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Turbidity Removal from Sullage Wastewater Using *Musa paradisiaca* Peels as a Natural Coagulant

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The use of inorganic commercial coagulants for water and wastewater clarification has been linked to the prevalence of human health and environmental issues. Natural coagulants are currently being explored as an alternative option for replacing synthetic coagulants. This present study, examines the use of *Musa paradisiaca* peels as a natural based coagulant for turbidity reduction in sullage wastewater. *Musa paradisiaca* peels, alum and blended were used in the study as coagulants for sullage wastewater clarification. The blended coagulant was prepared by combining the Alum and *Musa paradisiaca* peel powder in a ratio of 1:1. The sullage wastewater used in the study had an initial concentration of 151.8 NTU and was sourced within the University premises.

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The batch experimental procedure to examine the effectiveness of the natural coagulant was used. The study results show that the highest turbidity removal was for alum, blended, and coagulant, from 151.8 to 1.1 NTU, 151.8 to 14.43 NTU, and 151.8 to 29.32 NTU respectively. The maximum results for the effect of contact time on the rate of turbidity removal were attained at 6 h for all coagulants. The effect of natural coagulant performance on pH medium has indicated that it favours the acidic solution. The results obtained in this study recommend the efficiency and value of *Musa paradisiaca* peels as coagulant. The use of *Musa paradisiaca* peels as a natural coagulant offers a sustainable and cost-effective solution for the treatment of sullage wastewater. The use of *Musa paradisiaca* as a natural coagulant provides an alternative solution for replacing synthetic coagulants and overcomes health challenges associated with its usage, offers water treatment at low cost and reduces environmental issues associated with agri-food waste disposal, thereby promoting sustainable waste management.

Keywords: Sullage; wastewater; turbidity; natural coagulant; clarification.

1. INTRODUCTION

Water pollution is a major environmental concern that poses a threat to human health and ecosystems worldwide. One of the common sources of water pollution is sullage wastewater, which is generated from household activities such as; washing dishes, clothes, and bathing [1]. Sullage wastewater contains a high level of organic matter, suspended solids, and pathogens, making it unsuitable for direct discharge into water bodies without proper treatment. Conventional wastewater treatment methods such as, coagulation, flocculation, sedimentation, and filtration are commonly used to remove impurities from wastewater [2]. However, these methods are often expensive, energy-intensive, and require the use of commercial synthetic chemicals that can have adverse effects on the environment and human health [3].

In recent years, there has been a growing interest in the use of natural coagulants sourced from plant sources as an environmentally friendly and sustainable alternative to synthetic chemicals for water treatment [1]. The utilization of plant-based coagulants as natural coagulants for turbidity removal presents several advantages. The agro-wastes are abundant agricultural by-products that create disposal challenges; their usage makes them a cost-effective and sustainable alternative to conventional chemical coagulants [4,5]. This supports the principles of the circular economy by contributing to waste reduction and reducing the dependence on inorganic coagulant chemicals, promoting environmentally friendly practices in water treatment [6].

The natural coagulants have been extensively studied for their success in wastewater clarification and turbidity removal. Several studies have explored the use of locally available materials as natural coagulants, such as *Moringa oleifera*, okra, legumes and vegetables, papaya seeds, and *Cassia fistula* [7–12]. These studies have established that turbidity removal efficiencies range from 60% to as high as 97.33% using natural coagulants after performing optimization studies on doses and other conditions [13,14].

The treatment of wastewater to remove turbidity is a critical aspect of environmental protection and public health. One promising method is the use of natural coagulants derived from plant sources, such as *Musa paradisiaca* peels. *Musa paradisiaca* peels, the byproduct of banana consumption, have demonstrated a high content of polyphenols and other organic compounds. This manuscript reports the outcome of investigations on the use of *Musa paradisiaca* peels as a natural coagulant for turbidity removal in sullage wastewater. This research seeks to provide a sustainable and low-cost solution for the treatment of sullage wastewater, decreasing the environmental pollution associated with the disposal of agri-food wastes, providing a solution to wastewater treatment at a low cost, and promoting the use of eco-friendly alternatives in wastewater treatment. The findings attained in this study may be useful to the development of innovative and sustainable technologies for water treatment and safeguarding the environment.

2. MATERIALS AND METHODS

This research study was done on a laboratory scale. The research variables involved in this study were the effect of the coagulant dosage using jar test method.

2.1 Wastewater Sample Collection

The sullage wastewater sample used in this study was originally collected around Khondowe, Livingstonia Rumphi district, Malawi, from the Little Dove Cafeteria before its disposal. The physicochemical parameters examined in the study were pH and turbidity using portable meters. The sullage wastewater sample was collected in 2.5 sterilized polyethene bottles and taken in the laboratory for analysis. The samples were transferred into a 20 L clean plastic bucket for homogenization. The analysis was done within 24 h after sampling.

2.2 Preparation of Ashes from the *Musa Paradisiaca* Peels

The fresh banana peels used in the study were sourced from the Livingstonia Market as domestic waste. The *Musa paradisiaca* peels were washed thoroughly with tap water several times, followed by deionized water to get rid of the surface impurities. The peels were then subjected to the sun for 14 days to remove the moisture during the drying process. Finally, the *Musa paradisiaca* peels were crushed using the mortar and pestle and then sieved with a mesh size of 250 µm and kept in a tightly closed bottle.

2.3 Equipment and Chemicals

The following materials and chemicals were used in the study: 1 L of beakers and 500 mL of sullage wastewater, deionized water, *Musa paradisiaca* peel powder, aluminum sulfate (alum), a stopwatch, mass balances, stirring rods, and portable meters.

2.4 Experimental Procedure

Different masses of the coagulant doses of the *Musa paradisiaca* peels were measured using an electronic balance and used in the study. The study assessed the potential of *Musa paradisiaca* peel powder as a blended coagulant at the ratio of 1:1; thus, *Musa paradisiaca peel* powder with aluminum sulfate and aluminum sulfate were used as plant based coagulants for turbidity removal from sullage wastewater at room temperature (25 °C). The raw domestic wastewater samples were thoroughly mixed in a cleaned and sterilized 20 L bucket and homogenized. Eighteen labelled beakers (500 mL) and a set of six beakers for banana powder, blend, and aluminum sulfate, respectively, were used. 400 mL was sampled from 20 L of homogenized sullage wastewater and introduced to the labelled beakers. The beakers were then dosed with different quantities of coagulants. The beakers containing the raw wastewater were agitated for 10 minutes. The agitation process is crucial as it allows a thorough mixing of the coagulants with sullage wastewater, resulting in the formation of flocs. The treated wastewaters were allowed to settle for 1 to 6 h to allow coagulation, flocculation, and sedimentation to complete. The supernatants were then collected from the treated wastewater for turbidity analysis. Aluminum sulfate (alum) was used as a positive control in wastewater clarification.

2.5 Effect of Solution pH on the and Settling Time on Turbidity Reduction

The effect of settling time on the removal of turbidity was studied for the coagulant, banana peels, blend, and alum. 500 mL of wastewater was used while keeping all other parameters constant. The optimum dosage of the coagulant was adopted. The samples were agitated at first and then allowed to settle for 6 h. Then, 10 mL of treated wastewater was drawn from each beaker at an interval of 1 h to determine the level of turbidity. The pH adjustments of wastewater were carried out dropwise with either 0.1 M HCl or 0.1 M NaOH until the desired pH was achieved. The study focused on a pH range of 2 to 12 with 500 mL of wastewater, and the optimum dose established earlier for the coagulant was used. The beakers were mounted on the shaker and agitated for 30 minutes. After the designated time elapsed, they were withdrawn and allowed to settle for 6 h.

3. RESULTS AND DISCUSSION

Turbidity removal from wastewater is affected by a lot of parameters, which include the dosage of coagulants, contact time, and pH of the solution. An inadequate dose or overdose affects the flocculation process. While the pH parameter affects the performance of coagulation. Studies by other investigators recommend considering the pH ranges in order to better understand the optimum values for the reduction of turbidity and bacteria removal in both water and wastewater during the treatment. Therefore, this study reports the outcome of an investigation that assessed the effect of coagulant dosage, contact time, and pH of the aqueous solution in sullage wastewater clarification using banana peels as a natural coagulant for turbidity removal.

3.1 The Effect of Coagulant Dosage on Turbidity Reduction

The effect of coagulant dosage on turbidity reduction was carried out with dosages ranging from 0.1 to 0.5 g, and the results are presented in Fig. 1. The sullage wastewater used had an initial concentration of 151.8 NTU. The results obtained in the study showed the highest turbidity removal for aluminum sulfate, blended, and *Musa paradisiaca* peel powder, respectively. The aluminum sulfate reduced turbidity from 151.8 NTU to 1.1 NTU with 0.3 g per 500 mL of dosage, representing 99 percent turbidity removal. The blended coagulant dose of 0.3 g per 500 mL reduced turbidity from 151.8 NTU to 14.43, representing 91 percent removal. The *Musa paradisiaca* coagulant dosage of 0.4 g per 500 mL attained the maximum turbidity reduction from 151.8 NTU to 29.32 NTU, representing an 81 percent turbidity reduction. The study observed that the higher adsorbent dosage of *Musa paradisiaca* coagulant did reduce the level of turbidity in clarified wastewater, but instead the turbidity increased. This observation could be due to the fact that a higher dosage caused the flocs to crumble, thereby increasing the level of turbidity in clarified sullage wastewater [6]. These results attained in the present study are similar to those reported by other investigators who also explored the use of natural coagulants for wastewater [15–17].

3.2 Effect of Contact Time on Turbidity Removal

The effect of contact time was evaluated for a 6 h contact time for all the coagulants, with dosages of 0.3 g per 500 mL for aluminum and blended and 0.4 g per 500 mL for *Musa paradisiaca* coagulant wastewater with a turbidity of 151.8 NTU. The results attained in Fig. 2 indicate that as contact time was prolonged, the rate of turbidity removal increased for all the coagulants. The highest turbidity removal was produced by the positive control, which decreased turbidity from 151.8 to 0.8 NTU, This observation was achieved after 6 h of contact time. The blended coagulant and *Musa paradisiaca* coagulant decreased the turbidity, reducing it from 151.8 to 15.38 NTU and 151.8 to 27.32 NTU, respectively. These results were witnessed after 6 h of contact time. The rate of turbidity removal increased for the first hours; however, as the contact time was prolonged, the rate of removal decreased. This could be associated with the saturation of active sites, thereby slowing the rate of removal. These results are similar to those reported by several researchers elsewhere who worked on similar investigations [18–20].

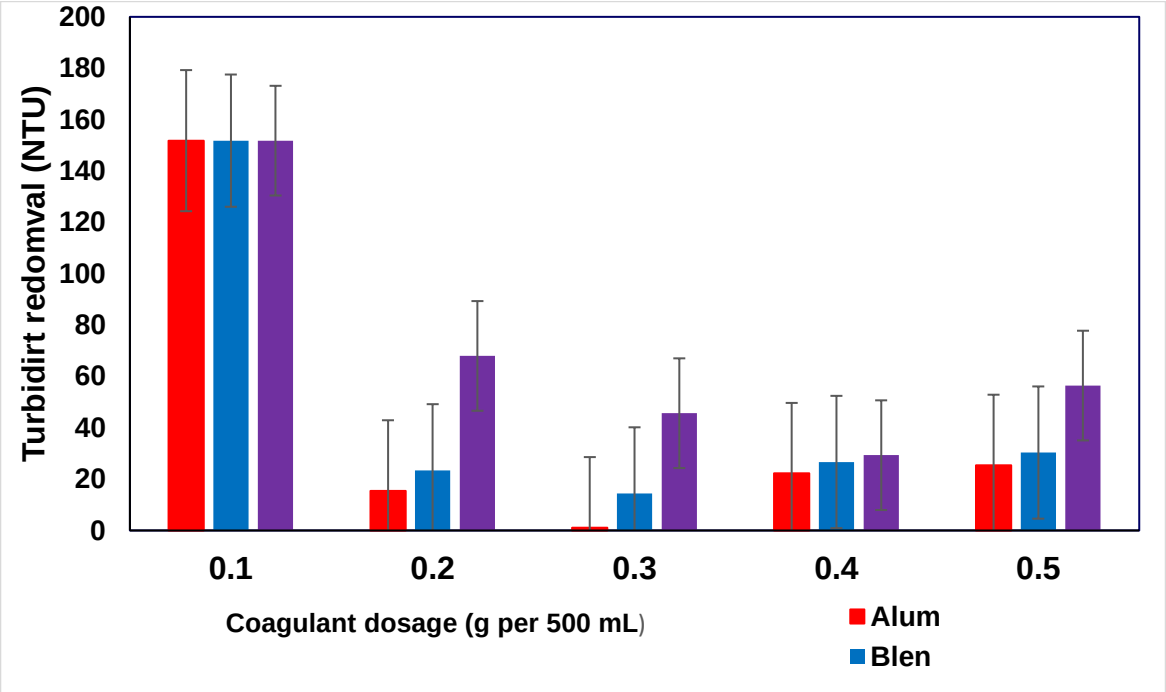

Fig. 1. The displays on effect of coagulant dosages on turbidity removal

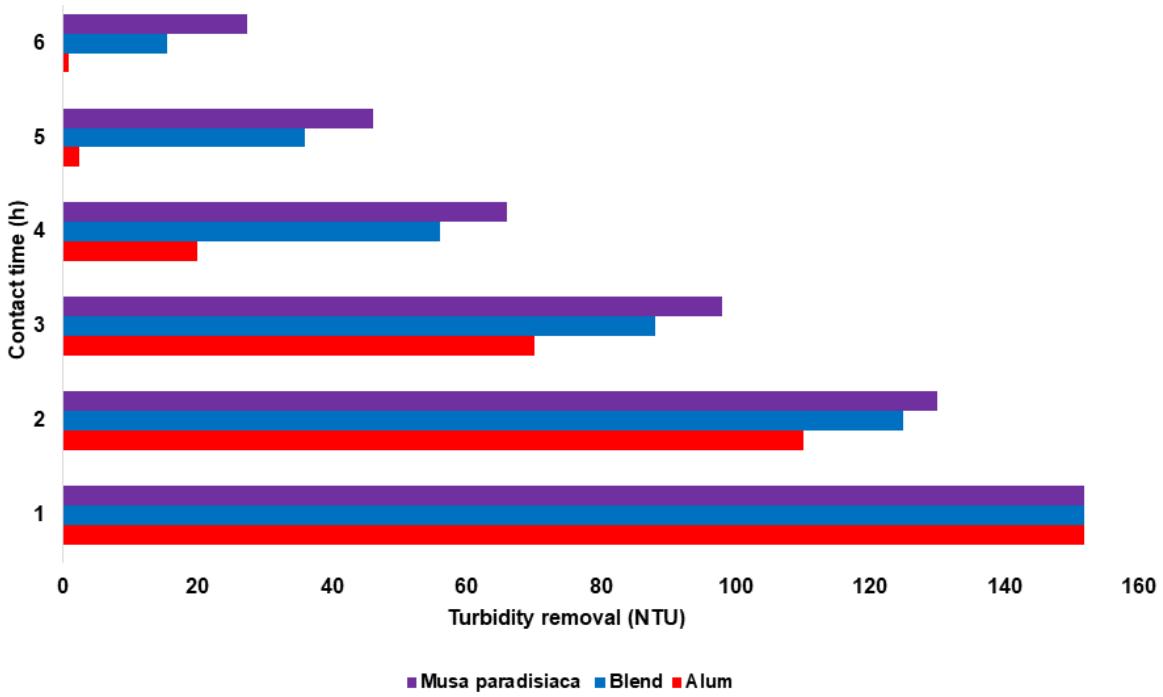

Fig. 2. Shows the Effect of Contact of Turbidity Removal

3.3 The Effect of pH on Turbidity Removal

Studies indicate that various coagulants have their own preferred pH for effective performance. The pH is defined as the negative logarithm of the concentration of hydrogen. This indicates the acidity and alkalinity of the solution. The present study has indicated that *Musa paradisiaca* peel powder worked best in an acidic environment at a pH of 4, with a 90 percent turbidity removal. The results obtained in the study are in line with those reported by [21], who also conducted a similar study in which Jatropha seed powder was used and the effect of pH on turbidity removal was considered. The study found that *Musa paradisiaca* peel powder performed best under acidic conditions at pH 4. The related investigation had a similar outcome in which the *Musa paradisiaca* natural coagulants registered maximum turbidity removal at a pH of 2 [17]. The other study showed that the best performance of *Musa paradisiaca* peel powder coagulants was in the pH range of 8 to 10, where turbidity was decreased to 8.8 NTU [22]. Another related observation was also observed by [23], in which it was reported that the maximum turbidity removal was observed at a pH of 4. The results above suggest that the natural coagulant *Musa paradisiaca* peels performance favours an acidic environment that may protonate the adsorbent surface, thereby attracting more suspended particles present in the water and leading to high turbidity removal.

4. CONCLUSION

In summary, the results attained in this study have shown that *Musa paradisiaca* peels are an ideal natural coagulant that can be used for wastewater clarification. The effectiveness of the banana peels can increase if combined with the alum, which is used in the clarification stage of wastewater treatment. The use of *Musa paradisiaca* peels for wastewater treatment can offer several benefits, including overcoming environmental challenges associated with agri-food waste disposal. Finally, the commercial inorganic coagulants used in both water and wastewater clarification are quite expensive, such that their importation requires huge forex. However, the use of plant based materials such as *Musa paradisiaca* for wastewater purification offers wastewater treatment at an affordable cost since these materials are locally available in abundance in most communities as waste materials. Further, natural coagulants solve health and environmental problems associated with the use of commercial synthetic inorganic coagulants for both water and wastewater clarification.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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