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Sustainable Treatment of Wastewater Using Natural Coagulants Based on Plants Seeds

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ABSTRACT- Lakes in urban expanses are ecologically very important. Those inland water bodies play a major role in sustainable urban development. As a result of the swelling land use and effluent disposal from domestic and industrial activities, water bodies in the urban regions have been suffering in recent times. The present study aims in understanding the physical, chemical and biological conditions of the Futala Lake. This Lake is situated in Nagpur, Maharashtra. 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, Soyabean seeds , Tulsi seeds and Moringa Olifera seeds promising bioflocculant whose seeds are plentily available in India which are popular and widely used in rural and tribal areas for the purification of water.

KEYWORDS- Sustainable, Biocoagualnts, Futala Lake, Water Treatment, Turbidity, NTU, Plant Seeds

I. INTRODUCTION

Water is the greatest gift of nature for the sustainability of the ecological system and people. The water cycle on Earth provides a continuous supply for all forms of living things, from the mountain tops down to the oceans and the smallest rivers. It is common knowledge that 71% of the earth's surface is covered by water, but only 2.5% of the water on earth is fresh water. The fresh water that is used is returned to the environment as wastewater, and not under the same conditions as when it was taken. Humans use and divert freshwater in many ways to conduct significant economic and agricultural activities and sustain countless livelihoods, which unfortunately puts pressure on natural water bodies. Turbidity is the clouding of a liquid caused by a large number of individual particles that are generally invisible to the naked eye, much like smoke in the air. Measuring turbidity is an important test of water quality. Liquids may contain suspended solids consisting of particles of many different sizes. While some suspended solids are large and heavy enough to settle quickly to the bottom of the container when a liquid sample is left to stand, very small particles settle very slowly or not at all if the sample is stirred regularly or if the particles are colloidal. These small solid particles make the liquid 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. Turbidity in open waters can be caused by the growth of phytoplankton. Human activities that disturb the soil, such as construction, mining, and agriculture, can cause high amounts of sediment to enter waterbodies during rain storms due to stormwater runoff. Areas with high bank erosion and urban areas also contribute large amounts of turbidity to nearby water bodies through stormwater pollution from paved surfaces such as roads, bridges, and parking lots. The higher the turbidity level in drinking water, the greater the risk that people will develop gastrointestinal illnesses. This is particularly problematic for people with weakened immune systems, as pollutants such as viruses or bacteria can attach themselves to the suspended solids. Suspended particles interfere with the disinfection of water with chlorine, as the particles act as a protective shield for viruses and bacteria. Likewise, suspended solids can protect bacteria from sterilization of the water with ultraviolet light.

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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.

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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.

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III. PROPOSED METHODOLOGY

3.1 MATERIALS USED

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'.

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.

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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.

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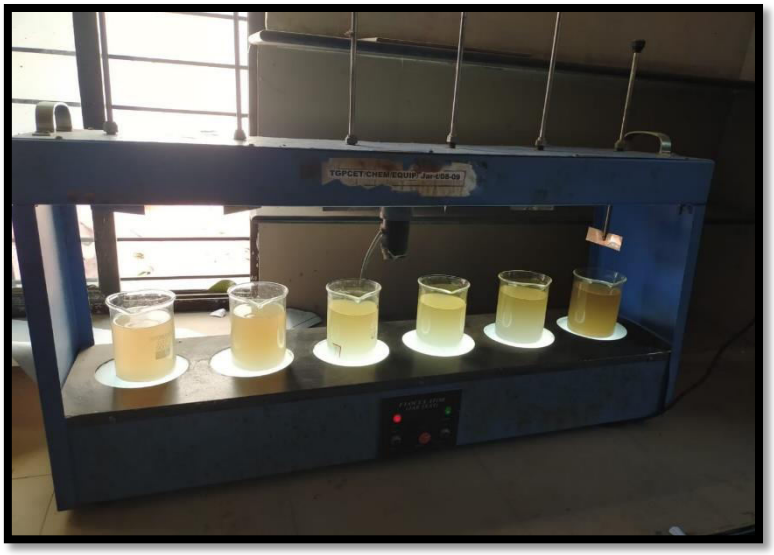
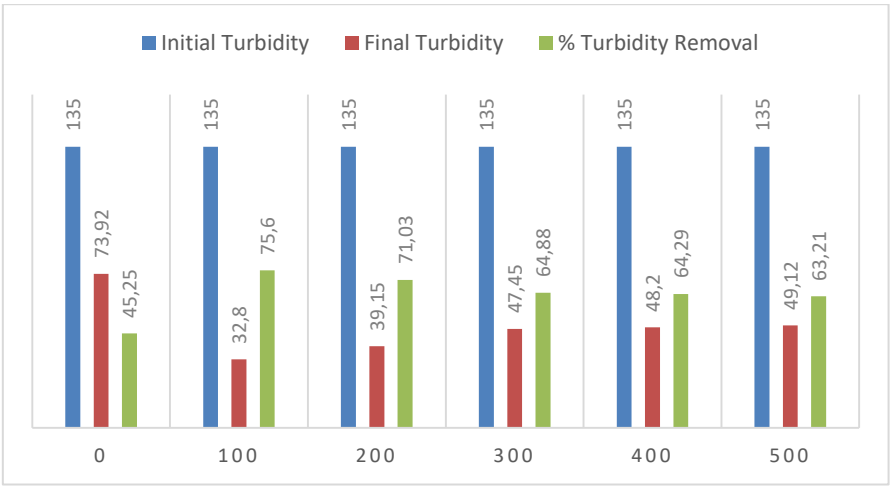


[Fig.3.2: Jar Test Operation]

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.

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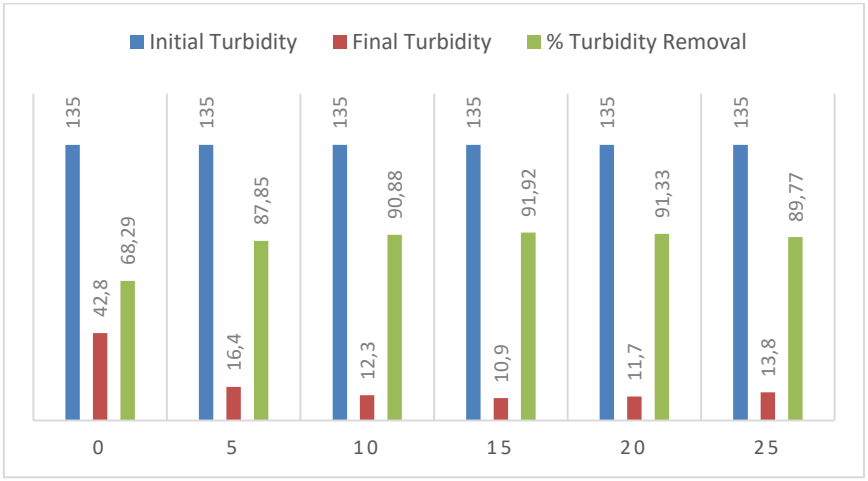
Turbidity removal (%) versus Coagulant dose (mg/L)



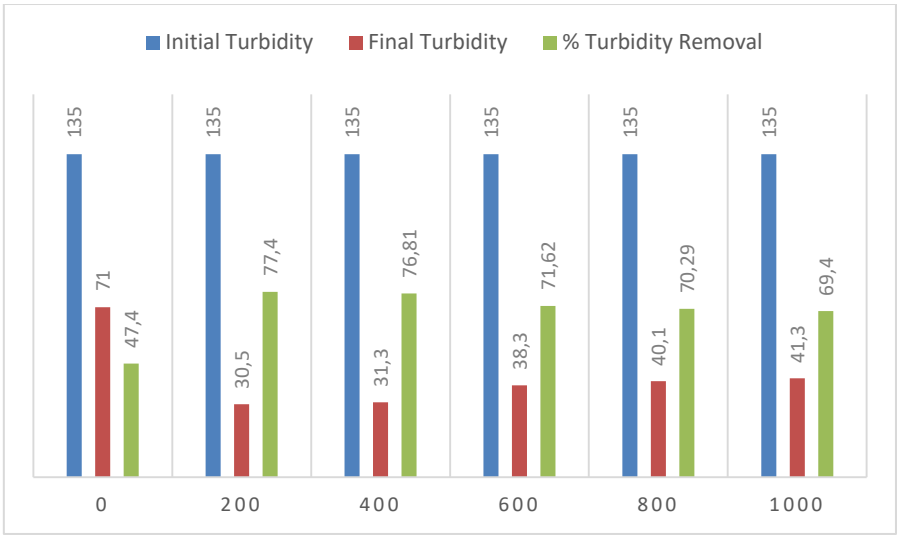
Coagulant dose (mg/L)

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)

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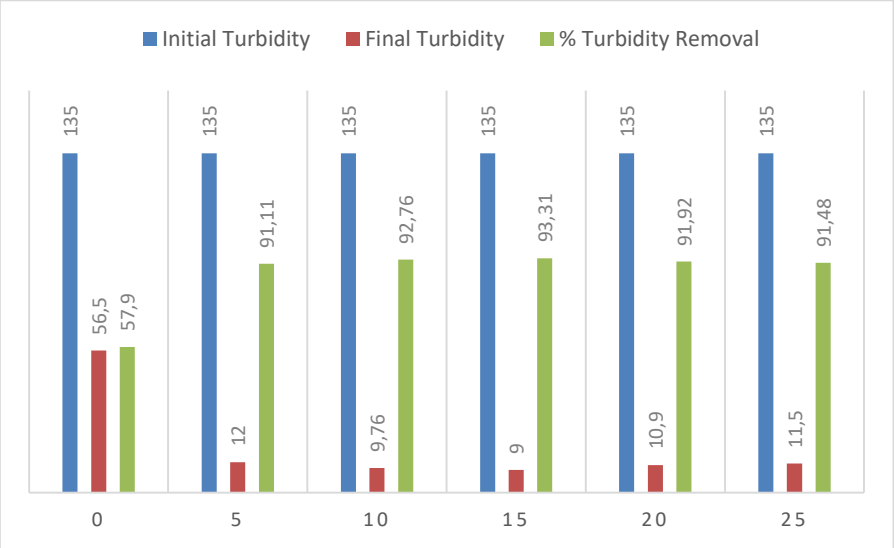
Turbidity removal (%) versus Coagulant dose (mg/L)

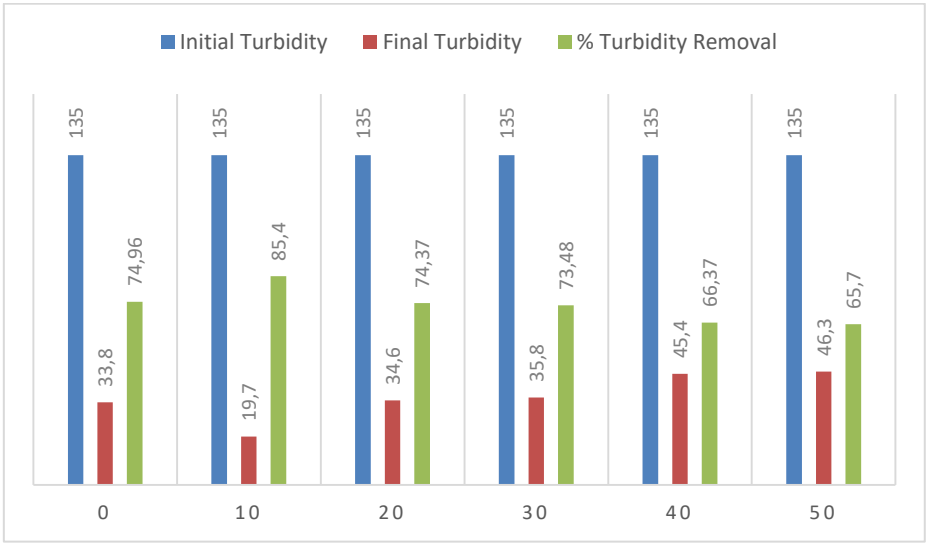


Coagulant dose (mg/L)

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.

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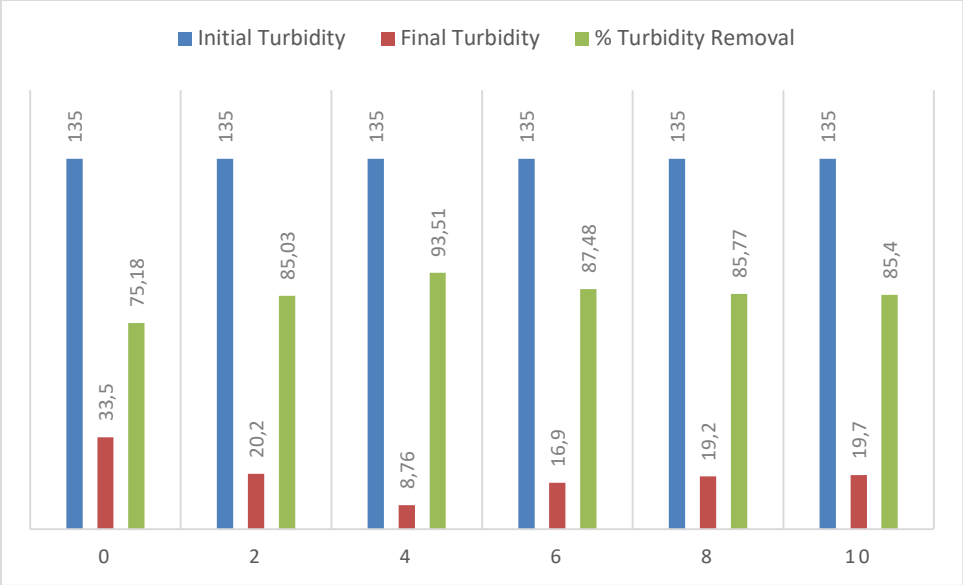
Turbidity removal (%) versus Coagulant dose (mg/L)



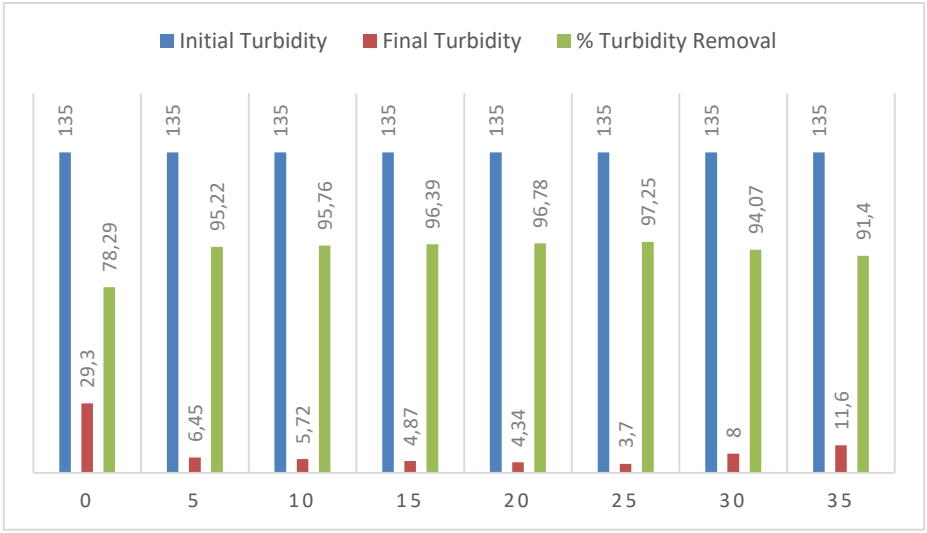
Coagulant dose (mg/L)

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)

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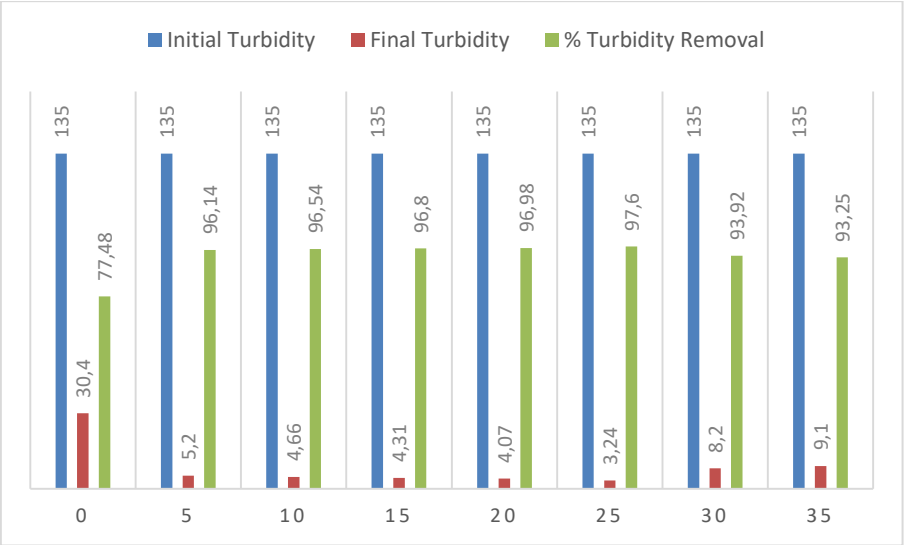
5. Glycine max (Soyabean)

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.

V. 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. This study will not only throw light on the traditional knowledge but also provide an insight of the available natural

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coagulants. In this project, we have presented natural coagulants whose availability is innate, their efficiency is also presented so that they can be considered for further study. It can be concluded that natural coagulants bring with them advantages of being low cost, copious, native and efficient for treatment. Further studies in optimizing working parameter of the coagulants along with increasing shelf life will benefit research in this area.

VI. FUTURE SCOPE

- The usage of plant based natural coagulants represents a fundamental development in sustainable environmental technology for the improvement of quality of life for communities. In an era of increasing environmental concerns, water scarcity admits the draw backs of chemical coagulants and poor sanitary facilities in most low-income earning countries, the need to further develop natural coagulants as alternative environmentally favorable water purifying chemicals is exigent.
- The usage of bio-coagulants derived from plant-based sources represents a vital development in 'grassroots' sustainable environmental technology through cost effectiveness.
- Design natural water purification techniques using plants extracts for bioremediation of turbid water. Application of this low-cost protocol will be recommended for simplified, point-of-use, low risk water treatment where rural and peri-urban people living in extreme poverty are presently drinking highly turbid and microbiologically contaminated water.
- The ultimate purpose of proposed research study is to come up with a compendium of plant coagulants that could be used as a technology that is cost effective and eco-friendly.

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