

Evaluation of Seeds *Moringa oleifera* Lam. Present in Urban Forests as a Coagulant-Flocculant for Water Treatment †

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Abstract: The objective of the work was to evaluate the efficiency of *Moringa oleifera* seeds as a natural coagulant-flocculant in the treatment of water for human consumption. Seeds were collected from trees present in forest remnants of the city of Ibagué (Colombia), dried, pulverized and subjected to the process of extraction of the active agents from organic solvents; samples were taken from river surface waters and with a latin square design (DCL) that grouped two factors (water pH and extract dosage), the coagulant action was evaluated in the tests carried out with jar tests. According to the ranges of pH (4, 5, 6 and 7) and dosages (5, 10, 15 and 20 mL) used, a greater reduction of the turbidity values was obtained in the conditions of pH 6 with a dosage of 10 mL of coagulant solution, and pH 7 with a dosage of 10 mL of coagulant solution. The tests carried out showed that the coagulation-flocculation levels of moringa seeds do not vary significantly concerning the reports in the literature for Colombia, their performance is associated with the factors established in the experimental design and maintains experimental efficiency against coagulants conventionals used for the purification of water.

Keywords: *Moringa oleifera*; seeds; coagulant-flocculant; treatment; water

1. Introduction

Water treatment is a process in which it seeks to remove or eliminate organic matter, silt, sand, and analyze the physicochemical and microbiological characteristics through regulations, to make it optimal for human consumption. Natural organic polymers have been used for over 4000 years in India, Africa, and China as efficient coagulants and as coagulation aids for high turbidity waters for domestic use in rural areas [1]. Starting in the 19th century, chemical coagulants such as ferric chloride (FeCl₃) and Aluminum sulfate Al(SO₄)₃ began to be used around the world in the treatment of water for human consumption, which left the use of coagulants in the background, except in rural and developing countries that still use them [2]. However, chemical coagulants have impacted the environment and human health [3] due to its composition and higher cost. For this reason, the present investigation in progress proposes to establish the optimal operational parameters for the use of *M. oleifera* seed extract as a natural coagulant in the “Acuambala” community aqueduct in the city of Ibagué-Tolima.

2. Experiments

M. oleifera seeds were collected in their dry pods in an urban forest from Ibagué-Tolima city. The preparation of *M. oleifera* seeds will be carried out under the method described by Okuda et al. [4]. The seeds stored at the moment of being used, their shell, or coating will be removed manually, and later they will be pulverized in a mortar. 10 g of the obtained powder will be taken and it will be suspended in 1 L of 1.0 M NaCl (saline solution), stirring for 10 min to extract the active component from the seeds, then, the obtained solution will be filtered by gravity using commercial filter paper [4]. To obtain the integral

power of the *M. oleifera* seed, the same steps described above will be followed without carrying out the saline extraction. The water sample will be taken from the Las Panelas stream under NTC ISO 5667-3 before the catchment point of the Acuambala community aqueduct located in the Ambalá neighborhood of the city of Ibagué-Tolima. The turbidity of the water sample was analyzed in the Laboratory for Taking and Analysis of Water and Air Samples of the Center for Industry and Construction SENA Tolima. In the jar tests, a latin square design (DCL) was applied that grouped two factors (pH of the water and dosage of the extract) where the coagulant action was evaluated in pH ranges of 4, 5, 6 and 7 and dosages of 5, 10, 15, and 20 mL coagulant. As a control test, the jug test was performed on a water sample without the coagulant and a second control sample with 10 mg/L of aluminum sulfate $Al(SO_4)_3$ only with pH 7. The samples were mixed at 120 rpm for 1 min and then one was mixed at 40 rpm for 20 min. Once finished, it was left to rest for half an hour. Finally, the percentage of turbidity removal was analyzed for each sample.

3. Results

The water sample shows turbidity of 500 NTU. According to the jar test, the results show a greater reduction in turbidity values was obtained under the conditions of pH 6 with a dose of 10 mL of coagulant solution, and pH 7 with a dose of 10 mL of coagulant solution (Table 1). The water sample without coagulant showed a 10% removal percentage and the water sample with aluminum sulfate showed a 99.8% removal percentage.

Table 1. Removal percentage of natural coagulant.

pH	Coagulant Dosage	Initial Turbidity	Final Turbidity	Removal Percentage
4	5 mL	500	22.5	95.50%
4	10 mL	500	23.57	95.29%
4	15 mL	500	24.63	95.07%
4	20 mL	500	12.5	97.50%
5	5 mL	500	24.6	95.08%
5	10 mL	500	10.49	97.90%
5	15 mL	500	11.05	97.79%
5	20 mL	500	9.5	98.10%
6	5 mL	500	6	98.80%
6	10 mL	500	2.03	99.59%
6	15 mL	500	3.04	99.39%
6	20 mL	500	3.95	99.21%
7	5 mL	500	3.4	99.32%
7	10 mL	500	2	99.60%
7	15 mL	500	3.9	99.22%
7	20 mL	500	4.5	99.10%

4. Discussion

Using *M. oleifera* seed powder without any previous treatment increases the organic load in the water to be treated, which decreases the efficiency of the process, as well as contributing to the formation of trihalomethanes when the water has residual chlorine [5,6] for this reason, the active agent must be extracted from the seeds, but it has been shown that these extractions continue to increase the organic load of the water, except for the NaCl saline solution that increases to a lesser extent the organic load [6] which is contradictory where the use of the natural coagulant of said seeds based on saline solutions (NaCl) does not increase the dissolved organic carbon (COD) and is effective in the treatment of low turbidity waters [4]. On the other hand, state that using the coagulant extracted from the seed to a lesser extent decreases the COD [7]. In the purification coagulant high costs are required for its realization [8], which is not economically viable for community treatment plants, for this reason, only spraying and extraction were carried out.

The coagulation-flocculation processes of the extracts or natural inputs help, in addition to reducing turbidity and apparent color, to eliminate pathogens and microorganisms associated with the colloidal material that is removed, in this context, *M. oleifera* powder shows efficacy as a natural coagulant in the removal of cyanobacteria and the removal of odorous organic matter when oil is extracted from seeds [6]; the ability of *M. oleifera* seed extracts to remove microalgae through coagulation and flocculation processes

have also been demonstrated [9]. Some of the reports on the efficacy of *M. oleifera* seed in the removal of turbidity above 85% up to 96%, as demonstrated by the results, should be highlighted.

5. Conclusions

The saline extraction of *M. oleifera* seeds has the potential as a natural coagulant for the purification of water for human consumption. It is expected to be a first step to design accessible and low cost methods for use in community aqueducts and in populations without access to potable water.

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Conflicts of Interest: The authors declare no conflict of interest.

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