A NEW TECHNIQUE FOR PURIFICATION OF WATER USING NATURAL COAGULANT

C. P. Pise
Research Scholar and Associate Professor, Department of Civil Engineering,
SKN Sinhgad College of Engineering, Pandharpur,
District-Solapur, Maharashtra, India.
Email: cppise@yahoo.co.in

Dr. S. A. Halkude
Professor and Principal, Department of Civil Engineering
Walchand Institute of Technology, Solapur, Maharashtra India.
Email: halkude60@gmail.com

Abstract: The use of chemical coagulants is not suitable due to health and economic considerations. Studies are carried out in laboratory scale on deionized and river water containing synthetic turbidity of kaolinite. Experiments are carried out in three turbidity ranges: 150, 450, 1000 (NTU) and the pH range 6-8. The efficiency of Moringa oleifera (MO) seed extract and alum is examined with jar test, settling column and pilot test. The aim of this study is to find out the optimum combination of MO and alum using alum as a coagulant aid in household treatment of natural river surface water for domestic use. The various coagulant combinations with which the raw water from the river is treated include Moringa oleifera seed powder only, Alum coagulant only and blended Moringa oleifera seeds and alum in different combinations. When Moringa oleifera seed powder is used as the sole coagulant, a filter was needed to obtain an acceptable turbidity value but there was no need for pH adjustment or correction. Moringa oleifera seed powder can be used in treating household drinking water either as a sole coagulant or in combination with alum as a coagulant aid. The recommended ratio for the combined coagulant dose is 60% MO seed powder and 40% alum.

Keywords – Coagulation, Aluminum Sulphate, Moringa Oleifera, Blended coagulant, Filtration.

I. INTRODUCTION

Moringa Oleifera is a tropical multipurpose tree that is commonly known as the miracle tree [1]. Among many other properties, M. Oleifera seeds contain a coagulant protein that can be used either in drinking water clarification [2] or wastewater treatment [3]. It is said to be one of the most effective natural coagulants and the investigation on these kinds of water treatment agents is growing nowadays [4].

Researchers have identified the coagulant component from M. Oleifera seed extract as a cationic protein [5], [6]. It is thought to consist of dimeric proteins with a molecular weight in the range of 6.5–14 kDa.

Using the crude extract as coagulant presented problems of residual dissolved organic carbon (DOC) [7] which makes its use in drinking water not feasible. It is therefore necessary to purify the coagulant [8]. However, the direct application of this isolated agent is not possible under the hypothesis of sustainable and appropriate technology [9]. Consequently, the search for simple and low cost purifications procedures as well as the use of the coagulant in combination with other coagulants and treatment processes needs to be adopted [10]. Some examples of drinking water treatment using crude extract in pilot plant set up have been conducted [11].

In order to overcome the drawbacks of the crude extract many scientists have investigated on purification methods. Okuda et al. [12] proposed a purification method that involves up to six stages, including dialysis. This research team explored the possibilities of other salts, such as KCl or $NaNO_3$ in previous studies [13]-[14]. A simple purification approach has been developed by using a single-step adsorption/elutions in an IEX matrix using sodium chloride solution [15]. Studies have indicated that the use of the single-step eluent results in residual DOC are significantly lower than the crude extract [16].

The use of Moringa Oleifera as a coagulant is mostly used in water treatment that too on small scale and major work has been reported in laboratory scale. The Moringa oleifera is not used in field because of the some drawbacks of Moringa oleifera as it requires large amounts of seeds for small water treatment plant. Also the settling time is more. if the blended coagulant of Moringa oleifera & alum is used then the drawbacks of alum

and Moringa oleifera is reduced and this blend coagulant gives best results, means it removes almost 99.4 % the turbidity. [17]-[22].

The aim of present study is to evaluate the effectiveness of MO and alum in water treatment. Also to find a suitable method of preparation for the MO coagulant i.e. purification of Moringa oleifera seed extract and establish a procedure. Also to find out the optimum dosage of blended Alum and MO for different levels of turbidity, and its removal efficiency at each level.

II. MATERIALS AND METHODS

A. Purification of seed extract:

Tree dried Moringa Oleifera seeds are procured from local trees. Good quality dry seeds of Moringa Oleifera are selected from the pods.

1) Grinding : The seeds coat and wings are removed manually. The seeds are grounded and sieved through sieve 250 µm. The powder with < 250 µm is used. After grinding MO seeds it acts as activated carbon, it can be used as coagulant.

2) Extraction of oil : A ethanol (95%) is added crushed powder of Moringa Oleifera, in 1:10 ratio (1gm of seed powder and 10ml ethanol) to form a suspension. Then it is mixed with the help of magnetic stirrer for 10 minutes. The resulting supernatant is separated by centrifugation (3000 rpm, 45 min) and the settled material is dried at room temperature for 24 hours. The oil content is 35% of the seed weight. The Moringa Oleifera cake residue stock after oil extraction is used. On large scale extracted oil can be used as edible oil.

3) Extraction of salt: Dried de-oiled Moringa Oleifera powder is used for extraction of polymer. This powder is then added to one molar (1M) sodium chloride solution. One molar (1M) NaCl solution can be prepared by adding 5.8 g NaCl powder to 100 ml distilled water and stirred for 10 minutes. Then Dried de-oiled Moringa Oleifera powder added to this 1 M NaCl solution. Then it is mixed with the help of magnetic stirrer for 10 minutes. The resulting supernatant is separated by centrifugation (3000 rpm, 45 min) and then supernatant is then filtered by Whatman filter paper no. 3 and clear solution is used as doses of seed extract for turbidity removal of water sample and remaining part on filter can be used as animal feed or fertilizer.

B. Water samples

Surface water used in the tests was collected in the river basin, which supplies the Pandharpur city. Samples of the water with high and low turbidity were mixed with stock solution of kaolin clay in order to obtain different initial turbidity in the range 150 - 1000 NTU. For preparation of turbid water sample 5gm of kaolin clay is mixed to 500 ml distilled water. Clay sample is soaked for 24 hrs. Suspension is then stirred in the rapid stirrer so as to achieve uniform and homogeneous sample. Resulting suspension is found to be colloidal and used as stock solution for preparation of turbid water samples. Everyday stock sample of kaolin clay is diluted to river water to desired turbidity.

After sample preparation, these are tested (1) coagulation/flocculation with Mo, Alum and blend of Alum-MO (2) Sand filtration and (3) combined coagulation/flocculation with Coagulants followed by sand filtration.

C. Coagulation/flocculation with Moringa

For Preparation of MO Seed Extracts: The coagulant solution of Moringa was prepared and used on the same day. Tree dried Moringa oleifera seeds are procured from local trees. Good quality seeds are then picked up and crushed to fine powder. From this seed extract is prepared. 5 gm of seed powder is mixed with 500 ml distilled water for 2 minutes. Then mixture is kept in the Rapid mixer apparatus for 20 minutes with 120 rpm. Then, mixture is filtered through Muslin/cotton Cloth. Resulting stock solution is having approximate concentration of 10000 mg/l (1%). Fresh stock solutions are prepared every day for the one-day's experimental run. For Preparation of 1% Alum Solution, 1 gm of the Alum is mixed with 100 ml of distilled water. This mixture is stirred for 5 minutes so that all the Alum powder is soluble into the distilled water. And for Preparation of 1% Lime Solution, 1 gm of the Lime is mixed with 100 ml of distilled water. This mixture is stirred for 5 minutes so that all the Lime powder is soluble into the distilled water. Moringa Oleifera and Alum Solution are prepared separately and entered separately with Alum first and Moringa Oleifera a couple of seconds later. Coagulation/flocculation with Moringa tests were conducted in a Jar-Test equipment, BTI Make with six stirrers, with rotation regulator of mixing rods. The experimental conditions for the Coagulation/flocculation with Moringa process were: rapid mixing gradient (120 rpm), rapid mixing time (2 min), slow mixing gradient (40 rpm), slow mixing time (30 min) and settling time (45 min). In this process, the measured parameters in experiment is turbidity, Turbidity meter is Lovibond make, Digital, microprocessor based turbidity meter capable of measuring turbidity from 0.1 NTU up to 2000 NTU is used.

D. Sand filtration process and coagulation/flocculation/ using Pilot treatment plant:

The sand filtration tests were performed on a Pilot treatment plant, sand filtration bench unit. A small set up of water treatment plant on small scale is made, which will give idea about how much purification of turbid water is done. By using obtained optimum doses for different levels of turbidity from jar test apparatus. It consists of water tank of 175 lit capacity at 1.5 m height from ground level. Two Settling columns of diameter 30 cm & 18.5 cm with six sampling port of 12 mm in diameter are Provided. Total depth of column is 1.2 m, the sampling port is provided at depth 0.1 m, 0.3m, 0.5m, 0.7m 0.9m, 1.1m. A 0.5 HP Pump to lift water from settling columns . A sand filter at the end of treatment plant to filter out water upto desired turbidity for drinking purpose.

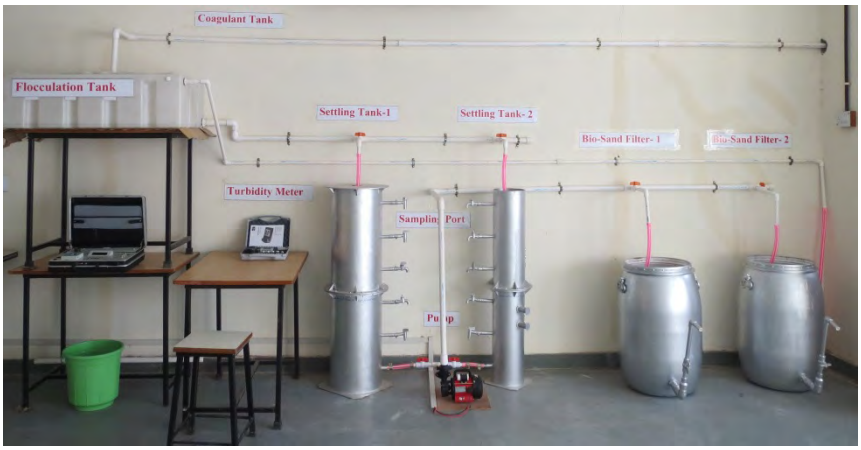


Figure 1 Schematic sketch of Pilot treatment plant

E. Sand filtration:

Even though in settling column suspended particles are settle down at the bottom of tank but still there is some amount of very small suspended particles along with some part seed extract of MO present in the tank. This effect causes a rapid degradation of treated water and forces consumers to consume the water before 48 hours, preventing its storage. To overcome this problem sand filters are provided after the settling column, where water is transferred after sedimentation. sand filter consist of various layers of sand i.e. gravel, coarse sand and fine sand arranged in plastic container of size 0.7 m in height and 0.5m in diameter.

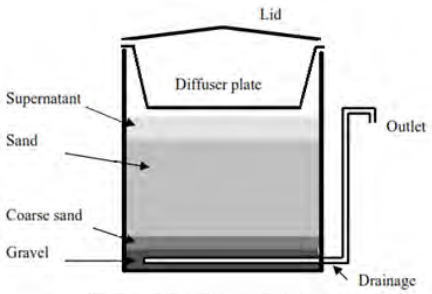


Figure 2 Schematic layout of a sand filter

Type of sand	Size	Depth
Gravel (from bottom)	6-15 mm	10 cm
Coarse sand	3-6 mm	5 cm
Fine sand (at top)	<1mm	18 cm

III. EXPERIMENTAL RUN

The raw water samples of required turbidity (150 NTU, 450 NTU & 1000 NTU) are prepared by using river water and stock solution of kaolin clay. Then all the required jars are filled by turbid water sample of 500 ml. Dose of coagulants are added to different jars. For pH adjustment lime solution is added to each jar containing doses of Alum solution. Dosed jars are put in the Jar Test apparatus for 2 minutes at 120 rpm for complete and effective dispersion of coagulant in the sample. Then slow mixing is continued for 30 minutes at 40 rpm. After 30 minutes jars are taken out from the Jar Test apparatus and kept 45 minutes for settling. At the end of settling period supernatant is taken from 2 cm below the water surface to measure the residual turbidity. Residual turbidity of water sample is then measured with the help of turbidity meter.

To make blend of MO seeds and Alum, Combination of percentage of their respective optimum doses MO-Alum (50%: 50%, 60%: 40%, 70%: 30%) for different turbidity levels are added to water sample. In this blend, amount of Alum dose is being reduced to 30-50%. Residual turbidity of water sample is then measured with the help of turbidity meter.

For the purification of seed extract, procedures for extraction of oil as well as extraction of salt are carried out and filtered supernatant is added to water sample jars according to required doses. For blend of MO and Alum with purification of seed extract, same procedure is adopted. Residual turbidity of water sample is then measured with the help of turbidity meter. Then Graphs are plotted for Residual turbidity versus dosage of coagulant to determine the optimum dose of coagulant.

Settling Column Tests are carried out using the optimum dosage of coagulants to see the turbidity removal efficiency at different settling time. Then water from these settling columns is then transferred to sand filter for further filtration. Turbidity of water after sand filtration is measured. Data obtained in settling column analysis is used for filtration test to find the efficiency of filter.

Table No. 1: Optimum doses of MO with purification of seed extract

Sr.no.	**Turbidity in NTU**	**150 NTU**	**450 NTU**	**1000 NTU**
	Dose mg/L	**Average Residual Turbidity**		
1	20	12.5	-	-
2	25	8.5	-	-
3	**30**	**3.2**	25.2	-
4	35	7.35	19.65	-
5	40	8.8	15.25	-
6	45	10.55	9.95	-
7	**50**	10.9	**2.8**	-
8	55	11.2	8.25	35.2
9	60	13.15	9.1	30.5
10	65	-	9.45	25.6
11	70	-	-	21.65
12	75	-	-	16.55
13	80	-	-	12.55
14	85	-	-	7.6
15	**90**	-	-	**2.5**
16	95	-	-	7.15

Table No. 2: Optimum doses of Alum (Aluminum Sulphate)

Sr.no.	**Turbidity in NTU**	150	450	1000
	Dose mg/L	**Average Residual turbidity**		
1	25	9.15	16.65	21.5
2	**50**	**4.4**	11.8	18.5
3	75	6.5	8.3	14.5
4	**100**	8.15	**4.5**	10.3
5	150	8.5	8.35	7.3
6	**200**	8.7	9.8	**4.4**
7	250	9	10	7.5

Table No. 3: Optimum doses of blend of Alum (Aluminum Sulphate) and MO seed extract

Turbidity in NTU	Dose mg/L Alum- MO	Proportions % Alum- MO	Average Residual turbidity
150 NTU	25, 15	50:50	8.6
	20, 18	**40:60**	**4.8**
	15, 21	30:70	7.6
450 NTU	50, 25	50:50	8.3
	40, 30	**40:60**	**4.6**
	30, 35	30:70	7.2
1000 NTU	80, 54	40:60	9.1
	100, 45	**50:50**	**4.7**
	60, 63	30:70	8.3

Figure 3 Dose of MO coagulent Vs. Residual Turbidity

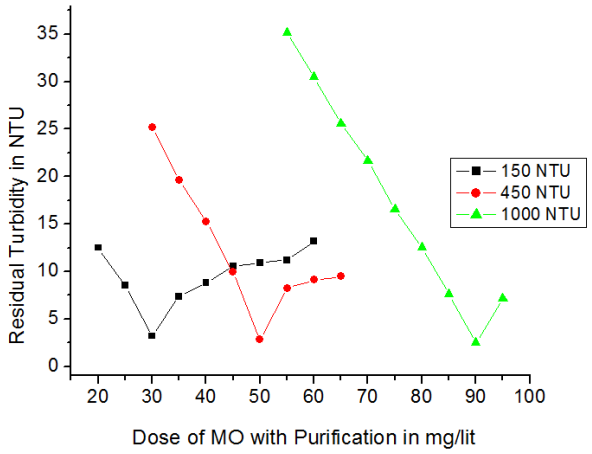
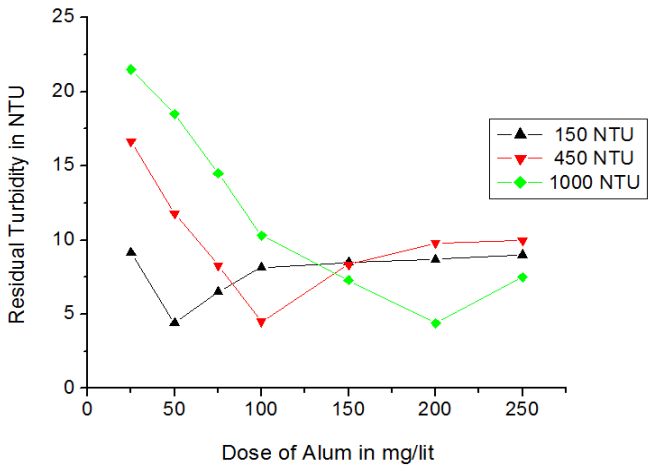


Figure 4 Dose of Alum coagulent Vs. Residual Turbidity



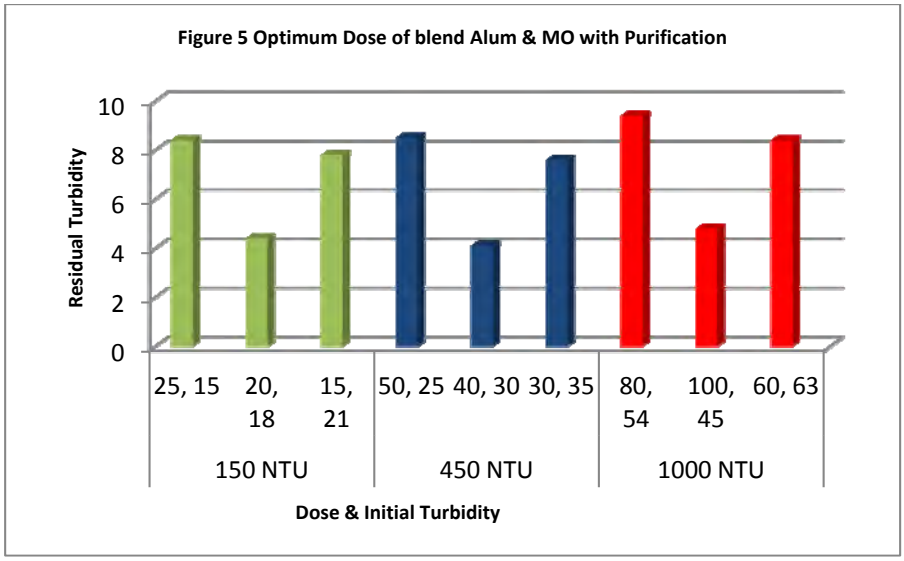


Figure 5 Optimum Dose of blend Alum & MO with Purification

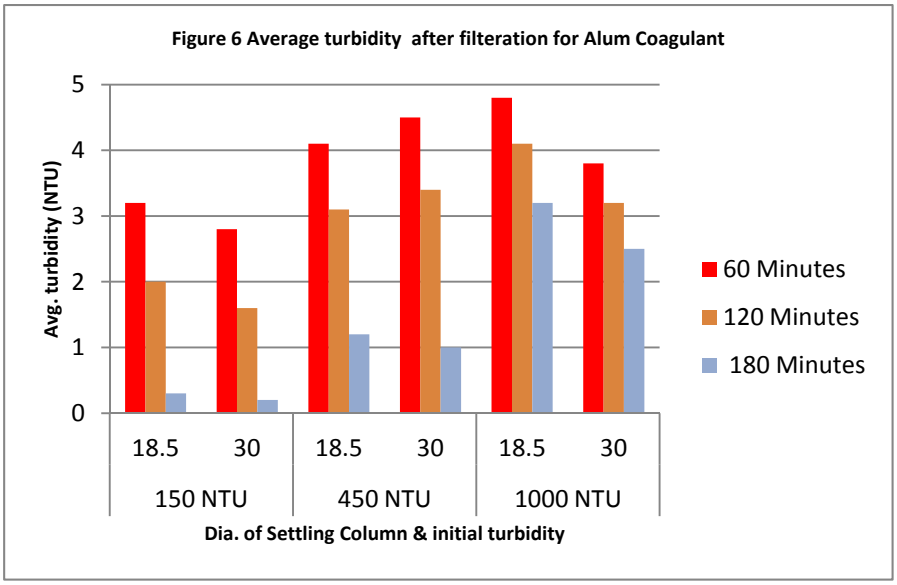
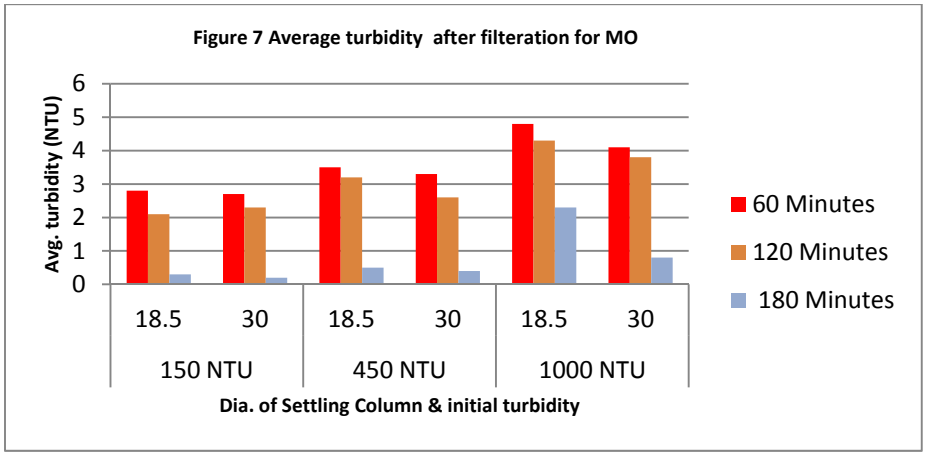
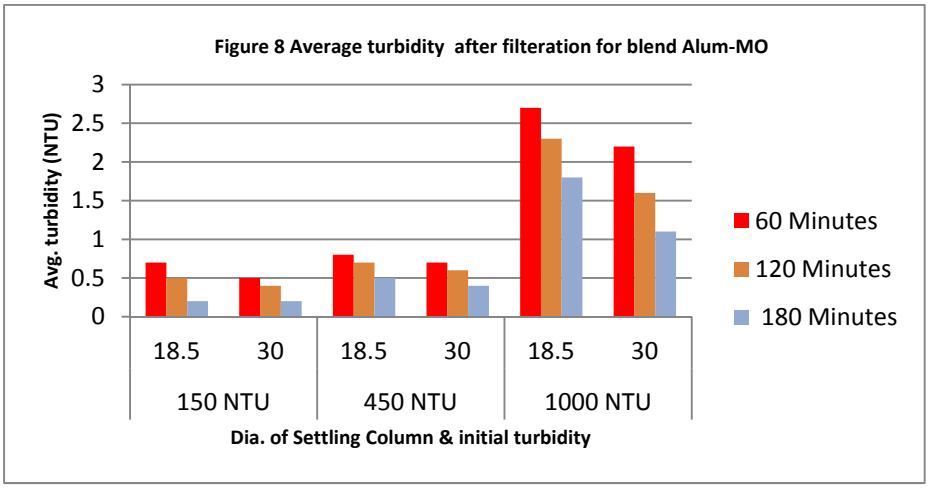


Figure 6 Average turbidity after filteration for Alum Coagulant

Table No. 4 Pilot tests Results for of Alum, MO & Blend Coagulant

Parameters	**Average values**			**Average values**			**Average values**		
Coagulant	**Alum**	**MO**	**Blend**	**Alum**	**MO**	**Blend**	**Alum**	**MO**	**Blend**
Initial turbidity (NTU)	150	150	150	450	450	450	1000	1000	1000
Settling Column Diameter cm	30	30	30	30	30	30	30	30	30
Dose mg/l	50	30	20, 18	100	50	40, 30	200	90	100, 45
Rapid mixing (rpm) -2 Minutes	120	120	120	120	120	120	120	120	120
Slow mixing (rpm) - 30 Minutes	40	40	40	40	40	40	40	40	40
Settling Time 60 Minutes	Filtration Test After 60 Minutes								
Average turbidity after sed. (NTU)	14	13.6	5.7	48.3	22.6	13.7	37.3	43.5	27.8
Average turbidity after filter (NTU)	2.8	2.7	0.5	4.5	3.3	0.7	3.8	4.1	2.2
Purification by sedimentation. tank (%)	90.70	90.90	96.20	89.30	95.00	96.90	96.30	95.70	97.20
Purification by sand filter (%)	80.00	80.15	91.23	90.68	85.40	94.89	89.81	90.57	92.09
Purification total (%)	98.13	98.20	99.67	99.00	99.27	99.84	99.62	99.59	99.78
Settling Time 120 Minutes	Filtration Test After 120 Minutes								
Average turbidity after sed. (NTU)	7.8	7.2	2.9	26.7	11.3	6.3	20.4	25.5	16.8
Average turbidity after filter (NTU)	1.6	2.3	0.4	3.4	2.6	0.6	3.2	3.8	1.6
Purification by sedimentation. tank (%)	94.80	95.20	98.10	94.10	97.50	98.60	98.00	97.50	98.30
Purification by sand filter (%)	79.49	68.06	86.21	87.27	76.99	90.48	84.31	85.10	90.48
Purification total (%)	98.93	98.47	99.73	99.24	99.42	99.87	99.68	99.62	99.84
Settling Time 180 Minutes	Filtration Test After 180 Minutes								
Average turbidity after sed. (NTU)	4.7	4.2	1.8	10.9	5.5	3.6	11	8.1	7
Average turbidity after filter (NTU)	0.2	0.2	0.2	1	0.4	0.4	2.5	0.8	1.1
Purification by sedimentation tank (%)	96.80	97.20	98.80	97.60	98.80	99.20	98.90	99.20	99.30
Purification by sand filter (%)	95.74	95.24	88.89	90.83	92.73	88.89	77.27	90.12	84.29
Purification total (%)	99.87	99.87	99.87	99.78	99.91	99.91	99.75	99.92	99.89





IV. RESULTS AND DISCUSSION

The Figure 3 shows that Moringa Oleifera coagulant, the optimum dose of the Moringa Oleifera for initial turbidity 150 NTU, 450 NTU and 1000 NTU are 30 mg/lit, 50 mg/lit and 90 mg/lit respectively. The addition of dosage beyond optimum dose is shows slight increasing the residual turbidity. Overdosing of coagulant is results in the saturation of the polymer bridge sites.

The Figure 4 shows that Alum coagulant, the optimum dose of the Moringa Oleifera for initial turbidity 150 NTU, 450 NTU and 1000 NTU are 50 mg/lit, 100 mg/lit and 200 mg/lit respectively.

Figure 5 shows that the optimum dose of the blended coagulant for initial turbidity 150 NTU are found as Alum - 20 mg/lit, M.O. – 18 mg/lit. For initial turbidity 450 NTU the optimum dose of the blended coagulant are found as Alum – 40 mg/lit, M.O. - 30 mg/lit. For initial turbidity 1000 NTU the optimum dose of the blended coagulant are found as Alum - 100 mg/lit, M.O. -45 mg/lit.

From the Figure 6, it is observed that the minimum average turbidity obtained after filtration for Alum coagulant at 180 minutes for 150 NTU, 450 NTU and 1000 NTU initial turbidity, with larger settling column diameter (30 cm) the values are 0.2, 1, and 2.5 NTU respectively. Also for the alum coagulant after 60 minutes of settling average turbidity values after filtration are below 5 NTU. So here settling time is 60 minutes.

The Figure 7 shows the average turbidity values after filtration for MO Coagulant with purification. The minimum average turbidity after filtration of 30 cm diameter settling column, for 150 NTU, 450 NTU and 1000 NTU initial turbidity at 180 minutes settling time, are 0.2, 0.4 and 0.8 NTU respectively. For the MO coagulant with purification after 60 minutes of settling, average turbidity values after filtration are below 5 NTU. So here settling time is 60 minutes.

From the Figure 8, it is observed that the minimum average turbidity obtained after filtration for Alum-MO coagulant with purification at 180 minutes for 150 NTU, 450 NTU and 1000 NTU initial turbidity, with larger settling column diameter (30 cm) the values are very low 0.2, 0.4, and 1.1 NTU respectively. Also for the Alum-MO coagulant with purification after 60 minutes of settling average turbidity values after filtration are

below 3 NTU. So here settling time is 60 minutes. This blended coagulant gives very low turbidity after filtration as compared to all coagulants.

V. CONCLUSION

Moringa oleifera seed powder can be used in treating household drinking water either as a sole coagulant or in combination with alum (using the alum) as a coagulant aid. Incorporating a filter medium into household water treatment will help improve the water quality. The use of MO seed powder is made economical because same weight of MO seed powder accomplishes more treatment than an equal weight of alum.

The overall turbidity removal efficiency at constant time interval of all these coagulants shows that the maximum removal efficiency is obtained by blended coagulant Alum and MO then it decreases for MO, and then for Alum. It is observed that blended coagulant Alum and MO gives maximum removal efficiency as compared to the traditional Alum coagulants at minimum settling time. Here in this blending process with purification of MO seeds extract the Alum dose reduced by 60 % for 150 NTU & 450 NTU initial turbidity samples and by 50 % for high turbidity i.e. 1000 NTU initial turbidity sample. Thus the drawbacks of Alum can be reduced. With purification of MO seeds extract amount of MO seeds can be reduced, so that useless parts of MO seeds extracts are removed and decreases the content of organic matter or load in the treated water. Also the cost of the treatment can be reduced by using the natural coagulant (MO) instead of traditional coagulant (Alum). It can be concluded that purification of MO seed extracts used as coagulant gives best results.

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