EFFECTS OF STORAGE DURATION AND TEMPERATURE OF *MORINGA OLEIFERA* STOCK SOLUTION ON ITS PERFORMANCE IN COAGULATION

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ABSTRACT

This study presents the effects of storage duration and temperature of Moringa oleifera stock solution on its coagulation efficiency. Moringa oleifera stock solutions, which were kept at room temperature (28℃), were able to remove turbidity from medium, high and very high turbidity water samples and no coagulation activity was observed for low turbidity water and surface water tested. The highest turbidity removals were observed for stock solutions, which were kept for one day. For Moringa oleifera stock solutions, which were stored longer up to 3 days, the turbidity removal efficiencies decreased to 73.6%, 86.8% and 92.3 % for medium, high and very high turbidity water samples respectively. In the case of medium and high turbidity water samples, Moringa oleifera stock solutions, which were kept for more than 3 days did not perform any coagulation process, while for very high turbidity water sample, it was found to coagulate slightly about 14.9 % and 3.9 % for those which were stored for 5 and 7 days, respectively. For those Moringa oleifera stock solutions, which were stored at 3℃ up to 5 days, no significant differences were found between their turbidity removal efficiency on medium, high and very high turbidity, while those that were stored for more than 5 day did not perform coagulation. For surface water and low turbidity water samples significant differences were observed between turbidity removal efficiency of Moringa oleifera stored for different durations. Highest turbidity removal for surface water and low turbidity water were obtained using Moringa oleifera which were kept for 3 days or less and it decreased when using Moringa oleifera stock solution, which were stored longer.

***Key words**: Moringa Oleifera, Natural Coagulant, Storage Duration, Storage Temperature, Turbidity Removal*

INTRODUCTION

Turbidity removal is one of the important steps in water treatment process and generally is achieved using coagulation process. Many coagulants have been widely used in conventional water-treatment processes depending on their chemical characteristics. Recent studies have pointed out several serious drawbacks of using two most common coagulants aluminum and iron salt, such as Alzheimer's disease, production of large sludge volume reduction of pH and low efficiency in coagulation in cold water [1]. In addition, their application is inappropriate in some developing countries because of the high cost and low availability.

Several studies on using natural coagulants produced or extracted from microorganisms, animals and plants have been carried out [2,3,4]. Among all the plant materials that have been tested over the years, the seeds of *Moringa oleifeira* have been shown to be one of the most effective primary coagulant for low-cost water purification with potential usage on a large scale in tropical developing countries [5,6,7,8,9,10]. Muyibi and Evison focused on the physical factors affecting the use of *Moringa oleifera* seeds in the coagulation of model turbid water [6]. Other studies have focused on quality of water treated by coagulation using two forms of the seed, shelled and unshelled [8]. However, systematic studies on the effects of storage duration and condition on its performance have not yet been carried out, which this study aimed to investigate.

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MATERIALS AND METHODS

Preparation of *Moringa Oleifera* Stock Solution

The *Moringa oleifera* was obtained from Klang, Selangor area. The seeds were dried in the oven (Memmert type ULE 400, Germany) for 24 hours at 50^{o}C. A rice husk removing machine (Satake Rice Machine type THU class 35A, kW: 0.2-0.4, 1900) and mortar and pastel were used to remove the hulls and wings from the kernels. The kernel were crushed and grounded to a medium fine powder with a domestic food blender (Moulinex). A 5000 mg of *Moringa oleifera* seeds powder was placed in a beaker containing 0.2 L of distilled water. The mixture was blended using domestic blender (Moulinex) for 2 minutes to extract the active ingredient of *Moringa oleifera*. The suspension was then filtered through a muslin cloth and the filtrate made up to 0.5 L to give a stock solution of 10,000 mg/L. 10000 mg/L of *Moringa oleifera* stock solution was used for jar test (BIBBY Stuart Scientific, UK) trials that were conducted to determine optimum dosages of *Moringa oleifera* on water samples of varying turbidities.

Storage of *Moringa Oleifera* Stock Solution

In order to study the effects of storage temperature, the stock solution were divided into two groups and stored at two different temperatures namely; room temperature (28°C) and at 3°C (refrigerator). The effects of storage duration on *Moringa oleifera* stock solution were investigated for 1, 3, 5 and 7 days.

Preparation of Water Samples

Experiments were carried out on different water samples including surface water and synthetic turbid water samples. Surface water samples were collected from a lake located at the Faculty Engineering, Universiti Putra Malaysia. Synthetic turbid water for coagulation tests was prepared by adding kaolin (Laguna Clay, USA) into distilled water. Ten grams of kaolin was added to 1 liter of distilled water. The suspension was stirred slowly at 20 rpm for 1 hour in a jar test apparatus (BIBBY Stuart Scientific, UK) for uniform dispersion of kaolin particle. The suspension was then allowed to stand for 24 hours to allow for complete hydration of the kaolin. This kaolin suspension was used as the stock solution for the preparation of water samples of varying turbidities for the coagulation tests. Four types of turbidities were carried out namely; low turbidity (<50 NTU), medium turbidity (50 NTU – 100 NTU), high turbidity (100 NTU – 200 NTU), and very high turbidity (> 300 NTU).

Experimental Procedures

Two sets of experimental studies were carried out as follows:

i. Optimization of *Moringa oleifera* dosages for coagulation of water samples (Table 1)
ii. Eight completely randomized experimental runs with varied storage durations and conditions using the design shown in Table 2.

Table 1. Operating variables used to run the jar test [11,12]

Initial turbidity (NTU)	Rapid mix velocity (rpm)	Rapid mix Duration (min)	Slow mix velocity (rpm)	Slow mix Duration (min)	Settling time (min)
Low	100	2	40	20	30
Medium	100	2	40	20	30
High	100	4	40	25	30
Very high	100	4	40	25	30

Table 2. Experimental runs for Moringa oleifera stock solution

Storage Duration	Storage Conditions									
	Room Temperature (28°C)					3°C				
	Water samples									
1 Day	SW	LT	MT	HT	VHT	SW	LT	MT	HT	VHT
3 Days	SW	LT	MT	HT	VHT	SW	LT	MT	HT	VHT
5 Days	SW	LT	MT	HT	VHT	SW	LT	MT	HT	VHT
7 Days	SW	LT	MT	HT	VHT	SW	LT	MT	HT	VHT

*surface water (SW), low turbidity (LT), medium turbidity (MT), high turbidity (HT), very high turbidity (VHT)

The water samples in the 500 ml beakers were agitated at the preselected intensity of rapid mixing (Table 1). During rapid mixing the *Moringa oleifera* was added into each beaker simultaneously. After rapid mixing, the preselected intensity of slow mixing was quickly established, subsequently the beakers were left for the sedimentation phase to take place. After settling, 20 ml of the sample was taken from the middle of each beaker using a pipette, and placed in small bottle for turbidity measurement. Turbidity measurements were conducted using Turbidimeter (HACH, model 2100P). For determination of optimum dosage, different amount of *Moringa oleifera* stock solution were added into the beakers and the amount that gave the lowest turbidity was the optimum dosage for that particular water.

RESULTS AND DISCUSSION

Optimization Of *Moringa Oleifera* Dosages

Results on optimum dosage of *Moringa oleifera* to obtain highest turbidity removal on different samples are presented in Table 3. Results showed that the optimum dosage of *Moringa oleifera* seeds extract was increased with increase in initial turbidity of the water sample. Furthermore higher turbidity removal was observed as initial turbidity of water samples was increased. This indicated that *Moringa oleifera* seed extract may not be an efficient coagulant for low turbid water. This result is in agreement with results reported by Muyibi and Evison [7].

Table 3. Optimization of Moringa oleifera dosages on different samples

Sample	*Moringa oleifera* concentration (mg/l)	Turbidity (NTU)		Turbidity Removal (%)	Zeta Potential (mV)		pH	
		Initial	Final		Initial	Final	Initial	Final
Surface Water	80	35.4	26.5	27	-22.4	-19.0	7.02	6.87
Low turbidity	80	48.3	26.0	61	-25.9	-7.81	6.56	6.22
Medium turbidity	160	87.8	21.3	79	-27.3	-13.3	6.77	6.36
High turbidity	300	194	22.0	89	-22.5	-5.89	6.82	6.49
Very high turbidity	400	390	23.6	94	-24.6	-8.82	6.85	6.65

Turbidity removal efficiency of *Moringa oleifera* on surface water and synthetic low initial turbidity water were 27 and 61%, respectively. This result revealed that although the same dosage of *Moringa oleifera* seed extract applied on both type of water samples, the synthetic turbid water showed better performance in terms of

turbidity removal. This phenomenon probably is due to the fact that the surface water is likely to contain substances like colour, organics, etc., which may inhibit the coagulation process.

Generally, the optimum dosages obtained in this study were found higher than those reported by Muyibi and Evison [7]. This difference is probably due to usage of different species of *Moringa oleifera*. According to Jahn about 14 species of *Moringa oleifera* have so far been identified and although all *Moringa* suspensions acted as primary coagulants, but the different species did not have the same coagulation efficiency [13].

As shown in Table 3, the initial zeta potentials of water samples were from -22.4 mV to -27.3 mV. This indicated that kaolin particles were charged negatively. After coagulation, the zeta potential was increased to a range of -5.89 to -19.0 mV. The result showed that there was a substantial increase in the absolute zeta potential, indicating a charge neutralization. Ndabigengesere *et al*. reported that the zeta potential of a 5 % solution of *Moringa oleifera* seeds is +6 mV [8].

Results presented in Table 3 indicated that *Moringa oleifera* seeds did not affect the pH value of water samples significantly. This result is in agreement with those reported by Ndabigengesere and Narasiah [1]. The overall pH of the treated water sample was around 6.5 to 7.0. A slight decrease in pH was observed after the coagulation process of *Moringa oleifera*. In practical terms, this indicates that further chemical addition is not required to correct the pH of the finished water to values between 6.5 and 8.5 [14]. The slightly decrease in pH may due to hydrogen ions of the weak acidity of *Moringa oleifera* stock solution, which balanced the hydroxide ions in the raw water.

Effects Of Storage Duration Of *Moringa Oleifera* Kept At Room Temperature (28°C) On Its Performance

Figure 1 shows the results of turbidity removal using *Moringa oleifera* stock solutions, which were kept for 1, 3, 5 and 7 days at room temperature. The results showed that *Moringa oleifera* kept under this condition were able to remove turbidity from medium, high and very high turbidity water samples. In the case of surface water and low turbidity water, the residual turbidity after coagulation was found higher than the initial turbidity.

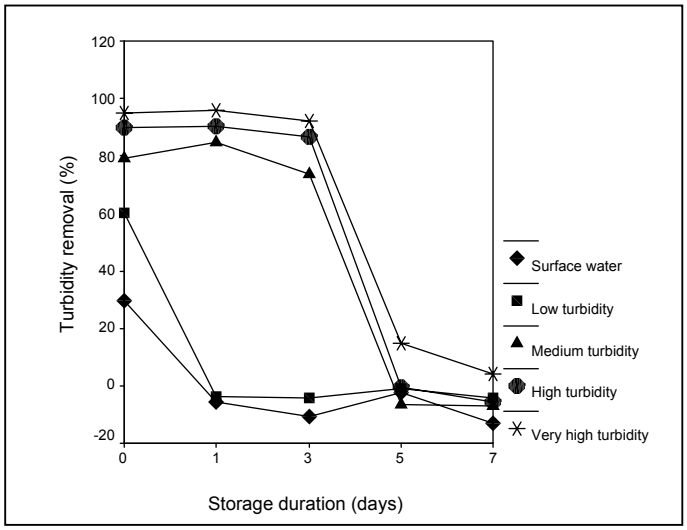

Figure 1. Turbidity removal efficiency of Moringa oleifera stock solution kept at room temperature for 1, 3, 5 and 7 days

For water samples with medium, high and very high initial turbidity values, highest turbidity removals were observed for stock solution which were kept for one day. For *Moringa oleifera* stock solution that were stored longer up to 3 days, the turbidity removal efficiencies decreased from 84.7 to 73.6%, 90.3 to 86.8% and 95.9 to 92.3 % for medium, high and very high turbidity water samples, respectively. In the case of medium and high turbidity water sample, *Moringa oleifera* which were kept for more than 3 days did not perform any coagulation process and residual turbidities were found higher than initial turbidities. While for very high turbidity water

sample, *Moringa oleifera* which were kept for 5 and 7 days it was found to coagulate slightly about 14.9 % and 3.9 %, respectively.

Effects Of Storage Duration Of *Moringa Oleifera* Kept At 3°C (Refrigerator) On Its Performance

Figure 2 shows the results of turbidity removal efficiency of *Moringa oleifer*a stock solution, which were kept at 3°C for 1, 3, 5 and 7 days. For medium, high and very high turbidity water, no significant differences were found between turbidity removal efficiency of *Moringa oleifera* kept at different durations. Turbidity removal efficiencies ranged between 78-85%, 85-92% and 93-96% for medium, high and very high turbidity water, respectively. Comparison between these water samples showed that the highest turbidity removals occurred using *Moringa oleifera,* which were stored up to 5 days.

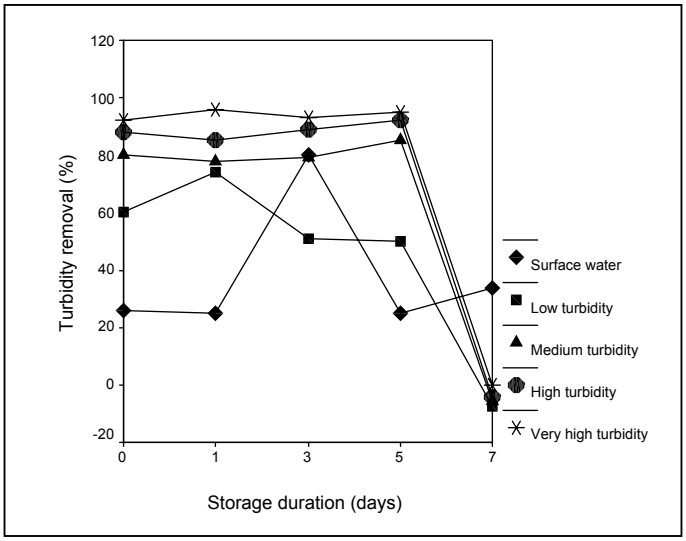

Figure 2. Turbidity removal efficiency of Moringa oleifera stock solution kept at 3 ℃ (refrigerator) for 1, 3, 5 and 7 days

The stock solutions which stored more than 5 days was not effective in removing the turbidity, and the residual turbidities were found higher that initial turbidities.

For surface water and low turbidity water samples significant differences were observed between turbidity removal efficiency of *Moringa oleifera* stored for different durations. For surface water sample the highest turbidity removal of 80% was obtained by *Moringa oleifera* which was stored for 3 days, while it decreased to 25% when using *Moringa oleifera* stock solution stored for 5 days. The unexpected increase in turbidity removal probably attributed to the higher initial turbidity of surface water (53.7 NTU) used to carry out that particular test, compared to others.

For low turbidity water sample *Moringa oleifera* stock solutions which were kept for one day showed highest coagulation efficiency (74%). However the coagulation efficiency while was decreased to about 50% when using *Moringa oleifera* stock solutions, which were stored for 3 and 5 days.

CONCLUSION

- Coagulation efficiency of *Moringa oleifera* stock solution on water samples depended on the initial turbidity of the water sample. The optimum dosage of *Moringa oleifera* was increased with an increase in initial turbidity of the water sample. For water with initial turbidity of <50, 50–100, 100–200 and >200 NTU were 80, 160, 300 and 400 mg/l, respectively.
- *Moringa oleifera* was not an effective coagulant for low turbidity water sample.
- At optimum dosage, the percentage of turbidity removal was found to increase with increasing initial turbidity

- Coagulation with *Moringa oleifera* stock solution which were kept at room temperature for duration of up to 3 days is most effective on medium, high and very high turbidity water.
- At 3°C, the active agents in the coagulation with *Moringa oleifera* stock solution well posses on medium, high and very high turbidity water for those which kept up to 5 days.
- An increase in zeta potential of water samples after coagulation indicated a charge neutralization phenomenon.

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