COMPREHENSIVE STUDY OF SURFACE AND GROUNDWATER TREATMENT TECHNIQUES UTILIZING VARIOUS BIOCOAGULANTS FOR SUSTAINABLE WATER MANAGEMENT

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Abstract:
Water scarcity and contamination have emerged as critical global challenges, prompting the need for innovative and sustainable water treatment solutions. This study focuses on a comprehensive examination of both surface and groundwater sources, investigating their quality, potential contaminants, and the application of bio coagulants as a promising treatment method. This study seeks to evaluate the effectiveness of bio coagulants in treating surface and groundwater, emphasizing their eco-friendly nature and potential for sustainable water management. The first phase of the study involves a thorough examination of surface and groundwater quality parameters. Physical, chemical, and biological characteristics are analysed to identify potential contaminants, including suspended solids, organic matter, heavy metals, and pathogens. The study explores the utilization of bio coagulants derived from natural sources such as plant extracts, microorganisms, and algae. Bio coagulants have gained attention due to their low environmental impact and potential for mitigating the adverse effects of conventional chemical coagulants. The research investigates the coagulation and flocculation capabilities of bio coagulants, assessing their efficacy in removing various impurities from water. To elucidate the effectiveness of bio coagulants, the study delves into the underlying mechanisms of bio coagulation. The interactions between bio coagulants and contaminants are examined, shedding light on the coagulation and flocculation processes that facilitate the removal of suspended particles and pollutants. Understanding these mechanisms is crucial for optimizing bio coagulant dosage and treatment efficiency.
Keywords: Surface Water, Groundwater, Bio coagulants, Sustainable Water Management, Water Treatment Technologies

1.0 INTRODUCTION

The Use of Natural Bio-Coagulants for Water Treatment Access to clean and safe water is a fundamental human right, yet a significant portion of the global population faces challenges related to water scarcity and contamination. As the world grapples with growing populations, urbanization, and environmental changes, innovative and sustainable solutions for water treatment are of paramount importance. In recent years, attention has turned towards harnessing the natural coagulation properties of plant-based materials to purify both surface and groundwater. This literature explores the diverse applications of Moringa leaf and seed, jackfruit peel, bitter gourd seed, and hibiscus seed as bio-coagulants for treating water, shedding light on their potential to revolutionize water treatment methods.

Scope of the work:

One of the primary advantages of exploring natural bio-coagulants is their diverse applicability across various water sources. Surface water bodies, such as rivers, lakes, and ponds, often suffer from high turbidity due to suspended particles and organic matter. Groundwater, while generally considered cleaner, can still harbor impurities that compromise its quality. The scope of using Moringa leaf and seed, jackfruit peel, bitter gourd seed, and hibiscus seed as bio-coagulants spans both surface and groundwater treatment, offering a versatile approach to address water quality challenges in different settings.

Problem Statement:

Access to clean and safe water remains a critical global challenge, with millions of people worldwide facing issues related to water scarcity and contamination. Traditional water treatment methods often rely on expensive

and environmentally impactful synthetic coagulants, and in many regions, particularly in developing countries, centralized water treatment infrastructure is lacking. This problem is further compounded by the inadequate disposal of agricultural byproducts, such as jackfruit peel and bitter gourd seeds, leading to environmental pollution. In this context, the exploration of Moringa leaf and seed, jackfruit peel, bitter gourd seed, and hibiscus seed as bio-coagulants for treating surface and groundwater emerges as a potential solution. The problem at hand involves the need for sustainable, cost-effective, and locally applicable water treatment methods that address both water quality and waste management challenges, especially in resource-constrained communities. This problem statement seeks to catalyse research and development efforts towards harnessing the coagulation properties of these natural materials for transformative and eco-friendly water treatment solutions.

Objectives:

- To determine the pH, TDS, BOD, COD etc of water sample of different sampling locations.
- To find out the methods & techniques used to reduce the water pollutions.
- To find out water sample analysis for further six months i.e. post winter & summer seasons.
- To find out the effect of deteriorating water quality on human & aquatic life.

2.0 LITERATURE REVIEW:

Water scarcity and contamination are significant challenges worldwide, necessitating innovative and sustainable water treatment approaches. Bio-coagulation using natural materials has emerged as an eco-friendly and cost-effective method for improving water quality [1]. This literature review explores the use of bio-coagulants derived from Moringa oleifera, jackfruit peel, bitter gourd seed, and hibiscus seed in treating both surface and groundwater.[2] Moringa has gained attention for its coagulation properties, attributed to cationic proteins present in its seeds and leaves. Numerous studies highlight the effectiveness of Moringa bio-coagulants in reducing turbidity and removing impurities from water. The coagulation process involves the formation of flocs, leading to improved water clarity. Moringa's availability, affordability, and biodegradability contribute to its suitability for water treatment in diverse settings.[4] Moringa oleifera seeds have presented strong evidence for their use as an effective natural coagulant in water treatment process for the improvement of chemical and physical characteristics of ground water such as pH, TDS (total dissolved solids), hardness, turbidity, alkalinity, suspended solids, and conductivity (Novita et al., 2019; Taiwo, Adenike, Aderonke, 2020). Also, they have depicted considerable decrease in biological impurities in water such as E. coli content (Camacho et al., 2017). Overall Moringa oleifera seeds pave a strong path towards focusing on its utilization as a strong alternative to chemical coagulant for water purification (Choudhary, Negi, 2017). Natural Coagulants can be extracted via several processes such as Soxhlet extraction process using different organic solvents including hexane, methanol, ethanol and water (Sánchez-Martín, Beltrán-Heredia, Peres, 2012). Generally, extraction and purification of all natural coagulants are based upon three stages as depicted in Figure 1. First stage comprises of the pre preparatory phase where the raw plant material is processed and converted into fine powder form suitable for extraction stage such as cleaning and drying. Second stage comprises of extraction where the processed raw material is combined with organic or aqueous solvent to obtain the extract. Lastly, obtained extract is further purified using several processes such as lyophilization and precipitation. Seed extract of Moringa oleifera plant has been recognized as one of the highly potent flocculating agent in the treatment of surface water. Moringa seeds have depicted better coagulation activity in the treatment of highly turbidity water. Several pilot scale studies utilized the seed extract of Moringa oleiferous primary coagulant in treatment of turbid surface water (Barbosa et al., 2018). Several researches have also stated its utility in the treatment of paint waste water which could be further reused for plants (Angelakis et al., 1999). Interestingly, water treated with Moringa seed extract has better quality than the water treated with inorganic solvent (aluminium sulphate) [16] Jackfruit peel, a byproduct often discarded, has demonstrated potential as a natural coagulant. Rich in polysaccharides and proteins, the peel aids in flocculation and sedimentation. Research indicates that jackfruit peel extracts effectively reduce turbidity in water, making it a viable option

for water treatment. Its utilization not only addresses waste management but also offers an eco-friendly alternative for communities facing water quality challenges. [11]

Bitter Gourd Seed:

Bitter gourd seeds, recognized for their coagulation properties, have been explored as an alternative to synthetic coagulants. Studies reveal the effectiveness of bitter gourd seed extracts in reducing turbidity and removing suspended particles. The coagulation mechanism involves the formation of flocs, making it suitable for water treatment. Bitter gourd seeds present an accessible and sustainable solution, especially in regions where bitter gourd cultivation is prevalent.

Hibiscus Seed:

Hibiscus seeds, often overlooked, have shown promise as bio-coagulants. The seeds contain proteins and polysaccharides that facilitate coagulation and flocculation processes. Research suggests that hibiscus seed extracts contribute to the removal of impurities and turbidity in water. The availability of hibiscus seeds in various regions enhances the potential for their application in community-level water treatment.[3]

Comparative Analysis: Understanding Strengths and Limitations

While each natural bio-coagulant exhibits coagulation properties, their effectiveness varies based on water composition, dosage, and regional factors. Moringa oleifera, with its established track record, is widely studied and implemented due to its proven efficacy and availability. Jackfruit peel and bitter gourd seeds offer dual benefits by addressing waste management concerns while providing effective coagulation.[6]

3.0 METHODOLOGY:

Moringa leaves and seeds have been traditionally used for water purification due to their coagulation and antimicrobial properties. Here's a brief overview of how Moringa leaves and seeds can be used for water purification:

Fig1: Moringa leaves and seeds

Water Purification Process:

Coagulation: Moringa leaves contain cationic proteins that can coagulate and bind impurities and particles in water.

Dosage: Add a small amount (usually around 0.1 to 0.5 grams per liter) of Moringa powder to the water to be treated.

Mixing: Stir the mixture well and let it sit for a while (about 1-2 hours) to allow coagulation to occur.

Settling and Filtration:

After coagulation, the impurities clump together and settle at the bottom of the container.

Carefully decant the clarified water, leaving the sediment behind.

For further purification, the water can be passed through a cloth or fine mesh to remove remaining particles.

Bitter gourd seeds (Momordica charantia): In their coagulation properties, similar to Moringa seeds. They can be used to purify water through a simple and natural process. Here's a basic guide on how bitter gourd seeds can be utilized for water purification:

Fig 2: Bitter gourd seed

Hibiscus seeds:

This can be used as a natural coagulant for water treatment. The coagulation process helps in aggregating impurities and suspended particles, making it easier to separate them from water. Here's a general guide on how hibiscus seeds can be utilized for water treatment:

Fig 3: Hibiscus seeds and flower

4.0 RESULTS AND DISCUSSIONS

Raw Water directly collected from the different fresh water source is collected and treated with natural coagulants like Moringa Oleifera seed powder, Momordica Charantia seed powder, Artocarpus heterophyllus peel Powder, Hibiscus seed powder.

Sample Collection:

Fig 4: Water sample collected for the project work.

We used Jar Test Apparatus to evaluate the initial and final turbidity values before and after coagulation process using natural coagulants. Then the optimum dosage of natural coagulant was obtained by varying parameter such Ph, alkalinity etc; and also, the concentration of extract and at last the removal of efficiency was compared. The optimum dosage was obtained.

Fig 5: Sample A- untreated water and Sample B- water treated with different Natural Coagulant samples.

Results obtained after treating Raw water with Moringa Oleifera Seed Powder:

sample collected from local reservoir was sampled in the laboratory in separate jars and mixed with moringa oleifera seed powder in different proportions and kept under for observation.

Table 1: Comparative Analysis of Water Purification Methods

Method	Efficacy	Cost	Accessibility
Moringa Seeds	High	Low	High
Bitter Gourd Seeds	moderate	low	low
Jack Fruit peel	high	Low	moderate
Hibiscus seed	high	high	high
Chlorination	High	Moderate	Moderate
Filtration	Moderate	High	Low
Boiling	Low	Low	High

Table 2: Turbidity Removal

Sl no	Coagulant Dosage in mg/L (MOseed powder)	Turbidity in NTU Before adding MO seed powder	Turbidity in NTU After adding MO seed powder
1	15	100	18
2	25	100	16
3	35	100	8
4	50	100	10
5	75	100	18.5
6	100	100	21

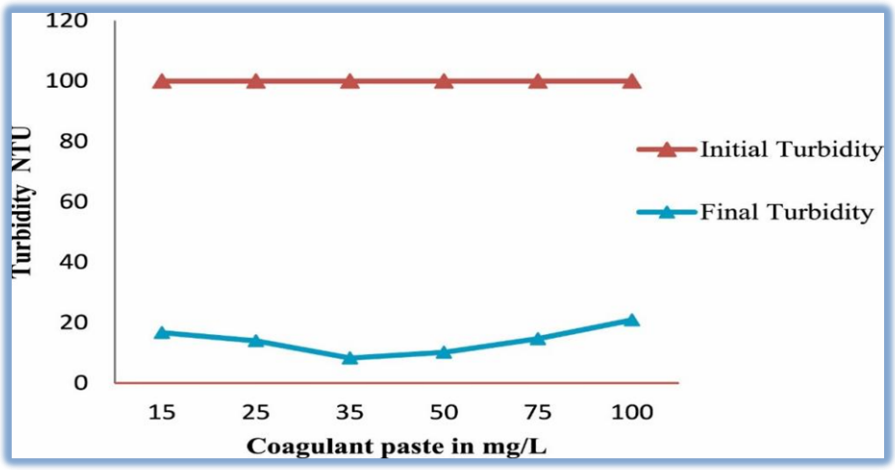

Fig 6: Turbidity removal Effect of Moringa Oleifera seed (MOs) coagulant.

Table 3: Effect of pH on effective Moringa Oleifera seed (MOs) dose:

Sl no	Coagulant Dosage in mg/L	Dosage of MOs in mg/L.	pH after adding MOs
1	15	15	6
2	25	25	6.5
3	35	35	7
4	50	50	7.5
5	75	75	8
6	100	100	8.5

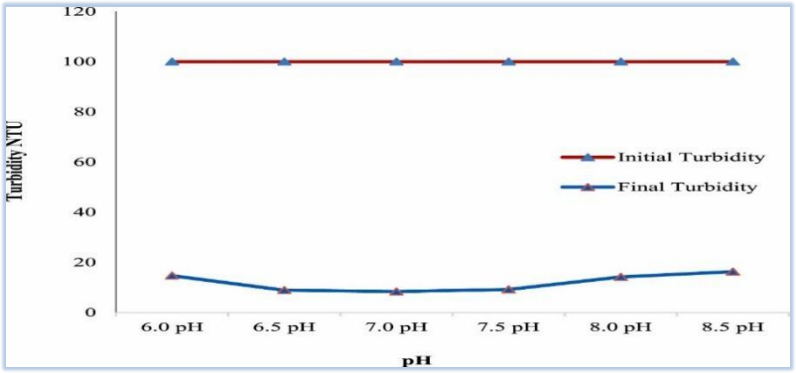

Fig 7: Effect of pH on effective Moringa Oleifera seed (MOs) dose.

The observed result shows that pH increase with increasing concentrations of the Moringa Oleifera seed coagulant. This suggests that in water, the basic amino acids present in the protein of Moringa Oleifera seed would accept a proton from water resulting in the release of a hydroxyl group making the solution basic.

Results obtained after treating Raw water with Bitter Gourd (Momordica charantia) Seed Powder:

Bitter gourd is an often-discarded vegetable, due to its bitter taste even though it is a source of several key nutrients. Sample collected from local reservoir was sampled in the laboratory in separate jars and mixed with Bitter Gourd seed powder in different proportions and kept under for observation. Vitamin C is one of the abundant compounds in the plant (Goo et al. 2016). Bitter gourd is one of the few edible fruit which contains conjugated α linolenic acid in its seeds. The presence of a long chain PUFA, α eleostearic acid has been reported in bitter gourd seed oil (Yoshime et al. 2016). They are one of the naturally best sources of chromium (5.65 mg / 100 g) and zinc (45.45 mg / 100 g) (Saeed et al. 2018).

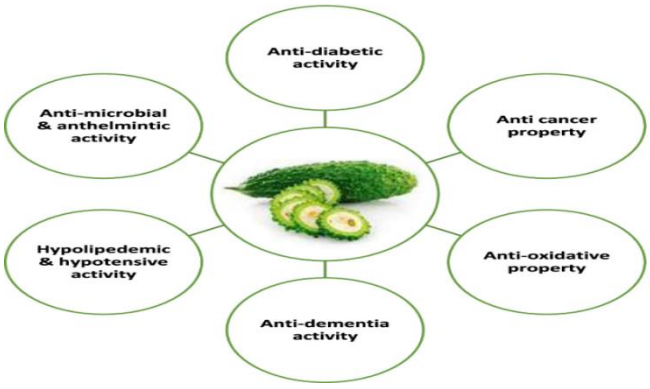

Fig 8: Nutraceutical properties of M. charantia

Table 4 : Turbidity Removal

Sl no	Coagulant Dosage in g/L (M. charantia)	Turbidity in NTU Before adding (M. charantia)	Turbidity in NTU After adding (M. charantia)
1	0.4	100	12.8
2	0.8	100	11.5
3	1.2	100	9.8
4	1.6	100	7
5	2.0	100	5.5
6	2.4	100	4.3

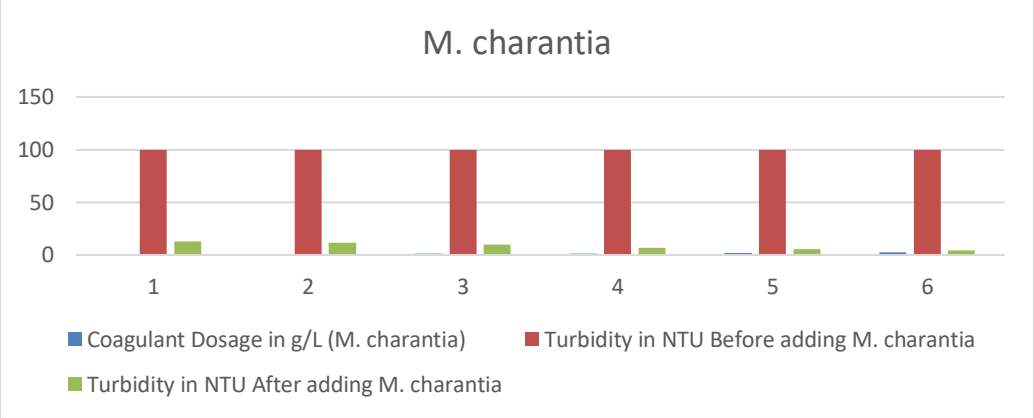

Fig 9: Dosage of M. Charantia effect on Turbidity.

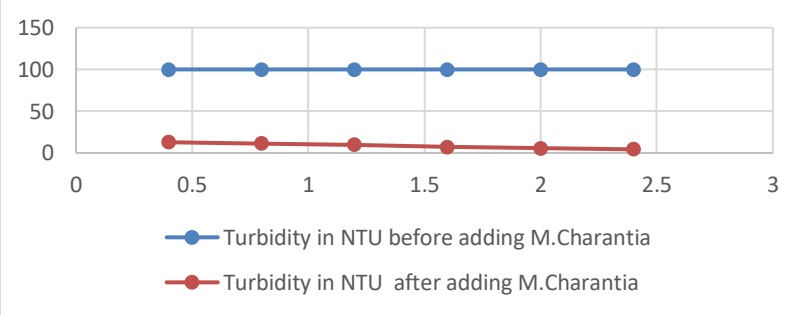

Fig 10: Dosage of M. Charantia effect on Turbidity.

Table5: Effect of pH on effective M. Charantia dose

Sl no	M.Charantia Dosage in g/L	pH after treating with M.Charantia.
1	0.4	10
2	0.8	8
3	1.2	8.3
4	1.6	7.6
5	2.0	6
6	2.4	5.8

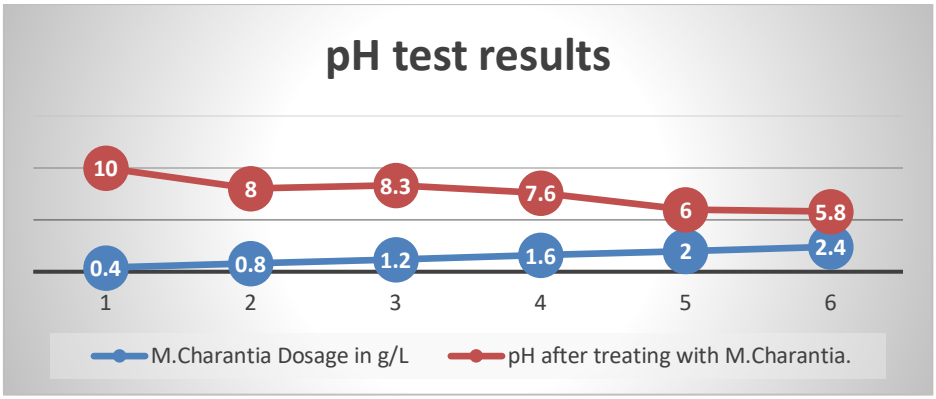

Fig 11: pH values of samples in different jars with dosage of Bitter Gourd seed powder.

Upon treatment with Bitter gourd seed powder, the optimum coagulant dosage was obtained at 1.6 g/l for polluted groundwater. Turbidity reduction was 76% and the optimum pH range can be found to be between 7.5-8.\

Results obtained after treating Raw water with Hibiscus seed Powder:

Fresh seed of Hibiscus rosa-sinensis were collected and washed with distilled water to remove dust and other impurities. Then these were dried in the presence of sunlight.

The dry seeds were weighed and grinded to get the pure Hibiscus seed powder. The grinding procedure was continued for further 15 minutes. The prepared powder is used for the coagulation experiments.

Freshly prepared HSE were used for all coagulation experiments.

Table 6: Effect of pH on Hibiscus seed powder dose

Sl no	Hibiscus seed powder Dosage in mg/L	pH before Treating with Hibiscus seed powder.	pH after Treating with Hibiscus seed powder.
1	50	9.1	8
2	100	9.1	8.4
3	150	8.6	8.2
4	200	8.8	8

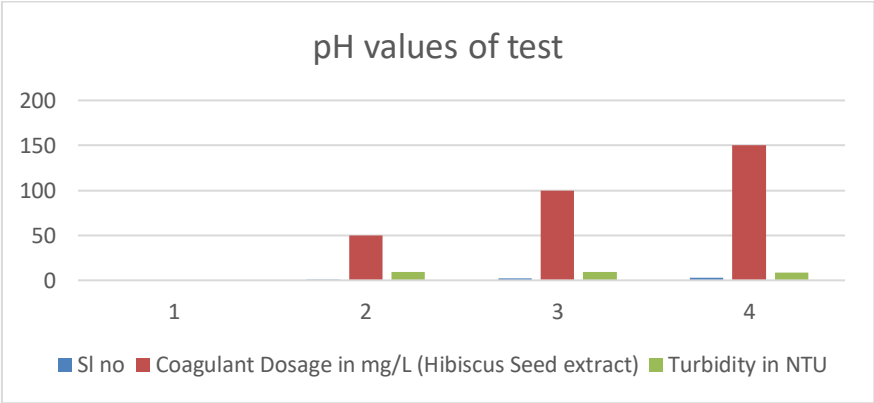

Fig 12: Change of pH with different dosage of Hibiscus seed powder.

Table 7: Turbidity Removal by Hibiscus seed powder

Sl no	Coagulant Dosage in mg/L (Hibiscus Seed extract)	Turbidity in NTU Before adding Hibiscus extract.	Turbidity in NTU After adding Hibiscus extract
1	50	670	**570**
2	100	660	600
3	150	690	610
4	200	670	630

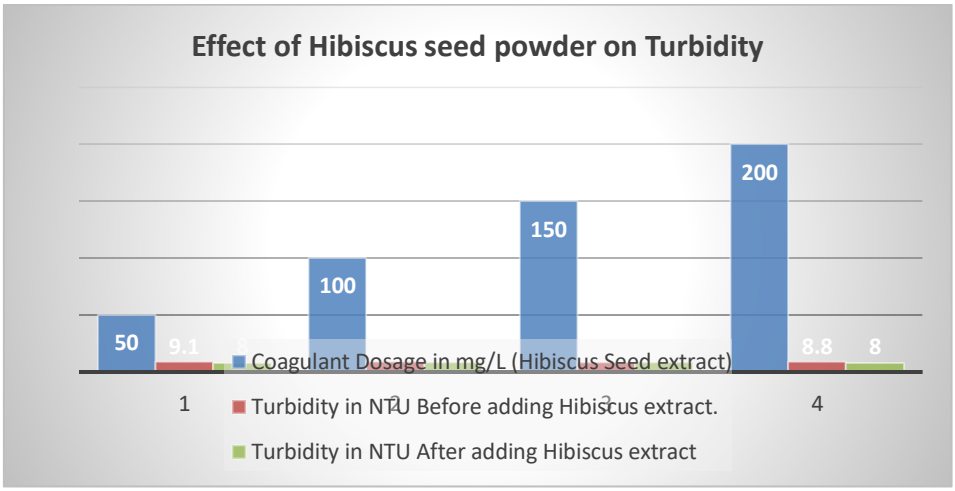

Figure 13: Effect of Hibiscus seed powder on Turbidity

Conclusion:

the Way for Sustainable Water Treatment the exploration of Moringa leaf and seed, jackfruit peel, bitter gourd seed, and hibiscus seed as bio-coagulants represents a significant stride towards sustainable water treatment practices. These natural alternatives not only offer effective solutions for reducing turbidity and improving water clarity but also address issues of waste management and environmental impact associated with traditional coagulants

The use of Moringa oleifera, jackfruit peel, bitter gourd seed, and hibiscus seed as bio-coagulants for water treatment represents a promising and sustainable approach. These natural alternatives have shown efficacy in reducing turbidity and improving water quality in both surface water. Further research and collaborative efforts are essential to refine processes, address challenges, and promote the widespread adoption of bio-coagulants, contributing to a more sustainable and accessible water treatment paradigm.

These are the few findings obtained from the above experiments using different natural coagulants:

1. 35 mg/L dose of Moringa Oleifera seed powder is found to be optimum dose for reducing the turbidity of the raw water to 8 NTU.
2. pH of the raw water sample is also optimized to 7 by using 35 mg/L dose of MO seed powder.
3. Maximum turbidity reduction in case of Momordica charantia seed powder is observed up to 4.3 NTU with 2.4 g/L of dosing.
4. Also, the pH of the raw water sample is also optimized to 7.6 with 1.6 g/L dose of Momordica charantia seed powder.
5. 200 mg/L of Hibiscus seed powder reduces the pH to a maximum of 8.
6. Turbidity is reduced maximum by adding 50 mg/L of Hibiscus seed powder to 570 NTU from 670 NTU.

Future Scope:

- Other bio coagulants may be used for treatment of Surface water may be conducted.
- Other bio coagulants may be used for treatment of Underground water may be conducted.
- Oxide content of various elements may be determined for the treated and untreated water and may be compared.
- Jack fruit Peel powder may be used for treating water in further work.
- Other chemical test may be conducted for determining the pathogenic bacteria and harmful chemicals present in the water after treatment.

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