A Study on the Efficiency of Fatted and Defatted *Moringa Oleifera Seed Extract* (MOSE) on Indigo Carmine Dye Removal

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Abstract

Moringa Oleifera (MO) has been tested as an environment-friendly natural coagulant/ flocculant agent in treating surface waters and wastewaters from dyestuffs. It is well known for its high coagulation properties with low cost. This study focused on the preparation of defatted and fatted natural coagulant known as Moringa Oleifera Seed Extract (MOSE), determination of the coagulation/flocculation efficiencies of MO seeds and compare with several inorganic coagulants, and lastly analyse the MOSE quality for long term storage. Two key parameters such as dye concentration and color were compared before and after the treatment of dye water. The sample used in this experiment was Indigo Carmine dye water of 250 ppm. The dosages for both defatted and fatted MOSE were varied taking 5g/L, 6g/L, 7.5g/L, 10g/L, and 12.5g/L at pH 4, 7, and 10. Also, the dosages for alum and ferric were varied taking 5g/L, 7.5g/L, and 12.5g/L at pH 4, 7, and 10. Ferric showed the highest color removal efficiency at the lowest dosage at all pH. On the other hand, defatted MOSE color removal efficiency at the lowest dosage was close to fatted MOSE at pH 4 and showed higher removal efficiency with the increasing dose and pH. Almost all the coagulants showed same concentration reduction efficiency and the range was between 86% and 96%. Alum showed no color/concentration reduction efficiency in all cases. Overall, this study indicates that MOSE can be a good choice as a potential coagulant in the treatment of textile wastewater, but more studies are required for the optimization of the efficiencies.

Keywords: Moringa Oleifera Seed Extract, coagulation, flocculation

1. Introduction

Bangladesh is facing a big challenge with managing the textile wastewater. There are almost 4500 textile factories in Bangladesh and the only source of water is mostly the groundwater for all these industries. The groundwater level is decreasing every year at an alarming rate. If this decrease in level continues, in 10 years the factories will start facing a scarcity of water. A search on something to remove the dye from the wastewater and reuse those has been going for a long time. Besides using the conventional inorganic coagulants like Alum or $FeCl_3$, seed extract from M. Oleifera, a plant based natural coagulant, has been used to treat wastewater in other countries. Stephenson & Duff (1996) have studied that coagulation flocculation is a very effective process for wastewater treatment. In these process, inorganic coagulants and synthetic or natural polymers are added to wastewater in order to destabilize colloidal material and to cause the aggregation of small particles into larger, more easily removed flocs. Narasiah et al.(2002) and Dezfooli et al.(2016) have studied that inorganic coagulants are not biodegradable, produce great amounts of silt and, their coagulant efficiency depends on pH. Ali et al.(2010) studied that naturally found coagulants are safe for human health and not toxic. Moringa Oleifera is the most suited natural coagulant to be compared with the inorganic for wastewater treatment in developing countries. Ndabigengesere, Narasiah, & Talbot (1995) have studied that MO is widely cultivated in this region. It can produce larger, denser and more complex flakes. Researchers say that Moringa has the water clarifying power due to a cationic protein of high molecular weight which destabilizes the particles of water. It can be used in large scale because of its low cost and high abundance in nature. It is used to reduce color and concentration of dye from textile wastewater. It can be used in both fatted and defatted condition. Defatted condition needs an extra step of extraction of fat from the dry seed. Yin(2010) has studied that using MO as a natural coagulant has some disadvantages too. It introduces unwanted amount of organic materials and microbes to the treated water. It works as a source of nutrients for the micro-organisms. So, it may carry some pathogenic germs. Long-time exposure to it may need another step of purification for the treated water. Overall, the need for treating this commonly used dyestuff in a noble way has been the prime concern. This paper mainly focuses on the process of treating dye water with both fatted and defatted moringa oleifera seed extract (MOSE) and, compare with Alum and $FeCl_3$

2. Methodology

2.1. Preparation of Powdered Moringa Oleifera Seed Powder

Firstly, MO seeds were washed and dried in the oven at high temperature (Approx. 100-120 °C) to weaken the protective outer covering. The dried seeds were then blended and manually grinded using a mortal shell to transform into homogeneous powder. The powdered seeds were then screened and stored in the room temperature (25ºC).

Fig. 2.1 Powdered *M. Oleifera* seed in two forms.

2.2. Preparation of Moringa Oleifera Solution

The powdered MO seeds were defatted using the hexane as a solvent in the soxhlet extractor. The powder was taken in a thimble and placed in the soxhlet apparatus. Hexane was taken in a round bottom flux. A heater was placed under the soxhlet apparatus to heat the whole system. Six cycles were run in total before the hexane beside the thimble had become colorless again. Then the following procedure was followed from Beltran-Heredia et al. (2009). 5 g of defatted MO was added in 100 mL distilled water and 5% (wt%) NaCl was added in this solution. This mixture was stirred and placed on a shaker for 30 minutes at 150 rpm. The solution was then filtered twice using commercial and whatman 44 filter paper sequentially. The filtrate was the stock solution. Five solutions of 5g/L, 6g/L, 7.5g/L, 10g/L,12.5g/L were prepared. Fatted MO solution was also prepared in the same manner.

2.3. Experimental

25 mg dye powder was added in 100 mL water. A 250 ppm dye solution was prepared. 10 ml of dye solution was taken in five different test tubes and different doses of defatted MO solution were added in each test tube. After mixing of each dose, the pH of these solutions was made 7. Similarly, another five different solutions were prepared for pH 4 and 10 where pH was controlled by using slight amount of H_2SO_4 and NaOH respectively. All the solutions were kept for 16 h to observe. Same procedure was applied for fatted MO solution. To compare the performance of coagulants, $FeCl_3$ and Alum solutions were also prepared. The solutions were prepared of 5g/L, 7.5g/L and 12.5g/L. These solutions were mixed with 10 ml dye solution in three different test tubes and the pH was set at 7. For $FeCl_3$, another three different mixed solutions were prepared for pH 4 and 10 where pH was controlled in the same manner. Alum was tested only at pH 7.

2.4. Measurement of Color and Concentration

The *M.Oleifera*, ferric and $FeCl_3$ solutions were placed on a shaker for 25 minutes at 150 rpm. This aided in the coagulation process. The solutions were remained stagnant for floc formation after the shaking. All the solutions with coagulants were taken after 16 hours observation. To measure the concentration, a calibration curve of known concentrations of the dye was first generated. All the samples were then placed into the HACH DR 6000 spectrophotometer one by one to observe the peaks of their absorption vs. wavelength curve. After taking the peak values, the concentration of each sample was determined with the help of the calibration curve. The color of the raw dye water and the treated dye solutions were measured using the spectrophotometer. The program color 465 nm was set. Some samples were needed dilution for determining the accurate color value. In this case, the dilution factor was multiplied with the read value.

2.5. Long term storage of MOSE

To check the storage condition further, the prepared fatted MOSE solution was kept for 1 month in a closed container at room temperature and pH 7.

3. Results and Discussion

The following results varied at some points from the previous literatures. MOSE didn't show any instant coagulation performance in this experiment. It took almost 16 hours to remove the color and form flocs. Whereas, $FeCl_3$ showed an instant color change of the dye solution but the floc formation took time for it too. pH had little effect on MOSE solution according to the Beltran-Heredia et al. (2009), but pH showed remarkable effect in this experiment. Fatted MOSE showed better efficiency at lower pH and the defatted MOSE at higher pH. This difference between the optimum pH in fatted and defatted part could be because of the oil content difference. Geological location could influence this matter too as none of the previous experiments were performed in Bangladesh to the best of author's knowledge. The optimum pH of $FeCl_3$ was found 6.8 before, but in this experiment the coagulation performance was not much affected by pH. It showed almost same performance at all pH.

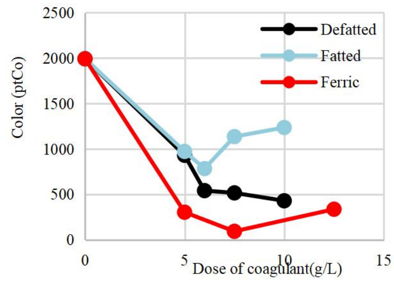
MOSE was not suitable for long time storage at room temperature. Long-time storage made the seed extracts dry, dark color which gave a turbid solution. After the given time interval, the MOSE solution turned into a turbid solution. This was probably due to huge amount of microorganisms grown in it. The finding was also observed in Katayon et al. (2006). The *M.Oleifera* seed typically contains protein, iron, calcium, ascorbic acid vitamin A and antioxidant compounds such as carotenoids, flavonoids, vitamin E and phenolics. It was also observed that the pH of the solution became slightly acidic. This was probably due to the acidic content (e.g. ascorbic acid) present in the solution.

Table 3.1. Color readings for defatted, fatted MO and $FeCl_3$ at different pH.

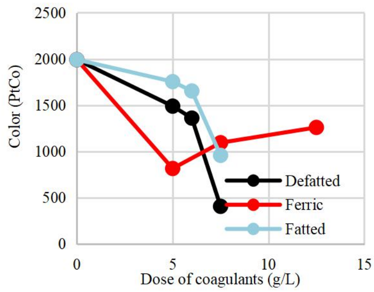
Dose of coagulants (mg/L)	Defatted MO Color Readings (Pt-Co)			Fatted MO Color Readings (Pt-Co)			$FeCl_3$ Color Readings(Pt-Co)		
	pH 4	pH 7	pH10	pH 4	pH 7	pH10	pH 4	pH 7	pH 10
0	1992.7	1992	1992	1992	1992	1992	199	1992	1992
5	930.6	1490	784.4	973	1755	817.8	304	67	816
7.5	516.8	407	452	1136	958	604	94	55	1094
12.5	3130	3840	4090	2090	3065	2500	337	323	1260

Table 3.2. Concentration readings for defatted, fatted MO and $FeCl_3$ at different pH.

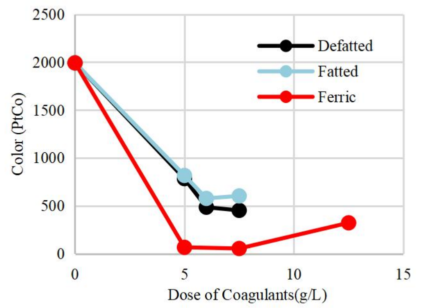
Dose of coagulants (mg/L)	Defatted MO Concentration Readings (ppm)			Fatted MO Concentration Readings (ppm)			$FeCl_3$ Concentration Readings(ppm)		
	pH 4	pH 7	pH 10	pH 4	pH 7	pH 10	pH 4	pH 7	pH 10
0	250	250	250	250	250	250	250	250	250
5	18	40	29	45	22	33	5	5.34	10
7.5	18	30	27	38	34	31	11	5.11	14.5
12.5	33	16	32	24.7	39	38	12.5	4.76	12.5



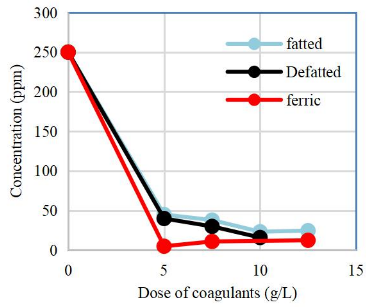
a. Color (PtCo) vs dose of different coagulants at pH 4



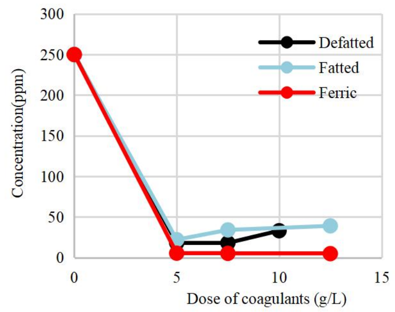
b. Color (PtCo) vs dose of different coagulants at pH 7



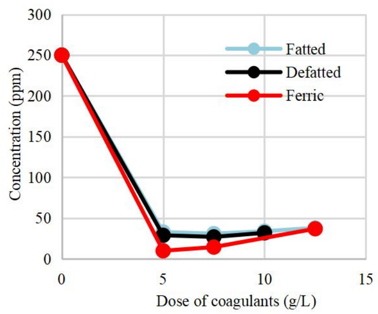
c. Color (PtCo) vs dose of different coagulants at pH 10



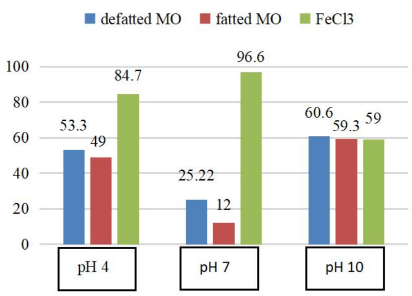
d. Concentration vs dose of different coagulants at pH 4



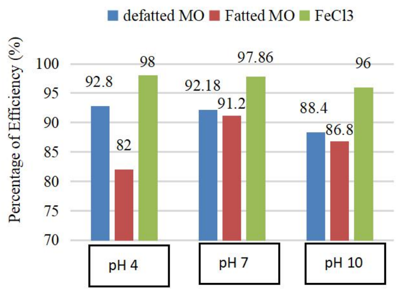
e. Concentration vs dose of different coagulants at pH 7



f. Concentration vs dose of different coagulants at pH 10



g. Color removal efficiency (%)



h. Concentration reduction efficiency (%)

Fig. 3.1 Graphical representations of a,b,c. Color removal at pH 4,7,10 of different coagulants. d,e,f. Concentration vs dose of different coagulants at pH 7,4,10. g,h. Color and Concentration removal efficiency

4. Conclusions

- In color removal, $FeCl_3$ showed better efficiency than other coagulants, but it worked better in acidic or neutral environment. Fatted MO seed was not so effective in neutral environment compared to defatted MO seed.

- In concentration reduction, all three coagulants showed considerably close efficiencies.
- Although this study showed a novel way of treating textile dyestuffs, further studies will be required for the optimization of the efficiencies.

5. References

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