International Journal of Scientific Research and Engineering Development-– Volume 8 Issue 4, July-Aug 2025
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Quality Check Parameters by Adding Different Natural Coagulants and Analyzing their Results

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Abstract:
Lakes in urban expanses hold significant ecological importance as they act as crucial components in maintaining the environmental balance and promoting sustainable urban development. These inland water bodies not only serve as habitats for diverse aquatic life but also contribute to groundwater recharge, microclimate regulation, and recreational benefits for city dwellers. However, in recent times, the health of such urban lakes has been severely impacted due to the rapid increase in land use, urbanization, and the indiscriminate disposal of untreated domestic and industrial effluents. Futala Lake, located in Nagpur, Maharashtra, is one such urban water body that has been facing degradation owing to these anthropogenic pressures. The current study focuses on assessing the physical, chemical, and biological conditions of Futala Lake with particular emphasis on analyzing turbidity parameters of effluents entering the lake and exploring low-cost, eco-friendly methods for reducing their concentrations. The direct discharge of untreated wastewater into the lake not only leads to deterioration of surface water quality but also poses a serious risk of groundwater contamination and soil pollution in the surrounding areas. Therefore, proper treatment of effluents is imperative to meet the discharge level requirements prescribed by environmental standards. In this context, the study investigates the potential of natural, abundantly available, and cost-effective bioflocculants such as Orange Peel, Neem seeds, Soybean seeds, Tulsi seeds, and Moringa Oleifera seeds, which have been traditionally known and widely used in rural and tribal regions of India for water purification. These bioflocculants, due to their natural coagulating properties, offer a sustainable alternative to conventional chemical treatment methods, thereby contributing to the restoration of water quality in Futala Lake while promoting an environmentally friendly approach to wastewater management.

Keywords- Bioflocculants, Futala Lake, Neem Seeds, Soybean Seeds, Tulsi Seeds, Moringa Oleifera Seeds.

I. INTRODUCTION

Water is the most precious gift of nature, essential for the sustainability of both ecological systems and human life. The natural water cycle ensures a continuous supply of water to support all forms of life, from the highest mountain ranges to the vast oceans and the smallest rivers. Although 71% of the Earth's surface is covered with water, only about 2.5% is freshwater, which is crucial for human consumption, agriculture, and industrial use. Unfortunately, the freshwater that is extracted for various purposes is often returned to the environment as wastewater, typically in a degraded condition. Human interventions such as economic development, urbanization, and intensive agricultural activities exert significant pressure on natural water bodies, further deteriorating their quality. One critical parameter that reflects water quality is turbidity, which refers to the cloudiness of water caused by the presence of a large number of suspended particles that are usually invisible to the naked eye, similar to how smoke clouds the air. These particles, varying in size, can include silt, clay, organic matter, and microorganisms. Larger particles tend to settle quickly, while smaller or colloidal particles may remain suspended, giving the water a persistent turbid appearance. Turbidity in natural water bodies is often caused by the growth of phytoplankton, but it can also be significantly elevated by human activities such as construction, mining, and agriculture, which

disturb soil and increase sediment runoff into water bodies during rainfall. In urban areas, stormwater runoff from paved surfaces like roads, bridges, and parking lots carries sediments and pollutants into nearby lakes and rivers, raising turbidity levels. Additionally, areas experiencing severe bank erosion contribute further to sedimentation. Elevated turbidity levels in drinking water pose serious health risks, particularly gastrointestinal illnesses, as suspended solids provide a medium where viruses and bacteria can thrive. These particles shield harmful microorganisms from conventional disinfection processes, such as chlorination and ultraviolet (UV) sterilization, making water treatment less effective. This situation is especially hazardous for individuals with weakened immune systems. Thus, turbidity not only impacts aquatic ecosystems by reducing light penetration and disrupting photosynthesis but also compromises the safety and quality of drinking water, underscoring the need for effective monitoring and control measures to safeguard public health and the environment.

II. 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 varing 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 Hedaoo, 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 Aloevera 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 Priyadharshini 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.

III. PROPOSED METHODOLOGY

3.1 MATERIALS USED

In this study, the powdered form of five locally available seeds, namely Orange Peel, Neem seeds, Soyabean seeds, Tulsi seeds, and Moringa Oleifera seeds, were utilized as natural coagulants to investigate their efficiency in reducing the turbidity of synthetic water. These natural coagulants were chosen due to their abundance, cost-effectiveness, and eco-friendly properties, making them suitable alternatives to chemical coagulants commonly used in water treatment. The experimental work was conducted using artificially prepared turbid water to ensure controlled conditions for assessing the coagulation performance of each seed powder. The standard laboratory procedure of the conventional Jar Test apparatus was employed, as it allows for the systematic evaluation of coagulant dosage and settling behavior by simulating the coagulation and flocculation processes on a small scale. Through this setup, the coagulation potential of the seed powders in removing suspended particles and thereby reducing

turbidity was effectively studied, highlighting their promising role as sustainable bioflocculants in water purification.

3.2 APPARATUS USED

3.2.1 JAR TEST APPARATUS

Jar test is the most widely used experimental methods for coagulation-flocculation. A conventional jar test apparatus was used in the experiments to coagulate sample of synthetic turbid water using some coagulants. It was carried out as a batch test, accommodating a series of six beakers together with sixs pindle steel paddles. Before operating the jar test, the sample was mixed homogenously. Then, the samples ought to be measured for turbidity, coliform count for representing an initial concentration. Coagulants of varying concentrations were added in the beakers. The whole procedures in the jar test were conducted in different rotating speed.

3.2.1.1 JAR TEST PROCEDURE

The jar test procedures involve the following steps:

- Fill the jar testing apparatus containers with sample water. One container will be used as a control while the other 5 containers can be adjusted depending on what conditions are being tested. For example, the pH of the jars can be adjusted or variations of coagulant dosages can be added to determine optimum operating conditions.
- Add the coagulant to each container and stir at approximately 100 rpm for 1 minute. The rapid mix stage helps to disperse the coagulant throughout each container.
- Turn off the mixers and allow the containers to settle for 30 to 45 minutes. Then measure the final turbidity in each container.
- Reduce the stirring speed to 25 to 35 rpm and continue mixing for 15 to 20 minutes. This slower mixing speed helps promote floc formation by enhancing particle collisions which lead to larger flocs.
- Residual turbidity vs. coagulant dose is then plotted and optimal conditions are determined. The values that are obtained through the experiment are correlated and adjusted in order to account for the actual treatment system.

3.2.2 NEPHELOMETER

A Nephelometer is an instrument for measuring concentration of suspended particulates in a liquid or gas colloid. A Nephelometer measures suspended particulates by employing a light beam (source beam) and a light detector set to one side (often 90°) of the source beam. The principle of nephelometry and turbidimetry is based on the scattering or absorption of light by solid or colloidal particles suspended in solution. When light is passed through the suspension, part of incident radiant energy is dissipated by absorption, reflection, and reaction while remainder is transmitted.

3.3 SAMPLING LOCATION

[Fig.3.1: Collection of wastewater sample from Futala Lake, Nagpur]

3.4 METHODOLOGY

3.4.1 Preparation of Synthetic water

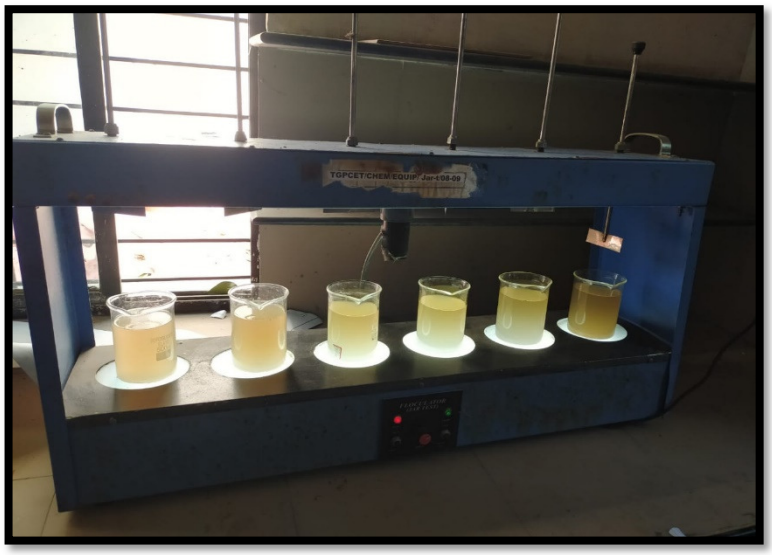
Exactly 2 grams of soil (with considerable amount of clay materials) was added to 1 litre of lake water sample from Futala lake, Nagpur in order to produce a muddy water sample. Suspension was stirred vigorously to uniformly distribute the soil particles. This sample was then allowed to pass through 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'.

3.4.2 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.

3.4.3 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.

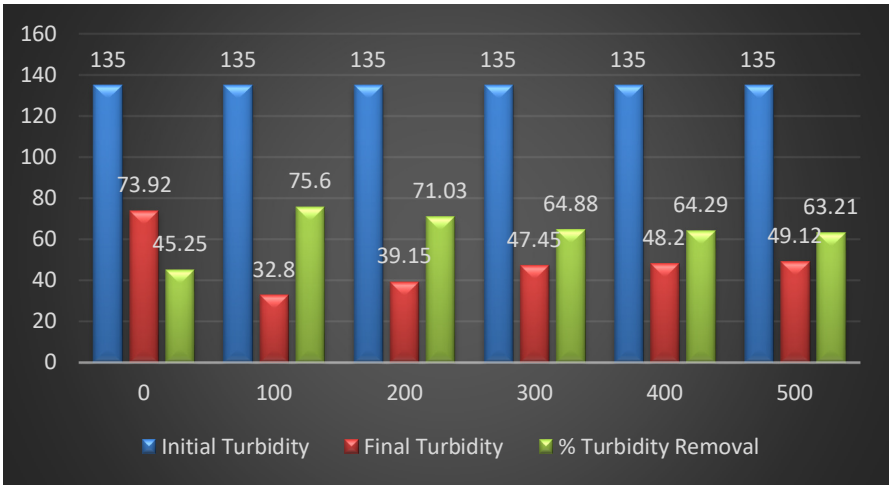


[Fig.3.2: Jar Test Operation]

IV. RESULTS

1. Neem Seeds:

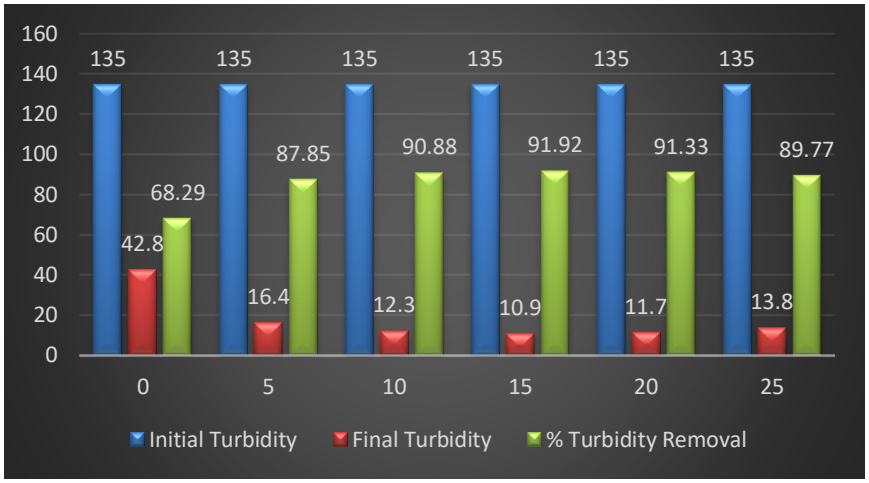
Turbidity removal (%) versus Coagulant dose (mg/L)



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)



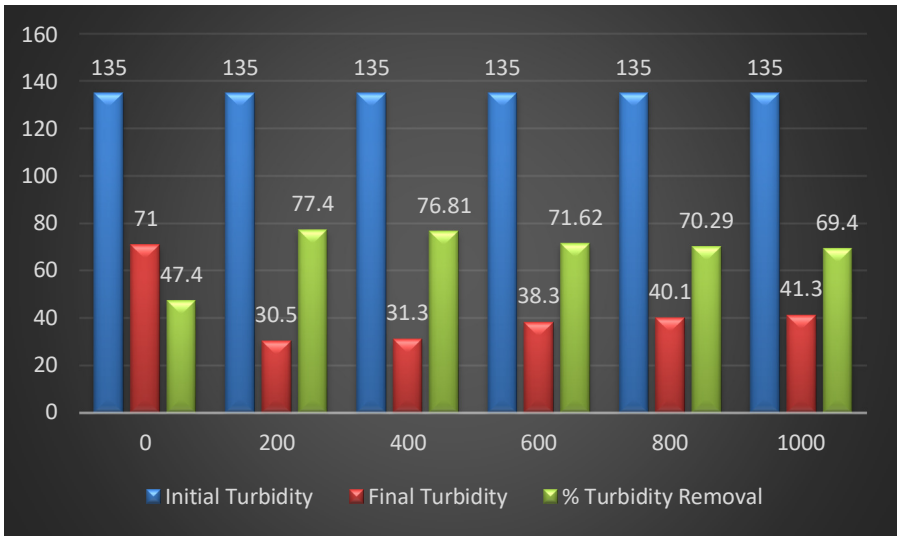
Coagulant dose (mg/L)

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:

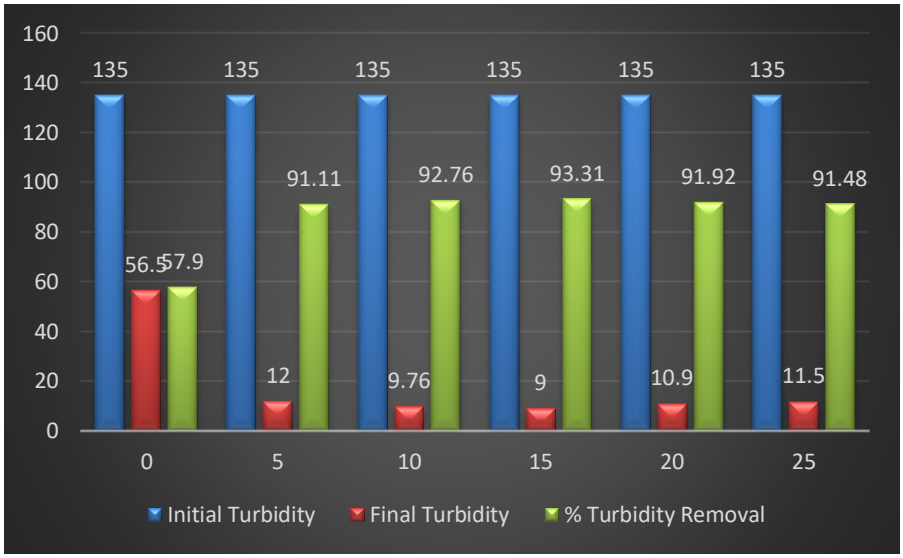
Orange peel seeds were made into a fine powder and used as coagulant. Varying doses were used as shown in the Bar chart. Since the nature and effectiveness of this natural coagulant was unknown, dosages of 200, 400, 600, 800, and 1000 mg/L respectively were used in each of the 5 jars. The Initial Turbidity 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)



Coagulant dose (mg/L)

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

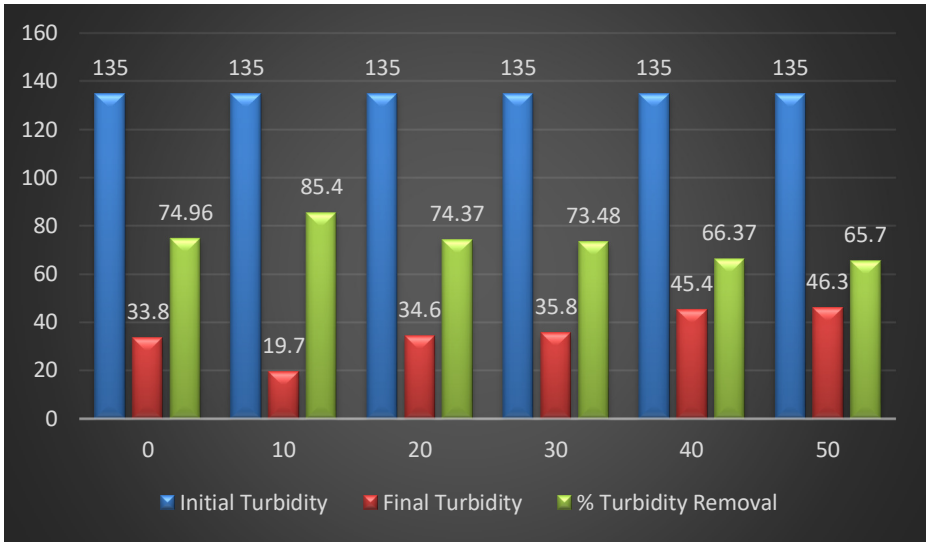


Coagulant dose (mg/L)

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):

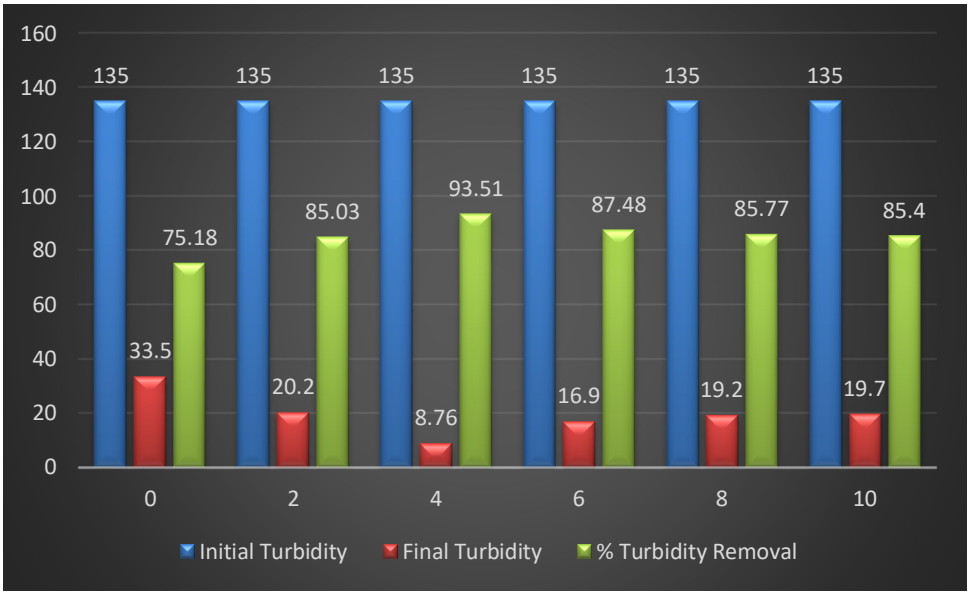
Turbidity removal (%) versus Coagulant dose (mg/L)



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)



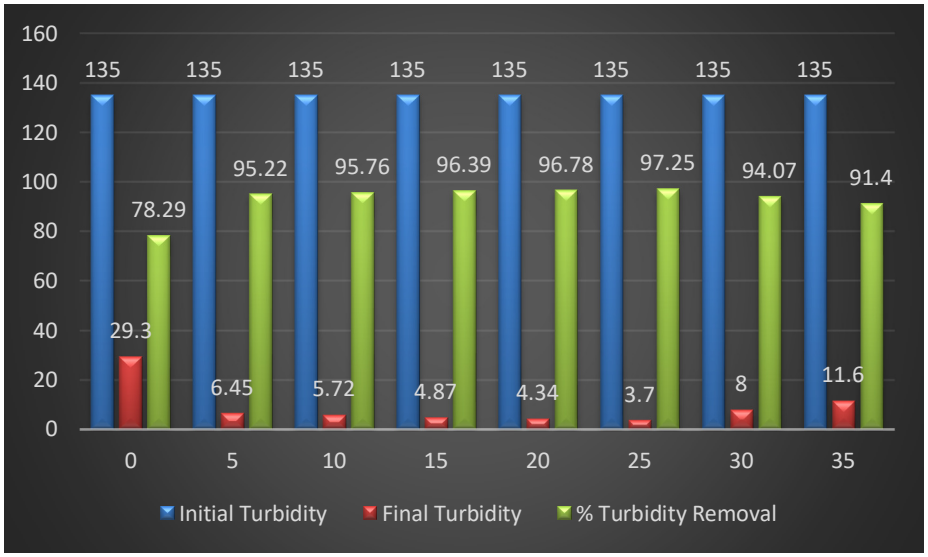
Coagulant dose (mg/L)

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.

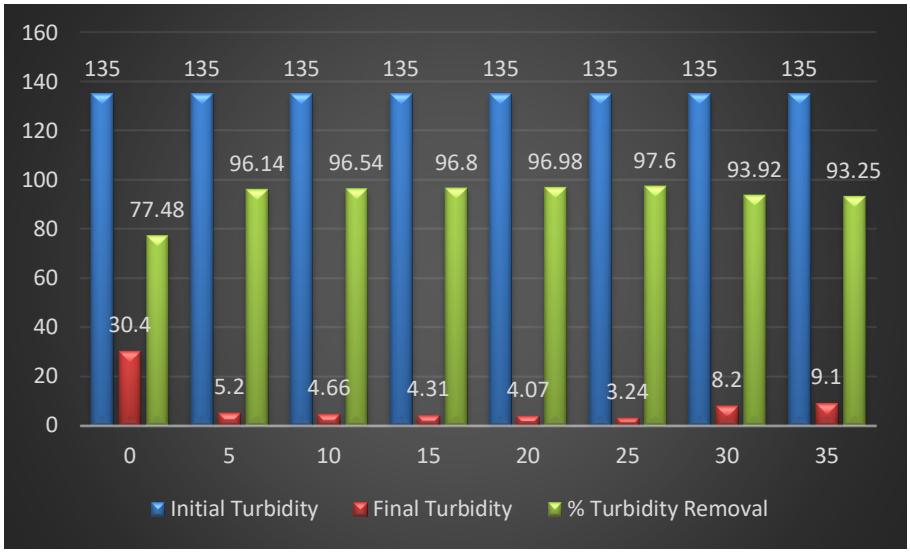
Turbidity removal (%) versus Coagulant dose (mg/L)



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 4.1 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.

CONCLUSION

After dosing water-soluble extracts of Neem seeds, Orange Peel, Drumstick (Moringa Oleifera) seeds, Tulsi seeds, and Soyabean (Glycine max) seeds into the synthetic turbid water, a significant reduction in turbidity was observed, decreasing from an initial 135 NTU to 10.9 NTU, 9.02 NTU, 8.76 NTU, 3.7 NTU, and 3.24 NTU, respectively. Among the tested natural coagulants, Soyabean seeds exhibited the highest turbidity reduction efficiency of 97.6% at an optimum dosage of 25 mg/L, followed closely by Tulsi seeds with a turbidity removal efficiency of 97.25%. Drumstick seeds, Orange Peel, and Neem seeds followed in descending order of effectiveness. The results clearly indicate that these locally

available natural coagulants are not only effective in turbidity removal but also provide an environmentally friendly and sustainable alternative to conventional chemical coagulants. The use of such natural coagulants offers a simple, low-cost, and community-adaptable technology for water purification, particularly beneficial in rural and resource-limited areas. Furthermore, these findings highlight the importance of reviving and incorporating traditional practices into modern water treatment technologies. The present study underscores the potential of naturally occurring coagulants, their inherent advantages, and their applicability for further research and development. By optimizing their working parameters and enhancing their shelf life, these bio-coagulants could become a viable solution for sustainable water treatment, promoting environmental protection and public health while reducing dependency on chemical-based treatment methods.

REFERENCES

1. Achupriya K R, Akshay Saseendran, Bino Benny, Dona Sunny, 2022, Sewage Water Treatment using Natural Coagulants, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) ICART – 2022 (Volume 10 – Issue 06)
2. Aggarwal, C.S. and Pandey, G.S. 1994. J. Environ. Biol. Vol. 15:49.
3. Antov, M.G.; Sciban, M.B. and Petrovic, N.J. (2009). Proteins from common bean (Phaseolus vulgaris) seed as a natural coagulant for potential application in water turbidity removal. Biosource Technology. 101: 2167-2172.
4. Anju S and K.Mophin-Kani, "Exploring the use of orange and Neem Leaf powder as alternative coagulant in treatment of dairy wastewater", International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016, ISSN 2229-5518.
5. Anwar, F.; Latif, S.; Ashraf, M. and Gilan, A.H. (2007). Moringa oleifera: A food plant with multiple medicinal uses. Phytother. Res. 21:17-25
6. Brix, H. (1994). Functions of macrophytes in constructed wetlands. Water Sci. Technol. 29, 71 78.
7. Cheremisinoff, N.P. (2002). Handbook of water and wastewater treatment technologies.
8. David Krantz and Brad Kifferstein, Water Pollution and Society.
9. Eman, N.A.,Muyibi,S.A., Salleh, H.M., Salleh, M.R.M. and Alam, Md. Z.,(2010). "Moringa Oleifera seeds as natural coagulant for water treatment", Thirteenth International Water Technology (Conference), Hurghada, Egypt.
10. Ekambaram Sanmuga Priya, Perumal Senthamil Selvan and Subramanian Venkataraman. 2011. Assessment of the in-vivo and in-vitro antioxidant potential of Strychnos potatorum Linn. Seeds in Freund's adjuvant induced arthritic rats; Journal of Medicinal Plants Research Vol. 5 (19): 4780-4787.
11. G. Folkard, J. Sutherland & Reya Al- Khalili, U.K- Natural Coagulants - A sustainable Approach, 21st WEDC Conference, 1995.
12. G.Vijayaragavan, T.Sivakumar, A.Vimal Kumar, "Application of plant based coagulants for wastewater treatment", International Journal of Advanced Engineering Research and Studies, Vol I, Issue I, 2011 December.
13. J.P. Sutherland, G.K. Folkard, and W.O. Grant- "Natural coagulants for appropriate water treatment – a Novel approach".
14. Namrata S Naragundakar, Naghma N, Padmavathi V, Mohan Naik B, Basanth Kumar U, 2022, Dairy Waste Water Treatment by using Natural Coagulants, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) ICEI – 2022 (Volume 10 – Issue 11)
15. Saravanan J., Priyadharshini D, Soundammal A., Sudha G,Suriyakala K, "Wastewater Treatment using Natural Coagulants" SSRG - IJCE Volume 4 Issue 3 – March (2017)
16. S P Ghule , M N Hedaoo, 2022, Practicability Study on Application of Natural Coagulants, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) Volume 11, Issue 07 (July 2022)

17. Tasneembano kazi, Arjun Virupakshi, "Treatment of tannery wastewater using natural coagulants", International journal of Innovative research in Science, Engineering and Technology, Vol II, Issue VIII, August 2013.

