

Behavior and Performance of Natural Coagulants in Polluted Water



A. Faizuneesa, S. P. Kanniyappan, S. Saranya

Abstract: In this project, Polluted water sample from a Pond is collected for treating it by using Natural Coagulants. The pond is located in Madarpakkam Village, near Gummudipoondi, Tamilnadu, India. There were 4 water samples collected from four different points around the pond at depth of 0.5m, 1m, 1.5m and 2m. The water samples were analyzed for physical and chemical parameters with reference to the code IS 10500-1991. The objective of this project is to reduce the level of turbidity and bacteriological contaminants from water using locally available Natural Coagulants and to reduce the concentration of particular matter such as suspended particles, parasites, bacteria, algae, virus and fungi and to make use of the treated water for domestic purpose, as it reduces cost about 30% to 70%, the usage of these Natural coagulants will be more in future. It is nontoxic and non-corrosive. So, it is safe for human health. The usage of Natural coagulants can be increased in future as it increases the Water quality.

Keywords: *Abelmoschesculents, Alum, Azadirachataindica, Coagulants, Ipomeabatas, Jar Test, Moringa Oleifera, Musa paradisiaca, Total solids, Turbidity, Suspended solids, Vitis vinifera.*

I. INTRODUCTION

A. Water Clarification

It is the process of removing undesirable chemicals, biological contaminants suspended solid and gases from contaminated water. It reduces the concentration of particular matter such as suspended particles, parasites, bacteria, algae, virus and fungi. The goal of this process is to produce water fit for a specific purpose. Water is disinfected for human consumption (drinking water).

B. Natural Coagulant

According to 2007, WHO resulted 1.1 billion people lack access to improved drinking water supply, 88% of the 4 billion annual cases of diarrheal diseases are attributed to unsafe water and inadequate sanitation. 1.8 million People die from diarrheal diseases each year. Treated water is more important for our drinking purposes mostly water is treated using chemical coagulant. But there is some problem to use of chemical coagulant.

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1. Aluminium is a causative agent in neurological diseases such as pre-senile dementia.
2. There is a fear that indigestion of aluminium ions may induce Alzheimer's diseases.
3. Cost of the chemical treatment is high

Under this consideration, we are going to use naturally available materials as coagulant for water purification. The natural materials that we are going to use are banana peel, drumstick seed, grape seed, lady's finger, sweet potato and Neem seed. Using standard jar test, we have compared our natural coagulants with chemical coagulants (lime and alum). By comparison we are going to find the best coagulant which is easily and most available in plenty.

II. METHODOLOGY

Collection of Water Sample, Water Quality Analysis, Preparation of Natural Coagulants and Water Quality Analysis for the Sample using Natural Coagulants and Chemical coagulants.

A. Field Data

- A Polluted Water sample from a Pond is collected for treating it by using Natural Coagulants.
- The pond is located in Madarpakkam Village near Gummudipoondi, Tamilnadu, India, as shown in Fig. 1.
- There were 4 water samples collected from four different points around the pond at a depth of 0.5m, 1m, 1.5m and 2m. The water samples were analysed for physical and chemical parameters with reference to the code IS 10500-1991.
- The temperature is 21°C at the time of sample collection.
- The test is carried out with 4th sample which is most polluted.



Fig. 1 Pond at Madarpakkam village near Gummudipoondi.

B. Parameter Tests

- Turbidity
- pH
- Total solids
- Suspended solids
- Jar Test is performed to find the Optimum dosage of the Natural Coagulant. Water Treatment using Chemical coagulants (Alum & Lime) is also done and the results were compared.

C. Sample Parameter Value

The parameter tests are done for the collected sample and the results are given in Table I with its permissible limits.

Table-I: Sample Parameter and Permissible Standards

S. No	Parameter	Sample parameter	Permissible limits As per IS: 2296-1982
1.	Turbidity	62.4 NTU	10 NTU
2.	pH	5.49	6.5 to 8.5
3.	Total solids	4300 mg/l	5000 mg/l
4.	Suspended solids	600 mg/l	800 mg/l

D. Natural Coagulants

Natural coagulants are coagulants which are naturally available in the environment. These coagulants are nontoxic, non-corrosive and good for human health. Cost of these coagulants are very low when compare to the chemical coagulants. It provides the sustainable and economical water treatment. No skilled labours are required for water treatment. Maintenance cost will be very low when comparing to the chemical water treatment. In this experiment, we are going to use the *Musa paradisiaca*, *Moringa oleifera*, *Vitis vinifera*, *Abelmoschus esculentus*, *Ipomoea batatas*, *Azadirachata indica*, Alum and Lime as a coagulant for water treatment.

E. Jar Test

Jar test is the physical test, for finding the performance of the natural coagulants used and to determine whether the used natural coagulants are having coagulant properties or not. Physical test is conducted by using standard jar test, six coagulants are added separately in the six jars with water sample. The coagulants are added with same dosage 5mg/l in all the six jars as shown in Fig. 2. By visual observation the performance of coagulants is determined. Visual observation includes the settling rate, size of flocs, colour and transparency.



Fig. 2 Water samples after Physical Test

III. EXPERIMENTAL INVESTIGATION

A. Jar Test for *Musa paradisiaca*

The coagulant dosage 15mg/l, 20mg/l, 25mg/l and 30mg/l of powders were weighed in weight balance machine. 250ml of water sample is taken in four jars. Weighed coagulant

powders is added in four jars separately. Then they are allowed for jar test. After the completion of jar test, they are rested for settling indicates the settling of impurities and floc formation after the addition of coagulant. *Banana peel* shows good clarity and also settlement in the water shows formation of floc and settling of impurities in closer. The shown settlement is for the coagulant dosage 15mg/l after settling of impurities the clear water from the top is pipetted out and collected in the container. This clear water is taken for the parameters test. The parameters test is done for all the four coagulant dosage treated clear water and the test results are shown in Table II.

Table-II: Jar Test Analysis and Parameters Test Results for *Musa paradisiaca*

S.No	Parameters	Observation & Results			
		Jar-1	Jar - 2	Jar - 3	Jar - 4
1.	Coagulant dosage (mg/l)	15	20	25	30
2.	Size of floc	Big	Big	Minute	Minute
3.	Settling Rate	Quick	Quick	Quick	Fair
4.	Color & Transparency	Clear	Slightly hazy	Clear	Slightly hazy
5.	Turbidity (NTU)	2	3	3	4
6.	pH	6.52	6.51	6.52	6.43
7.	Total solids(mg/l)	3700	3680	3650	3700
8.	Suspended solids(mg/l)	0	0	0.11	0.08

From the results, Jar-1 is selected with the optimum dosage for *Banana peel* as 15 mg/l.

B. Jar Test for *Moringa oleifera*

The coagulant dosage 15mg/l, 20mg/l, 25mg/l and 30mg/l of powders were weighed in weight balance machine. 250ml of water sample is taken in four jars. Weighed coagulant powders are added in four jars separately. Then they are allowed for jar test. After the completion of jar test, they rested for settling indicates the settling of impurities and floc formation after the addition of coagulant. *Drumstick seed* shows good clarity and also settlement in the water shows formation of floc and settling of impurities in closer. The size of floc is big in the drumstick seed. After the settling of impurities, the clear water from the top is pipetted out and collected in the container. This clear water is taken for the parameter tests. The parameter tests are done for all the coagulants dosage treated clear water the test results are shown in Table III.

Table-III: Jar Test Analysis and Parameters Test Results for *Moringa Oleifera*

S.No	Parameters	Observation & Results			
		Jar -1	Jar -2	Jar -3	Jar -4
1.	Coagulant dosage (mg/l)	15	20	25	30
2.	Size of floc	Minute	Big	Big	Minute
3.	Settling Rate	Quick	Quick	Quick	Fair
4.	Colour & Transparency	Clear	Slightly hazy	Clear	Slightly hazy
5.	Turbidity (NTU)	2	3	3	4
6.	pH	6.52	6.51	6.52	6.43
7.	Total solids(mg/l)	3700	3680	3650	3700
8.	Suspended solids(mg/l)	0	0	0.11	0.08

From the results, Jar-2 is selected with the optimum dosage for *Drumstick seed* as 20 mg/l.

C. Jar Test for Vitis vinifera

For the Grape seed, solution form coagulant is selected. 250ml of water sample is taken in four jars. Measured coagulant solution is added in four jars separately. Then they are allowed for jar test.

After the completion of jar test, they rested for settling indicates the settling of impurities and floc formation after the addition of coagulant (grape seed). *Grape seed* solution shows good clarity and also settlement in the water shows formation of floc and settling of impurities in closer. The shown settlement is for the coagulant dosage 8mg/l. The size of floc is big in the 8mg/l. After the settling of impurities, the clear water from the top is pipetted out and collected in the container. This clear water is taken for the parameters test. Table IV shows the analysis and parameters of vinus vinifera.

Table-IV: Jar Test Analysis and Parameters Test Results for Vitis Vinifera

S. No	Parameters	Observation & Results			
		Jar -1	Jar -2	Jar -3	Jar -4
1	Coagulant dosage (mg/l)	2	4	6	8
2.	Size of floc	Minute	Minute	Big	Fair
3.	Settling Rate	Poor	Fair	Quick	Quick
4.	Colour & Transparency	Hazy	Slightly hazy	Slightly hazy	Clear
5.	Turbidity (NTU)	3	3	4	4
6.	pH	6.7	6.8	6.72	6.81
7.	Total solids(mg/l)	3690	3690	3680	3650
8.	Suspended solids(mg/l)	0.06	0	0.04	0.01

From the results, Jar-4 is selected with the optimum dosage for *Grape seed* as 8 mg/l.

D. Jar Test for Abelmoschus esculentus

The coagulant dosage 15mg/l, 20mg/l, 25mg/l and 30mg/l of powders were weighed in weight balance machine. 250ml of water sample is taken in four jars. Weighed coagulant powders is added in four jars separately. Then they are allowed for jar test. After the completion of jar test, they rested for settling. *Lady's finger seed* shows good clarity and also settlement in the water shows formation of floc and settling of impurities in closer. The shown settlement is for coagulant dosage 20mg/l. The size of floc is big in the lady's finger. The lady's finger seed works similar to the drumstick seed. After the settling of impurities, the clear water from the top is pipetted out and collected in the container. This clear water is taken for the parameters test. The parameter test is done for all four coagulant dosage treated clear water. Table V shows the analysis and parameter test results of *Abelmoschus esculentus*.

Table-V: Jar Test Analysis and Parameters Test Results for Abelmoschus esculentus

S. No	Parameters	Observation & Results			
		Jar -1	Jar -2	Jar -3	Jar -4
1	Coagulant dosage (mg/l)	15	20	25	30
2.	Size of floc	Minute	Minute	Big	Big
3.	Settling Rate	Poor	Fair	Quick	Quick
4.	Colour & Transparency	Hazy	Slightly hazy	Slightly hazy	Clear
5.	Turbidity (NTU)	3	3	4	4
6.	pH	6.7	6.8	6.72	6.81
7.	Total solids(mg/l)	3690	3690	3680	3650
8.	Suspended solids(mg/l)	0.06	0	0.04	0.01

From the results, Jar-2 is selected with the optimum dosage for *Lady's finger Seed* as 20mg/l.

E. Jar Test for Ipomea batatas

The coagulant dosage 15mg/l, 20mg/l, 25mg/l and 30mg/l of powders were weighed in weight balance machine. 250ml of water sample is taken in four jars. Weighed coagulant powders is added in four jars separately. Then they are allowed for jar test. After the completion of jar test, they are rested for settling indicates the settling of impurities and floc formation after the adding of coagulant. *Sweet potato* shows good clarity and also settlement in the water shows formation of floc and settling of impurities in closer. The size of floc is small in the sweet potato when compared to other coagulants. But settling rate is quick for sweet potato. After the settling of impurities, the clear water from the top is pipetted out and collected in the container. This clear water is taken for the parameters test. The parameter test is done for all the four coagulant dosage treated clear water as shown in table VI.

Table- VI: Jar Test Analysis and Parameters Test Results for Ipomea batatas

S. No	Parameters	Observation & Results			
		Jar -1	Jar -2	Jar -3	Jar -4
1.	Coagulant dosage (mg/l)	15	20	25	30
2.	Size of floc	Minute	Big	Big	Fair
3.	Settling Rate	Poor	Quick	Quick	Quick
4.	Colour & Transparency	Slightly hazy	Clear	Clear	Slightly hazy
5.	Turbidity (NTU)	2	2	3	4
6.	pH	7.14	7.25	7.11	7.12
7.	Total solids(mg/l)	3690	3680	3650	3700
8.	Suspended solids(mg/l)	0	0	0	0

From the results, Jar-1 is selected with the optimum dosage for *Sweet potato* as 15 mg/l.

F. Jar Test for Azadirachata indica

The coagulant dosage 15mg/l, 20mg/l, 25mg/l and 30mg/l of powders were weighed in weight balance machine. 250ml of water sample is taken in four jars. Weighed coagulant powders is added in four jars separately. Then they are allowed for jar test. After the completion of jar test, they rested for settling indicates the settling of impurities and floc formation after the adding of coagulant.

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Neem seed shows good clarity and also settlement in the water shows format

ion of floc and settling of impurities in closer. The above settlements are for all the coagulant dosage. The size of floc is big in the all dosage of neem seed. *Neem seed* shows good results when compared to other coagulant. After the settling of impurities, the clear water from the top is pipetted out and collected in the container. This clear water is taken for the parameters test. The parameter test is done for all the four coagulant dosage treated clear water as shown in Table VII.

G. Jar Test for Alum and Lime

Alum and Lime solution is prepared according to kilpauk water treatment plant. 10g of alum and lime is dissolved in 1litre of distilled water separately. Now for the jar test, 250ml of water sample was taken in four jars. The dosage for alum is 2mg/l, 4mg/l, 6mg/l, and 8mg/l. The dosage for lime was 50% of alum dosage. The coagulant dosage is measured in the measuring jar. Measured alum dosage is added in the all the jars separately. In the jar test process, after completion of 100rpm speed for 1minute then the lime solution is added.

After the completion of jar test, they rested for settling indicates the settling of impurities and floc formation after the adding of coagulant. Alum and lime shows good clarity and also settlement in the water shows formation of floc and settling of impurities in closer. The size of floc is big in the all dosage of alum and lime. After the settling of impurities, the clear water from the top is pipetted out and collected in the container. This clear water is taken for the parameters test. The parameters tests are done for all the four coagulant dosage treated clear water as shown in Table VIII.

Table-VII: Jar Test Analysis and Parameters Test Results for Azadirachata indica

S. No	Parameters	Observation & Results			
		Jar -1	Jar -2	Jar -3	Jar -4
1.	Coagulant dosage (mg/l)	15	20	25	30
2.	Size of floc	Big	Big	Big	Big
3.	Settling Rate	Quick	Quick	Quick	Quick
4.	Colour & Transparency	Clear	Clear	Clear	Clear
5.	Turbidity (NTU)	0	0	1	2
6.	pH	7.1	7.1	6.83	6.79
7.	Total solids(mg/l)	550	540	570	600
8.	Suspended solids(mg/l)	0	0	0.07	0.08

From the results, Jar-1 is selected with the optimum dosage for *Neem seed* as 15 mg/l.

Table-VIII: Jar Test Analysis and Parameters Test Results for Alum and Lime

S. No	Parameters	Observation & Results			
		Jar -1	Jar -2	Jar -3	Jar -4
1.	Coagulant dosage (mg/l)	2	4	6	8
2.	Size of floc	Big	Big	Big	Big
3.	Settling Rate	Quick	Quick	Quick	Quick
4.	Colour & Transparency	Clear	Clear	Clear	Clear
5.	Turbidity (NTU)	4	4	3	3
6.	pH	7.8	7.6	7.8	7.8
7.	Total solids(mg/l)	600	650	520	600
8.	Suspended solids(mg/l)	0	0	0.07	0.08

From the results, Jar-1 is selected with the optimum dosage for *Alum* as 2mg/l and *Lime* as 1mg/l.

IV. RESULTS AND DISCUSSION

A. Percentage of Removal

Percentage of removal is determined to know the efficiency of the coagulants. Percentage of removal is the amount of reduction of turbidity and suspended solids after adding coagulant. Percentage of removal will help in the ranking of coagulants. Percentage of removal is calculated only for turbidity and suspended solids because the property of the coagulant is to reduce the turbidity and suspended solids.

B. Percentage of Removal for Turbidity

▪ For *Musa paradisiaca*

The percentage of removal for the coagulant dosage 15mg/l, 20mg/l, 25mg/l and 30mg/l was calculated separately for the *Banana peel*. Percentage of removal for *Banana peel* dosage 15mg/l = 96.79%

▪ For *Moringa oleifera*

The percentage of removal for the coagulant dosage 15mg/l, 20mg/l, 25mg/l and 30mg/l was calculated separately for the *drumstick seed*. Percentage of removal for *Drumstick seed* dosage 20mg/l = 93.58%

▪ For *Vitis vinifera*

The percentage of removal for the coagulant dosage 2mg/l, 4mg/l, 6mg/l and 8mg/l was calculated separately for the *grape seed*. Percentage of removal for *Grape seed* dosage 8mg/l = 95%

▪ For *Abelmoschus Esculentus*

The percentage of removal for the coagulant dosage 2mg/l, 4mg/l, 6mg/l and 8mg/l was calculated separately for the *lady's finger seed*. Percentage of removal for *Lady's finger seed* dosage 20mg/l = 95.19%

▪ For *Ipomoea batatas*

The percentage of removal for the coagulant dosage 15mg/l, 20mg/l, 25mg/l and 30mg/l was calculated separately for the *sweet potato*. Percentage of removal for *Sweet potato* dosage 15mg/l = 98.39%

▪ For *Azadirachata indica*

The percentage of removal for the coagulant dosage 15mg/l, 20mg/l, 25mg/l and 30mg/l was calculated separately for the *neem seed*. Percentage of removal for *Neem seed* dosage 15mg/l = 100%

▪ For Alum and Lime

The percentage of removal for the coagulant dosage 2mg/l, 4mg/l, 6mg/l and 8mg/l was calculated separately for the *alum and lime*. Percentage of removal for *Alum and Lime* dosage 2mg/l = 93.58%

C. Ranking of Natural coagulants

Table-IX: Ranking of coagulants

Materials	Rank
Azadirachata indica	1
Ipomoea batatas	2
Musa paradisiaca	3
Abelmoschus esculentus	4
Vitis vinifera	5
Moringa oleifera	6

V. CONCLUSION

The natural materials, Lady’s finger (Abelmoschus esculentus), Drumstick seed (Moringa oleifera), Neem seed (Azadirachata indica), Banana peel (Musa paradisiaca), Sweet potato (Ipomoea batatas), Grape seed (Vitis vinifera) were used as coagulant for water treatment resulting removal of turbidity, total solids, suspended solids, color and increase the pH. Cost of these materials are very low and cheap. Banana peel, grape seed and neem seed are waste materials they not fit for other purposes so costs of these materials are nil. By comparing all experimental results of each coagulant, Neem seed is considered as a Best coagulant, removal of turbidity, total solids, suspended solids, color and increase the pH.

It could be concluded that the neem seed could be an important in water treatment where neem trees are available and easy to cultivate.

This method is low cost compare to chemical treatment. These materials are easily and naturally available. Low maintenance and no skilled labor required. The natural coagulants are non-toxic and non-corrosive. By using these natural coagulants for water treatment, we will be able to make a healthy environment.

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REFERENCES

- G.K.Patil and Sadgir, “Study on utilization of Moringa oleifera as coagulation”, An International Journal of Research in Engineering and Technology, November 2013.
- Gideon Sarpong and Clinton P. Richardson, “Coagulation efficiency of Moringa oleifera for removal of turbidity and reduction of total coliform as compared to aluminum sulfate”, African Journal of Agricultural Research, 4th November 2010.
- Sunita Singh Thakur and Sonal Choubey, “Assessment of coagulant efficiency of Moringa oleifera and okra for treatment of turbid water”, Archives of Applied Science Research, 2014.
- MS. Renuka and A.Binayke, “Application of natural coagulants in water purification”, International Journal of Advanced Technology in Civil Engineering, 2013.
- Madhukar V. Jadhav and Yogesh S. Mahajan, “A comparative study of natural coagulants in flocculation of local clay suspensions of varied turbidities”, Journal of Civil Engineering and Technology, 2012.
- M.L.Jodi, U.A.Birnin Yauri and Y.Yahaya, “Removal of turbidity from drinking water using natural coagulants”, Global Advanced Research Journal of Chemistry and Material Science, December 2012.
- https://www.researchgate.net/publication/272524168_The_role_of_coagulation_in_water_treatment.
- <https://www.hindawi.com/journals/jac/2016/7815903/>.
- <https://www.drink-water-eng-sci.net/11/1/2018/dwes-11-1-2018.pdf>.

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