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Sustainable Water Purification: Efficiency of Mono and Tri-Blended Bio-Coagulants for Surface and Groundwater Treatment

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ABSTRACT

The increasing demand for safe and clean water has led to the exploration of eco-friendly and sustainable water treatment methods. Conventional chemical coagulants, though effective, pose health risks, environmental concerns, and economic challenges. Natural coagulants have emerged as a promising alternative due to their biodegradability, cost-effectiveness, and non-toxic nature. This study investigates the efficiency of bio-coagulants—sesame seeds (SS), Moringa oleifera (MO), and chickpea seeds (CS)—for treating highly turbid surface water and groundwater through the coagulation process.

The research focuses on the use of both mono and tri-blended natural coagulants to determine the optimal dosage required for effective water treatment. Different concentrations of mono-coagulants (10 mg/L, 20 mg/L, 40 mg/L, 60 mg/L, and 80 mg/L) were tested in surface and groundwater samples. Additionally, various tri-blended dosage ratios of MO:CS:SS, such as 10:10:80, 20:10:70, 30:10:60, and up to 80:10:10, were analyzed to determine the most efficient combination for maximum flocculation. The study evaluated the coagulation performance based on floc formation, turbidity reduction, and settling efficiency. Experimental results demonstrated that a mono-coagulant dosage of 60 mg/L of Moringa oleifera exhibited the best coagulation efficiency among the single-coagulant trials. For the tri-blended coagulants, the most effective combination was found to be MO:CS:SS (50:10:40), which achieved optimal floc formation and enhanced turbidity removal. The findings highlight that plant-based natural coagulants can significantly improve water quality by reducing turbidity and enhancing sedimentation, offering a sustainable alternative to chemical coagulants. The use of natural bio-coagulants not only minimizes health risks but also supports environmentally friendly water treatment solutions. The study suggests further research on the long-term performance of these natural coagulants, their impact on microbial activity, and potential applications in large-scale water treatment facilities. This research contributes to the advancement of green water purification technologies, promoting safe drinking water through cost-effective, non-toxic, and biodegradable solutions. The results emphasize the potential of plant-derived coagulants in addressing global water quality challenges while aligning with sustainable development goals.

Key words: MO (Moringa oleifera), CS(Chickpea seeds), SS(Sesame seeds), Bio-coagulants, Natural water treatment.

1. INTRODUCTION

Water is one of the most common and the most precious resource on earth without which there would have been no life on earth. Pollution is a serious problem in India as 70% of its surface water resources and ground water reserves have been contaminated by biological, organic and inorganic pollutants (Yadav S.S 2011). Groundwater is used for agricultural, industrial, household, recreational and environmental activities all over the world (S.Devi et al., 2012). Water is the life's matter and matrix and without it, life cannot exist. The presence of safe and reliable drinking water is an essential prerequisite for a stable community. So quality of water is to be determined for a locality for various purposes. As water balances human life system in a positive way, its negative effect is attributed by consequence of various parameters beyond the permissible limits (Sujata Sen, 2011).

Wastewater disposal is the major problem being faced by us. In developing countries, like India presently, only about 10% of the generated wastewater is treated; the rest is discharged into our water bodies. Water bodies have an inherent capability to dilute the pollutants which enter the system. However, dumping of untreated sewage and chemical wastes directly into lakes and drains has made these water bodies unable to cope with the pollutant load. The steady increase in the amount of water used and waste water produced by urban communities and industries throughout the world also poses potential health and environmental problems. The contaminated waters disrupt the aquatic life and reduce their reproductive capability. The most commonly faced problem in disposal of wastewater is the color and turbidity. Finely dispersed suspended and colloidal particles are responsible for the color and turbidity of the waste waters. Color in water results from the presence of natural metallic ions, humus and peat material, plankton, weeds, and industrial wastes. Suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms are responsible for turbid waters.

3. PROPOSED SYSTEM

3.1 Methodology

The methodology of the project work involves collection and processing of materials, sampling of materials, preparation of coagulant solutions, Physicochemical analysis of raw ground and surface water, Optimization of mono and Tri-Blended coagulant dosage with respect to floc formations, removal efficiency of turbidity, TDS and TSS with optimum dosage of coagulant, settling characteristics of mono coagulant and tri-blended coagulants. comparison of optimum coagulant dosage and settling characteristics of mono coagulant and tri-blended natural coagulants and suggestions and recommendations from the study.

3.2 Materials and methods

The materials used for the proposed research work are Moringa oleifera seeds, chickpea seeds, Sesame seeds, Chemical coagulant Alum, ground water and surface water.

Collection, sampling and processing of these materials were discussed in the following sections.

3.3 Collection and processing of M. oleifera

Moringa oleifera seeds were collected from farms in Narapally village of Medchal district. The seeds are allowed to dry in the laboratory oven at a temperature of 50 °C for 24 h. A rice husk removing machine was used to remove the hulls and wings from the kernels. The kernels were ground in to medium fine powder with domestic food blender. The Physical properties of Moringa oleifera dry powder was determined and given in the Table 4.1. The photo view of Moringa oleifera dry powders after processing were shown in Figure 4.1.

Table 3.1 Physical properties of Moringa oleifera seeds

Sl. No	Test particulars	Value obtained
1	pH	5.88
2	EC	4.03 µs
3	Particle Size	850 µ to 150 µ
4	Density	2.04 g/cm^3
5	Specific gravity	1.17 g/cm^3

Figure 3.1 Moring oleifera seed kernels and dry powder

3.4.2 Collection and processing of Chickpea

Tamarindus indica seeds used in this study was collected from the local market. It was soaked in water for an hour to remove the adhering pulp, washed well with tap water and then with double distilled water, dried in an air oven at 110º C for an hour, micronized in a four mill (Murugan et al 2006). The photo view of chickpea seeds collected from the local market were shown in Figure 4.2. The Physical properties of chickpea seeds was determined and given in the Table 4.2.

Table 3.2 Physical properties of chickpea seeds

Sl. No	Test particulars	Value obtained
1	P^H	7.91
2	EC	103.8 µs
3	Particle Size	850 µ to 150 µ
4	Density	2.04 g/cm^3
5	Specific gravity	1.50 g/cm^3

Figure 3.2 Chickpea dry powder

3.4.3 Collection and processing of Sesame seed

This seeds were collected from the local market in Hyderabad. Sesame seeds were shown in Figure 4.3. The Physical properties of this seeds was determined and given in the Table 4.3..

Table 3.3 Physical properties of Sesame seeds

Sl. No	Test particulars	Value obtained
1	pH	7.91
2	EC	103.8 µs
3	Particle Size	850 µ to 150 µ

4	Density	2.04 g/cm^3
5	Specific gravity	1.5 g/cm^3

Figure 3.4 Sesame seeds dry powder

Figure 3.5 Digital ELICO Nephelometre model CL 52 D

3.5 Optimization of mono coagulants and tri-blended natural coagulant dosage

The optimization for mono coagulant and tri-blended natural coagulants dosage were performed using the jar test apparatus. The apparatus permitted four beakers to be agitated all together. 0.5 L of textile wastewater were doused with 10, 20, 40, 60 and 80 mL of mono natural coagulants and 0:0:0, 10:10:80, 20:10:70, 30:10:60, 40:10:50, 50:10:40, 60:10:30, 70:10:20 and 80:10:10 respectively of different proportions were stirred rapidly for 1 min at 180 rpm, followed by 10 min slow stirring for flocculation. Floc formation can be observed throughout this time. Flocs were permitted to settle for one hour before obtained for samples analysis. These procedures are performed for several times so that the optimum dosage of coagulant can be calculated (Metcalf & Eddy 1979). After settling, 30 mL of the sample was taken from the middle of each beaker using a pipette and placed in small beaker for further analysis. Jar test apparatus used for optimization of coagulant dosage was shown in Figure 4.7.

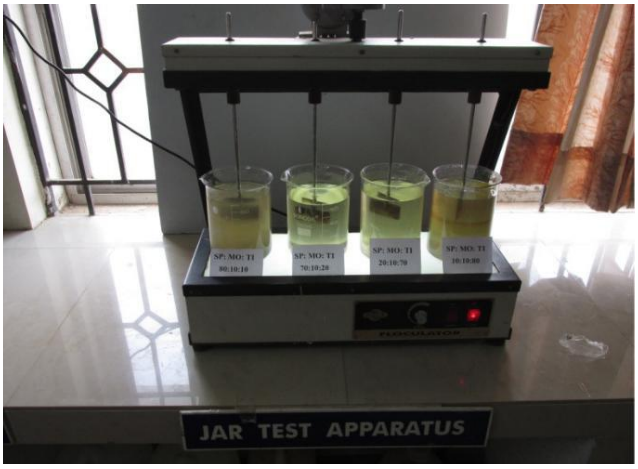

Figure 3.6 Jar Test Apparatus

4. RESULTS AND DISCUSSIONS

In the present project three sets of dosage proportions of Tri-Blended natural coagulants as MO : CS : SS, CS : SS : MO, SS: MO :CS were taken for the study. The performance characteristics of Tri-Blended natural coagulants on Musi river water as surface water with respect to its optimum dosages, removal efficiency of turbidity, TDS and TSS using Tri-Blended natural coagulants, effective particle size, settling time and volume of sludge production was analysed.

The Proportions of dosages added with the volume of the Musi river water in the project work as 0:0:0, 10:10:80, 20:10:70, 30:10:60, 40:10:50, 50:10:40, 60:10:30, 70:10:20 and 80:10:10 in the order of MO : CS : SS, CS : SS : MO, SS: MO :CS respectively. From Table 4.1 the test results of the optimization of coagulant dosage proportions for MO: CS: SS, CS: SS: MO, SS: MO: CS was performed using the jar test apparatus. 0.5 L of Surface water were doused with proportions of 10:10:80, 20:10:70, 30:10:60, 40:10:50, 50:10:40, 60:10:30, 70:10:20 and 80:10:10 respectively of MO: CS: SS, CS: SS: MO, SS: MO: CS were stirred rapidly for 10 min at 180 rpm, followed by 10 min slow stirring for flocculation. Floc formation can be observed throughout this time. Flocs were permitted to settle for one hour before obtained for samples analysis. The optimum coagulant dosage can be determined with respect to the floc formation.

Table 4.1 Optimum coagulant dosage proportions of Tri-Blended natural coagulant in Surface water with respect to floc formation.

Sl. No.	Dosage Proportion Index	Blended proportions	Floc formation (ml)		
			MO:CS:SS	CS:SS:MO	SS:MO:CS

1.	P1	0:0:0	0	0	0
2	P2	10 :10:80	87	74	81
3	P3	20 :10:70	98	83	93
4.	P4	30 :10:60	104	104	137
5.	P5	40 :10:50	123	**126**	**162**
6.	P6	50 :10:40	**167**	117	151
7.	P7	60 :10:30	184	111	122
8.	P8	70 :10:20	119	91	104
9.	P9	80 :10:10	103	79	86

4.3 Physical characteristics removal of tri-blended natural coagulant in surface water

The performance characteristics of removal efficiency of Tri-Blended natural coagulant with addition of dosage proportions of 10:10:80, 20:10:70, 30:10:60, 40:10:50, 50:10:40, 60:10:30, 70:10:20 and 80:10:10 in the order of MO: CS: SS, CS: SS: MO, SS: MO: CS, respectively were used to determine the removal of turbidity, TDS in Surface water. The removal efficiency of turbidity were determined by the analytical method 2130-B of standard methods for the examination of water and wastewater and the test results of removal of turbidity with respect to dosage proportions of 10:10:80, 20:10:70, 30:10:60, 40:10:50, 50:10:40, 60:10:30, 70:10:20 and 80:10:10 in the order of MO: CS SS, CS: SS: MO, SS: MO: CS respectively were given in Table 4.2.

Table 4.2 Turbidity removal of MO: CS: SS, CS: SS: MO, SS: MO: CS

Sl. No.	Dosage Proportion Index	Blended proportions	% removal of Turbidity		
			MO:CS:SS	CS:SS:MO	SS:MO:CS

1	P1	0:0:0	0	0	0
2	P2	10;10:80	30.75	49.24	51.69
3	P3	20:10:70	32.98	54.14	57.26
4	P4	30:10:60	43.19	67.43	68.93
5	P5	40:10:50	57.21	**71.30**	**75.20**
6	P6	50:10:40	73.11	64.73	66.27
7	P7	60:10:30	**80.20**	52.15	53.11
8	P8	70:10:20	69.97	50.88	51.94
9	P9	80:10:10	52.31	49.27	50.27

The test results of removal of TDS with respect to dosage proportions of 10:10:80, 20:10:70, 30:10:60, 40:10:50, 50:10:40, 60:10:30, 70:10:20 and 80:10:10 in the order of MO: CS: SS, CS: SS: MO, SS: MO: CS respectively were given in Table 6.3 The removal efficiency of TDS were determined by the analytical method 2540 - C of standard methods for the examination of wastewater.

Table 4.3 TDS removal of MO: CS: SS, CS: SS: MO, SS: MO: CS

Sl. No.	Dosage Proportion Index	Blended proportions	% removal of TDS		
			MO:CS:SS	CS:SS:MO	SS:MO:CS
1	P1	0:0:0	0	0	0
2	P2	10:10:80	40.15	42.46	47.39
3	P3	20:10:70	44.47	48.34	52.47
4	P4	30:10:60	57.25	56.98	60.47
5	P5	40:10:50	61.34	**60.42**	**67.91**
6	P6	50:10:40	69.37	59.14	54.32

7	P7	60:10:30	**71.25**	55.38	53.21
8	P8	70:10:20	67.23	53.17	50.47
9	P9	80:10:10	53.14	50.18	49.38

The removal of TSS were determined by the analytical method 2540-D of standard methods for the examination of wastewater and the test results of removal of TSS with respect to dosage proportions of 10:10:80, 20:10:70, 30:10:60, 40:10:50, 50:10:40, 60:10:30, 70:10:20 and 80:10:10 in the order of MO: CS: SS, CS: SS: MO, SS: MO: CS respectively were given in Table 4.4.

Table 4.4 TSS removal of MO: CS: SS, CS: SS: MO, SS: MO: CS

Sl. No.	Dosage Proportion Index	Blended proportions	% removal of TSS		
			MO:CS:SS	CS:SS:MO	SS:MO:CS
1	P1	0:0:0	0	0	0
2	P2	10;10:80	49.25	50.38	51.21
3	P3	20:10:70	52.14	57.35	57.21
4	P4	30:10:60	68.36	63.87	61.35
5	P5	40:10:50	75.24	**76.35**	**79.23**
6	P6	50:10:40	78.47	69.34	65.76
7	P7	60:10:30	**82.11**	66.98	65.24
8	P8	70:10:20	77.32	61.35	60.62
9	P9	80:10:10	62.74	59.24	56.21

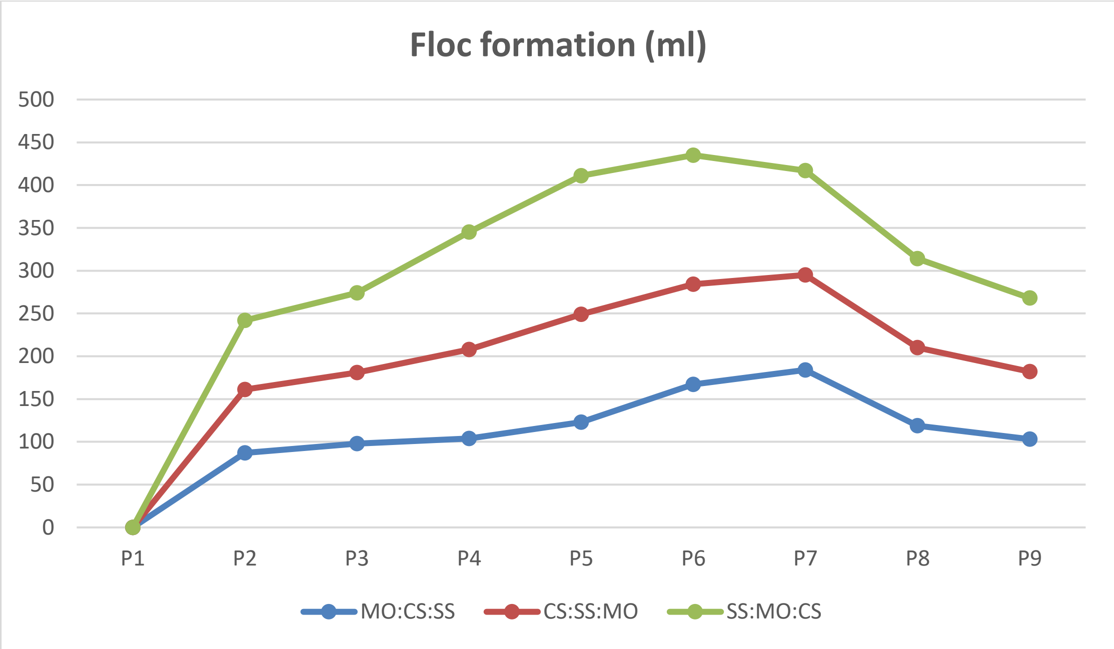

Figure 4.1 Optimum coagulant dosage proportions of Tri-Blended natural coagulant in Surface water with respect to floc formation.

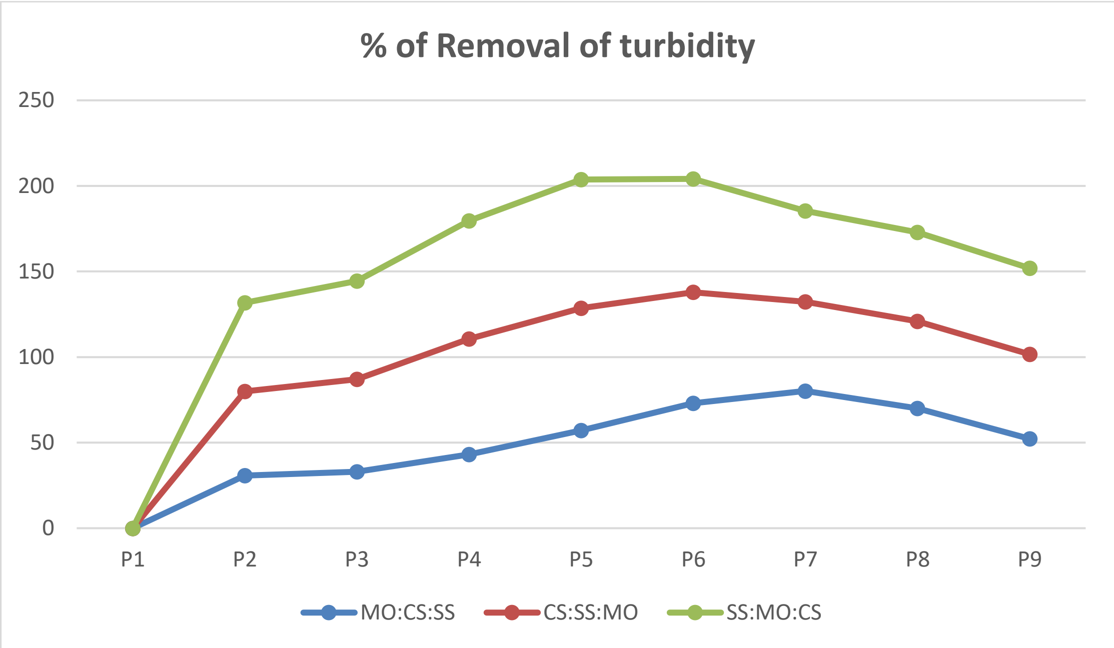

Figure 4.2 Turbidity removal of MO: CS: SS, CS: SS: MO, SS: MO: CS

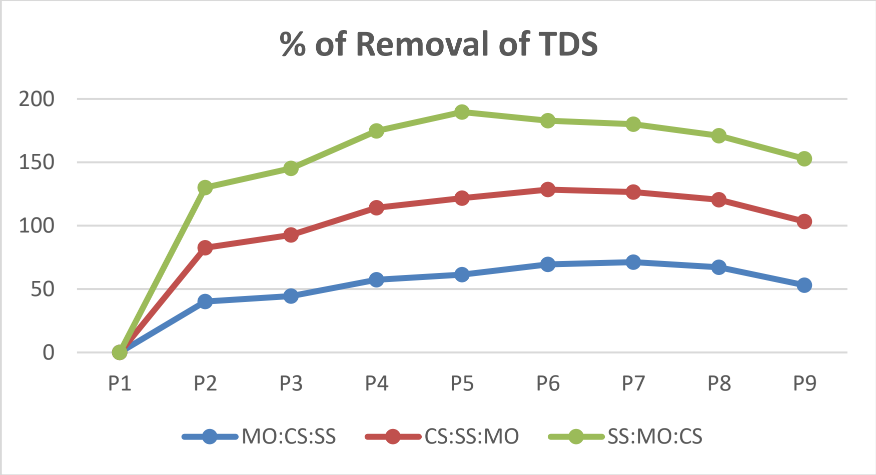

Figure 4.3 TDSremoval of MO: CS: SS, CS: SS: MO, SS: MO: CS

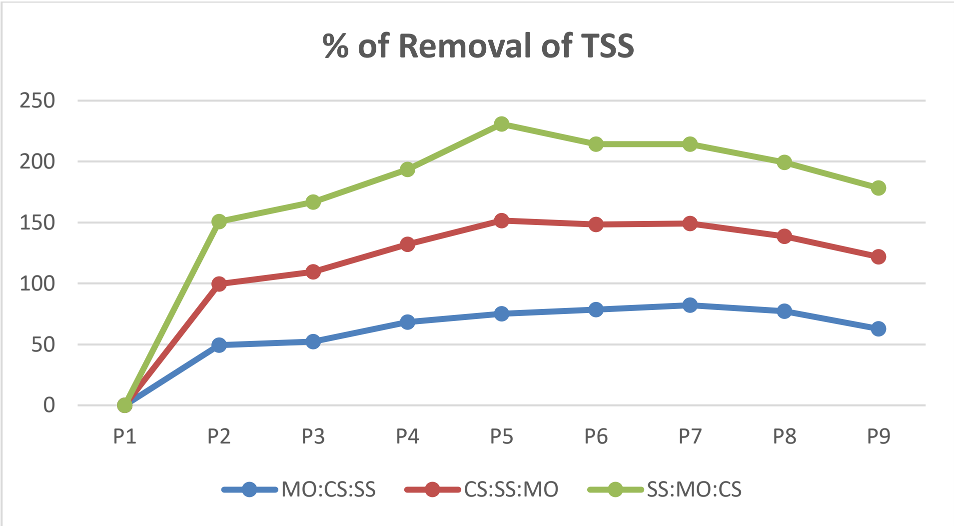

Figure 4.4 TSS removal of MO: CS: SS, CS: SS: MO, SS: MO: CS

5. CONCLUSIONS

The performance characteristics of mono natural coagulants, including Moringa oleifera (MO), Chickpea (CS), Sesame (SS), and Alum (control), were evaluated for surface water treatment through Jar tests. The results showed that the optimum dosages for effective treatment were 60 mg/L for M. oleifera and 40 mg/L each for Chickpea, Sesame, and Alum. In terms of floc formation, M. oleifera produced 82 mL, followed by Alum (77 mL), and Chickpea and Sesame (76 mL each). Turbidity removal efficiencies were 80.72% (MO), 70.28% (CS), 74.10% (SS), and 74.80% (Alum). The removal of total dissolved solids (TDS) was highest for M. oleifera (70.51%), followed by Alum (69%), Sesame (63.93%), and Chickpea (58.42%). Similarly, total suspended solids (TSS) removal was most effective with M. oleifera (80.86%), followed by Sesame (77.78%), Alum (77.36%), and Chickpea (75.71%). Overall, Moringa oleifera at 60 mg/L exhibited the highest efficiency in floc formation, turbidity reduction, and TDS/TSS removal, demonstrating its potential as a sustainable and eco-friendly alternative to conventional chemical coagulants for surface water treatment.

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