Application of *Moringa oleifera* Seed in Removing Colloids from Turbid Wastewater

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Abstract**—**The present study aims to investigate the performance of *Moringa oleifera* seed extract as natural coagulant in clarification of secondary wastewater treatment plant (MWWTP) located in East of Algiers, Algeria. Coagulation flocculation performance of *Moringa oleifera* was evaluated through supernatant residual turbidity after jar test trials. Various influence parameters namely *Moringa oleifera* dosage and pH have been considered. Tests on Reghaia wastewater, having 129 NTU of initial turbidity, showed a removal of 69.45% of residual turbidity with only 1.5 mg/l of *Moringa oleifera*. This sufficient removal capability encourages the use of this bioflocculant for treatment of turbid waters. Indeed, *Moringa oleifera* which is a natural resource available locally (South of Algeria) coupled to the non-toxicity, biocompatibility and biodegradability, may be a very interesting alternative to the conventional coagulants used so far.

Keywords**—**Coagulation flocculation, colloids, *Moringa oleifera*, secondary wastewater.

I. Introduction

COAGULATION flocculation process is commonly used in water treatment in order to remove turbidity and natural organic matter. This process occurs in two stages to accelerate the colloids sedimentation by the injection and the scattering of chemical coagulants [1]. These coagulants aggregate the colloidal particles and dissolved organic matter and easily eliminate them by sedimentation, flotation or filtration. Coagulation is generally induced by metals salts. The most widely and commonly used are aluminum and iron salts. The addition of these chemicals engenders colloidal destabilization by electronegative charge neutralization of colloids leading to the formation of micro-flocs [2]. Flocculation permits, by the addition of synthetic polymers such as polyacrylamide, to bind the micro-flocs together through slow mixing. Then, a simple separation step eliminates the flocs. These coagulants are classified into inorganic, synthetic organic polymer and natural coagulants. The two most commonly used as primary coagulants are aluminum and iron (III) salts [3]. However, the use of such chemicals, particularly aluminum, may have several environmental consequences:

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- ✓ human health implications such as Alzheimer’s and other diseases with carcinogenic properties [4];
- ✓ production of big volumes of sludges [5];
- ✓ the problem of reaction of alum with natural alkalinity present in the water leading to a reduction of pH and low efficiency in coagulation in cold water [6];
- ✓ the use of alum and iron salts is inappropriate in some developing countries because of the high cost and low availability of chemical coagulants [7].

To avoid such problems, different environmentally friendly coagulants are proposed. If they are locally available, natural coagulants can be suggested as an interesting alternative for water treatment.

Recently, an increasing interest has been heading for developing biomaterials. These later include modified starches, celluloses, chitosan, and microbial materials produced by micro-organisms as well as bacteria, fungi and yeast. Because they are natural materials, locally available, they may have a very low cost. Technically, these bioproducts are easy to use, don’t endanger the handler and they have a wider effective dosage range for flocculation of colloidal suspensions [5]. Moreover, sludge treated with bioflocculants can be reused on agricultural land [8].

Moringa oleifeira is a tropical plant belonging to the family of *Moringaceae*. *Moringa oleifera* is a no toxic [9] and natural organic polymer. From its seed (Fig. 1), a cationic polyelectrolyte, polypeptides in nature with molecular weight of 6 to 16 kDa can be extracted. Amino acid analysis and sequencing of *Moringa oleifera* showed high contents of glutamine, arginine and proline as well as total of other 60 residues [10]. It has been shown to be one of the most effective primary coagulants for water treatment [11]. Based on zeta- potential measurements, [12] has reported that the predominant mechanism of the coagulation with *Moringa oleifera* appeared to be adsorption and charge neutralization.

A literature review indicates that compared to alum, the *Moringa oleifera* seed in diverse, extracted and purified forms, has proved to be effective in removing suspended particles, generating a reduced volume of sludge [13]. *Moringa oleifera* powder has been reported to have the capability of reducing low and high turbidity values in surface water [14] and has a bacterial removal range of 90-99% [15].

The present study is aimed to evaluate the efficiency of *Moringa oleifera* as a biomaterial for clarify wastewater of secondary treatment by coagulation flocculation process. For this propose, coagulation flocculation sedimentation tests were conducted in laboratory using a conventional Jar Test. In this study, wastewater from Reghaia municipal WWTP (located at

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30 km East of Algiers, Algeria) was tested. The performance of the coagulation flocculation was assessed by measuring the supernatant residual turbidity of the aqueous solution for various parameters, namely, *Moringa oleifera* dose and pH.

II. Methods

To investigate the effectiveness of the natural organic coagulant namely *Moringa oleifera*, laboratory trials have been carried out. The experimental methods were predominantly based on the Standard Methods [16].

A. Preparation of Moringa olfeifera Solution

Moringa oleifera seeds used in this study come from Adrar city (1400 km south-west of Algiers). The product in its natural state is a solid yellow in color (Fig. 1). The Mature seeds removed from the dry pods were peeled and crushed using a laboratory blender. The obtained powder was dissolved in the solution (1M NaCl) distilled water) with slow stirring for 30 minutes at room temperature (laboratory). Each 1 ml of the solution corresponds to 1 mg of *Moringa oleifera*.

B. Coagulation Tests

Coagulation trials were carried out using a conventional Jar test apparatus (flocculator) with six beakers. Each one was filled with 1 litter wastewater.

Fig. 1 *Moringa oleifera*

C. Experimental Trials

Experimental runs were done to test the flocculation ability of *Moringa oleifera* as primary coagulant for treatment of Reghaia wastewater which have initial turbidity of 129 NTU. Beakers were filled with 1000 ml of samples, and placed on the flocculator and agitated at the preselected intensity of rapid mixing 125 rpm maintained for 4 minutes. During rapid mixing, the *Moringa oleifera* dosage was added into each beaker simultaneously. After that, slow mixing 40 rpm for 25 minutes was quickly established and the beakers were then carefully removed from flocculator and left for the sedimentation phase. After settling, 20 ml of the sample was taken from the middle of each beaker for turbidity measurement. Different dosages of *Moringa oleifera* stock solution were added into the beakers. Indeed, the optimum dosage corresponds to the lowest turbidity.

D. Analysis

To study the parameters involved in the coagulation of the colloidal particles, several methods may be used, such as COD analysis, determination of colloidal titration, electrophoretic mobility, spectrophotometric analysis, and measurement of turbidity. In our study, turbidity measurement has been adopted because it is easiest and most effective. For this purpose, we have used turbidimeter (Hanna Instruments®: LP2000). The turbidity is expressed in Nephelometric Turbidity Units (NTU). To assess analytically the coagulation flocculation effectiveness, in term of turbidity removal, the supernatant was removed from the top of the solution by siphoning.

III. Results and Discussion

A. Effect of Moringa oleifera Dosages

The residual turbidity of the supernatant of Raghaia wastewater as function of *Moringa oleifera* seed extract dosage, at actual pH and settling time of 30 min is plotted in Fig. 4. This later allows us to determine the most appropriate coagulant dose corresponding to the optimum one.

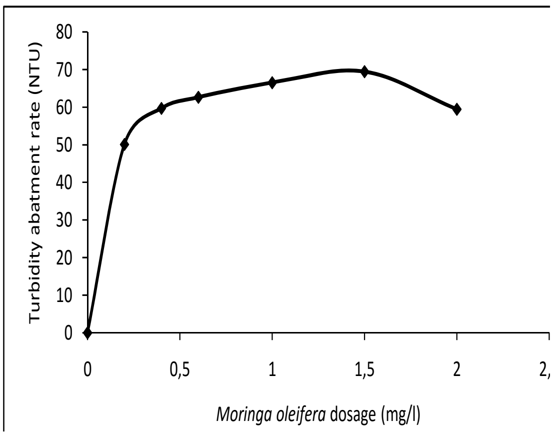

Fig. 2 Effect of *Moringa oleifera* dosage on abatement rate of turbidity at actual pH (7.8) and 30 min of settling time

From this figure, it can be detected that at 1.5 mg/l of *Moringa oleifera,* a reduction in residual turbidity from 129 NTU to 39.4 NTU corresponding to 69.45% of abatement rate. Beyond this dosage which is considered to be the optimal dose, the turbidity increases again.

As experimental observation, a numerous flocs of medium size appeared a few minutes after adding *Moringa oleifera.* Flocs are fibrous in form, falling down the beaker as snow. A quick clarification of the solution was appeared just when slow agitation is over (Fig. 3).

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Fig. 3 Secondary wastewater clarified by *Moringa oleifera*

The trend of the curve reflecting the influence of dose of *Moring oleifera* on the residual turbidity may be related to the coagulation function of *Moring oleifera* thanks to its active components called cationic peptides of molecular weight of 6 to 16 kDa and isoeletctric pH value of 10. Indeed, *Moringa oleifera* with its high cationic property is expected to neutralize the negative charges on the surface of particles. Even, *Moringa oleifera* cationic properties facilitate the adsorbing the particles causing an inter-particle collisions leading to the micro-bridge formation and hence improve effective water treatment [17]. Shapally [18] has reported that *Moringa oleifera* seed extract resulted in better settling of particles due to charge neutralization aiding particles to adhere each other forming larger particles, thus they settle very fast.

B. Effect of pH Adjustment

Fig. 4 corresponds to the changes in turbidity abatement as a function of the dose of *Moringa oleifera* for pH = 5 for a settling time of 30 min.

From this figure, it can be seen that 0.3 mg/l is the optimal dosage of *Moringa oleifera* for which turbidity has been reduced from 129 to 15.91 with an abatement rate of 87.66%. Flocs formed during rapid mixing were visible in the slow stirring. They settled rapidly due to their considerable size (1 to 2 mm).

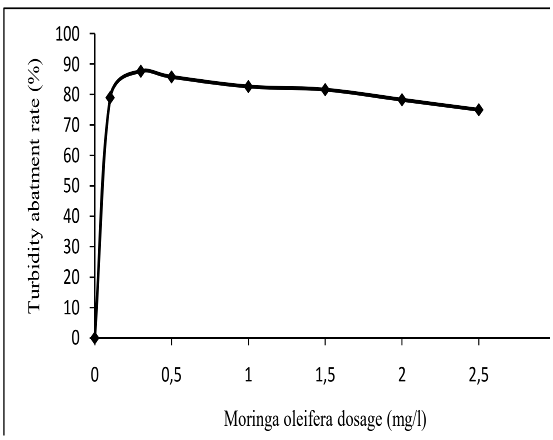

Fig. 4 Effect of *Moringa oleifera* dosage on abatement rate of turbidity at pH 5 and 30 min of settling time.

At low pH, proteinic nature of *Moringa oleifera* makes this extract in its cationic form, which allows inducing an Electrostatic attraction between *Moringa oleifera* cationic proteins and negative-charge of particles [19]. Beltrán-Heredia and Sánchez-Martín [20] investigated the influence of pH on the removal of sodium lauryl sulphate (a common surfactants), by M *Moringa oleifera* seed extract. They have reported that as pH increases, efficiency of the process decreases, due surely to the cationic character of the Moringa protein and to the fact that at acid pH hydrophobic links are enhanced.

IV. Conclusion

Experiments were conducted to determine the *Moringa oleifera* ability as natural flocculant for clarify Reghaia's wastewater. Through the experiments series, it is found that *Moringa oleifera* was effective for coagulation flocculation process. This bioflocculant may be more effecient at acidic pH (5). Hence, *Moringa oleifera* could be used as natural coagulant for wastewater treatment with the low environment risks.

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