

STUDIES ON TURBIDITY REDUCTION IN DRINKING WATER BY *MORINGA OLEIFERA* LAM. SEED EXTRACT¹Gayathri Parivallal, ²Ranadive Ananth G., ^{*2}Bijaya Kumar Nayak and ³Anima Nanda¹Chief Operating Officer, Green Enviro Polestar, Puducherry-605007, India.²Department of Botany, Kanchi Mamunivar Govt. Institute for Postgraduate Studies and Research (Autonomous), Puducherry - 605008, India.³Department of Biomedical Engineering, Sathyabama Institute of Science and Technology, Chennai-600119, India.

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ABSTRACT

Turbidity makes water unpleasant and becomes the major culprit helping microbes to stay and replicate in water, hence it needs to be treated and removed properly. Treatment methods are available viz., coagulation followed by flocculation, sedimentation and filtration in order to remove the turbidity. Coagulants such as Alum, PAC (Poly Aluminium Chloride), FeCl₃ etc, are mostly employed for the turbidity removal from water. Among them, Alum is the most widely used coagulant in water treatment because of its confirmed enactment and cost efficiency. Though alum has a established track best, usage of the same in drinking water system surges the concentration of Aluminium ion which does not fall under the WHO (World Health Organization) norms of drinking water standards. Hence the present study would be an alternate methodology towards turbidity reduction in water by using natural coagulants. The present study is an attempt to evaluate the effectiveness of *Moringa oleifera* seed extract in the removal of turbidity from the selected water samples. For this work a pre-existing water treatment system of capacity 2 m³/hr from a Residential Apartment named M/s. Ozone Pavillion was selected with an existing scheme of Alum dosing system, Pressure sand filter, Activated Carbon filter and Softener. In this scheme the Alum dosing was replaced with *Moringa oleifera* seed extract dosing and the softener filter was bypassed. Two different water samples were selected (Bore Well Water and Surface Water) and jar test was performed with the *Moringa oleifera* extract to arrive the best suited dose for the turbidity reduction. Here the jar test performed with different concentration of *Moringa oleifera* extract starting from 20 mg/l to 60 mg/l and selected the concentration of 60 mg/l as the best suited dose for turbidity reduction. The selected concentration was used for a pilot plant study in the existing water treatment plant designed by M/s. Green Enviro Polestar. The study showed the turbidity removal efficiency of 40% to 60% and highly emphasized the usage *Moringa oleifera* seed extract as a natural coagulant in water treatment systems.

KEYWORDS: *Moringa oleifera*, Water turbidity removal, Natural Coagulants, Plant Based Coagulants, Water Treatment, Waste Water Treatment.

1. INTRODUCTION

Turbidity is the measure of relative clarity and optical characteristic of water. It tends to scatter the light passes through it which can be measured by scattering intensity. Higher the intensity of scattered light, higher the turbidity in water. Turbidity makes water cloudy or opaque.^[2,3] Excessive turbidity or cloudiness in drinking water is aesthetically unappealing and leads to various health impacts. Turbidity can impact the process of disinfection by reducing their exposure to disinfectant chemicals in water. In water treatment technique turbidity is commonly treated using the process of settling followed by Filtration. Coagulation and flocculation of suspended and particulate matters in water will be the upstream procedure required to

improve the settling and filtration process. Henceforth it depends upon various applications the measured quantity of chemical agents will be dosed into the water stream to remove turbidity. There are a number of chemical reagents that are available for treating turbidity which includes Aluminum sulfate (Alum), Ferric chloride (FeCl₃), PAC (Poly aluminum chloride) etc. In water treatment, filtration is an essential step in the production of high-quality water, which is achieved by deposition of suspended solids within or on the filter media. Alum is the most widely used coagulant in water treatment, because of its proven performance and cost effectiveness. The use of alum as a coagulant in the treatment of drinking water increases the aluminum concentration in finished water.^[4-8] Hence we need an

alternate technique to remove turbidity from water. Conventional water treatment processes have the ability to effectively remove turbidity when operated properly (Source: U.S. Environmental Protection Agency). Hence we have selected natural coagulants (*Moringa oleifera* seed extract) to carry out the study. Although turbidity is not a direct indicator of health risk, numerous studies show the importance of turbidity removal. Conventional water treatment typically involves coagulation, sedimentation, filtration, and disinfection.^[9] Turbidity is measured in Nephelometric Turbidity Units (NTU). The seeds of *Moringa oleifera*, one of the best natural coagulants as per previous studies^[10-14] were used in this protocol. In the Sudan, dry *Moringa oleifera* seeds are used in place of alum by rural women to treat highly turbid Nile water.^[15] Suleyman^[13] carried out jar tests with *Moringa oleifera* as the primary coagulant using water from four different sources (viz., two surface and two shallow wells) with turbidity's from 100 to 800 NTU and 80 to 150 NTU respectively and hardness from 180 to 300 mg/l as CaCO₃.

In our present study, *Moringa oleifera* seed extracts were prepared and performed jar test to obtain the best required dosage for turbidity removal in the selected water samples. The obtained dosage (mg/l) of *Moringa oleifera* was dosed through the dosing system present in an existing water treatment system of capacity 2 m³/hr. The existing Water treatment system used in this study was erected by M/s. Green Enviro Polestar at Ozone Pavilion Apartment, Ozone Urbana, Bangalore. Schemes available with the system are Filter Feed Pumps, Alum Dosing System, Pressure Sand Filter, Activated Carbon Filter and Softener. Here we used the Alum Dosing system for dosing our *Moringa oleifera* extract with the obtained dosage of 60 mg/l at strength of 2% concentration. Also the softener filter was bypassed during the whole study. The selected water samples were checked for turbidity after treating through the system. There was a considerable reduction of hardness in all the selected water samples observed. The removal efficiency was observed between 30-50% after passing through the treatment system with *Moringa oleifera* dosage.

2. MATERIALS AND METHODS

2.1 *Moringa oleifera* Seeds Extract Preparation

Moringa oleifera seeds were collected from Poonthottam, Thiruvarur District, Tamilnadu, India. The Seeds collected were completely shade dried for 2 days, since the green seeds do not possess any coagulation activity.^[12] The shade dried seeds were collected and ground in a grinding machine to a fine powder. The seed powder was mixed with distilled water to prepare 2% (w/v) strength stock solution (5 grams of seed powder in 250 ml of distilled water). For each and every downstream steps freshly prepared seed suspension were used.

2.2 Collection of Water Samples

Bore well water collected from the existing bore well located at M/s. Ozone Pavilion apartment, Bangalore through the centrifugal pumps, Surface Water collected at Devanahalli Area Near Bangalore Airport through a water tanker having capacity 5000 L. Both the water samples were stored separately in the storage tank of capacity 10 m³ Volume (existing) during the operation. Each sample volume of 4000 Litres was used in this study.

2.3 Jar Test for Turbidity removal

For performing jar test procedure both the selected water samples were taken in (one set) 6 numbers of 250 ml beakers and made sample triplicate. Hence totally 36 beakers were taken for the procedure each with separate magnetic stirrer for mixing. The Freshly prepared *Moringa oleifera* extract was added to each set of beakers with dosage ranging from 20 mg/l to 60 mg/l and let for proper stirring. The stirring procedure was done for 2 minutes and allowed for coagulation, precipitation and settling for 10 minutes at 100 rpm (Jar testing Apparatus: Phipps and Bird Inc., USA) and tested for relative turbidity. In this procedure the dosage of 60 mg/l showed an efficient result in turbidity removal. Hence the same dosage was selected for pilot study.

2.4 Water Treatment Plant Existing

Project Name : Ozone Pavilion Apartment, Ozone Urbana, Bangalore
 Project Type : Water Softener
 Flow Capacity : 2 cum/hr.
 Operation Hours : 10 hrs.
 Water Sources : Surface Water and Bore Well Water from Bangalore City.
 System Erected by : M/s. Green Enviro Polestar, Pondicherry.

Table 1: The scheme and technical specifications of the existing water treatment plant.

| Sl. No. | Existing Scheme of Water Treatment Plant | Technical specification |
|---------|--|--|
| 1. | Water Storage Tank | Capacity: 20 KL |
| 2. | Filter Feed Pumps | Flow Rate: 2 m ³ /hr, Head: 35 m, Make: Kirloskar, Type: Vertical Submersible, MOC: Cast Iron. |
| 3. | Alum Dosing System | Pump Flow rate: 6 Lph, Make: Edose, Dosing Tank Capacity: 250 Litre, Make: HDPE (High Density Poly Propylene) |
| 4. | Pressure Sand Filter | Design Velocity: 12 – 15 m/hr, Operating Pressure: 3.5 Kg/cm ² , Filter Diameter: 600 mm, HOS (Height on Straight): 1250 mm, MOC (Material of Construction): MS (Mild Steel), Filter Make: GEPS |
| 5. | Activated Carbon Filter | Design Velocity: 14 – 18 m/hr, Operating Pressure: 3.5 Kg/cm ² , Filter Diameter: 600 mm, HOS (Height on Straight): 1250 mm, MOC (Material of Construction): MS (Mild Steel), Filter Make: GEPS. |
| 7. | Chlorine Dosing System | Pump Flow rate: 6 Lph, Make: Edose, Dosing Tank Capacity: 250 Litre, Make: HDPE (High Density Poly Propylene) |
| 8. | Treated Water Storage Tank | Capacity: 10 KL, RCC tank water proofed. |

Both the collected water samples were filled one by one in the untreated water tank. The Sample volume 4000 Litres of each was utilized and the system was operated for 1 hr each. For each batch 2000 L of the sample water was treated and the treated samples were taken for Turbidity analysis Standard Methods.^[1,14] Table 1 shows the scheme and technical specifications of the existing water treatment plant and Table 2 gives the routine Procedure of Turbidity removal by Dosing System.

2.5 Water Treatment Plant working with *Moringa oleifera* extracts

The available water treatment scheme does not require a softening process; hence the softener filter was bypassed during operation. The alum dosing system was replaced with *Moringa oleifera* extract. *Moringa oleifera* extract with 2% strength (2 Kg of *Moringa* extract in 100 Litres normal water) was prepared freshly and stirred with a mechanical mixer for 2 minutes at 100 rpm. After proper mixing the extract was dosed on line to the plant flow with a dosage concentration of 60 mg/l which was obtained from the jar test. The dosage was performed using the existing dosing pump of capacity 6 Lph with a 100% stroke rate.

Table 2: Procedure of Turbidity removal by Dosing System.

| | |
|--|--|
| Plant Flow Rate | 2 m ³ /hr |
| Operating hours | 10 hrs |
| Flow per day | Flow rate * Operating hrs 2 m ³ /hr * 10 hrs : 20 m³/day |
| Dosage obtained from jar test | 60 mg/l |
| Dosage for 20 m ³ /d capacity in (Kg) | (20 m ³ /d * 60 mg/l)/1000 : 1.2 Kg/days |
| Converting to Lpd (Litres/day) | Dosage in Kg/Solution strength 1.2 Kg/0.02 : 60 Lpd (Litres/day) |
| Dosing Pump Flow rate (per hr) | Dosage per day/operating hrs 60 Lpd/10 hrs : 6 Lph (Litre/hr) |
| Dosing Pump Stroke Rate (%) | 100 % |

Both the collected water samples were allowed to pass through the water treatment system separately at a designed flow rate of 2 cum/hr and the treated water was tested for Turbidity (Table 2).

3. RESULTS AND DISCUSSION

3.1 Jar test Results: The tabulated values obtained during the work showed a clear picture that 60 mg/l

dosage of *Moringa oleifera* extract of 2% strength that would be the best opted dose for effective hardness removal in all the three selected water samples. The removal efficiency observed in the range of 30-50%. Hence the same dosage was used in an existing water treatment plant of capacity 2 m³/hr, which can treat up to 20 cum of water per day.

Table 3: Bore Well Water Sample: Initial Turbidity (2.36 NTU).

| Water Source | Moringa Dosage (mg/l) | Turbidity Values (NTU) | | | |
|------------------|-----------------------|------------------------|-------------|-------------|-----------------------------------|
| | | Replicate 1 | Replicate 3 | Replicate 3 | Mean Value ($\mu = \sum x / n$) |
| Bore Well Sample | 0 | 2.4 | 2.3 | 2.4 | 2.36 |
| | 20 | 2.2 | 2.2 | 2.1 | 2.16 |
| | 30 | 1.7 | 1.8 | 1.8 | 1.76 |
| | 40 | 1.5 | 1.4 | 1.3 | 1.4 |
| | 50 | 1.2 | 1.5 | 1.3 | 1.33 |
| | 60 | 0.7 | 0.9 | 0.8 | 0.8 |

Table 4: Surface Water Sample: Initial Turbidity (3.6 NTU).

| Water Source | Moringa Dosage (mg/l) | Turbidity Values (NTU) | | | |
|----------------------|-----------------------|------------------------|-------------|-------------|-----------------------------------|
| | | Replicate 1 | Replicate 3 | Replicate 3 | Mean Value ($\mu = \sum x / n$) |
| Surface Water Sample | 0 | 3.6 | 3.6 | 3.6 | 3.6 |
| | 20 | 3.2 | 3.3 | 3.3 | 3.3 |
| | 30 | 2.9 | 2.8 | 2.8 | 2.8 |
| | 40 | 2.4 | 2.5 | 2.4 | 2.4 |
| | 50 | 1.9 | 2.1 | 2.1 | 2.03 |
| | 60 | 1.5 | 1.5 | 1.8 | 1.6 |

Whenever the bore well water sample with 2.36 NTU was treated with Moringa extracts, the turbidity mean value was recorded at 0.8 (Table 3). But the surface

water sample of 3.6 NTU turbidity mean value was documented at 1.6 NTU when treated with Moringa extracts in our study (Table 4).

Table 5: Evaluation of Turbidity removal efficiency of *Moringa oleifera* extracts.

| Water Source | Sample Type | Turbidity (NTU) Mean Value | Turbidity Removal Efficiency % |
|---------------|--------------------------------------|----------------------------|--------------------------------|
| Bore Well | Untreated (Control) | 2.36 | - |
| | Treated with <i>Moringa oleifera</i> | 0.8 | 33.89% |
| Surface Water | Untreated (Control) | 3.60 | - |
| | Treated with <i>Moringa oleifera</i> | 1.6 | 44.44% |

Turbidity removal efficiency of *Moringa oleifera* extract with 60 mg/l litre dosage was observed to be 30-50% which was likely to be the best eco-friendly procedure for turbidity removal (Table 5). The same procedure adopted in the pilot plant and also observed the turbidity reduction efficiency between 30 -50% (Fig 1 and 2). Hence in future, different seed extracts can be studied separately or in a combination to get a best efficacy.

From the present study it was emphasized exclusively about the usage of natural coagulants for turbidity removal in water treatment.

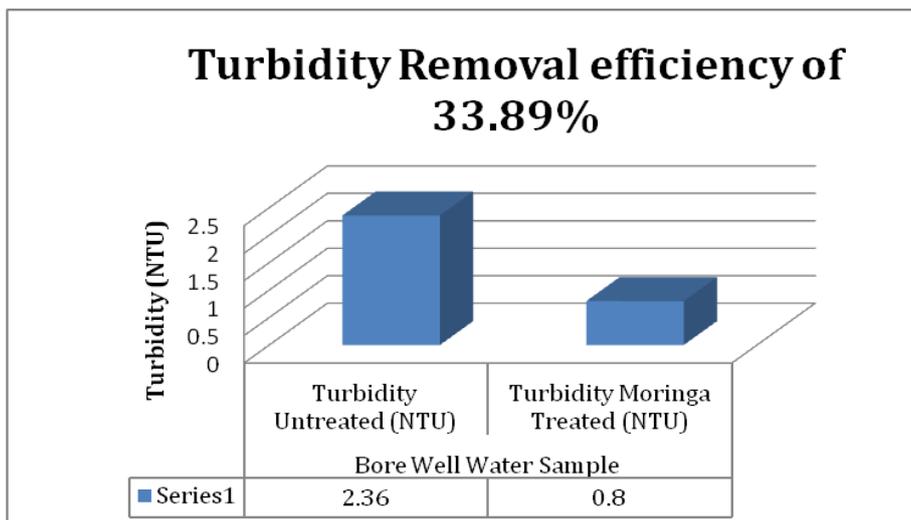


Fig 2: Turbidity removal efficiency of *Moringa oleifera* extract 0.8 turbidity value.

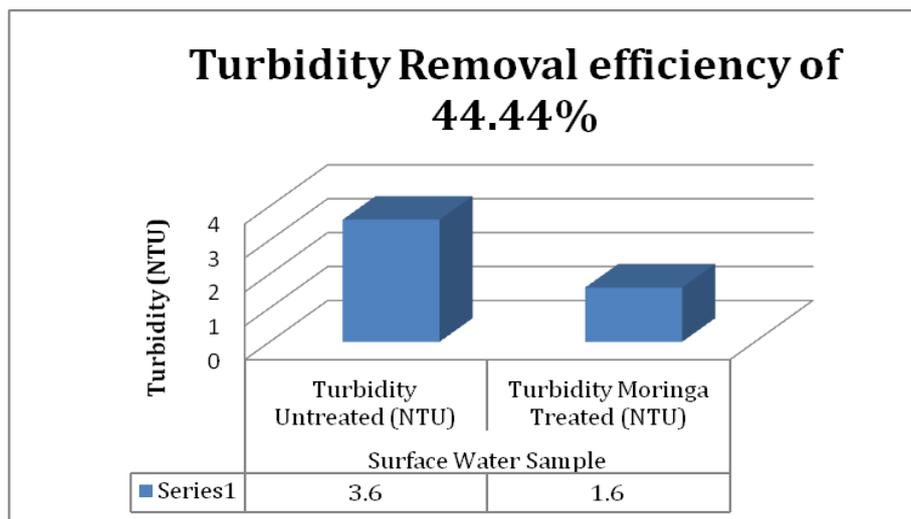


Fig 2: Turbidity removal efficiency of *Moringa oleifera* extract at 1.6 turbidity value.

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