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# Utilization of Sweet Potato Leaf Extract (*Ipomoea batatas* L.) as a Bioflocculant in Clean Water Treatment

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**ABSTRACT**

*The increasing demand for clean water due to population growth and human activities is not matched by its availability, as many regions still face pollution from domestic and industrial waste. This study explores the potential of sweet potato leaf extract (Ipomoea batatas L.) as a natural bioflocculant in water treatment. Sweet potato leaves contain secondary metabolites such as flavonoids, saponins, and tannins, which contribute to coagulation–flocculation processes. The extract was applied to contaminated water samples and evaluated for its effectiveness in reducing turbidity, suspended solids, and other water quality parameters. The results show that the extract significantly improved water quality at optimal concentrations, outperforming the control. Moreover, it is environmentally friendly as it does not produce hazardous residues. Therefore, sweet potato leaf extract has potential as an economical, sustainable, and safe alternative bioflocculant for clean water treatment.*

Keywords: Bioflocculant, sweet potato leaves, water treatment, turbidity reduction, natural coagulant

## 1. INTRODUCTION

Clean water is an essential natural resource for human life, domestic activities, and industrial processes. However, rapid population growth, industrial expansion, and urban development have contributed significantly to the decline in water quality in many regions. Contamination from domestic wastewater, agricultural runoff, and industrial effluents introduces suspended solids, heavy metals, organic pollutants, and pathogenic microorganisms into water bodies [1]. Conventional water treatment methods commonly employ chemical coagulants such as alum, ferric chloride, polyaluminium chloride (PAC), polyacrylamide (PAM), and polyvinyl alcohol (PVA) to remove turbidity and suspended particles [2]. Although effective,



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these synthetic coagulants pose several disadvantages, including high cost, production of toxic sludge, and potential health risks such as neurodegenerative diseases related to aluminum exposure [3].

To address these challenges, researchers have shifted their focus toward natural and eco-friendly alternatives known as bioflocculants. Bioflocculants are derived from plants, microorganisms, or animal-based biopolymers, and are characterized by their biodegradability, safety, and low environmental impact [4]. Several plant-based materials such as Moringa oleifera seeds, banana peels, and cassava peels have been reported to exhibit promising coagulation–flocculation capabilities [5]. These natural materials contain bioactive compounds such as polysaccharides, proteins, flavonoids, saponins, and tannins, which can neutralize particle charges or form polymer bridges to aggregate suspended impurities [6].

Sweet potato (Ipomoea batatas L.) is an abundant agricultural commodity in Indonesia. While its tubers are widely utilized as a food source, its leaves are often underutilized or discarded as agricultural waste. Sweet potato leaves contain various secondary metabolites such as flavonoids, tannins, saponins, polyphenols, and proteins [7]. These compounds exhibit coagulation–flocculation properties by neutralizing negatively charged colloids and bridging particles to form settleable flocs [8]. Despite existing studies on the antioxidant, antimicrobial, and nutritional properties of sweet potato leaves, only a limited number of studies have focused on their application as bioflocculants in water treatment [9].

This research investigates the potential of sweet potato leaf extract as a natural bioflocculant for clean water treatment. The study aims to: (1) prepare and characterize sweet potato leaf extract, (2) evaluate its efficiency in reducing turbidity, iron content, and suspended solids, and (3) determine optimum conditions of pH, coagulant–flocculant dosage, and stirring speed for maximum performance. The application of this plant-based bioflocculant is expected to provide a sustainable, low-cost, and environmentally friendly alternative to conventional synthetic coagulants.

## 2. EXPERIMENTAL

### *2.1. Chemicals, Equipment and Instrumentation*

The materials used in this study included raw water samples with a yellowish appearance, sweet potato (Ipomoea batatas L.) leaves collected from local plantations, alum ($Al_2(SO_4)_3 \cdot 18H_2O$, analytical grade, Merck), distilled water (aquadest), and Whatman No. 1 filter paper. The sweet potato leaves were washed, air-dried, oven-dried at 50 °C, and then ground into powder using a household blender (Philips HR2115). The treated and untreated water samples were stored in polypropylene plastic bottles (Nalgene). The equipment employed consisted of beaker glasses, measuring cylinders, volumetric flasks, and glass funnels (all from Pyrex/Iwaki), as well as a 35-mesh stainless steel sieve for filtering the leaf powder. A digital pH meter (Hanna HI98107) was used to measure the pH of the water samples. Turbidity was analyzed using a turbidimeter (Hach 2100N), while total dissolved solids (TDS) were measured using a TDS meter (Lutron CD-4303). The mass of chemicals and extracts was determined using an analytical balance (Mettler Toledo ME204). UV-Vis spectrophotometer (Shimadzu UV-1800) was used to measure iron (Fe) concentration and absorbance values in accordance with standard water quality testing procedures.

### *2.2. Research Procedure*

#### *2.2.1 Preparation of Sweet Potato Leaf Extract*


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Approximately 50 g of powdered sweet potato leaves were soaked (macerated) in 500 mL of 96% ethanol for 48 hours with occasional stirring. The mixture was filtered using Whatman No. 1 filter paper. The filtrate was concentrated using a rotary evaporator at 50 °C to remove the solvent and obtain a viscous extract. The extract was diluted with distilled water to prepare different concentrations (100 mg/L, 200 mg/L, 300 mg/L, and 400 mg/L).

*2.2.2 Coagulation–Flocculation Procedure*

The coagulation–flocculation process was carried out using the standard jar test method. A total of 200 mL of raw water sample was poured into a 250 mL beaker glass, and a specific concentration of sweet potato leaf extract was added. The mixture was then subjected to rapid mixing at 150 rpm for 2 minutes to ensure uniform dispersion of the bioflocculant. This was followed by slow mixing at 40 rpm for 15 minutes to promote the aggregation of suspended particles into larger flocs. After stirring, the samples were allowed to settle for 30 minutes without disturbance to enable sedimentation of the formed flocs. Following the settling period, the supernatant was carefully decanted and collected for further analysis. Variations in bioflocculant concentration (100–400 mg/L), pH (4, 6, 7, and 8), and mixing speed (120–200 rpm) were tested to determine the optimum conditions for maximum turbidity and suspended solids removal.

*2.2.3 Analytical Methods*

The water quality parameters were measured before and after treatment to evaluate the effectiveness of the bioflocculant. The pH of the samples was measured using a digital pH meter (Hanna HI98107). Turbidity was determined using a turbidimeter (Hach 2100N) and expressed in Nephelometric Turbidity Units (NTU). Total Suspended Solids (TSS) was analyzed using the gravimetric method, where the water sample was filtered through Whatman No. 1 filter paper, dried in an oven, and weighed using an analytical balance (Mettler Toledo ME204). Iron (Fe) concentration was measured using a UV-Vis spectrophotometer (Shimadzu UV-1800) at a specific wavelength after reaction with appropriate reagents. The percentage removal efficiency for each parameter was calculated using the equation: Removal (%) = $((C_0 - C_t) / C_0) \times 100$, where $C_0$ is the initial concentration and $C_t$ is the concentration after treatment.

## 3. RESULTS AND DISCUSSION

### *3.1. Initial Water Quality Characterization*

**Table 3.1** Initial Condition of the Sample

| Parameter | Hasil |
|---|---|
| Warna | Jernih Kekuningan |
| Bau | Berbau Karat |
| Ph | 5,00 |
| Besi (Fe) | 6,13 mg/L |
| Kekeruhan | 56,3 NTU |


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Based on the initial characterization, the water sample exhibited several indicators of physical and chemical contamination. The slightly clear yellowish appearance of the water suggests the presence of dissolved metals, particularly iron, which commonly exists in oxidized forms. This observation is further supported by the distinctive rusty odor detected from the water sample, indicating partial oxidation of iron compounds due to interaction with dissolved oxygen.

The pH value of 5.00 indicates that the sample is moderately acidic, a condition that does not comply with clean water quality standards. Such acidity can accelerate corrosion processes and enhance the solubility of heavy metals in water. The iron concentration was measured at 6.13 mg/L, significantly exceeding the permissible limit for drinking water set by the Indonesian Ministry of Health (0.3 mg/L). This high iron content not only affects the taste, odor, and coloration of the water but also poses potential health risks if consumed over a prolonged period.

In addition, the turbidity level reached 56.3 NTU, indicating a high concentration of suspended particles, possibly originating from metal precipitates or other solid contaminants. This value is far above the acceptable standard for clean water, which should be below 5 NTU. Overall, these findings confirm that the initial water sample is heavily contaminated and unsuitable for direct use, either for domestic purposes or human consumption, without prior treatment.

### *3.2. pH Optimization*

If the coagulation process does not occur within the appropriate pH range, floc formation becomes inefficient, resulting in decreased water treatment performance and lower effluent quality [10]. In this study, the optimal pH range for coagulation using $Al(OH)_3$ was identified between pH 5.0 and 8.0. Experimental results indicated that the most effective pH was pH 8, where the lowest turbidity value of 5.59 NTU was obtained. This finding confirms that at this pH, the destabilization of colloidal particles and subsequent floc formation occurred efficiently, allowing for maximum removal of suspended impurities.

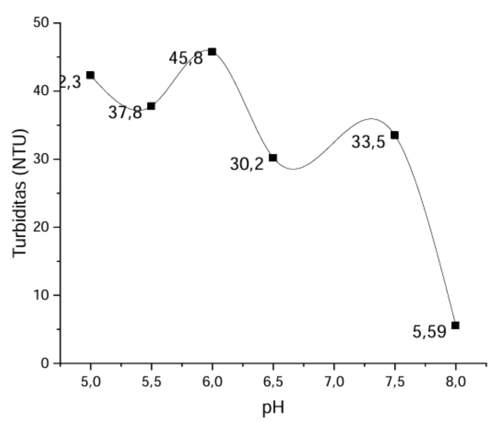


**Figure 3.1** Variation of pH against Turbidity



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*3.3. Optimization of Coagulant and Flocculant Dosage*

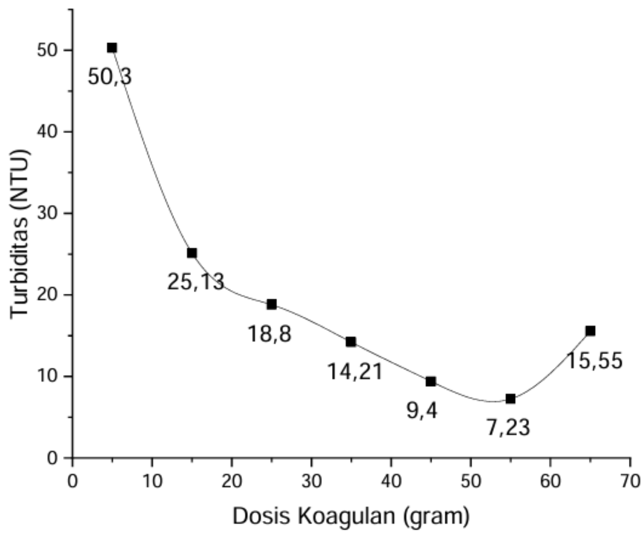


**Figure 3.2** Variation of Coagulant Dose on Turbidity

The graph illustrates the relationship between coagulant dosage and turbidity level after the coagulation–flocculation process. As the coagulant dose increased from 0 to 50 mg/L, turbidity decreased significantly from 50.3 NTU to 7.23 NTU. This trend indicates that the addition of an appropriate amount of coagulant enhances collisions between colloidal particles, promoting the formation of larger, heavier flocs that settle more easily, resulting in clearer water. The lowest turbidity value was observed at 50 mg/L, which represents the optimum coagulant dose where floc formation occurred most efficiently. However, further increases in dosage, specifically from 50 to 65 mg/L, resulted in a rise in turbidity to 15.55 NTU. This increase is attributed to coagulant overdose, which can cause charge reversal or excess surface charge in the solution, leading to restabilization or breakup of flocs into fine particles, thereby increasing turbidity again. Overall, this graph emphasizes the critical importance of determining the optimum coagulant dosage to ensure effective water treatment and achieve the highest clarity of treated water.


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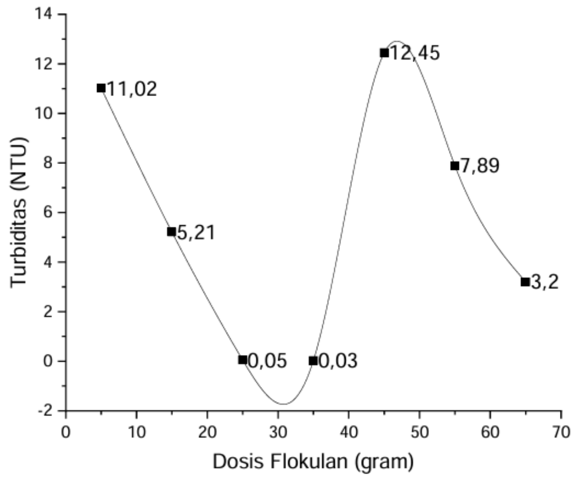


**Figure 3.3** Variation of Flocculant Dosage on Turbidity

The graph above illustrates the relationship between flocculant dosage and water turbidity after the flocculation process. The data show that increasing the flocculant dose from 0 to 30 mg/L significantly reduced turbidity from 11.02 NTU to 0.05 NTU, reaching its lowest value of 0.03 NTU at 35 mg/L. This indicates that at this concentration, the flocculant performed optimally in facilitating the aggregation and sedimentation of suspended particles, resulting in maximum water clarity. However, when the dosage exceeded the optimal point, turbidity sharply increased to 12.45 NTU at 45 mg/L. This rise is likely caused by overdosing, which can lead to charge reversal or destabilization of previously formed flocs, causing them to break apart into fine particles and re-enter suspension. Interestingly, at 55 and 65 mg/L, turbidity decreased again to 7.89 and 3.20 NTU, respectively, showing a partial recovery in flocculation efficiency, although not as effective as at the optimum dose. Overall, the graph demonstrates that flocculant dosage plays a critical role in water treatment performance. Both insufficient and excessive dosages can reduce efficiency and increase turbidity, emphasizing the importance of determining the optimal dosage for effective flocculation.

*3.4. Optimization of Coagulant and Flocculant Stirring Speed*

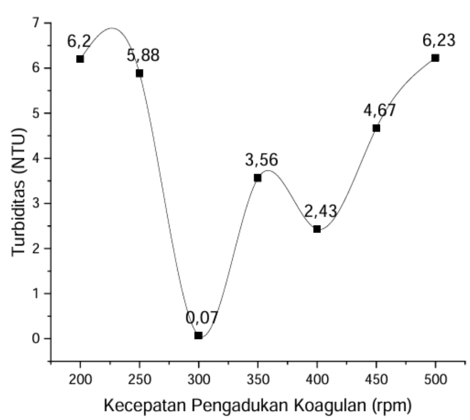


**Figure 3.4** Variation of Coagulant Stirring Speed on Turbidity

The graph illustrates the relationship between coagulant stirring speed (rpm) and the resulting turbidity of water after the coagulation process. At stirring speeds of 200–250 rpm, the turbidity remained relatively high, ranging from 6.2 to 5.88 NTU. However, a significant decrease in turbidity was observed at 300 rpm, reaching a minimum value of 0.07 NTU. This indicates that at 300 rpm, the mixing intensity was sufficient to disperse the coagulant uniformly and facilitate effective collisions among particles, resulting in optimal floc formation and exceptionally clear water. Beyond this optimum mixing speed, turbidity values began to fluctuate. At 350 rpm, turbidity increased to 3.56 NTU, slightly decreased to 2.43 NTU at 400 rpm, and rose again to 6.23 NTU at 500 rpm. These fluctuations suggest that excessively high stirring speeds generate strong shear forces capable of breaking the flocs already formed, causing particles to re-disperse into the water and subsequently increasing turbidity. Overall, the results highlight that stirring speed plays a crucial role in the coagulation process, where insufficient or excessive mixing can reduce treatment efficiency, while an optimal speed (300 rpm) ensures effective floc formation and maximum clarity.

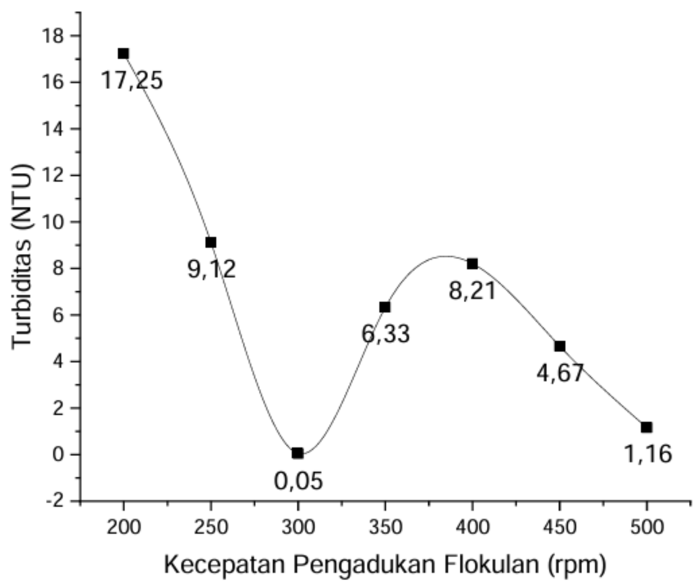


**Figure 3.5** Variation of Flocculant Stirring Speed on Turbidity

The graph illustrates the relationship between flocculant stirring speed (rpm) and turbidity of the treated water following the coagulation–flocculation process. At the initial stirring speed of 200 rpm, turbidity reached its highest value of 17.25 NTU, indicating that flocculation was not yet effective and a large number of suspended particles remained in the water. As the stirring speed increased, turbidity declined sharply, reaching its lowest point at 0.05 NTU at 300 rpm. This demonstrates that at this speed, the flocculant achieved maximum efficiency in aggregating fine particles into larger, denser flocs that settled rapidly, resulting in highly clear water. Beyond this optimal point, further increases in stirring speed led to fluctuations in turbidity. At 350 rpm, turbidity increased to 6.33 NTU, and further rose to 8.21 NTU at 400 rpm. This suggests that excessive mixing intensity can generate high shear forces that break apart previously formed flocs, redistributing the particles into the water and increasing turbidity. Interestingly, at stirring speeds above 400 rpm, turbidity began to decrease again, reaching 4.67 NTU at 450 rpm and 1.16 NTU at


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500 rpm. This indicates a partial recovery of system stability, although the performance was still inferior compared to the optimal condition at 300 rpm. Overall, these findings highlight that flocculant stirring speed is a critical parameter in achieving effective floc formation, where both insufficient and excessive agitation can hinder turbidity removal.

*3.5. Optimization of Coagulant and Flocculant Stirring Time*

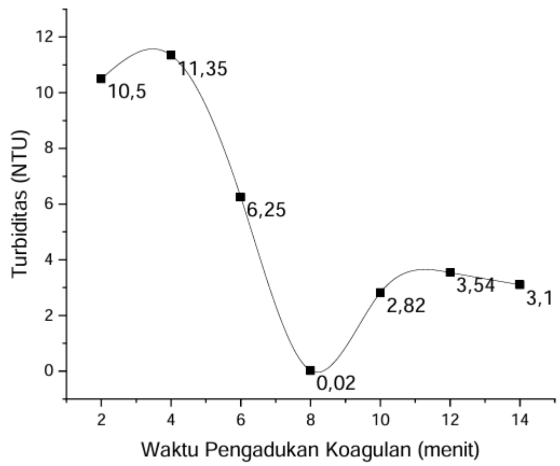


**Figure 3.6** Variation of Coagulant Stirring Time on Turbidity

The graph presents the relationship between coagulant mixing time and the turbidity of water after the coagulation process. At the initial mixing duration of 2 to 4 minutes, turbidity remained relatively high, ranging from 10.5 to 11.35 NTU, indicating that such short mixing times were insufficient for uniform coagulant dispersion and optimal floc formation. As the mixing time increased, turbidity decreased significantly, reaching its lowest value of 0.02 NTU at 8 minutes. This suggests that coagulation occurred most efficiently at this point, where colloidal particles were effectively destabilized and aggregated into settleable flocs. However, when the mixing duration exceeded the optimum time, turbidity began to rise again, reaching 2.82 to 3.54 NTU at 10 to 14 minutes. This increase is likely attributed to the breakup of flocs due to excessive shear forces from prolonged stirring. Therefore, the optimal coagulation mixing time to achieve maximum water clarity is approximately 8 minutes, where the floc formation process is most effective and stable.


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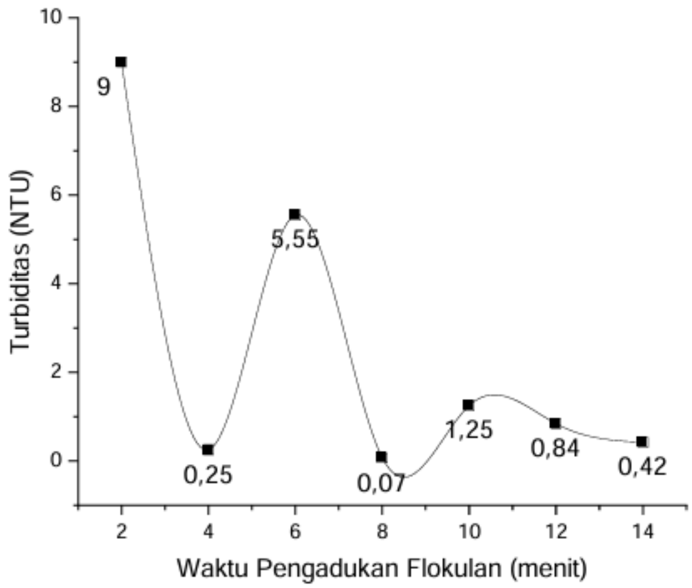


The graph illustrates the relationship between flocculant mixing time and the resulting turbidity of water after the flocculation process. At the initial mixing time of 2 minutes, turbidity was relatively high at 9 NTU, indicating that floc formation had not yet occurred effectively. As mixing time increased, turbidity decreased sharply, reaching 0.25 NTU at 4 minutes. However, turbidity increased again to 5.53 NTU at 6 minutes, likely due to shear forces disrupting the flocs that had already formed. Subsequently, turbidity dropped significantly and reached its lowest value of 0.07 NTU at 8 minutes, indicating that this was the optimal flocculation time for achieving maximum clarity. Beyond this point, at 10–14 minutes, turbidity fluctuated slightly between 0.42 and 1.25 NTU. Although still relatively low, these fluctuations suggest that extended mixing may lead to partial floc instability or breakage, although not as severe as at 6 minutes. Overall, the graph demonstrates that an optimal flocculant mixing time of approximately 8 minutes results in the most effective flocculation performance and produces the highest water clarity.

*3.6. Water Treatment*

After the treatment process, the water was allowed to settle for 20 minutes to facilitate sedimentation. Following this settling period, the upper layer of the water appeared clear, while the lower portion contained a white precipitate, indicating the formation and deposition of flocs. The clarified water from the upper layer was carefully collected and used for turbidity and pH measurements. The results showed a significant decrease in turbidity, confirming the effectiveness of the coagulation–flocculation process in improving water clarity.


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**Table 3.2** Turbidity of Untreated and Treated Water

| No | Sampel | Satuan | Turbiditas Awal (rata-rata) | Turbiditas Akhir (rata-rata) | pH Awal | pH Akhir |
|---|---|---|---|---|---|---|
| 1 | Air non olahan | NTU | 56,3 | - | 5,00 | - |
| 2 | Air olahan | NTU | 56,3 | 0,94 | 8,00 | 7,32 |

Based on the data presented in the table, the use of sweet potato leaf extract (Ipomoea batatas L.) as a natural bioflocculant demonstrated a significant improvement in water quality, particularly in reducing turbidity and adjusting pH toward a neutral range. The untreated water initially exhibited a turbidity of 56.3 NTU and an acidic pH of 5.00. After treatment with the bioflocculant, turbidity decreased sharply to 0.94 NTU, indicating a high efficiency in removing suspended particles. In addition, the pH of the water shifted from 5.00 to 7.32, approaching the neutral range required by clean water standards. This result shows that the sweet potato leaf extract not only functions effectively as a flocculating agent but also contributes to the stabilization of water chemistry. Overall, these findings suggest that sweet potato leaf extract has strong potential as an environmentally friendly and efficient alternative to synthetic coagulants, particularly in areas with limited access to conventional water treatment chemicals.

## 4. CONCLUSION

Based on the results of this study, it can be concluded that sweet potato leaf extract (Ipomoea batatas L.) is an effective natural bioflocculant for improving water quality. Initial characterization of the water samples revealed high levels of contamination, with turbidity of 56.3 NTU, iron (Fe) concentration of 6.13 mg/L, and an acidic pH of 5.00. After treatment using the bioflocculant, turbidity was significantly reduced to 0.94 NTU, while pH increased to 7.32, indicating that the natural coagulation–flocculation process was highly effective. Optimization of process parameters showed that the best treatment conditions were achieved at pH 8, coagulant dosage of 50 mg/L, flocculant dosage of 35 mg/L, mixing speed of 300 rpm, and mixing time of 8 minutes. Under these conditions, stable floc formation and efficient sedimentation occurred, resulting in maximum water clarity. Overall, sweet potato leaf extract demonstrates strong potential as an environmentally friendly, cost-effective, and efficient alternative to synthetic coagulants and flocculants for clean water treatment applications.

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