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RESEARCH ARTICLE

PERFORMANCE EVALUATION OF NATURAL COAGULANTS FOR WASTEWATER TREATMENT

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ABSTRACT

Fewer water resources and Wastewater is the main problem these days. There are many methods to treat water, one of them is coagulation and flocculation, used to remove impurities, turbidity, and absorbed metals in water. Aluminum, iron coagulant, charcoal, alum, and many other chemical methods are used for this purpose in industries. But these coagulants have bad effects on human health. So this study is to focus on alternatives of these coagulants by finding efficient natural coagulants. Good natural coagulants are those that contain protein soluble properties and basicity. Some of the Alternative coagulants are chosen; Moringa seed, neem leaves, eggshells, orange peels, and banana peels. Different coagulants are used to reduce TDS and other dissolved impurities from an industrial outlet water sample, to check the characteristics and efficiency of natural coagulants. These natural coagulants were then compared with commercially used coagulants. Each coagulant was studied in the spectrometer at a different wavelength and dilution, the sample was tested at different times after 5,10,15,20 minutes and by changing coagulant concentration. Moringa seed is most efficient, it shows up to 97% turbidity removal and 73% TDS removal. The controlled amount of banana peel absorbs up to 97% methyl orange dye. These Natural coagulants are easily available, cheap rates and have no side effects. Natural coagulants are a good alternative to commercially available natural coagulants. These can be prepared locally to treat sewage water and rainwater before discharge into groundwater or for use in agriculture purpose.

KEYWORDS

Flocculation, Moringa seed, groundwater

1. INTRODUCTION

In many developing countries, access to clean and safe water is a crucial issue. Many people die because of diarrhea which is caused by polluted water. Developing countries pay a high cost to import chemicals for water treatment. Wastewater needs treatment before consumption for agriculture or domestic use. Some major problems with water treatment are variations in turbidity, TDS, and metal ions. Coagulation and flocculation are widely used for wastewater treatment, its main objective is to remove suspended particles and to remove turbidity and TDS by absorbing contaminants and metal ions. To overcome the contaminated water problem, many countries used chemicals both organic and inorganic for clarification of water i.e. like Alum to reduce turbidity, activated charcoal, zeolite, and Nano zero-valent iron for chemical coagulation and to absorb contaminants like metal ions. These local chemicals vary from nation to nation. The major drawbacks of these chemicals are that they cause many environmental problems and also affect human and animal health (Kaggwa et al., 2001).

These chemical coagulants are costly and not environmentally friendly, so there is much need for an alternative method of clarification of water by some other sources. Some plants are very useful and effective for coagulation, by neutralizing the charged particle in water. Drinking water treatment involves a number of unit processes depending on the quality of the water source, afford-ability and existing guidelines or standards (Saharudin, 2014). The cost involved in achieving the desired level of treatment depends, among other things, on the cost and availability of chemicals. Commonly used chemicals for the various treatment units are synthetic organic and inorganic substances. In many places these are expensive and they have to be imported in hard currency. Many of the chemicals are also associated with human health and environmental problems and a number of them have been regulated for use in water treatment systems. Natural materials can minimize or avoid the concerns and significant treatment cost if avail able locally. This thesis presents a study on the use of natural materials for coagulation, sludge conditioning and filtration (Asrafuzzaman et al., 2011).

Natural coagulants can be used for coagulation and as an absorbent. The use of natural coagulants is very Environment-friendly and cost-effective. These coagulants can be prepared from natural plants, and fruits wastes. All the plants and fruits are not effective as coagulants. Many effective coagulants from plant origin have been identified: Nirmali, red bean, Okra, and red maize, Moringa oleifera, Cactus latifera, seed powder of Prosopis juliflora, orange peels, banana peels, and eggshells. Many countries are searching for alternatives to chemicals. These natural coagulants will be used widely in the future. The following objectives were developed.

2. METHODOLOGY

Experiments were carried out in the Department of Structure and Environmental Engineering laboratory, UAF. Moringa seeds, banana peels, neem leaves, eggshells, Isapghul, and orange peel were used in these experiments. Besides this, activated charcoal is also used as a synthetic coagulant to compare the efficiency of natural coagulants with a synthetic or commercial coagulant (Choy et al., 2014).

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2.1 Preparation of Material

2.1.1 Moringa Seeds

Moringa seeds were collected from Dr. Azhar, Department of Food Engineering, UAF. After collection of seed, these were put in sunlight for drying for 7 days, after drying crushed with kitchen blender to make powder with fine particles.

Figure 1: Moringa Seeds

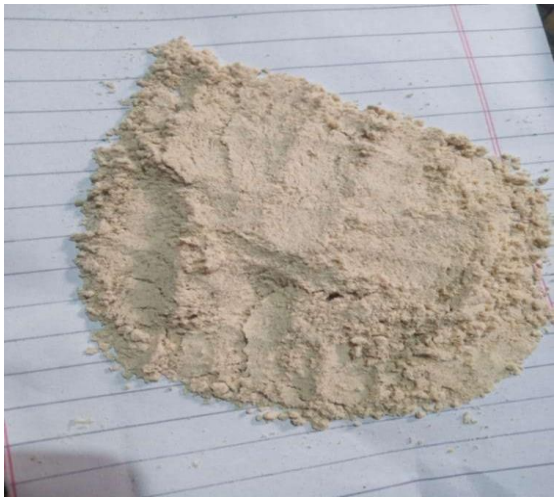


Figure 2: Moringa Seed Powder

2.1.2 Banana Peels

Banana peels were washed carefully to remove impurities and were put in sunlight for drying for at least 2 weeks. After drying peels, it was crushed with a kitchen blender to make fine powder particles.

Figure 3: Banana Peels

Figure 4: Banana Peel Powder

2.1.3 Eggshells

Eggshells were washed to remove all impurities and then put in the oven for 30 minutes for drying. After drying crushed eggshells to make fine powder, it was burnt in a furnace to get more fine particles for better results.

2.1.4 Neem Leaves

Neem leaves were collected and washed carefully to remove all impurities and were put in sunlight for drying and crushed in a kitchen blender when leaves were fully dried.

Figure 5: Neem Leaves

Figure 6: Neem Leaves Powder

Figure 7: Orange Peel

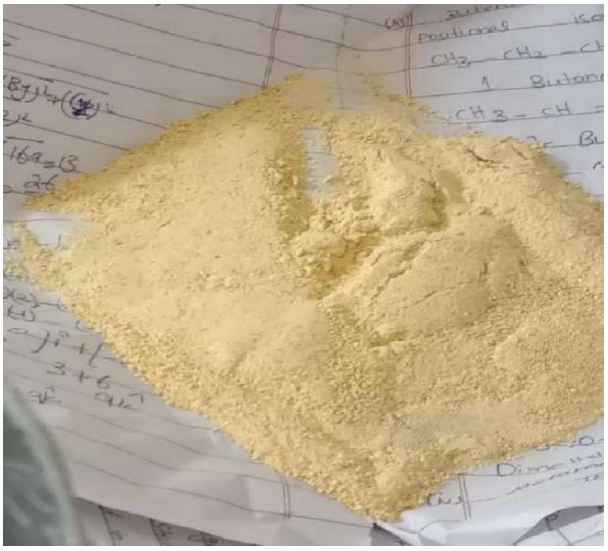


Figure 8: Orange peel powder

2.2 Commercial coagulants

Activated charcoal was bought from the market for laboratory use. NZVI was prepared in the laboratory for checking absorbance.

2.3 Water sample

2.3.1 Industrial Water Sample Collection

Two samples were taken from Malik ghee and cooking oil industry, Faisalabad. one from their final outlet and one from primary inlet groundwater and one liter of water with methyl orange dye was prepared in the laboratory.

2.3.2 Preparation of Synthetic water sample

One wastewater sample was prepared in the laboratory by mixing 1g of methyl orange dye in 1litre of water. Methyl orange was bought from a scientific store, Faisalabad. The solution was stirred with the help of a magnetic stirrer to make a suspension. Usable focuses is that natural coagulants are biodegradable.

Figure 8: Methyl Orange Dye Solution

2.4 Experimental Analysis

The sample was tested with the help of a spectrometer, turbidity meter, PH meter, TDS, and EC meter. The absorbance value of both industrial wastewater and synthetic prepared water was checked before performing an experiment. The actual abs. value of, synthetic water was 1.094 and of industrial wastewater was 0.270 (Kristianto, 2017).

In the first experiment, 7 beakers (b1, b2, b3, b4, b5, b6, b7) were taken with 250ml water in each. Each beaker was placed on a hot plate. 0.30g of Moringa powder, 0.60g of eggshell, 0.4g of activated charcoal, 0.2g of orange peel, 0.40g of banana peel, and 0.50g of neem leaves were put in beakers, respectively. The suspension was mixed with a magnetic stirrer. After 5 minutes, a small sample was taken from suspensions. UV/V spectrometer is used to check the sample. The samples were filled in cuvet of the spectrometer. Absorbance efficiency was checked in the spectrometer by placing cuvet in the spectrometer. The samples were taken from suspension after every 5 minutes to check the efficiency of the coagulant to remove turbidity and metal ions (Oladoja, 2015).

In the second experiment, a jar test was carried out with each coagulant in the second setup. In this test, six beakers were filled with equal water of 200ml each. Each beaker was tested with a different amount of coagulant 0.20g, 0.30g, 0.40g, 0.50g, 0.60g, 0.70g. the sample was taken after every 5 minutes for testing in the spectrometer to get the best time and concentration of coagulant for treating water (Assi et al., 2020). PH and Turbidity meter is used to check the value of every sample. Similarly, the jar test was repeated with the same sample by using each coagulant i.e. banana peel, eggshell, neem leaves, orange peel, and activated charcoal.

Figure 9: Spectrometer with some mixture of coagulants and wastewater

Figure 10: Suspension with a magnetic stirrer

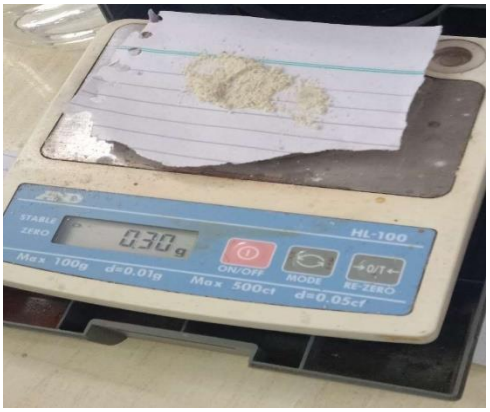


Figure 11: weight balance

3. Results And Discussion

3.1 Individual Absorption of natural coagulant

The Experiments were carried out with two kinds of samples i.e. Industry outlet sample having TDS 2800mg/l, PH 7.5, and conc. Of Chloride ion was 1200mg/l) and Synthetic methyl orange dye having (TDS 800mg/l). For each coagulant, four beakers were filled with the water sample, two with industrial wastewater and two for synthetic water prepared in the laboratory. Doses of natural coagulant for each beaker are different, to find a more efficient dose and time (Duranti et al., 1997).

3.1.1 Absorbance with Moringa

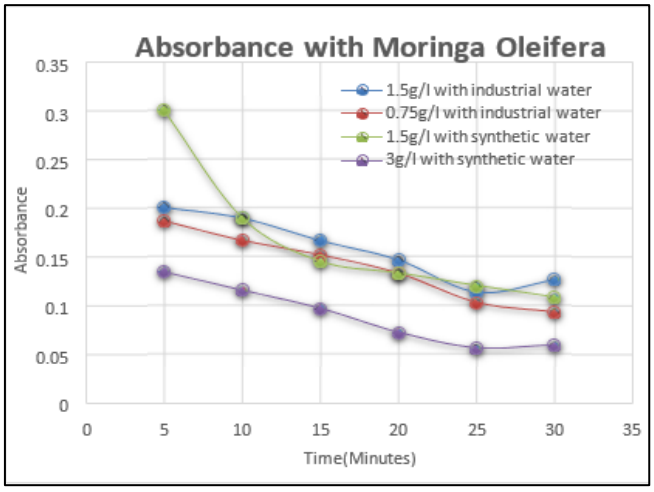
Two beakers (M1, and M2) of Industrial wastewater, with 200ml water in each, were taken. 1.5g/l, and 0.75g/l, of moringa powder, were taken in M1, and M2 beakers, respectively. Beakers were placed on a magnetic stirrer for dilution. The actual absorbance of the sample was 0.260 Samples from beakers were checked after every 5 minutes in the spectrometer (Kuppusamy et al., 2015). It was observed that moringa coagulant show effectiveness with more time. The corresponding value of absorbance in beaker M1 after 5, 10, 15, 20, 25 and 30 minutes were 0.205, 0.190, 0.167, 0.147, 0.114, and 0.127, and the corresponding value of absorbance in beaker M2 were 0.187, 0.167, 0.152, 0.133, 0.103, and 0.93.

Synthetic sample

The actual absorbance of the sample was 1.094, after dosing 1.5g/l the corresponding value of absorbance in beaker M3 were 0.301, 0.190, 0.145, 0.133, 0.120, and 0.108 and the corresponding value of absorbance in spectrometer against 3g/l beaker(M4) were 0.135, 0.116, 0.097, 0.072, 0.056, and 0.059.

Table 1: Dosages and absorbance of Moringa Oleifera

Time (minutes)	Industrial sample		Synthetic sample	
	1.5g/l	0.75g/l	1.5g/l	3g/l
5	0.205	0.187	0.301	0.135
10	0.190	0.167	0.190	0.116
15	0.167	0.152	0.145	0.097
20	0.147	0.133	0.133	0.072
25	0.114	0.103	0.120	0.056
30	0.127	0.93	0.108	0.059

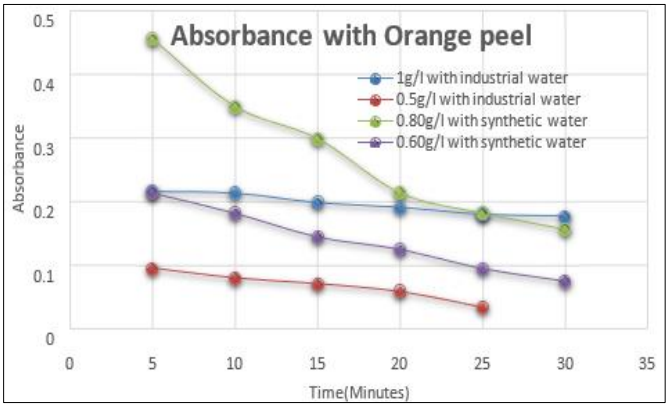


3.1.2 Absorbance with orange peel

1g/l and 0.5g/l of orange peel powder were taken in M1, and M2, respectively. The absorbance value after 5, 10, 15, 20, 25 and 30 minutes in M1 were 0.201, 0.192, 0.178, 0.162, 0.155 and 0.145, and in M2 were 0.214, 0.205, 0.199, 0.189, 0.179, and 0.170. The PH almost remain same. Synthetic sample:0.80g/l and 0.60g/l of orange peel powder were taken in M3, and M4, respectively. The corresponding value of absorbance in beaker M3 were 0.456, 0.350, 0.299, 0.214, 0.182, and 0.157, and in M4 were 0.214, 0.182, 0.145, 0.125, 0.095, and 0.075.

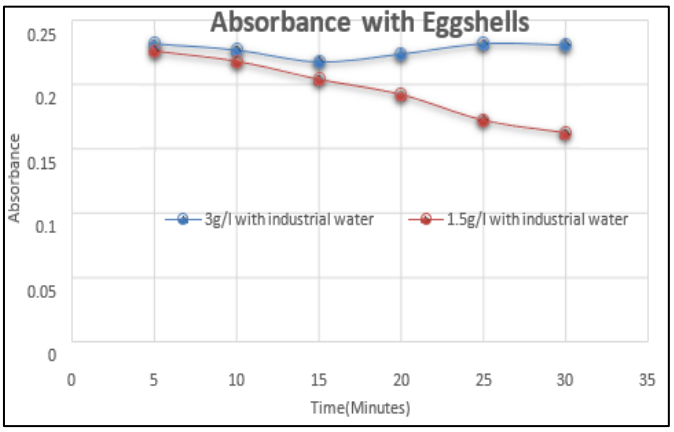
Table 2: Dosages and absorbance of orange peel

Time (min)	Spectrometer Absorbance (M1)	Spectrometer Absorbance (M2)	Spectrometer Absorbance (M3)	Spectrometer Absorbance (M4)
	Industrial Sample		Methyl orange Dye sample	
5	0.201	0.214	0.456	0.214
10	0.192	0.205	0.350	0.182
15	0.178	0.199	0.299	0.145
20	0.162	0.189	0.214	0.125
25	0.155	0.179	0.182	0.095
30	0.145	0.170	0.157	0.075



3.1.3 Absorbance with Eggshell

3g/l and 1.5g/l in M1 and M2 beakers, the corresponding values of absorbance in M1 were 0.232,0.227, 0.218, 0.224, 0.232, 0.231 and 0.227 in beaker and in M2 0.226, 0.218, 0.204, 0.192, 0.172 and 0.162.

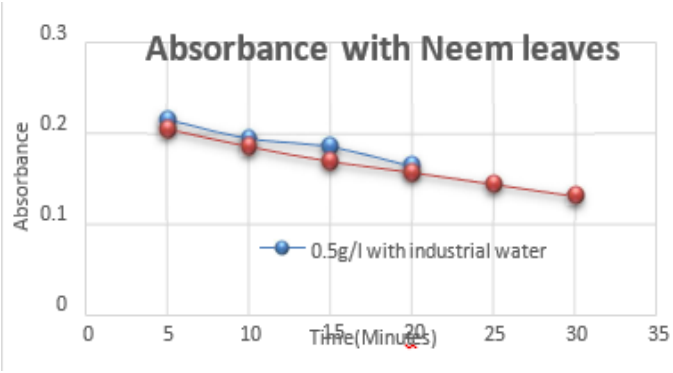


3.1.4 Absorption of Neem Leaves coagulant

0.50g/l and 1g/l of neem leaves were taken in M1 and M2. Absorption value are (0.215, 0.195, 0.186, and 0.165) and (0.205, 0.186, 0.170, 0.158, 0.145, and 0.132).

Table 3: Absorption of neem leaves

Time (min)	Spectrometer Absorbance(M1)	Spectrometer Absorbance(M2)
5	0.215	0.205
10	0.195	0.186
15	0.186	0.170
20	0.165	0.158

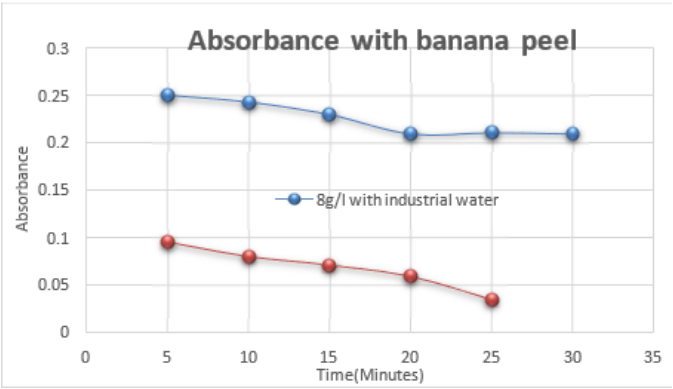


3.1.5 *Absorption of banana peel*

8g/l and 1g/l were taken in M1 and M2 beakers, the absorption values were (0.250,0.243, 0.230,0.210, and 0.211) and for 1g/l the absorption value were 0.095, 0.080, 0.071, 0.059, and 0.035.

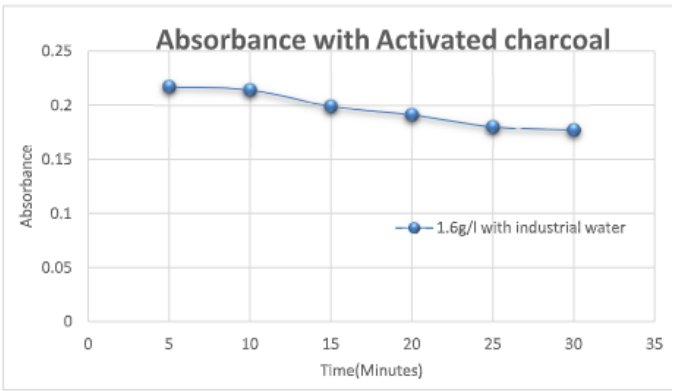
Table 4: Comparison of high and low dosage of banana peel

Time (minutes)	Banana peel High Dosage	Banana peel Moderate Dosage
	8g/l	1g/l
5	0.250	0.095
10	0.190	0.080
15	0.167	0.071
20	0.147	0.059
25	0.114	0.035
30	0.127	



3.1.6 *Absorption with commercial coagulant.*

1.6g/l of activated charcoal was taken in beaker to compare value with natural coagulant, the absorption value were 0.217, 0.214, 0.199, 0.191, and 0.180 after 5,10,15,20,25,and 30 minutes respectively.

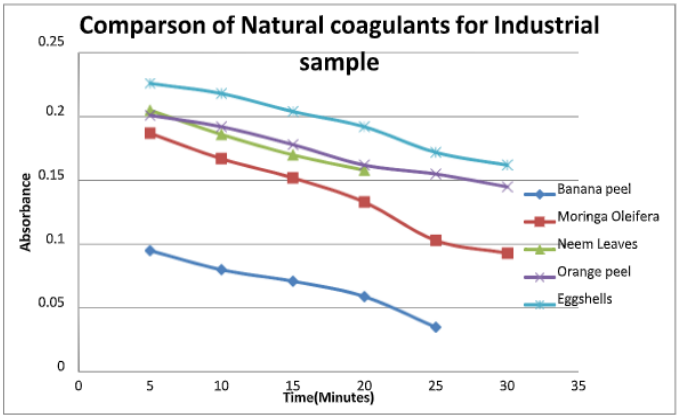


3.2 Comparison of Natural Coagulants

This is the comparison of effective dosages of all coagulants.

Table 5: Comparison of absorbance of effective dosage on industrial sample

Time (minutes)	Banana peel	Moringa Oliefera	Neem leaves	Orange peel	Eggshells
	1g/l	3g/l	1g/l	0.5g/l	1.5g/l
5	0.095	0.187	0.205	0.201	0.226
10	0.080	0.167	0.186	0.192	0.218
15	0.071	0.152	0.170	0.178	0.204
20	0.059	0.133	0.158	0.162	0.192
25	0.035	0.103		0.155	0.172
30		0.93		0.145	0.162



3.3 Efficiency of Natural coagulants

The study showed that natural coagulants are easily available, effective to treat water, and can be used as an alternative to commercially available coagulants. Natural coagulants are friendly, can't affect human health. This study also showed that a precise amount of coagulant is needed for effective results, High dosage of coagulant made water more turbid (Jeon et al., 2009). This was confirmed when we used a high dosage of coagulant, there was only 5% removal of methyl orange dye, by the precise amount of coagulant, results showed that there was up to 96% removal of methyl orange dye. Orange peels were good as a coagulant for turbidity removal. But high dosage can make more turbid. This study finds the suitable dosage per liter treatment of methyl orange dye and industrial wastewater. 0.5g/l of orange peel, 1g/l f banana peel, 3g/l of moringa oleifera, 1g/l of neem leaves and 1.5g/l of eggshells are precise dosages in this study. It was noticed that these natural coagulants showed high efficiency, when they were used to clean more turbid and concentrated methyl orange dye (Mohan, 2014).

However, increased dosages cause a significant increase in PH and the turbidity of water. Turbidity also defines its clearness. Precise dosage also reduces the turbidity of water. A study was conducted by Unnisa et al by using Dolichos lablab. This study shows that Initial turbidities of 20, 40, and 80 NTUs mainly considerably decreased when the coagulant doses increased. Coagulation was the most effective at a dose of 200 mg/500 ml, when the coagulation activity of the Dolichos lablab seed extract was 65, 62, and 68% at a 60-min settling time (Amran et al., 2018). This study showed that natural coagulants like moringa seed can be used for turbidity removal also. Another study for moringa oleifera showed that this can remove up to 97% of turbidity of high turbid water and up to 80% for low turbid water (Unnisa et al., 2010).

4. Conclusion

- Removal of TDS, Turbidity, and Metal ions from synthetic and industrial wastewater by using natural coagulants i.e. banana peel, moringa oleifera, orange peel, neem leaves, and eggshells were found in this study.
- It was found that these coagulants are found in precise amounts for treating water, over dosage can make more problems.

- These coagulants reduce the TDS of industrial water from 2800mg/l to 1100mg/l.
- These coagulants showed very effective behavior to absorb metal ions up to 80%.
- These were very effective up to 97% for turbidity removal.

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