A Comparative Study on the Treatment of Turbid Water Using MoringaOleifera and Alum as Coagulants

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ABSTRACT

Indiscriminate disposal of wastewater with suspended solids have led to higher amount of pollution to the natural water bodies. Turbidity imparts a great problem in wastewater treatment. When surface water is used as drinking water, turbidity removal is an essential part in the treatment processes. The current method uses various chemicals which significantly synthesize by products which may pollute the environment and may deteriorate the ecosystem at a slow rate. It attempts the investigation of the coagulation performance of some natural & synthetic materials to remove the suspended particles in contaminated surface water. The tests will be carried out using the conventional jar test apparatus. The removal of suspended particles as a function of time, dosage & pH will be explored. The seeds chosen for this study are from the plant species of Moringa oleifera. This study aims to add the fine powder of pre-mentioned seed as natural coagulant in treating the surface water which is turbid and the same water will be studied with the synthetic coagulants such as alum. Finally, the effectiveness over using both natural and synthetic coagulants in turbidity removal was studied. It shows about 70 and 75% removal efficiency for moringa and alum respectively with respect to its varying parameters.

Keywords: *Wastewater, Turbidity, Natural coagulants and Synthetic coagulants*

CHAPTER 1

INTRODUCTION

1.1 GENERAL

The removal of colloidal and suspended particles present in water would be extremely beneficial as it would assuage the majority of problems associated with turbidity. The contaminated waters disrupt the aquatic life and reduce their reproductive capability (P.N. Egbuikwem and A. Y. Sangodoyin, 2013). Control of the sources of water together with treatment of drinking water in remote areas where the infrastructure has not yet reached, is part of the solution to improve the life for many people. Good clarification has not always been obtained due to lack of knowledge on how the seed powder coagulates turbid water. By studying the seeds used in the traditional water treatment methods scientifically, it has been anticipated that achieved knowledge on the functionality of the seeds may not only provide benefits for the rural population, but also the urban water utilities which often produce insufficiently treated water (Annika blix, 2011).

Most particulate matter cannot settle by gravity and their sizes are so small that they pass through the pores of most common filtration media. Conventionally, the enmeshment and removal of the colloids in water could be achieved by coagulation, using certain chemical coagulants like alum. For many developing countries, this treatment process is not feasible because of the high costs involved and the difficulty in assessing chemical coagulants including alum.

Various methods are used to make water safe and attractive to the consumer. The method employed depends on the character of the raw water. One of the problems with treatment of water is the large seasonal variation in turbidity. For the treatment of water, some traditional chemicals are used during the treatment of water to its various steps (Md. Asrafuzzaman et al, 2011).Commonly used chemicals for various treatment units are synthetic organic and inorganic substances. In most of the cases, these are expensive since they are required in higher dose and does not show cost effectiveness.

The history of the use of natural coagulants is long. Natural organic polymers have been used for more than 2000 years in India, Africa, and China as effective coagulants and coagulant aids at high water turbidity.Research works by several researchers confirmed that natural coagulants are both economical and efficient (Phani Madhavi, 2013). They may be

manufactured from plant seeds, leaves, and roots. These natural organic polymers are interesting because, comparative to the use of synthetic organic polymers containing acryl amide monomers, there is no human health danger and the cost of these natural coagulants would be less expensive than the conventional chemicals alike since it is locally available in most rural communities of India (Md. Asrafuzzaman et al, 2011). This study is to confirm and compare the efficacy of natural coagulants and commercial coagulants in treatment of surface water.

1.2 PRESENT STATUS OF THE STUDY

Many flocculants and coagulants are widely used in conventional water treatment processes. All of them are very efficient at turbidity removal from water. The cost of achieving the desired level of water quality depends primarily on the cost and the availability of coagulation agents. Alum is most widely used. Many of the chemicals are also associated with human health and environmental problems. So there raised a voice to develop cost-effective, easier and environmental friendly process of water clarification.

1.3 NEED FOR THE STUDY

The need of using natural coagulant such as seeds of *Moringa oleifera*(Drumstick seed) as water treatment materials are cost-effective, unlikely to produce treated water with extreme pH and highly biodegradable. Naturally occurring coagulants are usually presumed safe for human health. While the commercial coagulants are effective only at certain pH range and good flocculation may not be possible in some water.

1.4 OBJECTIVES OF THE STUDY

- To characterize the collected water sample.
- To use various natural cum eco-friendly materials for the treatment.
- To treat collected samples by Natural and synthetic coagulant.
- To find the optimum coagulant dosage, Time and pH.
- To study the coagulation efficiency of Natural and Commercial coagulants in the collected sample of water.
- To analyse and compare the treatment efficiency and the cost effectiveness of natural coagulants with synthetic coagulants.

1.5 SCOPE OF THE STUDY

This work will reduce the health threats arising from the consumption of residual aluminium present in water, such as Alzheimer's diseases and neurodegenerative illness, reduce production of large sludge volumes, reduce alteration of water pH, poor coagulation efficiency in cold weather will be minimized, sludge produced will be highly biodegradable andto reduce surface and ground water pollutant. So, the environmental friendly natural coagulants would present a viable alternative for the treatment of contaminated surface water which will be economical and efficient at domestic level. The use of natural coagulant as coagulant aid with synthetic coagulants can reduce the chemical costs and threats can be minimized.

CHAPTER 2
LITERATURE REVIEW

2.1CONVENTIONAL WATER TREATMENT PROCESS

Drinking water treatment involves a number of combined processes (Figure 2.1) based on the quality of the water source such as turbidity, amount of microbial load present in water and the others include cost and availability of chemicals in achieving desired level of treatment. Generally drinking water treatment protocols consist of two major steps: coagulation/flocculation and disinfection. Commonly alum (aluminium sulphate) is used as a coagulation agent, as it is efficient and relatively cost-effective in developed countries; while, disinfection is achieved by the addition of chemical disinfectants like chlorine-based compounds (Ida Bodlund, 2013).

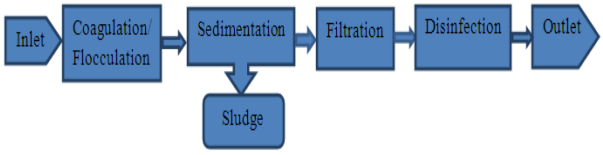

Fig 2.1 Conventional water treatment process.

2.2 COAGULATION AND FLOCCULATION

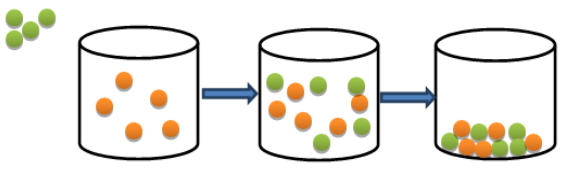

Fig 2.2 Coagulation/Flocculation process.

2.3 ALUM IN WATER TREATMENT

2.3.1 A fact on Alum

There has been ongoing debate in the water industry for a number of years regarding the use of alum in the water treatment process and the 'suspicion' that aluminium is linked to Alzheimer's disease. The cause of Alzheimer's disease is subject to international research. Avariety of possible causes have been considered, however, no link between aluminium intake and the disease has been established.

2.3.2Research Findings

The CSIRO has conducted extensive research in this matter and in late 1998 found convincing evidence that the use of alum to treat drinking water is safe. The CSIRO found that the aluminium we obtain from treated drinking water is an insignificant amount: only 1 to 2% of our daily intake of aluminium comes from water and only the barest trace of this is absorbed. Most of the aluminium absorbed is excreted through urine (Hunter water, 2011).

2.4 PLANT MATERIALS IN WATER TREATMENT

Natural materials have been used by humans throughout history in treating drinking water. When chemical salts were introduced to the market, natural materials were abandoned as coagulating agents. The traditional treatment methods have not been able to compete efficiently with chemical salts due to lack of scientific knowledge on how the materials function. The use of natural coagulants of vegetable and mineral origin have survived in parts of the world where modernization has not reached. Issues concerning handling of chemicals and sludge has awakened an interest for plant-based materials as alternatives to chemical coagulants in water treatment.

Several plant-based coagulants have been studied scientifically, some of them are listed here: Seeds of *Strychnos potatorum*(Nirmali), a tree found in India, Sri Lanka and Burma contain anionic polyelectrolytes that destabilize particles through inter-particle bridging. Sanskrit writings imply that *Strychnos potatorum* has been used to clarify turbid surface waters for over 4000 years. *Moringa oleifera* (Drum stick tree), is a tropical plant found in Asia, Sub Saharan Africa, Latin America. Moringa oleifera has coagulant properties related to cationic proteins. The main mechanisms for coagulation is adsorption and charge neutralization. *Vigna unguiculata* and *Parkinsonia aculeata* are plants containing cationic proteins which are active in coagulation of turbid waters (Annika blix, 2011).

2.5 APPLICATION OF PLANT BASED COAGULANTS

A review of plant-based coagulant sources, processes, effectiveness and relevant coagulating mechanisms for treatment of water and wastewater is presented. These coagulants are, in general, used as point-of-use technology in less-developed communities since they are relatively cost-effective compared to chemical coagulants, can be easily processed in usable form and biodegradable. These natural coagulants, when used for treatment of waters with low-to-medium turbidity range (50–500 NTU), are comparable to their chemical counterparts in terms of treatment efficiency. Their application for industrial wastewater treatment is still at their infancy, though they are technically promising as coagulant for dyeing effluent as afforded by Yoshida intermolecular interactions.These natural coagulants function by means of adsorption mechanism followed by charge neutralization or polymeric bridging effect. Frequently studied plant-based coagulants include Nirmali seeds (*Strychnos potatorum*), *Moringa oleifera*, Tannin and Cactus. Utilization of these coagulants represents important progress in sustainable environmental technology as they are renewable resources and their application is directly related to the improvement of quality of life for underdeveloped communities (G. Vijayaraghavan,2011).

CHAPTER 3

MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Conventional Coagulant

In this Study, Aluminium sulphate (Alum) was used as a conventional coagulant and the stock solution (1 % strength) was prepared by adding 10 grams of Alum to 1000 ml of distilled water.

3.1.2 Natural Coagulants

The natural coagulants such as Drumstick Seeds *(Moringa oleifera)*, used in this study were depicted in Figure 3.1.

3.2 METHODOLOGY

The methodology adopted for the proposed study was shown in Figure 3.1.

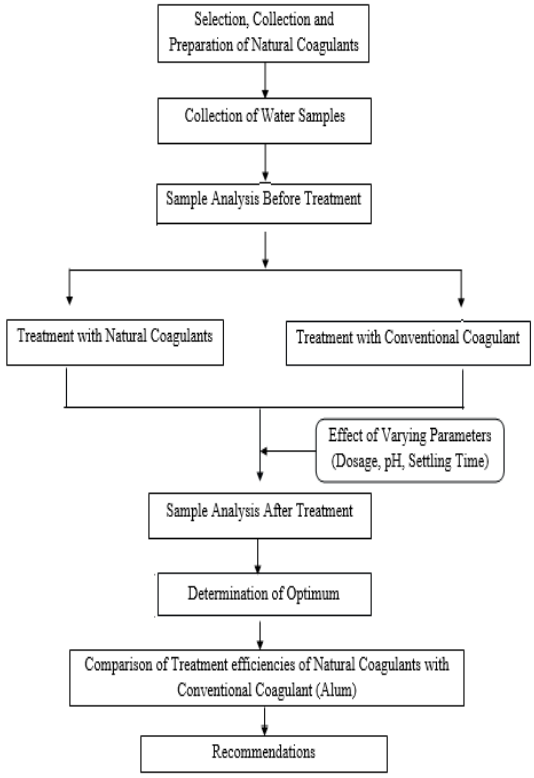

Fig 3.1An Overview of Methodology

3.2.1 Collection of Natural Coagulants

The selected seeds were obtained from the local market and thoroughly washed with tap water to remove the sticks adhered on their surfaces and stored for preparation.

3.2.2 Preparation of Natural Coagulants

The collected seeds were dried at room temperature or in sunlight until its moisture content was completely removed. The dried seeds were then grinded to fine powder and stored in plastic containers.

3.3 COLLECTION OF WATER SAMPLES

The required amount of water samples were collected in sterile cans from different days of PeriyaEri Lake, Rathinamangalam for analysis and the cans used were rinsed with the same sample before collection.

Fig 3.2 Collected Water Samples

3.4 TREATMENT WITH COAGULANTS

3.4.1 Experimental Procedure

In this study, different natural coagulants and conventional coagulant were used to treat the samples and the process parameters such as pH, coagulant dosage and settling time were varied and optimized. A conventional jar test apparatus was used to carry out the batch coagulation process for the treatment of water samples. It accommodates a series of six beakers together with six-spindle steel paddles. For each beaker, 1000 ml of sample was taken to which varying amount of coagulant dosage was added to the respective beakers followed by variation in pH and settling time were done.Then the apparatus was switched on and the speed of paddles were adjusted to about 100 rpm thus rapid mixing of about 1 - 2 minutes was done. After rapid mixing, the speed of paddles were reduced to about 30 to 40 rpm followed by slow mixing for 20 minutes. After slow mixing, the apparatus was switched off and the samples were allowed to settle for 10 - 60 minutes. The treated samples were then analyzed for alkalinity and turbidity level with respect to the effect of varying parameters and the removal efficiencies were obtained.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 GENERAL

In this section, the effects of natural coagulants and a conventional coagulant (Alum) with respect to varying dosages, pH and settling time were investigated and compared.

4.1.1 Drumstick Seeds

The raw water sample 3 turbidity was found to be 118.6 NTU. The dosage was varied in the range from 0.25 g/l to 1.25 g/l followed by variation in pH and settling time from which the optimum was determined.

From the Table 4.1, it was observed that *Moringa oleifera* (Drumstick) has shown 75 % removal efficiency for 0.75 g/l of optimum dosage at pH 7 in 30 min of settling time. The raw and treated water samples were depicted in the Figure 4.1.

Fig 4.1 Raw and Drumstick Seed Powder Treated Water Samples

Table 4.1 Removal Efficiencies of Drumstick Seed Powder as Coagulant

Volume of Sample = 1000 ml

S. No.	Varying Parameter		Constant Parameter	Initial Turbidity	Final Turbidity	% Removal
1	Dosage (ml)	0.25	–	117.2	41.6	64.51
		0.5		117.2	36.9	68.52
		0.75		117.2	36.7	68.69
		1		**117.2**	**33.9**	**71.08**
		1.25		117.2	34.9	70.22
		1.5		117.2	34.7	70.39
2	pH	5	Dosage (1 ml)	117.2	39.2	66.5
		6		117.2	37.7	67.83
		7		117.2	35.8	69.45
		8		**117.2**	**34.6**	**70.48**
		9		117.2	36.1	69.20
		10		117.2	37	68.43
3	Settling Time (min)	10	Dosage (1 ml) and pH 8	117.2	39.6	66.21
		20		117.2	34.6	70.48
		30		**117.2**	**35.3**	**69.88**
		40		117.2	35.5	69.71
		50		117.2	35.2	69.97
		60		117.2	35	70.14

4.2 EFFECT OF CONVENTIONAL COAGULANT ON TURBIDITY REMOVAL

The raw water sample turbidity was found to be 117.2 NTU. The dosage was varied in the range from 0.25 ml to 1.25 ml followed by variation in pH and settling time from which the optimum was determined.

From the Table 4.2, it was observed that alum has shown 70 % removal efficiency for 1 ml of optimum dosage at pH 8 in 30 min of settling time. The raw and treated water samples were depicted in the Figure 4.2.

Fig 4.2 Raw and Alum Treated Water Samples

Table 4.2 Removal Efficiencies of Alum as CoagulantVolume of Sample = 1000 ml

S. No.	Varying Parameter		Constant Parameter	Initial Turbidity	Final Turbidity	% Removal
1	Dosage (g/l)	0.25	–	118.4	38.9	67.14
		0.5		118.4	36.1	69.51
		0.75		**118.4**	**29.1**	**75.42**
		1		118.4	32	72.97
		1.25		118.4	31.2	73.65
		1.5		118.4	31.9	73.05
2	pH	5	Dosage (0.75 g/l)	118.4	31.3	73.56
		6		118.4	33.2	71.96
		7		**118.4**	**31.2**	**73.6**
		8		118.4	31.5	73.4
		9		118.4	30.8	73.99
		10		118.4	41.3	65.12
3	Settling Time (min)	10	Dosage (0.75 g/l) and pH 7	118.4	56.3	52.45
		20		118.4	43.2	63.51
		30		**118.4**	**29.8**	**74.83**
		40		118.4	29.4	75.17
		50		118.4	29.3	75.25
		60		118.4	29.4	75.20

4.3 COMPARISION STUDY

From the Table 4.1,*Moringa oleifera* was determined as the most effective natural coagulant among the other natural coagulants and when compared to alum (1 % strength) solution, Moringa was found to produce an equal and better results. The comparative efficiencies of alum and *Moringa oleifera* were represented in the following Figures 4.3(a),4.3 (b)4.4 (a) and 4.4 (b).

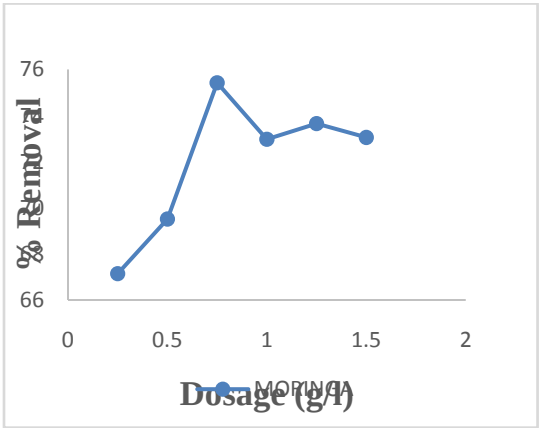

Fig 4.3(a) Moringa Dosage Vs % Removal

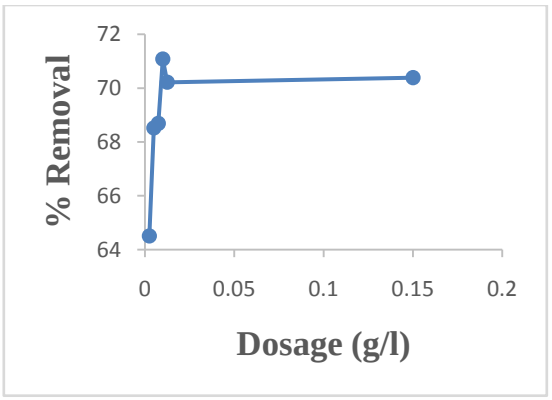

Fig 4.3(b) Alum Dosage Vs % Removal

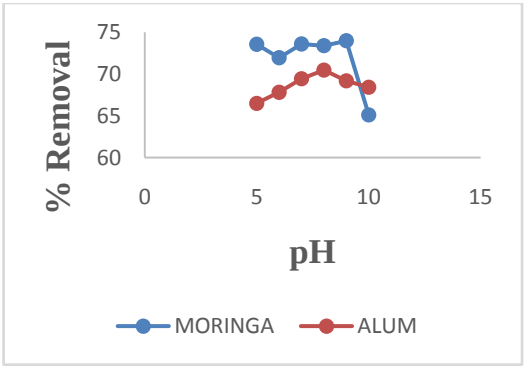

Fig 4.4 (a)pH Vs % Removal

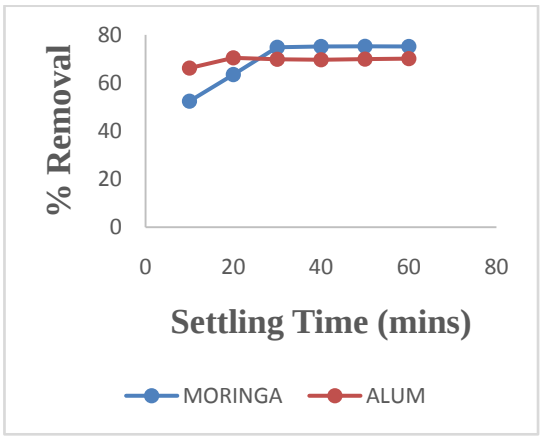

Fig 4.4 (b) Settling Time Vs % Removal

CHAPTER 5

CONCLUSION

Moringa oleifera (Drumstick) has shown 75 % removal efficiency for 0.75 g/l of optimum dosage at pH

7 in 30 min of settling time.Alum has shown 70 % removal efficiency for 1 ml of optimum dosage at pH 8 in 30 min of settling time. It can be concluded that *Moringa oleifera*shows high turbidity removal efficiency when compared to the other coagulants and alum, in which both alum and Moringa were observed to play an equal role in the water treatment process.

Moringa oleifera is biodegradable, eco-friendly and has non-toxic. Hence, it is highly recommended in rural areas where no facilities are available for drinking water treatment. For its optimum utilization, "boil before use" approach should be applied immediately after treatment. *Moringa oleifera* stands to be a suitable substitute for commercial alum in the nearest future of water treatment technology. It is recommended that studies must be carried out determine the optimum detention time for water treated with the coagulants so as to obtain higher removal efficiency. It is also suggested, that the Moringa seed can be administered in a mini-water treatment plant so as to quantify and justify its performance with the high level of confidence.

Use of this technology can reduce poverty, decrease excess morbidity and mortality from waterborne diseases and improve overall quality of life in rural areas. The study showed that natural coagulants will be efficient for surface water but would require some modification to attain maximum efficiency. Thus, further study is required on blended coagulant (combination of natural and conventional coagulant) in order to achieve maximum removal efficiency in minimum time. It is recommended that effective filtration will be made necessary after coagulation process that done with the natural coagulants to achieve full removal efficiencies on turbidity removal. And in an era of increasing environmental concerns , water scarcity admist the drawbacks of chemical coagulants and poor sanitation facilities in most low income earning countries, the need to further develop natural coagulants as alternative environmentally favourable water purifying chemical is exigent.

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