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Biocoagulants as Ecofriendly Alternatives in the Dairy Wastewater Treatment

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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

Coagulation is a simple and widely used method for water and wastewater treatment. Chemical coagulants, on the other hand, not only produce vast volumes of toxic sludge, but they also have negative impacts on living organisms. This study demonstrates the use of neem tree leaf and banana leaf powders as natural coagulants for the treatment of dairy effluent. The jar test was used to determine the pH, turbidity, and metal ion content of the treated samples. The biocoagulants were experimented at a rate of 100 mg/L, 200 mg/L, and 300 mg/L at pH of 5, 6, and 7. The levels of turbidity, sodium (Na), potassium (K), calcium (Ca), barium (Ba), lithium (Li), and copper (Cu) were measured after the treatment process. Turbidity was reduced by 52%, and coagulants at 200 mg/L and 300 mg/L were more successful at removing metal ions from dairy effluent except in copper, where 100 mg/L was shown to be more effective. In the scattering between adjacent, similarly charged particles, the zeta potential reveals the strength of repulsive powers. There are more dispersion and suspension rates in the treatment of dairy wastewater using banana and

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neem leaf biocoagulants. Neem tree leaf and banana leaf powders were efficient and cost-effective eco-friendly biocoagulants for the treatment of dairy effluent.

Keywords: Banana leaf; dairy wastewater; jar test apparatus; neem leaf; turbidity.

1. INTRODUCTION

Water is the most crucial normal asset and is a necessity for all living organisms [1]. Non-industrial and third-world nations are confronting consumable water supply issues because of insufficient monetary assets. In non-industrial nations, 15 million newborn children bite the dust consistently due to tainted drinking water, helpless cleanliness, and lack of healthy sustenance [2]. Around 80% of illnesses in agricultural nations are straightforwardly associated with polluted drinking water [3]. Groundwater, surface water, and rainwater are frequently the major sources of water accessibility in a community. Consumable water must be liberated from pathogenic microorganisms, harmful substances, and an overabundance of minerals and natural poisons [4]. It should be dull, tasteless, and unscented to be alluring to buyers [5].

Bio coagulation is used to eliminate turbidity from raw water sources before it is used in portable water [6]. The amount of drainage poured into water sources has contaminated the water quality because of the fast population increase and industrialization. Water quality can be improved using a variety of sanitation procedures. Primary coagulants are aluminum and iron salt. However, these coagulants are harmful to both the environment and humans. Coagulation and flocculation processes are the most preferred among the large variety of available wastewater treatment technologies [7]. This therapy is widely utilized since it is cost-effective, dependable, easy, and considered to be a low-energy method [8].

This highlights the need to find natural ecofriendly alternatives such as biocoagulant for easy and inexpensive wastewater treatment. Banana leaf and neem leaf powders are used as natural biocoagulants. Water treatment is very economical when using natural biocoagulants. The objective of the study is to measure the effectiveness of banana leaf and neem leaf powder as biocoagulants in dairy wastewater treatment using the reduction in turbidity and metal ion levels as an indicator for the success of the treatment process.

2. MATERIALS AND METHODS

2.1 Preparation of Biocoagulant

The neem leaves and banana leaves were collected from the UTAS-Salalah premises, cleaned with distilled water, and sundried for three days. The samples were granulated using a grinding tool (ACE Machine Tools Co., Ltd.). The powder was sieved through a 90-micron sieve. The fine powder was collected and stored in an airtight container to protect it from moisture.

2.2 Chemicals

Wastewater from the local dairy industry was collected. The pH was adjusted with 0.1 N HCl and NaOH.

All the experiments were repeated, as well as blank trials were also carried out and the average results were published.

2.3 Apparatus

The Jar test method was implemented to determine the best operating conditions for wastewater treatment. A flame photometer (A.KRÜSS Optronics, Germany) was used for the determination of Na, K, Ca, Ba, and Li concentrations, and for the copper concentration, a UV-Vis Spectrophotometer (Shimadzu) was used. The values of turbidity were measured by a digital turbidity meter (S. Schmidt Haensch GmbH & Co).

Fig. 1. Neem (*Azadirachta indica)* and banana leaf (*Musa acuminate*) powder (Biocoagulants)

(a) (b) (c)

Fig. 2. Apparatus used: (a) jar test (b) turbidity meter (c) flame photometer

2.4 Batch Coagulation Experiment

Color, turbidity, germs, suspended matter, and odor-producing elements were all removed during the coagulation process. The coagulant was added to break down the small-destabilized particles into a big matter, which was decanted and separated from the effluent by gravity. Different doses of neem leaf powder/banana powder were added to the effluent. Rapid mixing for 3 min/100 rpm was carried out, gentle mixing for 25 min/20 rpm, allowing 30 min to rest, the supernatant water was filtered, and various turbidity, pH, and metals parameters were measured using a flame photometer (A. KRÜSS Optronics, Germany) and a UV Spectrophotometer (S. Schmidt Haensch GmbH & Co).

3. RESULTS AND DISCUSSION

3.1 Effect of Biocoagulant Dosage on pH and Turbidity

The results revealed that a dosage of 0.4 g/L of neem leaf and banana leaf powder was sufficient to maintain a pH of 7.8 (Fig. 3.a) and turbidity of 34 nephelometric turbidity unit (NTU) (Fig. 3.b) [9,10]. It delivers that the pH (8 to 7.84) and the turbidity values decreased and then increased as the coagulant's dosage was increased from 0 to 1 g/L. Therefore, the optimum dosage of the biocoagulant was considered to be 0.4 g/L.

3.2 Effect of Bio-Coagulant Dosage on Removal of Various Metals

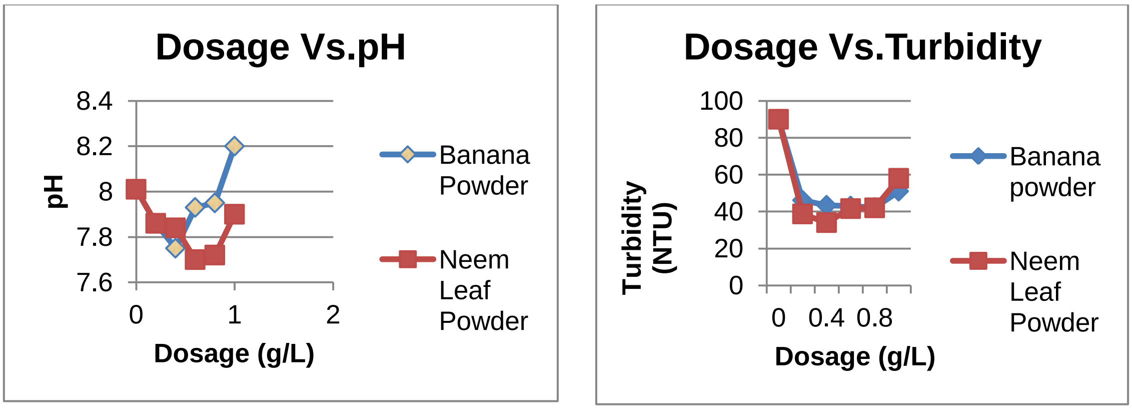
Understandably, the effect of biocoagulant's quantity showed various effects on the removal of metal ions. The initial concentrations of Na, K, Ca, Ba, Li, and Cu were 152, 21, 10.3, 11.6, zero, and 1029 ppm, respectively. It was found that the 100 mg/L (Fig. 4) of both neem and banana leaf powder coagulant at pH 5 showed the highest removal of Na, K, Ca, Ba, Li, and Cu. Similar trends were observed at the bio coagulant dosage of 200 and 300 mg/L (Fig. 5 and Fig. 6). It was found that the removal of Na, K, Ca, Ba, and Li was found to be maximum at 300 mg/L and 100 mg/L for Cu for both neem (Table 1, Fig. 7) and banana leaf (Table 2, Fig. 8) due to the mechanism of coagulation.

Neem leaf and banana leaf powder produced absorption and neutralization actions of colloidal positive charges that attract negatively charged contaminants in water [11]. Coagulation is insufficient if the biocoagulant quantity is too low, resulting in reduced efficacy. When the biocoagulant concentration is too high, the particles in the wastewater are encased in too much biocoagulant, and their surfaces become saturated, resulting in a decreased particle coagulation and stability, making it difficult for the particles to coagulate [12,13].

3.3 Zeta Potential of Banana and Neem Leaf Coagulant

The stability of colloidal suspension was investigated using zeta potential analysis to measure the degree of electrostatic repulsion in the dispersion between the natural coagulants nearest equally charged particles, as illustrated in Fig. 9. The zeta potential of particles ranges from +100 mV to -100 mV. Well-scattered NPs have a Zeta potential of greater than +30 mV or less than -30 mV. The zeta potential of neutral NPs ranges from -10 to +10 mV. The zeta potential of banana and neem is (-20.77 mV and -19.22 mV, respectively) [14].

Dispersions, emulsions, and suspensions are frequently improved using zeta potential analysis. The zeta potential of both banana and neem coagulants describes the degree of repulsive forces in the dispersion between contiguous, equally charged particles [15]. Its findings disclose detailed diffusion, aggregation, and flocculation principles that can be used to improve dispersions, emulsions, and suspension formulations between dairy wastewater pollutants and natural coagulants [16].



(a) (b)

Fig. 3. Effect of bio coagulant dosage on (a) pH and (b) turbidity

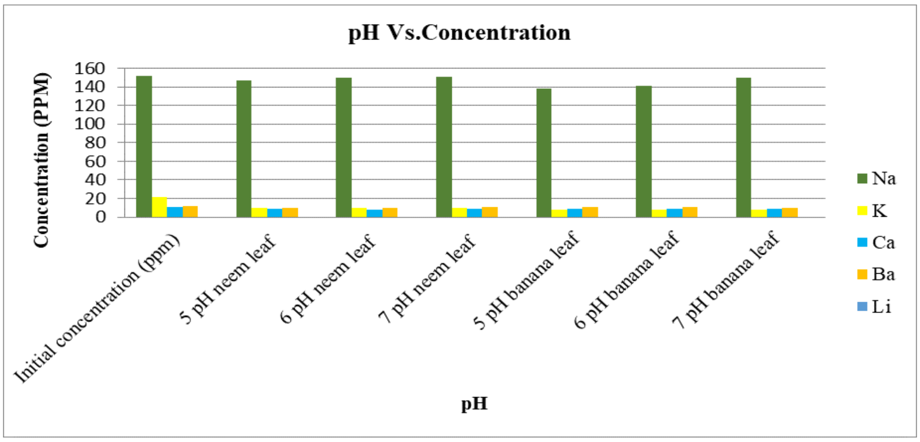


Fig. 4. Flame photometer analysis for 100 mg/L of neem and banana coagulants

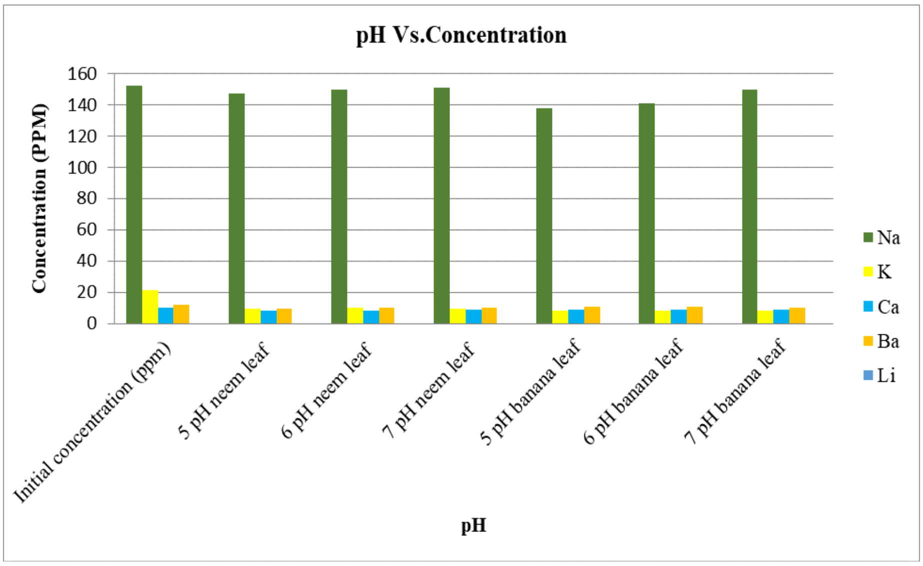


Fig. 5. Flame photometer analysis for 200 mg/L of neem and banana coagulants

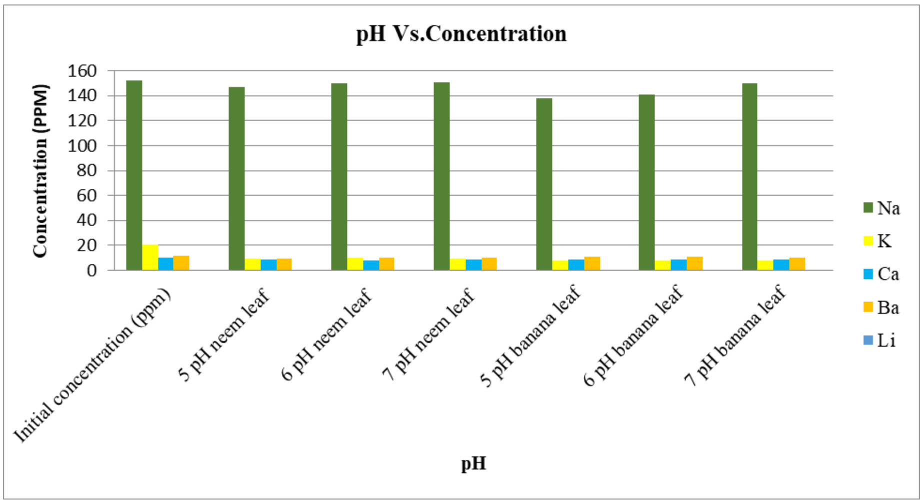


Fig. 6. Flame photometer analysis for 300 mg/L of neem and banana coagulants

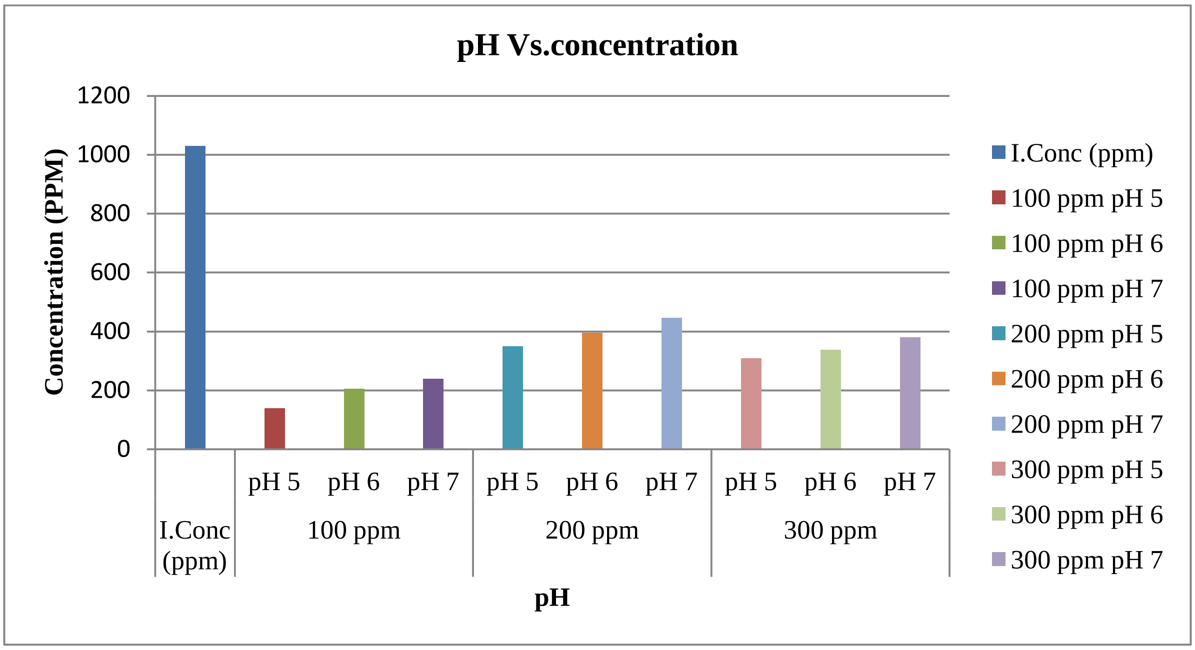


Fig. 7. UV-Spectrophotometry analysis for the copper ion at 100, 200, and 300 mg/L of neem leaf biocoagulant

Table 1. UV-Spectrophotometry analysis for the copper ion at 100, 200, and 300 mg/L of neem leaf biocoagulant

Initial concentration (ppm)	100 ppm			200 ppm			300 ppm		
	pH 5	pH 6	pH 7	pH 5	pH 6	pH 7	pH 5	pH 6	pH 7
1029	139.5	204.7	238.5	349	395	445.6	307.8	338	379

Table 2. UV-Spectrophotometry analysis for the copper ion at 100, 200, and 300 mg/L of banana leaf biocoagulant

Initial concentration (ppm)	100 ppm			200 ppm			300 ppm		
	pH 5	pH 6	pH 7	pH 5	pH 6	pH 7	pH 5	pH 6	pH 7
1029	206.7	208	238.5	354.2	382.7	422.2	314.9	352.9	505.8

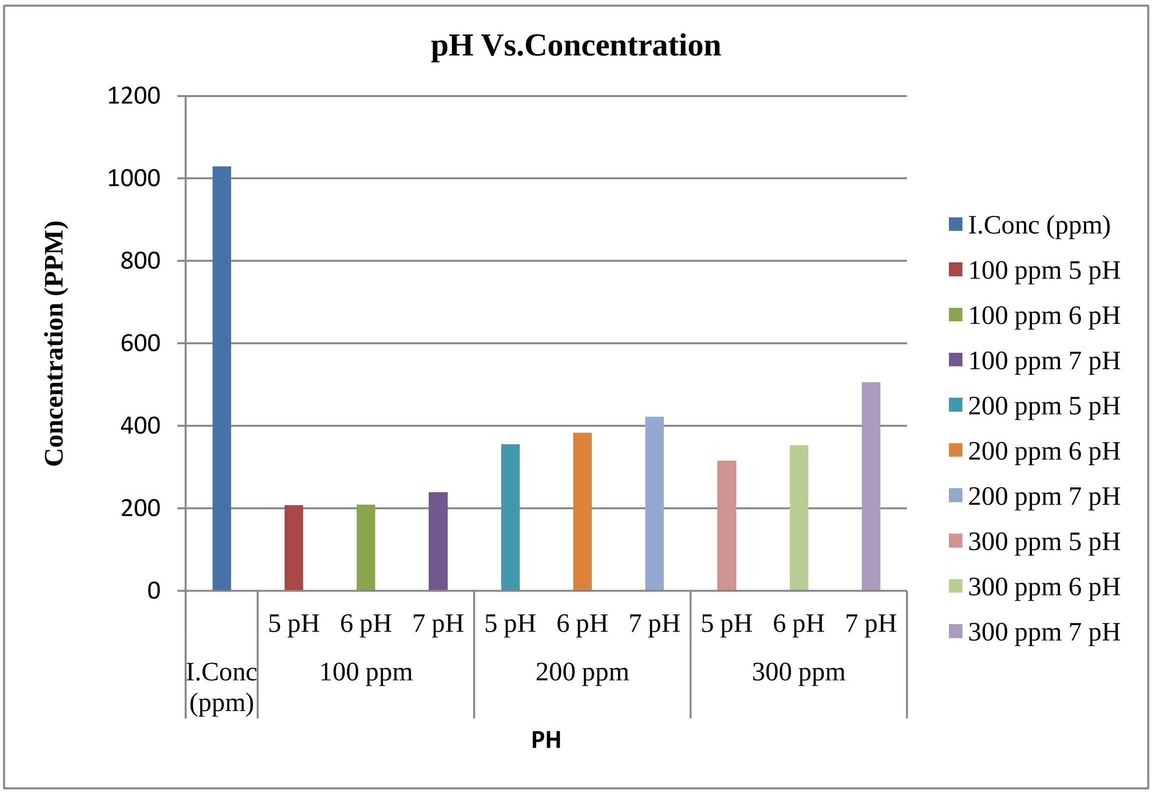
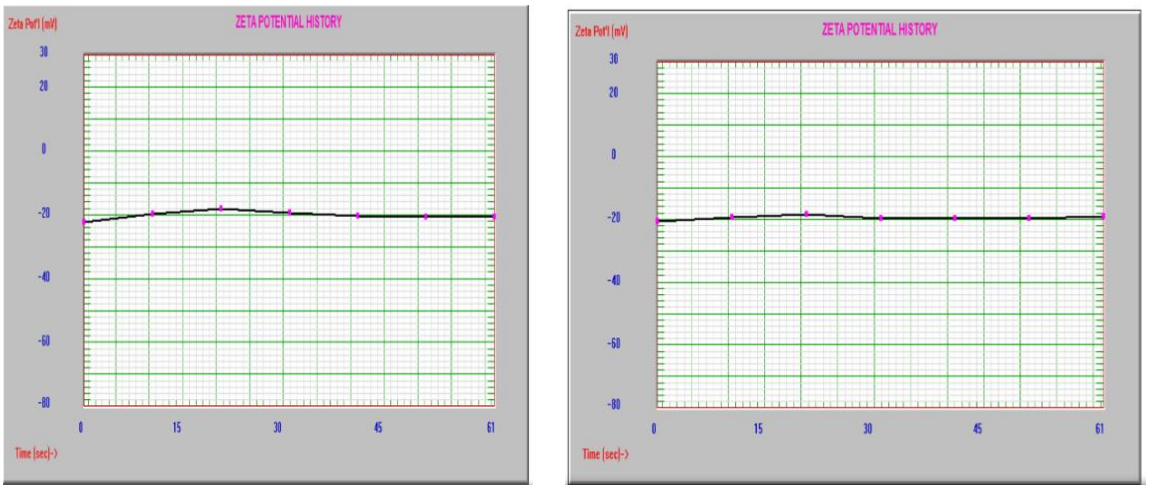


Fig. 8. UV-Spectrophotometry analysis for the copper ion at 100, 200, and 300 mg/L of banana leaf biocoagulant.



(a) (b)

Fig. 9. Zeta potential of (a) banana leaf powder and (b) neem leaf powder

4. CONCLUSION

The turbidity levels were reduced by a rate of 55 and 65% using neem and banana biocoagulants, respectively. The amount of Na and Ca increased as pH decreased, but there was a minute change in the case of K and Ba, and there was no change in the case of Li. Copper was greatly reduced at pH 5 with 100 mg/L for both the biocoagulants and the lower the pH, the lower the copper percentage concerning banana leaf powder.

The zeta potential also showed that the more dispersion and suspension rates in the treatment of dairy wastewater by banana and neem leaf bio coagulants, the better. Neem and banana powder were found to be non-toxic and eco-friendly ways for the treatment of wastewater and can be used as an alternative coagulant in water treatment plants.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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