

Effectiveness and Viability of a Bio-Material Based Coagulant in Removing Realistic Turbidity

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Abstract

It deals with bio-material based coagulant and determination of its residual turbidity removal. The objective of this thesis is to identify Planet-friendly materials for the water treatment, to remove the suspended impurities, to find optimum coagulant dosages and to check the water quality standards as per World Health Organisation (WHO). The bio-materials are identified by studying the Journal papers collected from various reliable sources. The materials are selected based on the following criteria: i. The turbidity removal should be greater than 70% ii. Easily available and economical. The Turbid water is prepared using Red soil available locally. The pH of water is determined initially for the purpose of deciding effective turbidity removal. So far, the bio-materials chosen is Acacia catechu bark powder. The extracts of the chosen material is prepared using distilled water. The extracts are added to the turbid water samples at various dosages, various pH, various levels of turbidity, various volume of extract and various soaking time. Three different sizes of powdered material are used. Finally, using optimum values, water collected from lakes in and around Coimbatore were tested. For the above mentioned purpose, Jar Testing Apparatus and Nephelo Turbidity Meter are to be used.

Keywords: Acacia catechu, Bark, Dosage, Levels of Turbidity, Volume of extract, Soaking time, pH.

Introduction

Because of the rise in water demand for domestic purposes, caused by growth of population and by the uprising standard of living together with increasing environmental pollution problems have led to over-utilization of renewable drinking water sources and the reduction of water quality. Water scarcity problem prevails in most of the countries, particularly in large cities. For fulfilling the water demand for Urban areas and for the adjacent industries, the construction of water supply reservoir plays a significant role. The parameters used for assessing the quality of river or reservoir water are suspended solids concentration, colloidal particles, natural organic matter and other soluble, mostly inorganic compounds. Therefore, necessary water treatment is required, before supplying the water for human consumption. One of the most important steps during the conventional treatment process is coagulation/flocculation, which serves mainly for the removal of SS (including colloidal micro particles) and NOM¹. Due to the negativity of the colloidal impurities in natural water system, mutual electrical repulsion exists. As a result, stable condition predominates in the natural water system. According to the coagulation and flocculation theory, colloidal destabilization can be achieved by adding cations that interact specifically with the negative colloids and reduce (or neutralize) their charge. Most of the naturally occurring polyelectrolytes are of plant origin and the coagulants are derived from the seeds, leaves, pieces of bark or sap, roots and fruit extracts of trees and plants¹.

Studies on the performance of natural active constituents derived from Acacia catechu bark powder have been conducted using turbid water with turbidity values of 20, 40, 60, 80, 100, and 120 NTU. The main chemical constituent of *Acaciacatechu* are catechin, epicatechin, epigallocatechin, epicatechingallate, phloroglucin, protocatechuic acid, quercetin, poriferasterol glycosides, lupenone, procyanidin, kaemferol, L-arabinose, D-galactose, D-rhamnose and aldoburonic acid, afzelchin gum, mineral and taxifolin². The optimum dosage for the Acacia extract was 50 mg/100ml, which produced an 84% reduction in turbidity. The study was made by i. varying dosage from 10 to 60 mg/100ml, ii. varying pH from 4 to 9, iii. varying turbidity levels from 20 to 120 NTU, iv. varying volume of extract from 2 to 12ml, and v. soaking time from 4 to 12 h.

Materials and Methods

The material used in this study is the powder of the bark of Acacia catechu Tree. The powder was purchased from an ayurvedic medical shop. The physicochemical characteristics of the material were determined i.e., Bulk-Density=0.352g/cm³, Specific-Gravity=1.35, Moisture content=7, porosity=86.72%. The preparation of extract and turbid water has been elucidated below:

Preparation of extract: Initially, the extract was prepared by soaking the powder in distilled water for 24hrs. The extract was filtered using Muslin cloth and then made ready for usage.

While varying the soaking time, the filtrate was extracted accordingly.

Preparation of Turbid water: Locally available red soil was used to prepare turbid water with natural effect by soaking for 24 hours in tap water. This was kept as a stock suspension for preparation of different turbidities. A portion of the stock suspension was diluted with tap water, the supernatant was carefully decanted and desired turbidities of 20, 40, 60, 80, 100 and 120 NTU were obtained.

Experimental Work: Jar test apparatus was used to determine the coagulation properties of the tannin derived coagulants. In six beakers, various dosage of coagulants was added separately. The experiment was conducted on 1000 ml turbid water samples. The samples were subjected to a rapid mixing at 150 rpm for 1 minute, and a slow mixing at 10 rpm for 20 min. The stirrer was then switched off and the floc was allowed to settle undisturbed for 30 minutes. The samples for residual turbidity measurement were obtained from the supernatant of each beaker. Effect of size of AC variation of pH, volume of extract, initial turbidity levels and soaking time on turbidity removal were also studied by varying size of AC, pH, volume of extract, turbidity level, and soaking time of turbid water³. Initially, the study was started by varying the dosage from 10, 20, 30, 40, 50 and 60; pH of the suspension was adjusted to the desired value such as 4, 5, 6, 7, 8 and 9 by adding either 0.1 N HCl solution or 0.1N NaOH solution. The volume of extract varied from 2, 4, 6, 8, 10 and 12ml; initial turbidity levels varied from 20, 40, 60, 80, 100 and 120 NTU; soaking time from 4, 8, 12, 16, 20 and 24h. While varying each parameter, the optimum value was carried out to the next successive parameter. The variations were carried out on all the three sizes of AC (i.e., GMSs of 2.67, 1.73, and 0.82 mm).

Results and Discussion

Table-1

Optimum values obtained using coarse particles of Acacia catechu (AC) (Geometric Mean Size (GMS) of 2.67mm)

Turbidity Level, NTU	Initial Turbidity, NTU	Final Turbidity, NTU	% Removal efficiency
20	25.8	16.13	37.5
40	44.6	25.09	43.75
60	65.4	35.43	45.83
80	83.5	48.53	41.88
100	100.2	58.82	41.30
120	120.2	75.82	36.92

Table-2

Optimum values obtained using medium particles of Acacia catechu (GMS of 1.73 mm)

Contact Time, hrs	Initial Turbidity, NTU	Final Turbidity, NTU	% Removal efficiency
4	62	38.1	38.55
8	62	32.62	47.38
12	62	32.63	47.37
16	62	33.96	45.23
20	62	23.44	62.20
24	62	21.58	65.20

Table-3

Optimum values obtained using fine particles of Acacia catechu (GMS of 0.82mm)

Contact Time, hrs	Initial Turbidity, NTU	Final Turbidity, NTU	% Removal efficiency
4	60.2	16.93	71.88
8	60.2	16.10	73.25
12	60.2	15.2	74.75
16	60.2	15.05	75
20	60.2	13.39	77.75
24	60.2	9.40	84.38

The Figure-1 shows the removal efficiencies of three sizes of particles. Based on Soaking time, the fine particle of size 0.82 mm provided a greater turbidity removal value compared to other two sizes. With the criteria's used for selecting the material as stated above, the material produced more than 70% efficiency.

The Figure-2 shows the effect of varying turbidity levels for three sizes of particles. Similar to the Figure-1, here also the finer particle shows greater performance compared to other sizes.

In lieu of the assessment of realistic performance of ACE on actual turbidity removals, the assessed probable optimal values were adopted in these studies. For this purpose, appropriate and adequate samples were collected from three different lakes (i.e., L1- 'Ukkadam lake', near Ukkadam area; L2 - 'Kumaraswamy lake', near Gandhipark area; and L3 - 'Selva Chinthamani lake', near Perur area). The respective duplicate grab samples of

water were drawn at specific locations in the lakes, brought to the Environmental Engineering laboratory of Department of Civil Engineering, CIT, Coimbatore – 14, and analyzed as per the Standard Methods for the Examination of Water and

Wastewater. As of now, these lakes are not protected from non-point source pollution and chiefly being used for fishing activities.

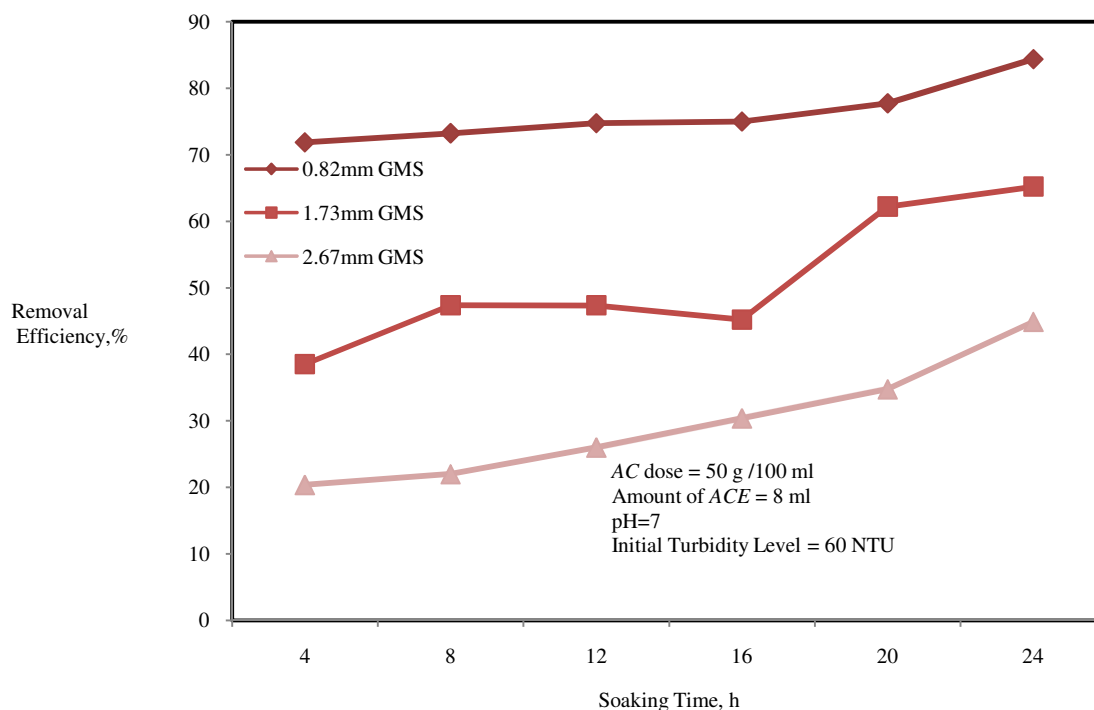


Figure-1
Graph Showing Effect of Soaking Time on Turbidity Removal among Three Sizes of Particles

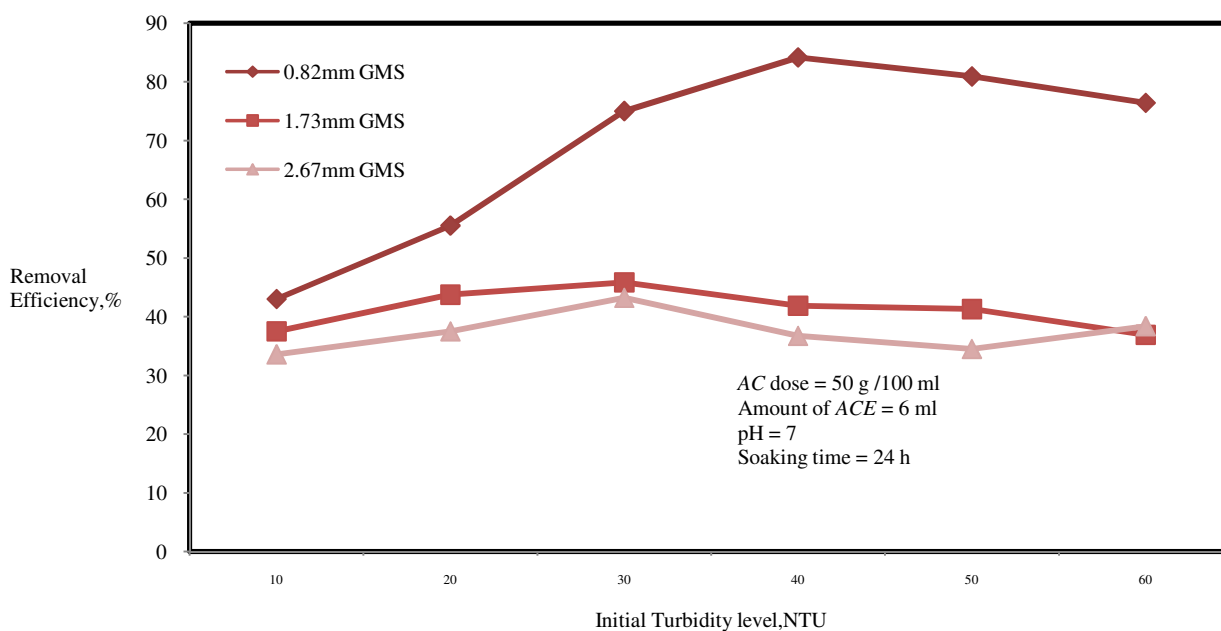


Figure-2
Graph Showing Effect of Varying Turbidity Level on Turbidity Removal among Three Varying Sizes of Particles

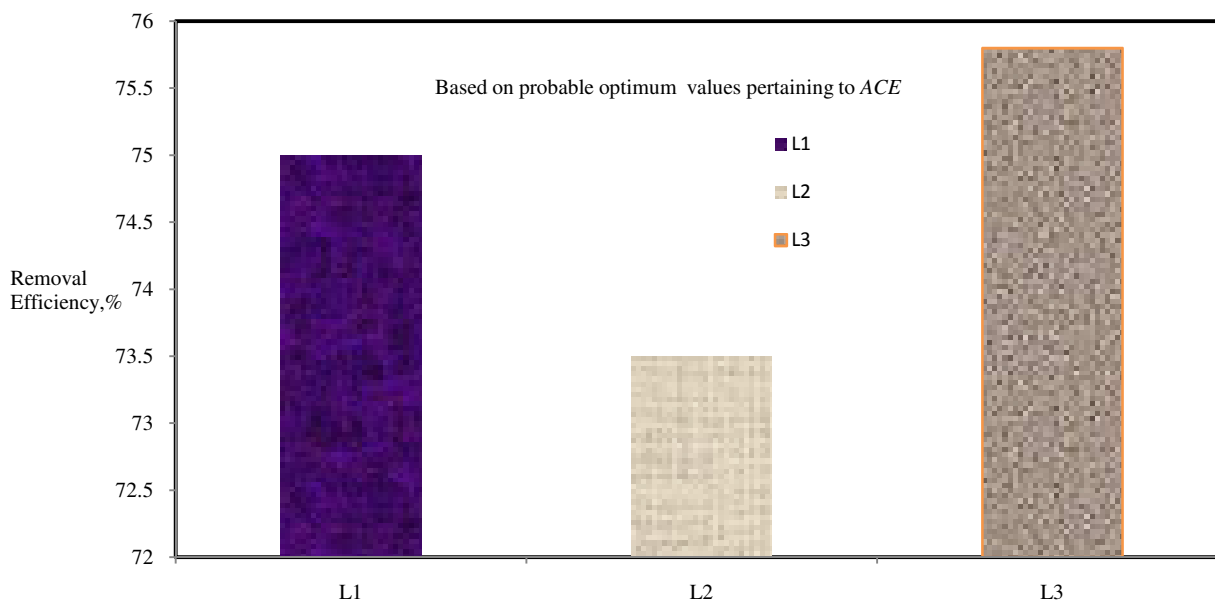


Figure-3
Realistic Performance of ACE in Turbidity Removal

The realistic performance of ACE (i.e., based on probable optimal values) is shown in Figure-3. Under the optimum conditions of ACE adopted in this studies, the turbidity removal efficiencies were substantially high with respective values of about 75, 73.5 and 75.8 %, for the turbidity levels of 90, 40, and 90 NTU. Comparing the results of Figure-3, it can be understood that ACE from AC could exhibit almost similar performance of turbidity removals, both under concocted and realistic systems. However, a slight lesser performance regarding realistic turbidities might be due to the presence of various chemical species.

In spite of several mechanisms (i.e., both major and minor), identified in the literature addressing the interactions of turbid particles with natural coagulants and / or their extracts, an attempt was made to identify the probable appropriate mechanisms between the colloidal particles and ACE. In the bulk literature on the utilization of natural coagulants in removing turbidity from water environment, tannin based coagulants have been identified as an excellent in coagulation-cum-flocculation processes.

Conclusion

Thus, AC is a good natural coagulant in removing either concocted and / or realistic turbid particles in aqueous environment. 0.82 mm GMS of AC seems to be highly suitable in appropriately leaching the active ingredient present in it. There is significant or substantial influence of dose of AC, soaking time of AC, amount of ACE, pH of the medium, and particle size of AC on turbidity removal. As far as 0.82 mm optimal size of AC concerned, the turbidity removal efficiencies varies between 43 and 84.4%. Few peculiar or unusual behavior

of turbidity removals needs to be addressed appropriately. A maximum turbidity removal of about 80% can be achieved, under the optimum conditions of 6 ml of ACE leached over a period of 24h in distilled water from 50 g, from 0.82 mm size of AC and under a pH of 7. The performance of AC in turbidity removal from lake waters is highly satisfactory, even under the presence of substantial amounts of several chemical species in aqueous phase. The chief mechanism of removal of hydrophobic colloidal turbid particles is due to chelation on to tannin molecules present in ACE. However, other minor mechanisms like co-precipitation, co-flocculation, and self-agglomeration are expected to probably occur in the process.

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