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Assessment of coagulation efficiency of *Moringa oleifera* and Okra for treatment of turbid water

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ABSTRACT

Conventional drinking water treatments are often inappropriate in developing countries, due to its high cost, lack of inappropriate infrastructures or availability of chemicals. The present study deals with the evaluation of treatment efficiency of natural coagulants Moringa oleifera, Okra seed, commonly available in nearby market. Primarily the basic operational parameters- pH and coagulant dosages were optimized. Coagulation ability of both seed extract was assessed by the use of standard jar test experiment in synthetic water with various coagulant doses. Its positive coagulation activity was measured on the basis of removal of turbidity and total dissolve solid (TDS). Best turbidity removal efficiency was achieved near neutral pH with optimal doses 200 mg/L and 220 mg/L for M. Oleifera and Okra and TDS removal efficiency was achieved with optimal dosage of 180 mg/L and 200 mg/L for Moringa oleifera and Okra.

Key words: Coagulation, Jar test experiments, *Moringa oleifera*, Okra, Turbidity, Total dissolved solids.

INTRODUCTION

Availability of pure drinking water has become scarce nowadays due to poor land use management. Surface water was polluted by sewage, industrial water discharge and run off from the land clearing, while ground water was polluted by salt water intrusion and waste dumping site. This polluted water will have to go through treatment process before it can be circulated to the consumers for domestic use including for drinking [1].

For many developing countries water treatment process involved coagulation, flocculation and sedimentation (which are the processes involved in removing turbidity from water) and disinfection are expensive processes because of the high costs involved and the difficulty in assessing the chemical coagulants including alum. This is the reason why these countries need low cost methods requiring low maintenance and skill. Nowadays, polyaluminium chloride is widely used in water treatment plants all over the world. Polyaluminium chloride and alum added impurities such as epichlodine are carcinogenic [2-3]. Aluminium is regarded as an important poisoning factor in dialysis encephalopathy. Aluminium is one of the factors which might contribute to Alzimer disease [4-5]. Aluminium reaction with water reduces water pH and its efficiency in cold water [6-7]. Coagulation has been subject of much research, most of which has been related to coagulation in the context of water treatment. Inorganic coagulants such as alum in combination with lime have been conventionally used for removal of turbidity from surface waters. The sludge formed from such treatment poses disposal problems because of its aluminium content and tend to accumulate in the environment and also because of large volume [8]. Therefore, it is desirable that other cost effective and more environmentally acceptable alternative coagulants be developed to supplement if not replace

alum, ferric salts and synthetic polymers. However, there have been studies on the use of indigenous natural coagulants. The use of locally grown and natural coagulants may result in a more sustainable and economically viable alternative [9-11].

Many plants have been used to clarify water. Naturally occurring coagulants are usually presumed safe for human health. These include *Moringa oleifera*, Moringa stenopetala, Vicia faba [12-13], Canavalia ensiformis, Bombax constatum [14] and okra [15]. Sutherland *et. al* [16] have reported Crushed *Moringa oleifera*, seed have been found to be viable replacement coagulant for chemicals such as aluminum sulphate (alum). Yao *et al* [17] studied the flocculating activities of the fresh stems of mucilage of Gumbo (Hibiscus esculents) and achieved the lowering of turbidity.

Many researchers have reported *Moringa oleifera* various uses and as a coagulant specifically for the last 25years. They have found that the *Moringa oleifera* seed is non-toxic and good coagulant in water treatment. It is recommended to be used as a coagulant in developing countries. Encouraged results of these studies, many developing countries have turned to use this plant as a viable coagulant in water and wastewater treatment on a small scale [18-24].

Muyibi and Evison [25] have reported *Moringa oleifera* powder have the capability of reducing low and high turbidity values in surface water. Various settling times for *Moringa oleifera* water treatment have been used or proposed on softening of hard water with *Moringa oleifera* seed powder used a settling time of one hour. At a *Moringa oleifera* dosage of 1800 mg/L the calcium hardness had reduced to almost zero. Doerr [26], on showing steps for household water treatment, recommended a settling time of one to two hours for all the particles and contaminants to settle to the bottom of the storage container. Lilliehook [27] while studying the use of sand filtration on river water flocculated with *Moringa oleifera* employed a settling period of 30 minutes to 120 minutes for low, medium and high turbidity water. Hsu *et al* [28] prescribed that *Moringa oleifera* seed powder mixed with water should be kept for hours (number not specified) in order to obtained clean water.

It was observed that whatever the volume of gumbo mucilage turbidity of water decreases when pH increases, its flocculating activity can be either due to a chemical reaction, or a complex formation [29]**.** Agarwal M. *et al*.[30] used okra gum for treatment of tannery effluent; they found that okra gum acts as a very effective flocculent, capable of removing more than 95 percent suspended solid and 69 percent dissolved solid from the effluent. Rajani Srinivasan *et al*. [31] have done research on okra (Hibiscus esculentus) and fenugreek (Trigonella foenum graceum) mucilage for flocculation of textile effluent. Results showed that polysaccharides (mucilage) obtained from okra and fenugreek was capable of removing 90%−94% of suspended solids, 30%−44% of total dissolved solids. Natural coagulants have been reported to have several other advantages compared to synthetic coagulants such as alum and ferric chloride, in that, they produce much lower sludge volume and are safe to humans. Ghebremichael *et.al* [32] investigated that the sludge produced from *Moringa oleifera* coagulated turbid water is only 20–30% that of alum Natural coagulants are biodegradable and cost effective for developing countries since they can be locally grown and have a wider effective dosage range for flocculation of various colloidal suspensions[33].

In the present study we have chosen two widely available natural coagulants i.e. *Moringa oleifera* and Okra. In this context their effectiveness is compared for removal of turbidity and total dissolved solid in synthetic water and also their effectiveness is also checked with varying pH of water sample.

MATERIALS AND METHODS

All the materials and chemicals were purchased from nearby market. In this study seeds of M. Oleifera, Okra were used for preparation of coagulant extract and synthetic turbid water is prepared by using kaolin clay, hydrochloric acid and sodium hydroxide were used to adjust pH of stock solution. Detailed description of preparation of synthetic water and coagulant extract described here:-

2.1 preparation of synthetic turbid water:

The turbidity of natural raw water varies from 10 to 500 NTU. So the experiment was carried out by making synthetic turbid water with150 NTU turbidity. Turbid water sample were prepared by using kaolin clay. About 10 g of kaolin clay was added to 500 ml of distill water sample. The suspension was stirred for 1h to achieve uniform and homogenous sample. Then it was allowed to settle for at least 24 hours for complete hydration of clay materials. The

supernatant of suspension were diluted to desired turbidity values. Resulting suspension was found to be colloidal and used as stock solution for preparation of turbid water samples. Everyday stock sample of kaolin clay was diluted by using distilled water to get desired turbidity.

2.2 Preparation of coagulant extracts

M.Oleifera-

- Plant species - Genus Moringa
- Family- Moringaceae.
- Common Name- Drum stick (Golden shower)

Moringa oleifera, known as Moringa, is native to north India but is now found throughout the tropics. Moringa is full of nutrients and vitamins and is good in your food as well as in the food of your animals. Moringa helps to clean dirty Water and is a useful source of medicines

Okra (lady's finger) -

- Plant species – A.esculentus
- Family- Mavacae
- Common Name- lady's finger or Gumbo

Okra Abelmoschus esculentus L. (Moench), is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. In the range of studied, it is observed that whatever the volume of gumbo mucilage, the turbidity decreases when the pH increases. The mucilage, from its sticky nature, contains polymer molecules (Nacoulima et al, 2000).The flocculating activity can be either due to a chemical reaction, or a complex formation.

Plant origin material M. oleifera (seed) and Okra (seed) were air dried, grinded in a mortar and pestle into powder-form and sieved to remove large particles. 1 g of powder was mixed with 100 ml distilled water to form 100 ml of suspension. The suspension was then thoroughly mixed using a clean magnetic stirrer for 5 min to extract the active component, followed by filtration of the solution through a piece of clean white cloth so as to remove solid materials The filtrate was then centrifuged at 30 rpm for 5 min, followed by filtration using What man filter paper No 41. The obtained stock solutions from each of these methods were preserved at -4°C until analyzed.

2.3 Experimental work

Sedimentation Jar test were carried to determine the coagulation properties of the plant derived coagulants. One beaker was used as control and in other beakers varying dosage of coagulants was added. Jar tests were conducted on 1000 ml synthetic turbid water samples. Following the addition of the coagulants dosages, M. Oleifera**,** Okra gum), the samples were subjected to a rapid mixing at 100 rpm for 1 minute, and a slow mixing step at 30 rpm for 30 min., The stirrer was then switched off and the flock allowed to Settle undisturbed for 30 minutes. The samples for residual turbidity measurement were withdrawn using a pipette from a height of 5cm below the surface of each beaker, and residual turbidity was measured. Effect of dose of natural coagulants on removal of turbidity also studied.

The effect of pH on turbidity removal was also studied by varying pH of turbid water. pH of the suspension was adjusted to the desired value by adding either 0.1 M HCl solution or 0.1M NaOH solution. Turbidity measurement was carried out by 'Globe Instrument' Turbidity meter. pH value of the suspension was measured using a digital pH meter model (Electronics India, Model 111 E).

RESULTS AND DISCUSSION

3.1 **Effect of pH on the flocculation of synthetic turbid water**

In this study the effects of pH, tests were conducted on medium turbid water (150 NTU) with varying pH value (Shown in Table1) from 2 to 12 with optimum dosage 100 mg/L of coagulant extract. Figure 1 shows the results, based on this figure it was found that both natural coagulants produce appreciable reduction of turbidity at 6-8 pH and it was declined at 10 to 12 pH.

TABLE1. Percentage turbidity removal with optimum dosage 100mg/L

S.NO.	pH	TURBIDITY REMOVAL (BY *MORINGA OLEIFERA*)	TURBIDITY REMOVAL (BY OKRA)
1	2	26	20
2	4	33	28
3	6	45	43
4	8	80	76
5	10	73	64
6	12	68	59

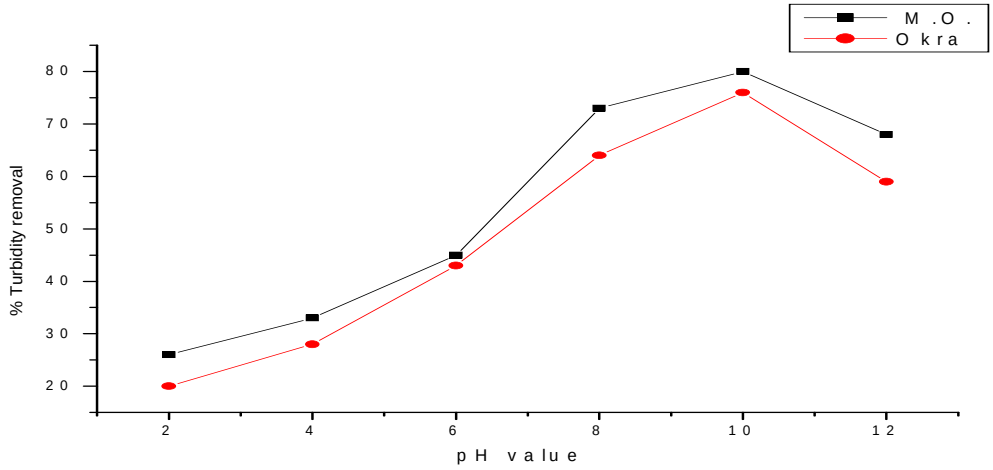

Figure1. Plot of effects of pH value on Turbidity removal

3.2 Determination of optimum dosage of coagulant for turbidity removal

Turbidity is the measure of the degree to which the water loses its transparency due to the presence of suspended particulates. Turbidity measurement could also be used to provide an estimation of the TSS (Total Suspended Solids) concentration. It is essential to eliminate the turbidity of water in order to effectively disinfect it for drinking purposes. Jar test experiments were performed by varying the coagulant dosage (compared in Table2 for *Moringa oleifera* and Okra) to find the optimum dosage for maximum turbidity removal at their optimum pH. From figure 2, it was observed that turbidity of synthetic water sample decreases with increase of coagulant dosage both coagulants gave good results. Optimum dosage of *Moringa oleifera* for maximum turbidity removal was found to be 200 mg/L with a removal efficiency 80.7% and for Okra seed extract optimum dose was found to be 220 mg/L with a removal efficiency of 78.7 %. Above this dosage suspensions showed a tendency to reestablishes**.**

TABLE 2. Comparison of turbidity removal efficiency of morienga oleifera and okra on medium turbid water sample -150 NTU

S.NO.	VOLUME OF SAMPLE	REDUCTION OF TURBIDITY BY MOREINGA OLEIFERA		REDUCTION OF TURBIDITY BY OKRA	
		DOSAGE OF COAGULANT	RESIDUAL TURBIDITY	DOSAGE OF COAGULANT	RESIDUAL TURBIDITY
1	1000 ml	160	80	160	96
2	1000 ml	180	69	180	88
3	1000 ml	200	29	200	75
4	1000 ml	220	43	220	32
5	1000 ml	240	63	240	83
6	1000 ml	Blank sample	150	Blank sample	150

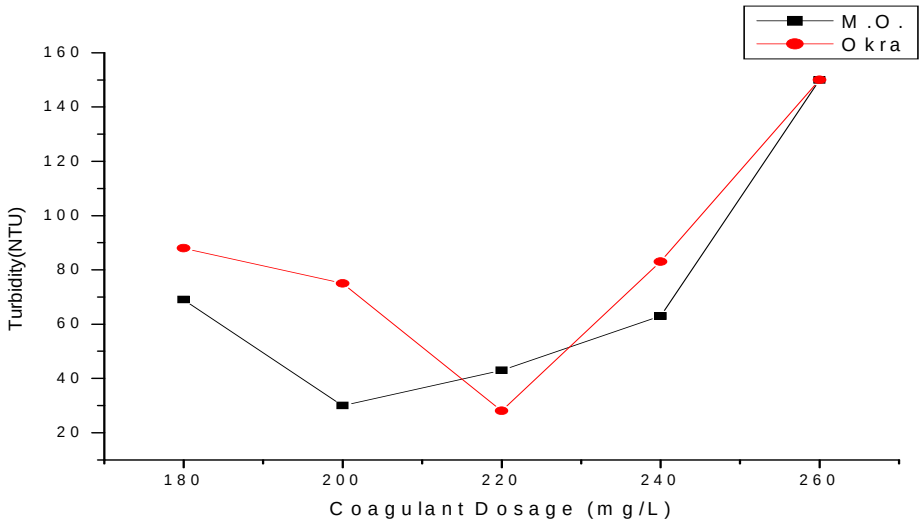

Figure 2. Comparison of turbidity removal efficiency of *Moringa oleifera*, and Okra on 150 NTU synthetic turbid water sample

3.3 Determination of optimum dosage of coagulant for total dissolved solid removal

Total Dissolved Solids is the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, expressed in units of mg per unit volume of water (mg/L). TDS is directly related to the purity of water and the quality of water purification systems. This includes anything present in water other than the pure water molecule and suspended solids. Experimental jar tests were performed by varying the coagulant dosage. TDS removal efficiency is compared in Table 3 for *Moringa oleifera* and okra extract, to find the optimum dosage for maximum removal of total dissolved solids (TDS) at their optimum pH. From Figure 3, the optimum dosage for maximum removal of total dissolved solids for Moringa seed extract the optimum was found to be 180 mg/L, with a removal efficiency 37.8% and for okra seed extract optimum dose was found to be 200 mg/L with a removal efficiency 44.5%.

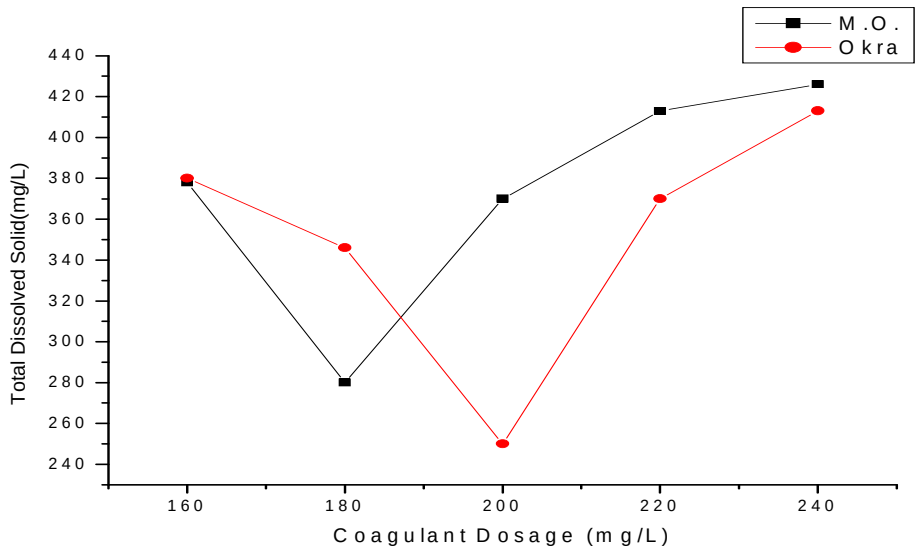

Figure 3. Comparison of Moringa and Okra for Varying dosage of coagulant for removal of total dissolved solid

TABLE 3- Comparison of total dissolved solid (tds) removal efficiency of *Moringa oleifera* and okra on medium turbid water sample -150 NTU

S.NO.	VOLUME OF SAMPLE	REDUCTION OF TDS BY MOREINGA OLEIFERA		REDUCTION OF TDS BY OKRA	
		DOSAGE OF COAGULANT (mg/L)	RESIDUAL TOTAL DISSOLVED SOLID(mg/L)	DOSAGE OF COAGULANT (mg/L)	RESIDUAL TOTAL DISSOLVED SOLID(mg/L)
1	1000 ml	160	378	160	380
2	1000 ml	180	280	180	346
3	1000 ml	200	370	200	250
4	1000 ml	220	413	220	370
5	1000 ml	240	426	240	413
6	1000 ml	Blank sample	450	Blank sample	450

CONCLUSION

This is evident from present study, both coagulants were effective for removal of turbidity and total dissolved solid. Turbidity was removed effectively at an optimum dose of 200mg/L for *Moringa oleifera* and 220 mg/L for okra seed powder with optimum pH about 7.0 as shown in Table 4.

Table 4. Final result of analyzed water sample - 150NTU

S.NO.	COAGULANT EXTRACT USED	OPTIMUM DOSAGE OF COAGULANT (mg/L)	MAXIMUM REMOVAL OF TURBIDITY	OPTIMUM DOSAGE OF COAGULANT (mg/L)	MAXIMUM REMOVAL OF TDS
1	*Moringa oleifera*	200	80.7%	180	37.8 %
2	Okra	220	78.7%	200	44.5 %

It was concluded that the maximum removal of turbidity for the sample was achieved as 80.7% by *Moringa oleifera* however it was not as effective for removal of TDS . 45.5% TDS removed by okra so, it was suggested that, we can use locally available natural *Moringa oleifera* and okra to treat the low turbid wastewater which is cost effective and environment friendly. Natural coagulant is sustainable and economical way of water treatment process.

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