulose membrane demonstrates high clogging resistance, outperforming pure cellulose in this aspect. This property is crucial for long-term filtration efficiency and reduced maintenance requirements. The superior clogging resistance of corn stalks cellulose might be due to its fibrous structure and potential antimicrobial

Table 2. The average flow rate and permeability and potential clogging from both of membranes

Membrane type	Average flow rate (mL/min)	Observed clogging after 3 cycles
Corn stalks cellulose	55	Minor
Pure cellulose	50	Moderate

Table 3. Evaluation criteria of corn stalks cellulose and pure cellulose membranes

Evaluation criteria	Cellulose yield membrane	Pure cellulose membrane
Filtration efficiency	90%	92.5%
Water flow rate	Faster	Slower
Clogging resistance	High	Moderate
Durability	High	Moderate

properties, as suggested by Pelissari et al. (2014). Cellulose from corn stalks shows high durability compared to the moderate durability of pure cellulose. This enhanced durability could be attributed to the natural fiber structure and potential presence of other components like lignin in corn stalks cellulose (Mohapatra et al., 2010). Higher durability translates to longer filter life and improved cost-effectiveness in real-world applications.

Overall, the corn stalks cellulose membrane performs comparably or better than pure cellulose in most criteria, except for a slight difference in filtration efficiency. The corn stalks cellulose membrane advantages in water flow rate, clogging resistance, and durability make it a promising material for microplastic filtration. These results highlight the potential of agricultural waste products, such as corn stalks, in developing sustainable and effective filtration solutions for microplastic pollution. The use of such materials aligns with circular economy principles and could provide an eco-friendly alternative to conventional filtration methods (Koszewska, 2018). Furthermore, the high performance of corn stalks cellulose membrane in this application supports the growing body of research on utilizing agricultural by-products for environmental remediation (Varghese et al., 2019). This approach not only addresses the issue of microplastic pollution but also provides a value-added use for agricultural waste, potentially benefiting both environmental and economic sustainability.

CONCLUSIONS

The extraction and utilization of cellulose from sweet corn stalks present a promising avenue for sustainable material development, particularly in the context of environmental remediation and microplastic filtration. The study successfully achieved a cellulose recovery rate of 43% from 100 grams of corn stalk powder, indicating the effectiveness of the extraction methods employed. The resulting cellulose fibers, characterized by their desirable physical properties and high purity, demonstrate significant potential for application in advanced membrane technology.

The Fourier Transform Infrared Spectroscopy (FTIR) analysis revealed critical differences between the cellulose extracted from corn stalks and pure cellulose, particularly in the spectral peaks associated with functional groups. The pronounced absence of peaks corresponding to lignin and hemicellulose in the FTIR spectrum of the extracted cellulose underscores the efficacy of the extraction process, resulting in a material rich in hydroxyl groups. This high oxygen content enhances the cellulose's chemical properties, making it suitable for biofiltration applications.

The membranes manufactured from corn stalks cellulose exhibited impressive filtration efficiencies, achieving 90% in microplastic removal, closely approaching the 92.5% efficiency of pure cellulose membranes. This performance is particularly relevant given the increasing concern over microplastic contamination in aquatic environments. The slight difference in filtration efficiency between the two membrane types may be attributed to variations in structural uniformity and pore distribution, with pure cellulose membranes likely offering more optimized filtration pathways.

The elemental composition analysis via energy dispersive spectroscopy (EDS) confirmed the increasing purity of cellulose through the extraction process, with a notable reduction in carbon content and an increase in oxygen content. This shift is indicative of the removal of non-cellulosic components, thereby enhancing the cellulose's utility for applications requiring high purity, such as membrane technologies

The corn stalks cellulose membranes demonstrated superior flow rates and clogging resistance compared to their pure cellulose counterparts. The average flow rate of 55 mL/min for the corn stalks cellulose membrane, coupled with only minor clogging observed after three filtration cycles, highlights its practical advantages in filtration applications. These characteristics not only enhance the efficiency of water treatment processes but also suggest a lower maintenance burden, thus aligning with the principles of sustainable engineering.

The findings of this study underscore the viability of corn stalks as a sustainable source of cellulose for membrane production. The high performance of the corn stalks cellulose membranes in microplastic filtration not only addresses the pressing issue of environmental pollution but also exemplifies the potential for agricultural waste to be repurposed into valuable materials. Future research should focus on optimizing extraction methods further, exploring additional applications for cellulose derived from agricultural waste, and investigating the long-term performance and durability of these membranes in real-world filtration scenarios.

The integration of agricultural by-products like corn stalks into the development of filtration technologies aligns with circular economy principles, promoting resource efficiency and environmental sustainability. This approach not only mitigates the impact of microplastic pollution but also contributes to the broader goals of sustainable development and environmental stewardship.

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