



Optimization of Coagulation Performance Using Bio-Coagulants from Banana and Pineapple Waste as an Alternative to Aluminium Alum

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Access to clean water is essential for human health, agriculture, and industry; however, freshwater resources are increasingly threatened by pollution from industrial effluents, agricultural runoff, and other human activities. Raw water sources such as rivers, lakes, and groundwater often contain suspended solids, organic matter, heavy metals, and microorganisms that must be removed before use. Although conventional coagulants like Aluminium Sulfate (Aluminium Alum) are effective in removing turbidity and impurities, they have notable drawbacks, including the production of non-biodegradable sludge, potential health risks from residual Aluminium, and environmental impacts associated with their manufacture and disposal. Therefore, our study evaluated eco-friendly substitutes derived from banana peels, banana pseudo-stem, and pineapple peels with Aluminium Alum ($\text{Al}_2(\text{SO}_4)_3 \cdot x\text{H}_2\text{O}$) for treating turbid raw water. The raw ingredients were collected, washed, depectinated, oven-dried, ground, and sieved into fine powders. Coagulation experiments compared their performance with Aluminium Alum to identify the effectiveness. After determining the most efficient bio-coagulant, we aimed to replace 25%, 50%, 75%, and 100% of the Alum with the selected bio-coagulant to evaluate its potential as a partial or complete substitute. This would help determine the optimum percentage at which Alum can be effectively replaced by the bio-coagulant without compromising treatment efficiency. The results demonstrated that banana pseudo-stem powder was the most effective replacement compared to banana peel and pineapple peel powder. The 50% Banana Trunk + 50% Alum had a 94.5% turbidity removal efficiency, while 100% Alum remained at 91% ($p < 0.01$). Further, the 75% Banana Trunk + 25% Alum demonstrated 93.1% turbidity removal efficiency, and it was significant compared to the control ($p < 0.01$). COD of raw water (223.2 ± 0.3) was reduced to 87.3 ± 0.7 by 100% Alum, while 50% Banana Trunk + 50% Alum reduced the COD to 61.8 ± 0.7 , and it was significant. COD of 75% banana + 25% Alum treatment was 92.8 ± 0.6 , and it was significantly higher than both. pH was not significant among all treatments while the TSS followed the same trend of turbidity. These findings highlighted the potential of replacing 50% of the Alum dose by banana pseudo-stem powder as an alternative to conventional coagulants without disturbing the efficiency of the conventional chemical coagulation process.

Keywords: Bio-coagulant, Coagulation-flocculation, Raw water treatment, Sustainable water purification, Turbidity removal