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Performance of Moringa oleifera seed extract in the coagulation-flocculation process for the treatment of domestic wastewater

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ABSTRACT/RESUME

Abstract: *Moringa oleifera (MO) is a multipurpose tree with considerable potential and its cultivation is currently being actively promoted in Algeria. The coagulant capacity of MO seed extract for the wastewaters of Sidi Bel Abbes, was assessed by sedimentation time, removal of turbidity and effect of acidity. The local seeds of MO from the city of Ghardaïa (Algeria) were prepared using different equipment, including a grinder, a mortar, blender, and a mixer. The coagulation process has been studied in terms of pH, dose of coagulant, and sedimentation time. The absorbance profiles and the FTIR spectra reveal the presence of amino acids, in MO seed extract, the arginine and histidine are the main constitute, their intense bands are very characteristics. These proteins are the active agents responsible of the coagulation. Furthermore, the results showed that extraction with NaCl is more efficient than extraction with water, since the elimination of turbidity has reached a very high rate of 99%, during a short sedimentation time of 1h. This is due to the salting-in mechanism of NaCl extract. The MO seed extract is proved to be an excellent coagulant for the wastewaters treatment.*

I. Introduction

Coagulation−flocculation is a longtime technology having worldwide applications in water and wastewater treatment. As a result of the public's increased awareness, more attention has been focused on environment friendly and eco-safety measures based on natural coagulants to combat the prevailing difficulties. MO seeds are one of the natural materials that can act as primary coagulant. In term of the degree of purification required, they are three main steps in MO coagulant preparation: a) flour preparation (primary), b) protein extract (secondary), and c) purification (tertiary)**.** The active compound for coagulation from MO can be extracted using water or salt solution [1]. In addition**,** previous studies have described the active component from MO as a water-soluble protein with a net positive charge [2], as dimeric cationic proteins with molecular mass of 12–14 kDa and isoelectric point between 10 and 11 [3]. Others reported a molecular mass of 6.5 kDa and a isoelectric point greater than 10 [4]. On the other side, [5] reported that the active component from an aqueous salt extraction was not a protein, polysaccharide or lipid, but an organic polyelectrolyte with molecular weight of about 3.0 kDa. This suggests that the water and salt extract is also of different nature.

Several studies have shown that NaCl is the extracting agent of MO protein, [6], [7], [8]. Moreover, [9] compared the efficacy of different MO seed extracts obtained, using different concentrations of NaCl solution as a natural coagulant in drinking water treatment. The obtained results disclosed that the best removal efficiency of color, turbidity, and UV-254 nm occurred with 1M NaCl.

The varying reports on the nature and properties of the coagulant protein from MO thus necessitate

further study. Additionally, currently used purification methods involve multiple steps, which complicate the use of MO seed extracts in large-scale treatment applications [6].
Our purpose was to improve the extraction process of the coagulant agent from MO. Since the active coagulant agent in the MO seed is considered as a soluble cationic protein, it becomes interest to investigate coagulant agent extraction using 1M NaCl solution and distillate water. Those disposing of high potential of solubility.

II. Materials and methods

II.1. Preparation of MO seeds as coagulant

The processing of MO were prepared at Materials and Catalysis laboratory, University of Sidi Bel Abbes, Algeria. Local MO seed was purchased from Ghardaia city (Algéria), they were used as a coagulant in this study. The seeds were removed from the pods and the husk enveloping of each seed was deshelled by hand**.** Thereafter, dries seeds were then selected, and the kernel was ground to a fine powder using an electric grinder, the powder was then stored at room temperature. In order to obtain the active components for coagulation process the resultant powder was dissolved with suitable solvent following the methodology described by [10], 5.0 g of the obtained powder was dissolved in100mL of extract (NaCl 1.0 mol L^{-1}, distillate water). This mixture was kept under magnetic stirring for 30 min and then passed through filter paper and kept refrigerated at 4 °C.

II.2. Wastewater sampling

The effluent samples were collected from the wastewater collection station of a large residential area in Sidi Bel Abbes city, Algeria.
The samples were collected, stored and refrigerated at 4 °C, The different physicochemical parameters are presented in Table 1.

Table 1. Physicochemical characteristics of Sidi Bel-Abbes plant wastewater.

Parameter	Range
pH	8.31-8.58
Turbidity (NTU)	720-1000
Total suspended solids	80-250
UV-Vis $_{254\text{-abs}}$ (cm^{-1})	0.186-0.312
COD (mg/L)	468-531
TOC/SCWO (mg/L)	198-227
Colour as Vis-abs. at 400 nm (cm^{-1})	0.085-0.12

II.3. Coagulation-flocculation assay

The jar test was performed to optimize the coagulation process and to determine the optimum parameters (coagulant dosage, pH) on coagulation mechanism. The coagulation activity of MO was verified by using a four-paddle jar-test apparatus (Lovibond ET 730 Portable Floc Tester). A rotation speed of 200 rpm was applied for 2 min pursued by a slow stirring of 40 rpm for 20 min. After sedimentation time of 60 min**,** 20 ml of the supernatant, which was sampled from a depth of 3 cm from each beaker, was collected to perform analyses. All tests were operated in a temperature-controlled room at 25°C.
The removal efficiency for turbidity was calculated according to equation 1.

$$Removal\ Efficiency(\%) = \frac{(T_i - T_f)}{T_i} * 100 \qquad \textbf{(1)}$$

In which T_i and T_f are the initial and final values of turbidity.

Turbidity test of wastewater samples was measured using DR/890 (HACH) colorimeter.

III. Results and discussion

III.1. Characterization of coagulants

III.1.1. Infrared Analysis

Figure 1 shows FTIR analysis from 400 to 4000 cm^{-1}, to analyze the presence of different active functional sites.

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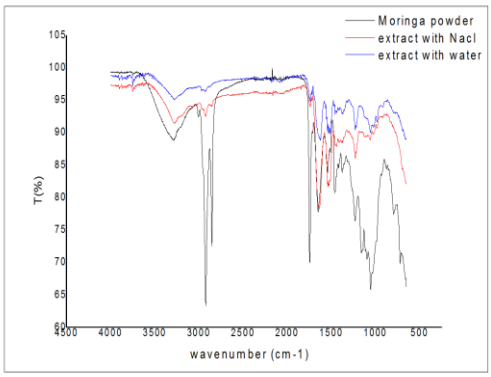

Figure 1. *The FTIR spectra of MO powder and extracts.*

The bands in the region of 3200–3500 cm^{-1} may be attributed to the presence of amine groups (NH) present in the proteins, the bands in approximately 2933cm^{-1} are assigned to the symmetric and asymmetric stretching of group C-H-CH_2 [11]. The peak manifested at 1736 cm^{-1} can be related to the C=O vibration stretching of − COOH [12]. The peaks illustrated at 1624 cm^{-1} and 1510 cm^{-1} can be assigned to C–O stretching vibration mode of the I and II amines in the proteins (NH2 C–O) [12].The peak at 1230 cm^{-1} can be assigned to the C–O vibration stretching in phenols [13]. Thus, in general, the FTIR's spectra of Moringa showed the presence of various functional groups.

III.1.2. Absorbance profiles of MO seeds extract samples

Figure 2 shows the absorbance profiles of MO seeds extract samples from 200 to 320 nm wavelengths. The procedure used for UV absorption spectrum analysis of both protein extracts 0.1 ml of crude protein extract was added to 6 ml of the extracts, mixed well, and the absorbance value was taken from A_{200}-A_{320} UV wavelengths

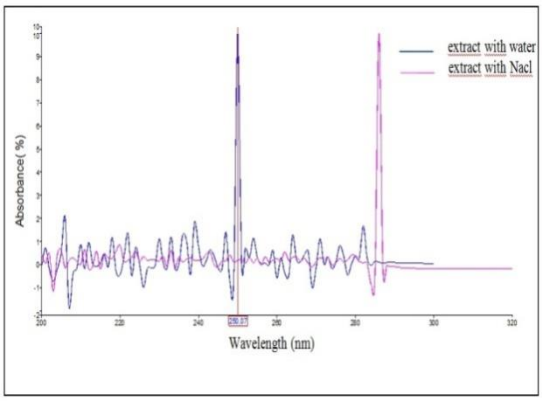

Figure 2. *Absorbance profiles of MO seed extracts samples from 200 to 320 nm wavelengths.*

The spectrum presented in Figure 2, reveals two intense bands at 250 and 286 nm respectively, these bands are characteristic of the presence of amino derivatives in Moringa seeds. As seen, the extraction depends on the type of extract, so with NaCl extract, the spectrum shows an intense band at 280 nm characteristic of the arginine species (amino acids). While with distillated water extract, the spectrum shows an intense band at 250 nm characteristic of aniline and its derivatives (histidine or pyridine) carrying auxochromic groups (OH). The improvement of coagulation efficiency by NaCl solution as extract is apparently due to the salting-in mechanism in proteins wherein a salt increases protein-protein dissociations and protein solubility as the salt ionic strength increases [7].

III.2. Effect of initial pH

Different trials were carried out, varying the pH of wastewater between the interval 4-9 of pH unit. The pH was adjusted by the addition of HCl (0.1M) or NaOH (0.1M) solutions. Figure 3 illustrates the effects of pH on turbidity removal using both NaCl 1M and distillate water extract. The extract with NaCl showed high coagulation activity at pH= 6. As we see, a concentration of this extract can remove till a rate of 93,8% after 1 hour of sedimentation, and little coagulation activity was noted below pH 5. At higher pH around 7unités of pH, a concentration of 20ml/L of distillate water can remove 92.3% of turbidity for the same time of decantation. The coagulation active agent of MO seed was recognized to be a protein with cationic peptides of relatively low molecular weight, and the proposed mechanism of coagulation could be explained by neutralization charge. The protein has eight positively charged amino acids (7 arginines and 1 histidine) and 15 glutamine residues. Through electrostatic interactions, negatively charged particles are attracted by cationic charges of the MO protein [14].

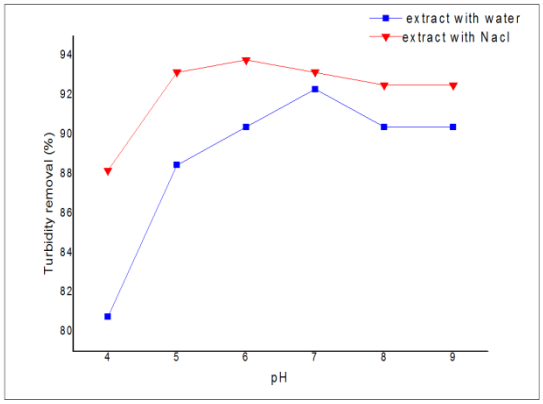

Figure 3*. Effect of initial pH on turbidity removal. Coagulant dosage 20ml/L, sedimentation time 1h, room temperature 25± 1°C.*

III.3. Effect of coagulant dosage

Coagulant dosage is an essential parameter to be considered during flocculation as overdosing or insufficient dosing might affect the treatment efficiency.

As showed in Figure 4, a rate of 99% of the turbidity removal can be achieved by using 20ml/L of the NaCl extract solution. Better coagulant properties have been reported for salt solution extraction compared with water extraction [15]. Additionally, small flocs formed were observed by using NaCl in MO solution.

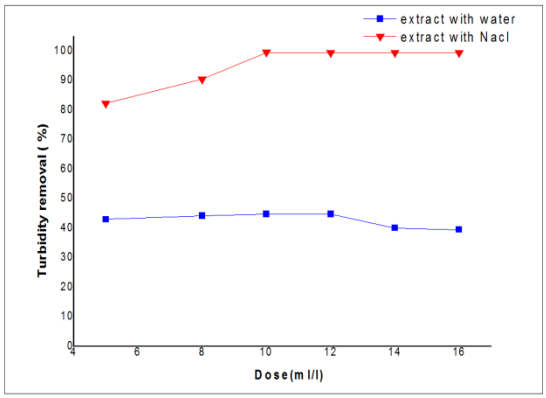

Figure 4*. Effect of coagulant dose on turbidity removal.*

III.4. Effect of settling time

As shown in Figure 5, the turbidity removal increases with the increasing of sedimentation time. After 1h we note that high rate of 99.35% of turbidity can removed by NaCl 1M extract, during the same time of 1h, a rate of 94.17 % of turbidity was removed by distillate water extract, beyond 1h the removal efficiency begin to decreases.

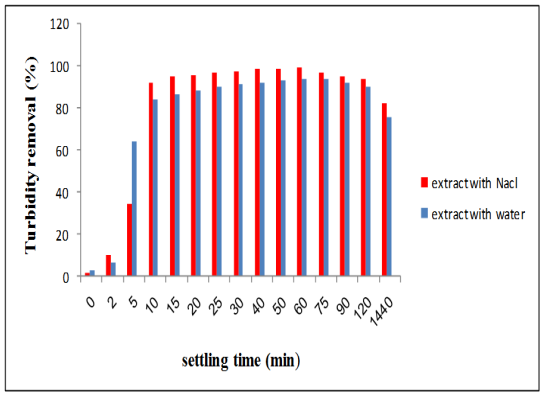

Figure 5. *Effect of settling time on turbidity removal.Eextract dosage 20ml /L, pH=6, room temperature 25 ± 1°C.*

IV. Conclusion

An improvement method of extracting active agents of MO seeds was investigated. These agents acting as substitute coagulants for conventional coagulants. The extraction of the active agent of moringa by the electrolyte NaCl 1M, gave better results than the extraction with distilled water, since the elimination of turbidity reaches high rates of 99% for relatively short sedimentation times of 1 hour. From an economic point of view, these extraction methods are less expensive than another extraction method because less energy is required for its operation.

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