



Sustainable Treatment of Wastewater Using Natural Coagulants Based on Plants Seeds

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ABSTRACT

Water is undoubtedly the most vital element among all the natural resources. In many developing countries, access to clean and safe water is a crucial issue. More than 6 million people die because of diarrhea which is caused by polluted water. Due to rapid urbanization and migration from rural areas, there is a tremendous load on water consumption in all major cities. Water condition of surface water of most of the highly populated regions have become highly polluted due to indiscriminate discharge of untreated waste from tannery, textile, municipal waste into water bodies, etc. One of the problems with treatment of surface water is the large seasonal variation in 'Turbidity'. This study aims in finding remedial solutions for the Sonegaon Lake and making it into beneficial use. In this project use 5-10 different types seeds as a natural coagulant, an alternative to chemical coagulants.

Keywords- Bio-coagulants, Sonegaon Lake, Water Treatment, Turbidity, NTU

1. INTRODUCTION

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. Fluids can contain suspended solid matter consisting of particles of many different sizes. While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand, very small particles will settle only very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear

turbid. Turbidity in open water may be caused by growth of phytoplankton. Human activities that disturb land, such as construction, mining and agriculture, can lead to high sediment levels entering water bodies during rain storms due to storm water runoff. Areas prone to high bank erosion rates as well as urbanized areas also contribute large amounts of turbidity to nearby waters, through stormwater pollution from paved surfaces such as roads, bridges and parking lots. In drinking water, the higher the turbidity level, the higher the risk that people may develop gastrointestinal diseases. This is especially problematic for immuno-compromised people, because contaminants like viruses or bacteria can become

attached to the suspended solids. The suspended solids interfere with water disinfection with chlorine because the particles act as shields for the virus and bacteria. Similarly, suspended solids can protect bacteria from ultraviolet sterilization of water. Water is one of the most important and abundant compounds of the ecosystem. All living organisms on the earth need water for their survival and growth. Water is a ubiquitously chemical substance vital to all known forms of life. In nature water exists in liquid, solid and gaseous states. Larger amount of water is present on the earth about three-quarters of the earth surface is covered with water occupying around 97% as seawater and 3% as fresh water. Around two-third of fresh water is icebergs and glaciers. Availability of fresh water for our daily life is only 0.8% of the total amount of water present on earth. Water is a colorless, tasteless and odorless transparent liquid at ambient temperature. Water is a good solvent it is often called as the universal solvent. The polarity of water is an important factor in determining its solvent properties. Water dissolves most of inorganic substances and some organic substances having ionic bonds by dissociating and hydrating them. Uses of water comprise agricultural, industrial, household and environmental activities. Drinking water is a vital resource for all aspects of human beings. Access to safe and clean drinking water is a major concern throughout the world. Ground water surface water and rainwater are often the major sources of water in a community. Ground Water is often the most appropriate source of water for drinking as long as it does not contain high mineral content. Ground water could be extracted through wells or bore holes. Surface Water requires treatment to make it safe for human consumption. Surface water is almost always contaminated by people and animals who defecate in or near the water. Rain water is pure it can be collected in large storage basin or smaller containers. However rain water collected in dirty or unclean containers have to be treated to make it safe for drinking. Natural waters occurring in the environment are not chemically pure waters. While circulating in the environment water contacts with atmosphere, rocks and soil. Due to physical, chemical and biological processes water passing through the ground undergoes purification. Physical processes include dilution, coagulation, precipitation and adsorption. Chemical processes

include degradation, oxidation and hydrolysis while biological process includes biodegradation.

2. LITERATURE REVIEW

1. "Sustainable Treatment of Water and Wastewater using Natural Plant-based Coagulants: A Review" By Upendra Kumar, Kanchan Nahar, Ajay Singh Thakur (2022)

- Natural coagulants (NC) are collected from plants that can be used as a coagulant in coagulation-flocculation process of water and wastewater treatment. Natural coagulants such as: Neem, Tulsi, Moringa, Orange Peel, Sponge Guard, vetiver, Banana Peel etc. can effectively be used in the treatment of water and wastewater.
- The authors after reviewing available literature have emphasized that Natural Plant Based Coagulants (NPBC) are very effective for sweeping physio-chemical parameter of water such as: turbidity, TSS, TDS, coliform bacteria and wastewater parameter such as: BOD, COD, Heavy metals (chromium, lead etc), colour etc.
- The authors also have emphasized the nature, mechanism of working, advantages and disadvantages of using these NPBC with their all-round performance in water and wastewater treatments.

2. "Sewage Water Treatment using Natural Coagulants" By Achupriya K R, Bino Benny, Akshay Saseendran (2022)

- The study aimed to evaluate the efficiency of natural coagulants like orange peel, papaya seed and neem leaf powder for the evaluation of purity in collected waste water sample.
- Three characteristics of water sample are tested this includes Turbidity, PH, and TSS. Jar test apparatus was used for determining the optimum dosage of natural coagulants. After the preparation and application of coagulants in the collected sample a dosage of 0.6g of natural coagulant is best suited for purification. Since natural coagulants are environmental friendly and low cost it could be widely used in future.

3. "Dairy Waste Water Treatment by using Natural Coagulants" By Namrata S Naragundakar, Naghma N, Padmavathi V (2022)

- The present study focuses to treat Dairy Waste water with environment friendly natural coagulants like

Moringa Oleifera, Neem leaves, Saw dust, Custard Apple seeds are in powdered form resulting an effective natural agent that is modification for highly turbid and untreated pathogenic water. Various doses of natural coagulants are evaluated for the efficiency of dairy wastewater treatment. On comparison various parameters like of TDS, chloride, pH, turbidity obtained for each coagulant.

- It was observed that moringa Oleifera seed powder showed best results with effect of pH varies as 9.08 – 4.42, TDS varies from 5.02 – 4.38 ppm, turbidity varies from 162 – 44.6 NTU are experimental found out with the extension. By varying dosage of coagulant that is Moringa oleifera seeds is recommended as eco-friendly non-toxic coagulant for dairy waste water treatment.

4. “Feasibility of Dairy Wastewater Treatment by using Natural Coagulants” By Renuka R, Prasad B C, Umesha S H (2022)

- The dairy industry is one of the most polluted water generating industry, not only in terms of the volume of effluent generated, but also in terms of its characteristics as well.
- This paper deals treating of dairy waste water with natural seeds like carica papaya Seeds and saw dust. Various tests are conducted to evaluate the properties of dairy waste water and treated dairy waste water.

5. “Practicability Study on Application of Natural Coagulants” By M N Hedao, S P Ghule (2022)

- In this study, the effects of natural coagulants such as Neem leaves, Okra seeds, Watermelon seeds, Papaya seed, Aloe Vera, and Cactus on water turbidity reduction are investigated. The clump coagulation test was used to determine the ideal coagulant amount needed to evacuate 100 NTU of turbidity and to identify the successful coagulant among the six coagulants.
- It can be concluded from this study that neem leaf can be used as an effective coagulant for low and medium turbid water, whereas aloe Vera used as an effective coagulant for high turbid water. Further tests were carried using the recognized coagulant to streamline factors such as coagulant readings, pH, turbidity induction, blending time, blending rate, and settling time. When the pH was kept at 6.5, the starting turbid concentration was 500NTU, the rapid

mixing time was 1 minute, the slow mixing time was 22 minutes and the settling period was 27 minutes, the higher percentage of turbidity was removed.

6. “Experimental Study on Treating Dairy and Kitchen Waste Water using Pappaya seed powder and Aloe vera Gel” By Christeena Thomas, Anjana Raj, Vilbin Varghese (2021)

- In conventional method of coagulation and flocculation alum, ferric chloride and ferrous sulphate were used as coagulant for effective removal of turbidity. But in one of the research it is found that continuous use of alum has caused several problems affecting human health. So this study is mainly focused on decreasing alum dose with use of natural materials.
- Natural coagulants are natural based coagulants that can be used in coagulation process of waste water treatment for reducing turbidity.
- The study aimed to, Carica papaya L. (papaya seed) powder, Aloe barbadensis (Aloe Vera) gel as a coagulant in dairy waste water and kitchen waste water samples collected. The experiments proved that turbidity and chlorides had reduced effectively.

7. “Effectiveness of natural coagulants in water and wastewater treatment” By S. Nimesha, C. Hewawasam, D.J. Jayasanka, Y. Murakami, N. Araki, N. Maharjan (2021)

- The primary purpose of this review is to refine the knowledge on the potential use and optimization of the effectiveness of eco-friendly and sustainable natural coagulants.
- Besides, the development efforts and the barriers reported by recent findings for the commercialization of natural coagulants are also discussed. Further, few modified natural have also been presented for exploring the other possible approaches to promote their usage in water and wastewater treatment in the future studies.

8. “Treatment of Waste Water Using Natural Coagulants” By Rajesh Kumar Kaushal, Hemant Goyal (2019)

- The use of natural coagulants like Moringa Oleifera and Okra plants are receiving attention for their effectiveness in waste water treatment. The technologies involved are economical, traditional and easy to implement and ideal for rural areas.

- The process being biological in nature does not generate any non-treatable wastes. These processes are easy to operate and require little or no maintenance.
- After the treatment of both the municipal and dairy waste water samples by two natural coagulants Moringa Oleifera and Okra seeds and synthetic coagulant alum, the results show that there is a reduction in the percentage of various polluting parameters like COD, BOD, turbidity, hardness, TSS and TDS etc.

9. "Applications of Natural Coagulants to Treat Wastewater – A Review" By Vicky Kumar, Norzila Othman, and Syazwani Asharuddin (2017)

- The water becomes wastewater due to population growth, urbanization, industrialization, sewage from household, institutions, hospitals, industries and etc.
- The coagulant chemicals and its associated products are resourceful but these may change the characteristics of water in terms of physical and chemical characteristics, this make matters worse in the disposal of sludge.
- An option of natural polymer can be used in water and wastewater in this review.
- The natural polymers are most efficient that provide several benefits such as; prolific, exempt from physical and chemical changes from the treated water.

10. "Wastewater Treatment using Natural Coagulants" By Saravanan Priyadarshini D, Soundammal A, Sudha G, Suriyakala K (2017)

- The objectives of this study were to assess the possibility of using natural coagulants as an alternative to the current commercial synthetic coagulant such as aluminium sulphate and to optimize the coagulation process.
- Based on the experimental results, it was concluded that natural coagulants which have been obtained from Dolichas lablab, Azadirachta Indica, Moringa Oleifera, Hibiscus Rosa Sinensis have showed an merely equalant coagulation comparing to alum. The turbidity removal efficiency for Dolichas lablab, Azadirachta Indica, Moringa Oleifera, Hibiscus Rosa Sinensis respectively were 37.45%, 63.01%, 31.47%, 12.95% against 75.01% obtained from alum.

11. "Production of Natural Coagulant from Moringa Oleifera Seed for Application in Treatment of Low Turbidity Water" By Eman N. Ali , Suleyman A. Muyibi, Hamzah M. Salleh, Md Zahangir Alam, Mohd Ramlan M. Salleh (2009)

- This study focused on developing an efficient and cost-effective processing technique for Moringa oleifera seeds to produce natural coagulant for use in drinking water treatment.
- This study investigates processing Moringa oleifera seeds to concentrate the bio-active constituents which have coagulation activity.

12. "Application of Natural Coagulants for Pharmaceutical Removal from Water and Wastewater: A Review" By Motasem Y. D. Alazaiza Ahmed Albahnasawi , Gomaa A. M. Ali , Mohammed J. K. Bashir (2008)

- The main mechanisms of natural coagulants for pharmaceutical removal from water and wastewater are charge neutralization and polymer bridges.
- Natural coagulants extracted from plants are more commonly investigated than those extracted from animals due to their affordability.
- Natural coagulants are competitive in terms of their performance and environmental sustainability.
- Developing a reliable extraction method is required, and therefore further investigation is essential to obtain a complete insight regarding the performance and the effect of environmental factors during pharmaceutical removal by natural coagulants. Finally, the indirect application of natural coagulants is an essential step for implementing green water and wastewater treatment technologies.

3. PROPOSED METHODOLOGY

In India, the majority of the population still lives in villages and small towns. These rural/tribal communities do not have access to public water supply. People living in these areas get their water from unprotected sources such as open wells or small streams and ponds that are polluted. Water treatment in these areas is a particular problem. Therefore, there is an urgent need to develop and disseminate simple treatment techniques for rural or farming areas. The proteins in natural coagulants are thought to act similarly to synthetic, positively charged polymeric coagulants of non-plant origin. When added to raw water, the positively charged proteins bind to the negatively charged particles that cloud the raw water.

With appropriate circulation, these bound particles enlarge by agglomeration and form flocs that settle by gravity or can be removed by filtration.

The present study aims at analysis of turbidity parameters of effluent and their reduction in concentrations in low and economical process. Discharging of effluent waste water without treating not only polluting surface water it may also show effect on ground water pollution and soil pollution. So the effluent must be treated in a proper way to meet discharge level requirements. Thus we have opted for Orange Peel, Neem seeds powder, Soyabean seeds powder, Tulsi seeds powder and Moringa Olifera seeds powder promising bio-flocculant whose seeds are plentifully available in India which are popular and widely used in rural and tribal areas for the purification of water.

In this project use of powdered form of five different types of seeds. These natural coagulants function by means of adsorption mechanism followed by charge neutralization or polymeric bridging effect. Utilization of these coagulants represents important progress in sustainable environmental technology as they are renewable resources and their application is directly related to the improvement of quality of life for underdeveloped communities. The tests were carried out using artificially prepared turbid water with conventional 'Jar test apparatus'. The powdered form of 5 seeds, namely 'Orange Peel, Neem seeds, Soyabean seeds, Tulsi seeds and Moringa Olifera seeds were used as locally available natural coagulants in this study to reduce turbidity of synthetic water. The tests were carried out using artificially prepared turbid water with conventional 'Jar test apparatus'.



Fig.1.1: Collection of wastewater sample from Sonegaon Lake

4. METHODOLOGY

1.1 Preparation of Synthetic water: Exactly 2 grams of soil (with considerable amount of clay materials) was added to 1 litre of lake water sample from Sonegaonlake, Nagpur in order to produce a muddy water sample. Suspension was stirred vigorously to uniformly distribute the soil particles. This sample was then allowed to pass through a screen to remove the bigger sized particles. Synthetic water sample was thus prepared and transferred into the beakers which would then be placed in the 'Jar test apparatus'.

1.2 Preparation of Stock solution of Natural coagulants: Seed kernels of all 5 seeds were ground to fine powder whose size was maintained at approximately 600 micrometers in order to achieve solubilisation of active ingredients in the seed. 100 ml Distilled water was added to the powdered form of each seed of known quantity. It was then vigorously mixed to promote water extraction of the coagulant proteins.

1.3 Jar test operation: In order to obtain the value of optimum dosage of each coagulant, different dosages were added in each of the 6 beakers. The first jar containing the synthetic water in every experiment was considered as a 'Control sample'. It contained 900 ml of muddy water and 100 ml of Distilled water without any coagulant. The remaining 5 jars were each filled with varying doses of coagulant (whose weight was carefully measured) in 100 ml distilled water, thoroughly mixed and then added into the beaker containing 900 ml turbid synthetic water sample.



[Fig.1.2: Jar Test Operation]

Before starting the apparatus, Initial Turbidity of the sample is to be measured. Calibration of the instrument was done using a buffer solution whose Turbidity value

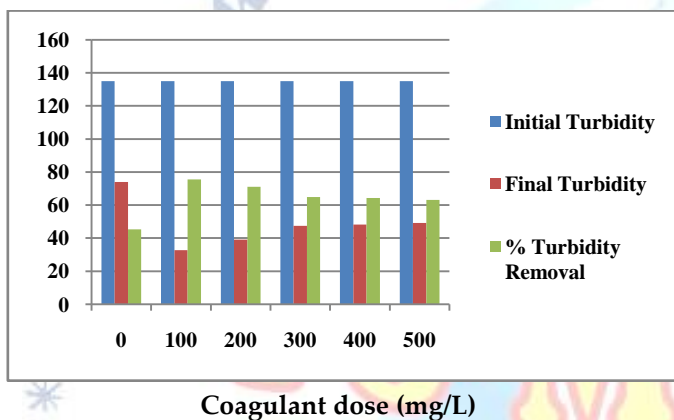
was already known. Initial Turbidity is measured using an instrument called 'Nephelometer'. Then the rotating paddles were lowered into all the 6 jars. The apparatus was switched on and the required mixing speed and duration of mixing was set.

5. RESULTS & DISCUSSION

The following Bar charts indicate the values of Coagulant dose (mg/L), Initial Turbidity (NTU), Final Turbidity (NTU), Turbidity removal (%). 'NTU' refers to Nephelometric Turbidity units.

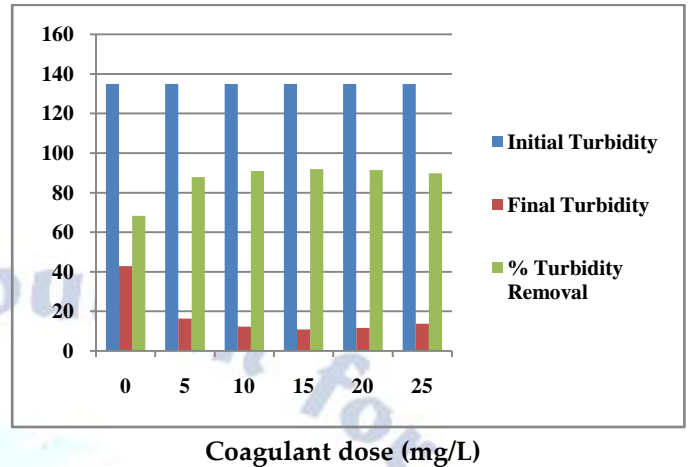
1. Neem Seeds:

Turbidity removal (%) versus Coagulant dose (mg/L)



Neem seeds were made into a fine powder and used as coagulant. Varying doses were used as shown in the Bar chart above. Since the nature and effectiveness of this natural coagulant was unknown, dosages of 100, 200, 300, 400, and 500 mg/L respectively were used in each of the 5 jars. The Initial Turbidity of synthetic water sample was found to be 135 NTU. Once the Jar test experiment was completed, Final (Supernatant) Turbidity of all samples was measured using a Nephelometer. As per the observations and Bar chart plotted above, maximum percentage Turbidity removal in this case was found at a dosage of 100 mg/L. But this is not the optimum coagulant dose as the Turbidity values kept increasing. So, doses were changed and the Jar test experiment was conducted once again in order to obtain the optimum dosage.

Turbidity removal (%) versus Coagulant dose (mg/L)

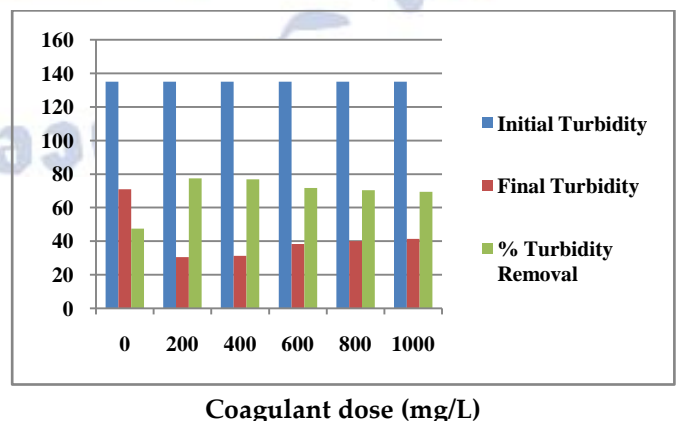


As per the new measured values, maximum percentage Turbidity removal of 91.92% was obtained at an optimum dose (Neem seeds powder) of 15 mg/L.

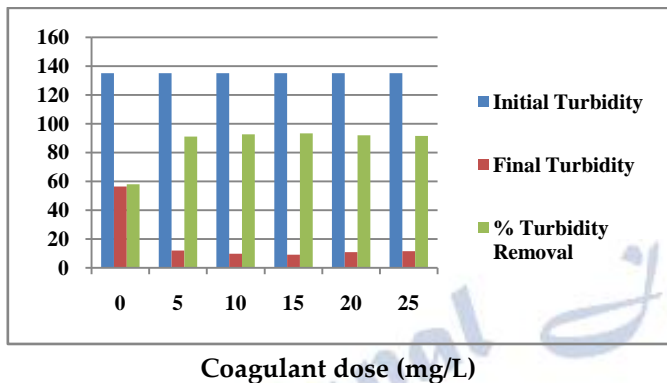
2. Orange peel:

Orange peel seeds were made into a fine powder and used as coagulant. Varying doses were used as shown in the Bar chart. Since the nature and effectiveness of this natural coagulant was unknown, dosages of 200, 400, 600, 800, and 1000 mg/L respectively were used in each of the 5 jars. The Initial Turbidity of synthetic water sample was found to be 135 NTU. Once the Jar test experiment was completed, Final Turbidity of all samples was measured using a Nephelometer. As per the observations and Bar chart plotted, maximum percentage Turbidity removal in this case was found at a dosage of 200 mg/L. But this is not the optimum coagulant dose as the Turbidity values kept increasing.

Turbidity removal (%) versus Coagulant dose (mg/L)



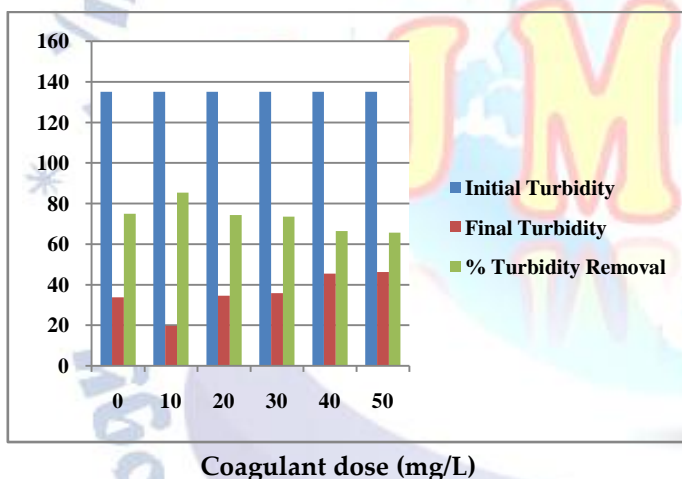
Turbidity removal (%) versus Coagulant dose (mg/L)



As per the new measured values, maximum percentage Turbidity removal of 93.31% was obtained at an optimum dose (orange peel seeds powder) of 15 mg/L.

3. Moringa oleifera (Drumstick):

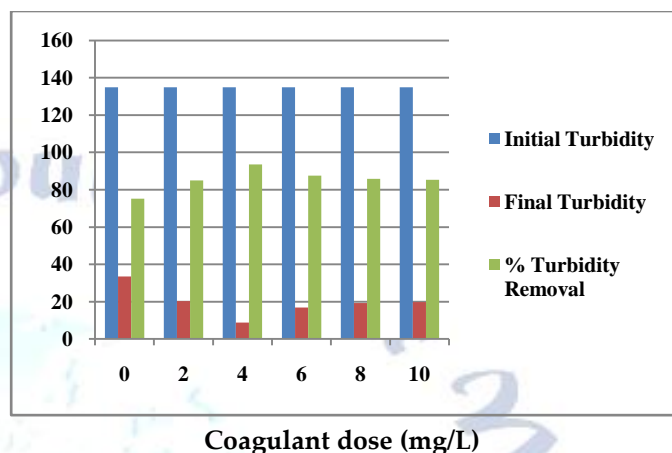
Turbidity removal (%) versus Coagulant dose (mg/L)



Dried Drumstick seeds (only the white pods) were made into a fine powder and used as coagulant. Varying doses were used as shown in the Bar chart. Since the nature and effectiveness of this natural coagulant was unknown, dosages of 10, 20, 30, 40, and 50 mg/L respectively were used in each of the 5 jars. The Initial Turbidity of synthetic water sample was found to be 135 NTU. Once the Jar test experiment was completed, Final Turbidity of all samples was measured using a Nephelometer. As per the observations and Bar chart plotted, maximum percentage Turbidity removal in this case was found at a dosage of 10 mg/L. But this is not the optimum coagulant dose as the Turbidity values kept increasing. So, doses were changed and the Jar test

experiment was conducted once again in order to obtain the optimum dosage.

Turbidity removal (%) versus Coagulant dose (mg/L)

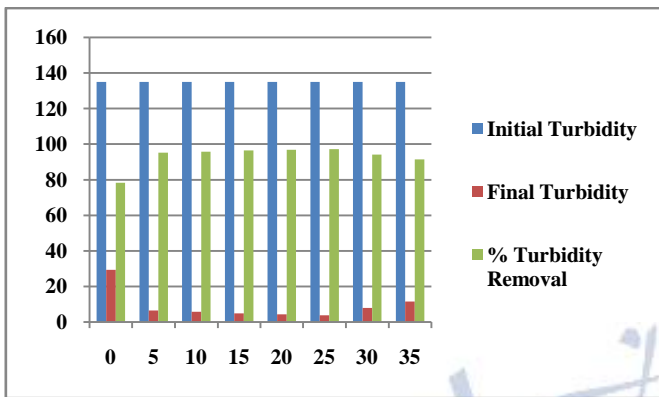


As per the new measured values, maximum percentage Turbidity removal of 93.51% was obtained at an optimum dose (Drumstick seeds powder) of 4 mg/L.

4. Tulsi Seeds:

Tulsi seeds were made into a fine powder and used as coagulant. Varying doses were used as shown in the Bar chart. Since the nature and effectiveness of this natural coagulant was unknown, dosages of 5, 10, 15, 20, 25, 30, and 35 mg/L respectively were used in each of the jars. The Initial Turbidity of synthetic water sample was found to be 135 NTU. Once the Jar test experiment was completed, Final Turbidity of all samples was measured using a Nephelometer. As per the observations and Bar chart plotted, maximum percentage Turbidity removal of 97.25 % in this case was found at an optimum dosage of 25 mg/L. Since optimum dosage is obtained, Jar test experiment using Tulsi as a coagulant was not conducted once again.

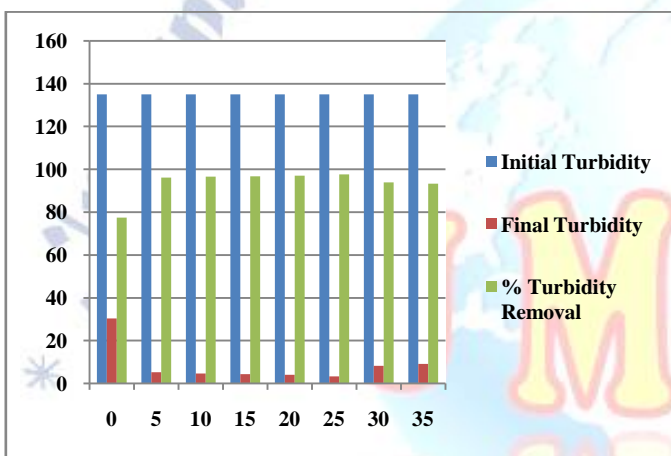
Turbidity removal (%) versus Coagulant dose (mg/L)



Coagulant dose (mg/L)

5. Glycine max (Soyabean)

Turbidity removal (%) versus Coagulant dose (mg/L)



Coagulant dose (mg/L)

Dried Soyabean seeds were made into a fine powder and used as coagulant. Varying doses were used as shown in the Bar chart. Since the nature and effectiveness of this natural coagulant was unknown, dosages of 5, 10, 15, 20, 25, 30, and 35 mg/L respectively were used in each of the jars. The Initial Turbidity of synthetic water sample was found to be 135 NTU. Once the Jar test experiment was completed, Final Turbidity of all samples was measured using a Nephelometer. As per the observations and Bar chart plotted, maximum percentage Turbidity removal of 97.6 % in this case was found at an optimum dosage of 25 mg/L.

Table 1.1 Efficiency of Bio-Coagulants

NAME OF COAGULANT	FINAL TURBIDITY (NTU)	TURBIDITY REMOVAL (%)
Neem seeds	10.9	91.92
Orange peel seeds	9.02	93.31
Drumstick seeds	8.76	93.51

Tulsi seeds	3.7	97.25
Soyabean seeds	3.24	97.6

The Final Turbidity values and the Percentage Turbidity removal values are tabulated . So, out of all the seeds considered, ‘Soyabean seeds’ have been found to be the most suitable and effective natural coagulants.

6. CONCLUSION

After dosing water-soluble extracts of Neem seeds, orange peel seeds, Drumstick seeds, Tulsi seeds, and Soyabean seeds, Turbidity reduced from 135 NTU to 10.9, 9.02, 8.76, 3.7, and 3.24 Nephelometric turbidity unit (NTU), respectively. Highest turbidity reduction efficiency (97.6%) was found with ‘Glycine max’ (Soyabean) at an optimum dosage of 25 mg/L. Tulsi seeds were the next most effective natural coagulant as a Turbidity reduction efficiency of 97.25% was observed. Then comes Drumstick seeds, orange peel seeds, and Neem seeds respectively in the order of effectiveness as far as Turbidity reduction is considered. Therefore, by using locally available natural coagulants, suitable, easier, and environment friendly options for water treatment were observed. Hence, there is a need to search for the native materials which can be used for water purification as these can provide technology near to the point of use that can be adapted by communities. In these lines, the present study has been focused on reviewing natural coagulants for water treatment owing to the disadvantages of chemical coagulants. Present technologies of water treatment have been created on the foundation of traditional practices/ methods, which have been ignored off late.

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Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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