Journal of Human, Environment, and Health Promotion

Journal homepage: www.zums.ac.ir/jhehp

Comparison of Water Turbidity Removal Efficiencies of Descurainia *Sophia* Seed Extract and Ferric chloride

Tooran Yarahmadi [a], Mazyar Peyda [a,*], Mehran Mohammadian Fazli[a], Rezan Rezaeian [a], Negin Soleimani[a]

[a] *Department of Environmental Health Engineering, School of Public Health, Zanjan University of Medical Sciences, Zanjan, Iran.*

***Corresponding Author E- mail:** mazyarpeyda@zums.ac.ir

ARTICLEINFO

Article history:
Received August 22, 2015
Accepted October 20, 2015

Article Type:
Original Article

Keywords:
Water treatment
Coagulation
Descurainia Sophia
Ferric chloride

ABSTRACT

Background Turbidity removal using inorganic coagulants such as iron and aluminum salts in water treatment processes causes environmental and human health concern. Historically, the use of natural coagulant to purify turbid water has been practiced for a long time. Recent research indicates that *Descurainia Sophia* seed can be effectively used as a natural coagulant to remove water turbidity.
Method: In this work, turbidity removal efficiency of *Descurainia Sophia* seed extract was compared with *Ferric chloride*. Experiments were performed in laboratory scale. The coagulation experiments were done with kaolin as a model soil to produce turbidity in distilled water. The turbidity removal efficiency of *Descurainia Sophia* seed extract and *Ferric chloride* were conducted with jar test apparatus. In all experiments, initial turbidity was kept constant 100(NTU). Optimum combination of independent variables was used to compare two different types of coagulants.
Result: The obtained results showed that *Ferric chloride* could remove 89.75% of the initial turbidity, while in case of *Descurainia Sophia* this value was 43.13%. The total organic carbon (TOC) analysis of the treated water using seed extract showed an increased concentration of TOC equal to 0.99 mg/L.
Conclusions: This research has shown that *Descurainia Sophia* seed extract has an acceptable potential in the coagulation/flocculation process to treat turbid water.

1. Introduction

Coagulation/flocculation as a step in water treatment processes is applying for removal of turbidity in raw water that comes from suspended particles and colloidal material (1).Coagulation with metal salts, such as aluminum or iron salts, can effectively increase the size of the particles in water, after which they can be removed by sedimentation. There have been increasing interests on the use of natural coagulants in coagulation-flocculation process due to environmental and human health concerns regarding the use of inorganic coagulants(2). Nowadays, there is a high demand to find an alternative coagulant which is preferably from natural and renewable sources. Natural coagulants produced or extracted from animals, plant tissues or microorganisms (3). *Descurainia sophia* with a straight and branched stem belongs to *Brassiaceae* family and produces large numbers of seeds from early to late summer (4). This plant is native to temperate and tropical Asia and Europe. The seeds containing mucilaginous substance are dull red to light brown with 0.7–1.5 mm long (5). The purpose of this study is comparing the efficacy of *Descurainia Sophia* seed extract and ferric chloride as a coagulant for removal of turbidity in water treatment processes.

2. Material and Methods

Sodium chloride and NaOH (analytical grade) were purchased from Merck (Germany). Commercially available kaolin was supplied by Loghman Pajohesh Co. (Iran).

2.1. Preparation of turbid water

In this study samples of turbid water were prepared by adding 10 g of kaolin to 1 L of distilled water. The suspension was stirred slowly for 24 h to obtain a uniform dispersion. The resulting suspension was kept for 30 minutes at room temperature. One liter of supernatant was transferred to Erlenmeyer flask and was kept as a stock solution. The prepared stock solution was used to make water samples of varying turbidity for the coagulation tests (6, 7).

2.2. Preparation of Descurainia Sophia seed coagulant

Descurainia Sophia seeds were purchased from local markets in Zanjan, Sanandaj and Dorud (Iran). According to the previous research, the optimum extraction conditions of coagulation agents from *Descurainia Sophia* seeds were determined using D-Optimal design under response surface methodology. The optimal conditions to achieve maximum efficiency of turbidity removal occurs by using ultrasound assisted extraction of coagulation agent from seed powder with distilled water containing sodium chloride and sodium hydroxide.

Briefly, 5 g *Descurainia Sophia* seed was crushed using a grinder and added to 500 mL distilled water containing 1.0 g L^{-1} sodium chloride and 0.03 g L^{-1} sodium hydroxide, then mixed by a magnetic stirrer for 5 minutes .The obtained Suspension was kept at room temperature. After 48 hours, the obtained suspension was irradiated with ultrasound (75 KHz) for 13 minutes then clarified by passing through a muslin cloth. After that the filtered extract was used in experiments.

2.3. Coagulation experiments

The efficiency of coagulation test was carried out using jar test apparatus (AL46-4). The initial turbidity was 100 NTU in all experiments. The jar test procedure included rapid mixing (120 rpm, 2.0 min.), slow mixing (40 rpm, 20 min.) followed by 30 min sedimentation (6). After sedimentation, water samples were taken from a depth of 5 cm below the water surface. The residual turbidity of water samples were measured by using turbidity meter (Hach2100P). In order to determine optimum pH, experiments were run at different pH values. The pH was adjusted to 6, 7, and 8 by the addition of 1 M HCl or 1 M NaOH (7, 8).

2.4. Determination of optimum concentration of Descurainia Sophia and Ferric chloride

In order to study the effect of coagulant dosage, several experiments were run with various amounts of *Descurainia Sophia* seed extract (from 10 ml/L to 100 ml/L) and different doses of *Ferric chloride* (5 mg/L to 40 mg/L).

2.5. Total Organic Carbon analysis

The residual total Organic Carbon (TOC) of the water samples which was clarified in the Optimum conditions was measured by the use of TOC analyzer (Shimadzu -VCSH) (9).

2.6. Settling test

The optimum dosages of coagulants found in the jar test was used in the settling test. Settling test were performed in a 2 L beaker (20 cm high and 20 cm in diameter) to compare the turbidity removal efficiency at different settling time and depth. At different time intervals (5, 10, 15, 20, 25, and 30 min), separate water samples were taken from depth of 4, 8, 12, 16, and 20 cm. All Samples were analyzed for suspended solids, and then removal efficiencies were calculated (10, 11).

3.Results

3.1. Effect of coagulant dosage

In order to compare the effects of *Ferric chloride* and *Descurainia Sophia* seed extract on turbidity removal, the jar test experiments were performed for the coagulation-flocculation process. It has been shown that, with an initial turbidity of 100 NTU, the optimum dose of the *Descurainia Sophia* seed extract is 10 ml/L to achieve 96.08% turbidity removal. Detailed quantitative analysis of these data will be published elsewhere, but the experimental results were used for the present study. The experimental data of turbidity removal using 30 mg/L of *Ferric chloride* with an initial turbidity of 100 NTU are illustrated in Figure 1. The presented data in Figure 1 illustrates the influence of coagulant dosage on turbidity removal. As seen from this figure, turbidity removal sharply increases with increasing *Ferric chloride* dosage and then decreases slightly. The maximum value of turbidity removal equal to 97% was achieved in the 30 mg/L coagulant dosage. In accordance with this observation, it was reported that optimum dosage of *Ferric chloride* is in the range of 5-40 mg/L (12).

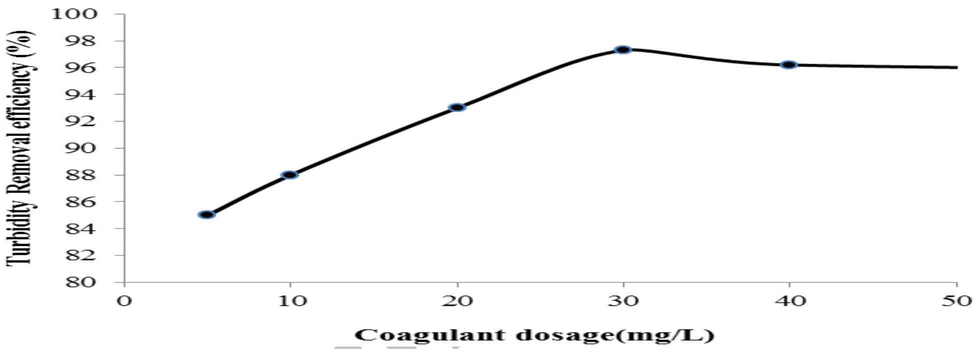

Fig.1: Effects of Coagulant Dosage on Turbidity Removal efficiency using Ferric chloride with an initial turbidity of 100 NTU.

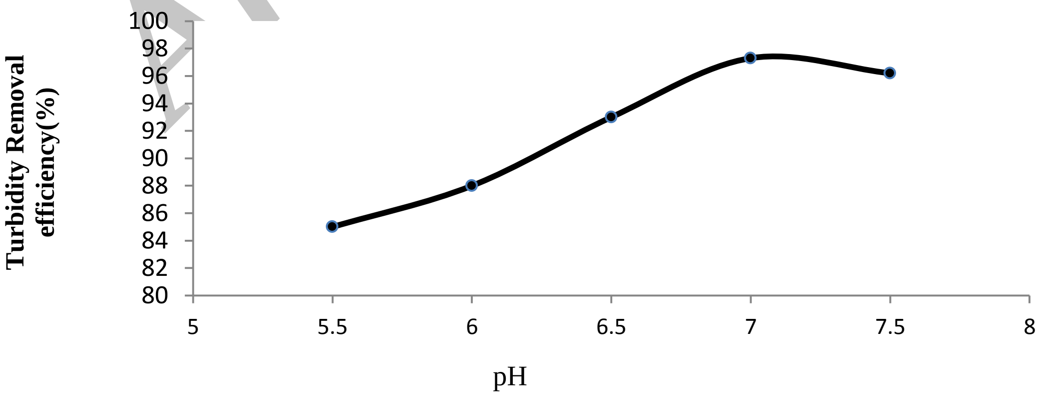

Fig. 2: Effects of pH Value on Turbidity Removal using Ferric chloride.

3.2. Effect of pH

The influence of pH values of 5.5, 6.0, 6.5, 7.0, and 7.5 on coagulation process using *Ferric chloride* was studied. The results indicate that, although better turbidity removal for *Ferric chloride* was

observed at pH 7, the optimum pH for *Descurainia Sophia* was occurred at 8.
The pH values of water before and at the end of coagulation/flocculation processes presented in table 1. It is obvious from the presented data that, during the coagulation process, *Ferric chloride* reduces about one pH unit of the treated water. On the other hand, in the case of *D.Sophia*, there were no changes in pH values before and at the end of experiments. An earlier study revealed that in the case of *M. Oleifera*, turbidity removal was independent of the initial pH value (13).

Table1: initial and final pH values of treated water using Ferric Chloride and Descurainia Sophia with an initial turbidity of 100 NTU.

coagulant	initial pH	final pH
Ferric chloride	5.5	4.5
	6	5
	6.5	5.5
	7	6
	7.5	6.5
Descurainia Sophia	6	6
	7	7
	8	8

3.3 Analysis of settling column

The settling behavior of the floc obtained by *D.* Sophia and Ferric chloride is well represented by the settling curves shown in Fig.3 and 4 respectively. The removal efficiency was determined at different time and depth intervals.

According to the Figure 3 and 4, the settling time and depth were found to be quite different in coagulation processes with *Descurainia Sophia* and *Ferric chloride.* Generally it is obvious from Figure 3 and 4, that the removal efficiency using both coagulants decreases with an increase in the sampling depth. By using *Descurainia Sophia* at 30 min. sedimentation time, the removal efficiency decreases from 64.7% to 52.9% as the depth increases from 4 to 20 cm. Comparison between *Descurainia Sophia* (Figure 3) and *Ferric Chloride* (Figure4) shows that, removal efficiency decreases slightly from 95.16% to 94.11% while depth increases from 4 to 25 cm and sedimentation time was 30 minutes.

These figures also show that, removal efficiency increases while settling time increases. When the settling time increases to 30 min., difference between removal efficiency of two types of coagulant become significant. For instance the removal efficiency of *Descurainia Sophia* and Ferric chloride at mid depth of column and 30 min. settling time are 56.8% and 96.4% respectively.

The summary of overall removal efficiency of *Descurainia Sophia* and *Ferric Chloride* presented in tables 2 and 3. The overall Removal efficiency using *Ferric chloride* and *Descurainia Sophia* was 89.75% and 43.13% respectively.

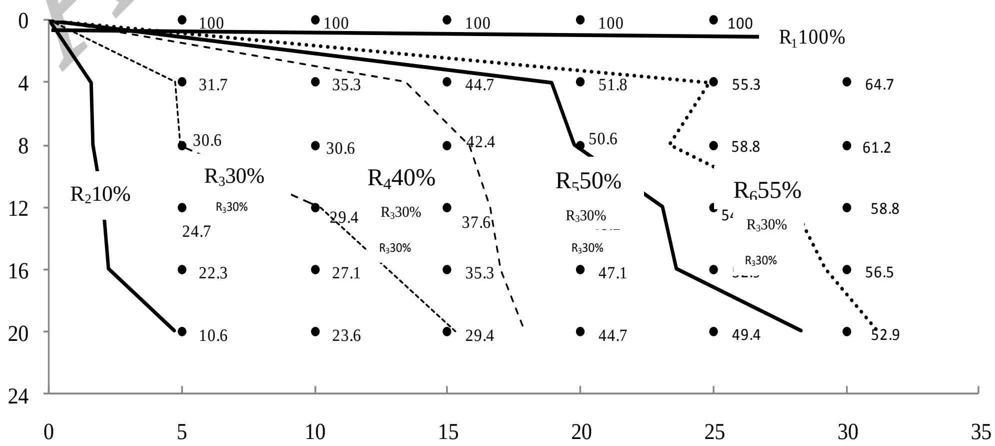

Fig. 3: Settling curves for Descurainia Sophia. Initial turbidity: 100 NTU.

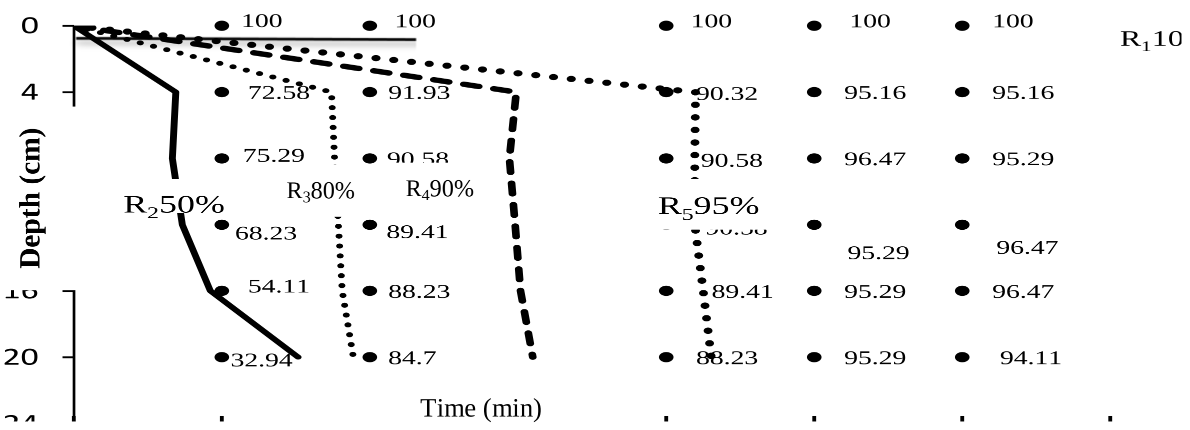

Fig. 4: Settling curves for Ferric chloride. Initial turbidity: 100 NTU.

Table 2: Overall removal efficiency of Descurainia Sophia (initia turbidity 100 NTU).

Δh(cm)	**Δh/h$_{20}$**	$\frac{Rn+Rn1}{2}$	Turbidity removal efficiency (%)
2.7	$\frac{2.7}{20}$ z	$\frac{100+55}{2}$	10.46
1	$\frac{1}{20}$	$\frac{55+50}{2}$	2.62
3.5	$\frac{3.4}{20}$	$\frac{50+40}{2}$	7.65
12.8	$\frac{12.8}{20}$	$\frac{40+30}{2}$	22.4
Sum 20			**3.13**

Δh: Depth of iso-removal curve
Rn: removal efficiency %
h$_{20}$: depth of columnz

Table 3: Percentage removal of Turbidity for Ferric chloride coagulant for turbidity 100 NTU.

Δh(cm)	**Δh/h$_{20}$**	$\frac{Rn+Rn1}{2}$	Turbidity removal efficiency (%)
2.5	$\frac{2.5}{20}$	$\frac{100+95}{2}$	12.18
8.5	$\frac{8.5}{20}$	$\frac{95+90}{2}$	39.32
9	$\frac{9}{20}$	$\frac{90+80}{2}$	38.25
Sum 20			**89.75**

Δh: Depth of iso-removal curve
Rn: removal efficiency %
h$_{20}$: depth of column

This observation is in accordance with other research which reported that turbidity removal using Moringa *Oleifera* seeds increases while time and initiasl turbidity increases(14). Furthermore ,The efficiency of removal in a settling basin depends on the characteristics of the particles to be settled such as size, charge, type of coagulant, and chemical characteristics of the turbid water (15).

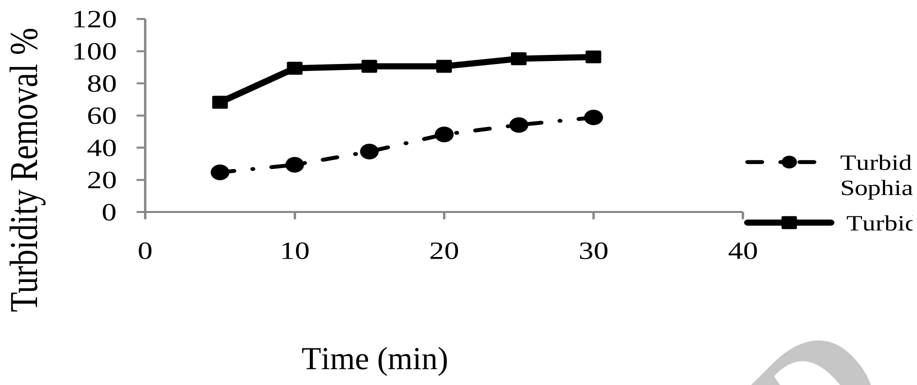

Fig. 5: Turbidity removal efficiency in settling column.

After 30 min settling time, samples were collected from the middle depth of the settling column to evaluate coagulation performance of the coagulants. As illustrated in Fig. 4, *Ferric chloride* shows better removal efficiency than *Descurainia Sophia* over the time range from 0 to 30 minutesThese results indicated that, *Ferric chloride* causes more removal efficiency than *Descurainia Sophia* seed extract. Furthermore, *Ferric chloride* flocs were shown a better sedimentation characteristic than those produced by *D.Sophia*.

This result is in accordance with the previous findings indicate that, Jatropha produces slightly more sludge in the turbidity removal processes compared to the alum(7).

3.4. Total Organic Carbon

Total organic carbon (TOC) content in turbid water was analyzed before and after treatment process using *Ferric chloride* and *Descurainia Sophia* as a coagulant.

At optimum dosage of coagulants, the average Total Organic Carbon (TOC) of the treated water using *Ferric chloride* was 0.01 mg/L and up to 0.99 mg/L was recorded using *Descurainia Sophia*. This observation can be attributed to the organic nature of the *Descurainia Sophia* seed extract.

These results match those in literature for application of chitosan as a coagulant, which increases 0.8 mg/L to the TOC content of the treated water(16).

4. Discussion and Conclusion

This research has shown that *Descurainia Sophia* seed extract has an acceptable potential in the coagulation/flocculation process to treat turbid water. However, further research is needed in order to improve *Descurainia Sophia* seed extract performance. It is recommended for future research to study co-coagulation effects of *Descurainia Sophia* seed extract with other types of inorganic coagulants.

References

1. Antov MG, Šćiban MB, Petrović NJ. Proteins from common bean (Phaseolus vulgaris) seed as a natural coagulant for potential application in water turbidity removal. *Bioresource technology*. 2010; 101(7):2167-72.

2- Choy SY, Prasad KM, Wu TY, Ramanan RN. A review on common vegetables and legumes as promising plant-based natural coagulants in water clarification. I*nternational Journal of Environmental Science and Technology*. 2015; 12(1):367-90.

3. Mohamed R, Saphira RM, Kutty AI, Mariam N, Kassim M, Hashim A. Efficiency of using commercial and natural coagulants in treating car wash wastewater treatment. Australian *Journal of Basic and Applied Sciences.* 2014; 8(16):227-34.

4. Golalikhani M, Khodaiyan F, Khosravi A. Response surface optimization of mucilage aqueous extraction from flixweed (Descurainia sophia) seeds. *International journal of biological macromolecules*. 2014; 70:444-9.

5. Lee YJ, Kim NS, Kim H, Yi JM, Oh SM, Bang OS, Lee J. Cytotoxic and anti-inflammatory constituents from the seeds of Descurainia sophia. *Archives of pharmacal research*. 2013; 36(5):536-41.

6. Yarahmadi M, Hossieni M, Bina B, Mahmoudian MH, Naimabadie A, Shahsavani A. Application of Moringa oleifera seed extract and poly aluminium chloride in water treatment. *World Application Sciences Journal*. 2009; 7(8):962-7.

7. Abidin ZZ, Shamsudin NS, Madehi N, Sobri S. Optimisation of a method to extract the active coagulant agent from Jatropha curcas seeds for use in turbidity removal. *Industrial Crops and Products*. 2013; 41:319-23.

8. Shafad MR, Ahamad IS, Idris A, Abidin ZZ. A Preliminary Study on Dragon Fruit Foliage as Natural Coagulant for Water Treatment. InInternational *Journal of Engineering Research and Technology*. 2013; 2(12).

9. Cleceri L, Greenberg A, Eaton A. Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association, and Water Environment Association, Washington, DC, USA. 1998.

10. METCALF & EDDY I. Wastewater engineering treatment: Tate McGraw-Hill publishing Company Ltd. 1979: 950 .

11. Shamim A, Wais MT. Potential of tube settlers in removing raw water turbidity prior to coagulant. *Aqua*. 1980; 8: 166-9.

12. Kord Mostafapoor F. Effectiveness of three coagulants of polyaluminum chloride, aluminum sulfate and ferric chloride in turbidity removal from drinking water. *Zahedan Journal of Research in Medical Sciences*. 2008; 10(2).

13.Amagloh FK, Benang A. Effectiveness of Moringa oleifera seed as coagulant for water purification. *African Journal of Agricultural Research*. 2009; 4(1):119-23.

14. Muyibi SA, Evison LM. Floc settling characteristics of turbid water coagulated with Moringa oleifera seeds. *International Journal of Environmental Studies*. 1999; 56(4): 483-95.

15. Halkude SA, Pise CP. Study of Type–II Suspensions with Moringa Oleifera & Alum Coagulants Using Settling Column Analysis. *International Journal of Scientific & Engineering Research*. 2014; 5(4):3137-45.

16. Bina B, Mehdinejad M, Nikaeen M, Attar HM. Effectiveness of chitosan as natural coagulant aid in treating turbid waters. *Iranian Journal of Environmental Health Science & Engineering.* 2009; 6(4):247-52.