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To Study the Wastewater Treatment Using Bio Flocculants Okra Gel: Green Chemistry Approach for a Safe Environment

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Abstract
This investigation delves into the substitute for flocculants, also referred to as bio-flocculants, used in wastewater treatment processes. Traditional sludge removal methods involve the use of Polyelectrolyte alongside coagulants like aluminum chloride, ferric chloride, and alum. Our study focuses on evaluating the efficacy of natural versus synthetic flocculants and comparing their outcomes. Parameters such as agitation settings, okra preparation techniques, and the dosage of coagulant/bio-flocculant were analyzed to determine the optimal sludge settling conditions. Utilizing quantities of 10, 15, and 20 ml for okra gel and alum respectively, we identified the most effective dosage. Plant-based flocculants emerge as superior substitutes compared to synthetic polymers due to their high efficiency and easy availability. Graphical performance analysis illustrates that okra gel can serve as a viable alternative to chemical polyelectrolytes as a flocculant. Our findings highlight the role of hydroxyl groups in okra gel, which act as active sites for removing colloidal particles during the treatment process.

Keywords: Sludge Reduction, Bio- Flocculants, Wastewater Treatment, Flocculant Substitutes and Sustainability

Introduction
Pollution has become a pressing issue due to industrial development and human activities in both industrialized and developing nations. The discharge of large volumes of dissolved solids, organic and inorganic particles, heavy metals, dyes, and other toxins into water bodies poses significant threats to human health and aquatic life. As a result, effective water treatment methods are essential before the safe discharge of effluents into rivers and oceans can be ensured.

The emergence of eco-friendly bio-flocculants in wastewater treatment has become crucial, driven by concerns over the environmental and health impacts of chemical flocculants. Recent advancements in plant-derived coagulants/flocculants and bio-flocculants have shown promising progress in addressing these challenges. These bio-flocculants, derived from natural sources such as plants, offer advantages such as biodegradability, non-toxicity, and cost-effectiveness, making them attractive alternatives to traditional chemical flocculants [1]. While conventional water treatment processes often rely on chemical polymers like poly-aluminum chloride and aluminum sulfate, these substances pose risks to human health. Therefore, there is a growing need for substitutes that are both effective and environmentally friendly. Plant-based bio-flocculants, such as okra gel, offer a viable solution due to their availability, non-toxic nature, and biodegradability [2].

Despite the progress in bio-flocculant research, several key challenges remain. These include optimizing the efficiency of bio-flocculants compared to synthetic polymers, ensuring scalability for industrial applications, and conducting comprehensive assessments of their long-term effectiveness and environmental impact. Addressing these challenges is critical to fully realize the potential of bio-flocculants in revolutionizing wastewater treatment processes.

In this study, our primary objective is to contribute to the ongoing progress in bio-flocculants and address key challenges by focusing on the development and evaluation of a novel bio-flocculant derived from okra gel. By examining its efficiency, scalability, and environmental impact, we aim to highlight the novelty and potential of this bio-flocculant as a sustainable alternative in wastewater treatment.

Materials and Methods

Materials

- Effluent Sample: Obtained from chemical Industry.
- Coagulants/Flocculants
- Okra Gel
- Alum (aluminum sulfate)
- Equipment
- Magnetic stirrer
- Distilled water
- Weighing scale
- Graduated cylinders
- Jar test apparatus
- Centrifuge

Experimental Procedure

➢ **Effluent Analysis**

- Conducted initial analysis for parameters including pH, turbidity, total hardness, TDS, TSS, chemical oxygen demand, ammonical nitrogen, odor, and conductivity.

➢ **Dosing Solution Preparation**

- **Alum Solution:** Dissolved 1.25g of alum in 125ml of distilled water to make a 10% solution.
- **Okra Gel Solution:** Dissolved 10ml of okra gel in 1000ml of distilled water to make a 0.1% solution.

➢ **Jar Test Experiment**

- Set the RPM at 150 for alum solution and 100 for okra gel solution.
- Observed physical settling of generated sludge and floc formation using the magnetic stirrer.

➢ **Evaluation of Optimal Dosages**

- Tested different percentages of coagulant and flocculant solutions to determine optimal dosages for efficient sludge settling.

➢ **Data Collection and Analysis**

- Recorded observations of floc generation and sludge settling during treatment.
- Analyzed data using graphical methods to compare the performance of synthetic polymers vs. plant-based flocculants.

Take 1kg of dry okra using weight machine. Now take 1000ml of distilled water by using measuring cylinder and mix them manually now stands for 24 hours. Heat the water with Okra for 30minutes. then do the filtration process. After the filter them by using laboratory filter paper extraction is ready for use.

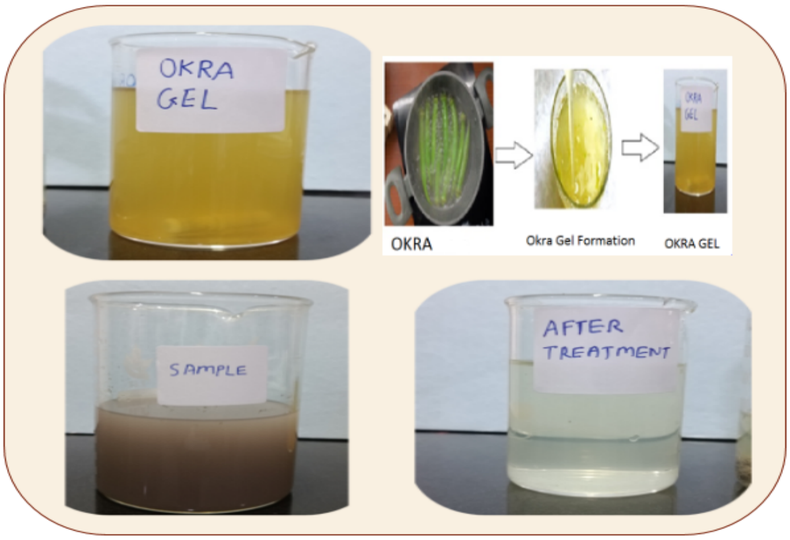


Figure 1: Preparation of Okra gel

Experimental Investigation

Plant-Based Bio-Flocculants vs. Synthetic Polymers in Wastewater Treatment. The method for extracting okra gel bio-flocculant was adapted from Lee Chai Siah et al. [3]. Experimental setup followed standard protocols as described by Bolto et al.

For the treatment of industrial effluent, we collected samples from a chemical industry. Before treating the water samples, their initial parameters were checked, especially pH, turbidity, total hardness, TDS, TSS, chemical oxygen demand, ammonical nitrogen, odor, and conductivity.

After the initial analysis of the effluent, we prepared dosing solutions for the experimental work. For this experiment, we used a magnetic stirrer and observed the physical settling of generated sludge as well as flocs generation at different percentages of coagulant and flocculant solutions. Since the pH did not change during flocculation, no pH control was used. We used alum as the coagulant for flocs generation and Okra gel as a flocculant. As shown in the figure below, we observed flocs generation and sludge settling in the treatment.

To prepare the dosing solutions, we took 1.25g of alum and dissolved it in 125ml of distilled water to make a 10% solution. For Okra gel, we used 10ml and dissolved it in 1000ml of water to make a 0.1% solution. The RPM was set at 150 and 100 for the magnetic stirrer and alum solution, respectively. Below are the physical observations of the effluent we observed while mixing using the magnetic stirrer.

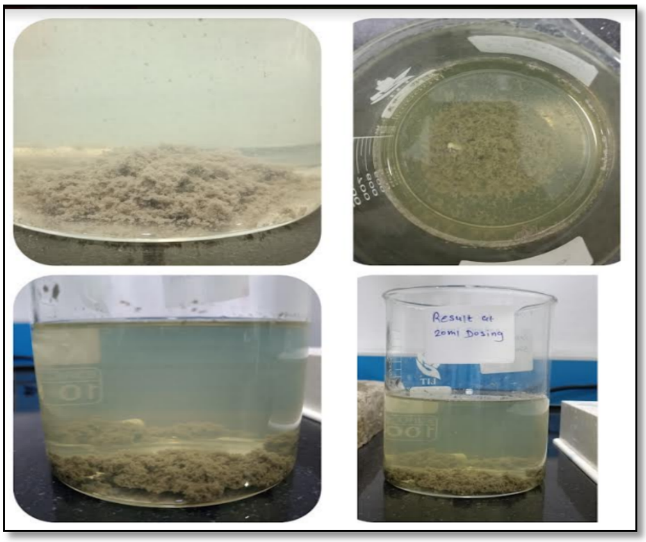


Figure 2: Sludge generation (Mehul Rana et al. Match 2024)

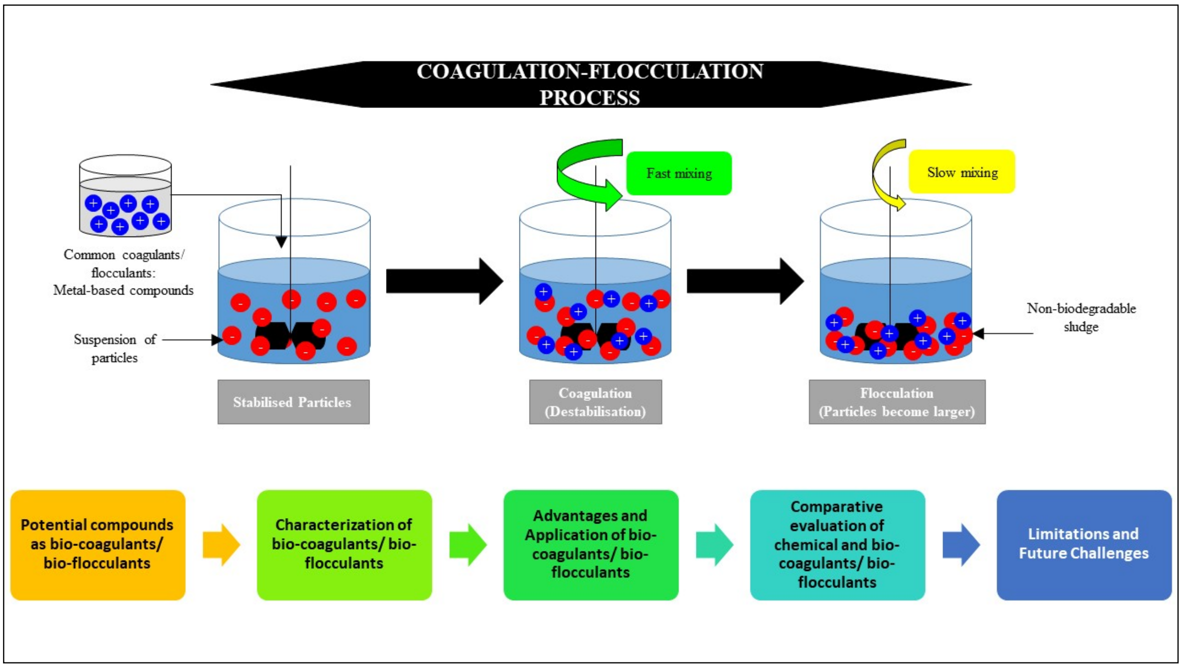


Figure 3: Material & Methodology

Result & Discussion

To treat 500ml of effluent, we used 15ml of Okra gel with 10ml of alum solution, as shown in the figure below. We observed that Okra gel gave excellent results when combined with alum. It was determined that these dosages would be applied to the primary experimental work mentioned above.

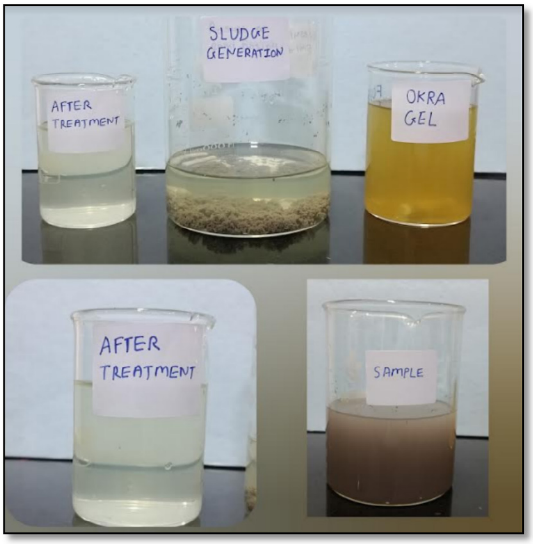


Figure 4: Result After Treatment (okra gel:20ml, Alum:15ml)

Characterization of Industrial Effluent

For treating the wastewater of primary treatment, effluent is collected and all initial parameters are measured in laboratory. As shown in below table all parameters are analyzed.

Sr. No.	Parameters	Characteristics of water sample before Treatment
1	TSS(mg/l)	209
2	PH	7.11
3	Total dissolved solids(mg/l)	725
4	Temperature(C0)	28.9
5	Chemical oxygen demand(mg/l)	1160
6	NH3-N(mg/l)	39
7	Turbidity(NTU)	22.0
8	Odour	30
9	Conductivity	625

Table 1: Effluent Characteristics Parameters

Treating the effluent with 10% alum and 0.1% polyelectrolytes following results reget as shown in table 3. The RPM is set at 500 for 30 minutes and consumption of polyelectrolyte is 18ml for treatment of 500 ml.

Sr.No	1
Weight of poly(gm)	0.25
% Solution	1%
RPM	500
Dosing(ppm)	15
Consumption(ml)	18
pH	6.9
TSS(ppm)	43
TDS(ppm)	590
Temperature©	26.2
COD(ppm)	744
Turbidity(NTU)	18
Ammonical Nitrogen(ppm)	33
Conductivity(PPM)	625

Table 2: Traditional Polyelectrolyte Chemical Treatment Result

Sludge Removal Performance Stage

To identify the sludge removal efficiency the alum is added with okra gel at 10% solution. as shown in table 4 and table 5 the different RPM is set and the different consumption based on settling strength of dosage required.

Sr.No	**1**	**2**	**3**
Weight of alum(gm)	1.25	1.25	1.25
% Solution	10%	10%	10%
RPM	500	500	500
Dosing(PPM)	150	100	200
Consumption(ml)	5	10	15

Table 3: Alum Dosage

Okra gel results when used in coagulation-flocculation process at different doses and different settling time 10,15,20 minutes respectively in below result:

Sr. No	**1**	**2**	**3**
Weight of gel(ml)	1000	1000	1000
% Solution	0.1	0.1	0.1
RPM	200	180	150
Dosing(PPM)	100	150	200
Consumption	10	15	20
pH	6.91	6.86	6.95
TSS(mg/l)	66	49	18
TDS(mg/l)	622	582	403
Temperature©	25.7	25.1	24.5
COD(mg/l)	623	582	403
NH3-N(mg/l)	29	27.3	22
Conductivity	625	422	181
Turbidity(NTU)	11.1	9.2	1.1
Sedimentation time (min)	10	15	20

Table 4: Okra Gel Consumption and Result

Alum Dosing Consumption

- The first set of experiments used 1.25 grams of alum at a 10% solution, with an RPM of 500 and a dosing of 150 PPM, resulting in a consumption of 15 milliliters.
- The second set of experiments also used 1.25 grams of alum at a 10% solution, with an RPM of 500 and a dosing of 100 PPM, resulting in a consumption of 10 milliliters.
- The third set of experiments employed 1.25 grams of alum at a 10% solution, with an RPM of 500 and a dosing of 200 PPM, resulting in a consumption of 20 milliliters.

Treated Water Sample Parameters

Okra gel results when used in coagulation-flocculation process at different doses and different sedimentation time 10,20,30 minutes respectively in below result.

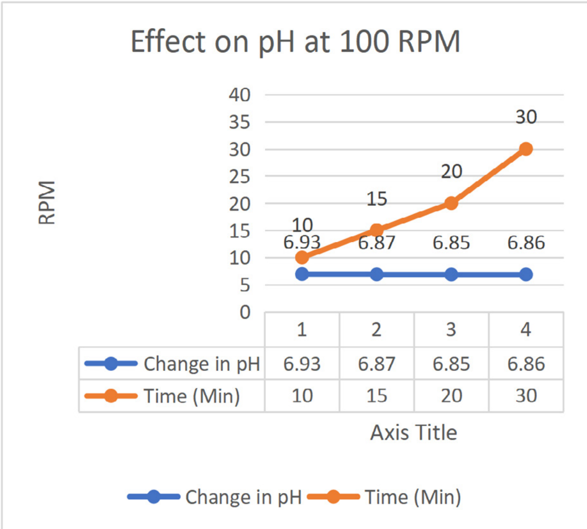
Sr. No	**1**	**2**	**3**
Weight of gel(ml)	1000	1000	1000
% Solution	0.1	0.1	0.1
RPM	200	180	150
Dosing(PPM)	100	150	200
Consumption	10	15	20
pH	6.91	6.86	6.87
TSS(mg/l)	66	49	18
TDS(mg/l)	622	582	403
Temperature©	25.7	25.1	24.5
COD(mg/l)	623	582	403
NH3-N(mg/l)	29	27.3	22

Conductivity	625	422	181
Sedimentation time (min)	10	20	30
Turbidity(NTU)	22.3	1.6	1.19

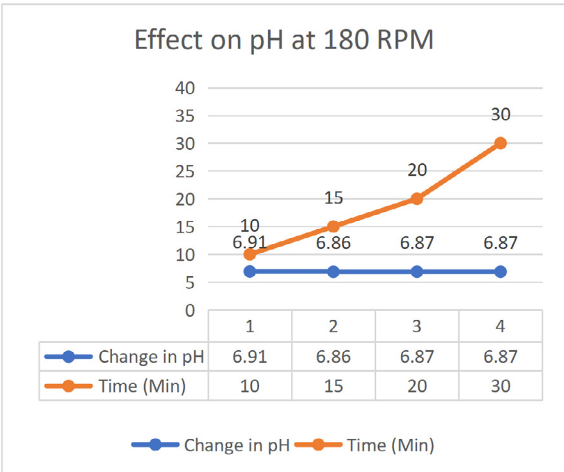
Table 5: Okra Gel Consumption and Results

Effect of pH at Different RPM

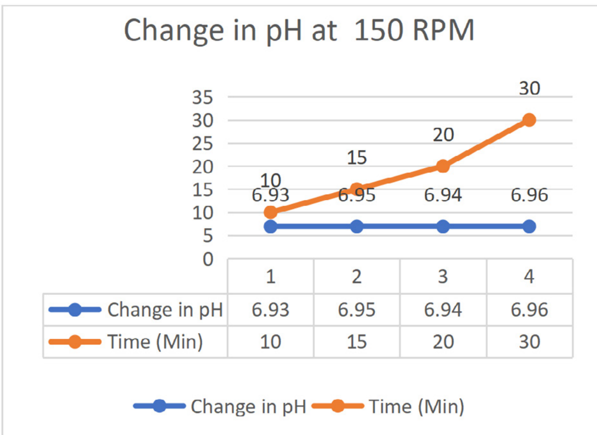
The statement suggests that the graph illustrates how increasing the RPM (rotations per minute) from 100 to 150 has a minimal effect on pH, but beyond 150 RPM, there's little to no further change in pH. This implies that the pH is relatively stable within the range of 100 to 150 RPM, but any increase beyond 150 RPM doesn't significantly impact pH levels.



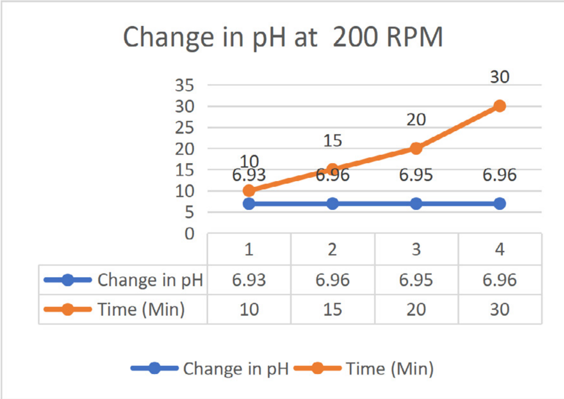
Graph 1: Change in pH at 100 RPM



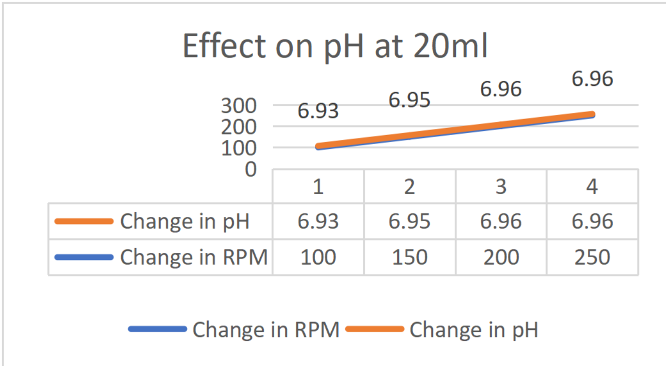
Graph 2: Change in pH at 180 RPM



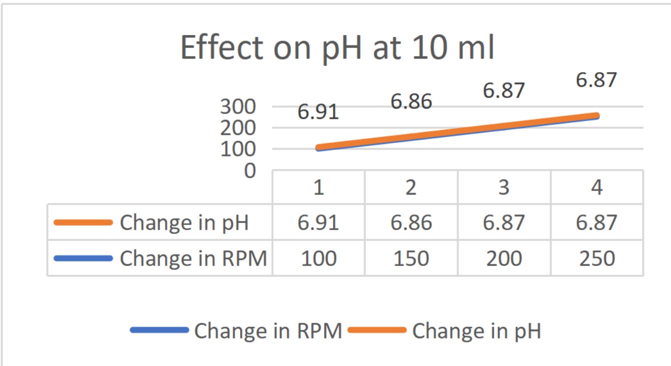
Graph 3: Change in pH at 150 RPM



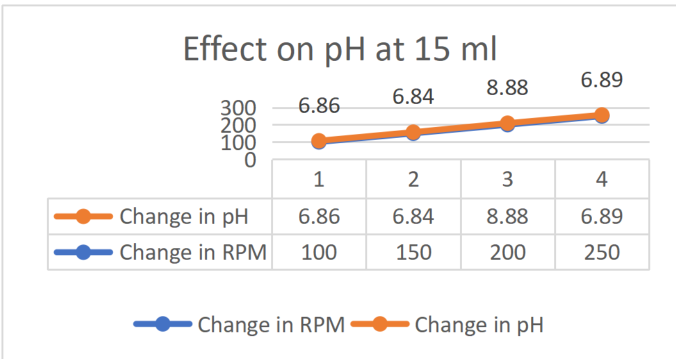
Graph 4: Change in pH at 200 RPM



Graph 5: Change in pH at 15 ml

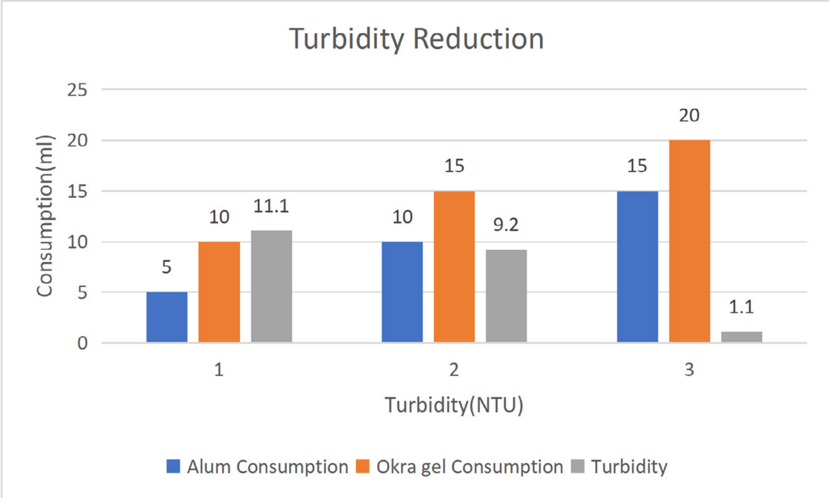


Graph 6: Change in pH at 10 ml



Graph 7: Change in pH at 15 ml

From the graph it shows clearly that turbidity is reduce while we add dose of alum 15mg/l and okra gel 20mg/l.

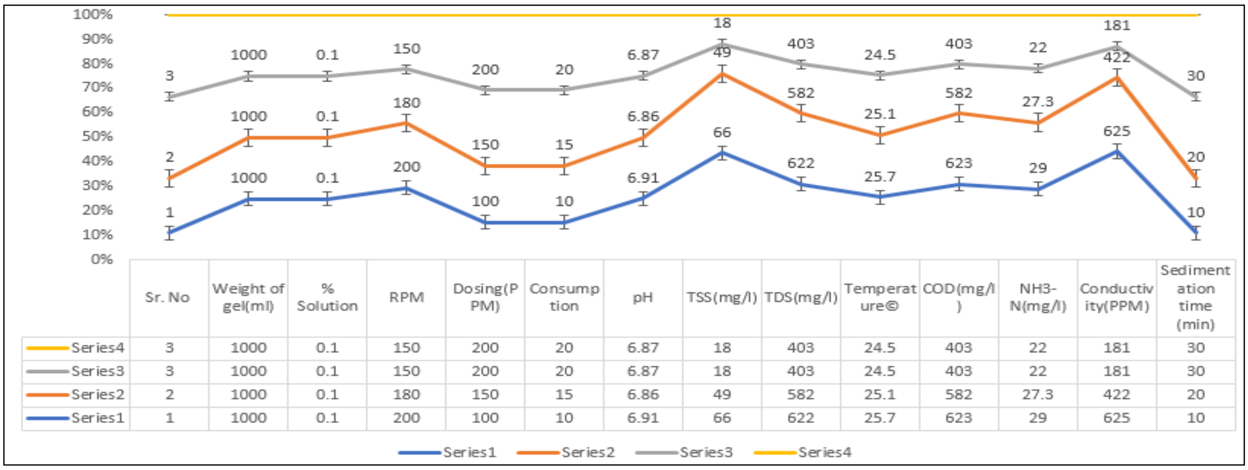


Graph 8: Turbidity Reduction

Comparison of Cost of Synthetic Poly Electrolyte Vs Bio-Flocculant

Compared to synthetic polymers, plant-based flocculants are the best substitute due to their high efficiency of performance and easy availability. Plant-based Okra gel bio-flocculants have an efficiency of settling more than 80% of colloidal solids in primary treatment. They also lead to a decrease in sludge reduction of up to 90%, as we have observed in the results and conditions mentioned above.

Graph show the comparison results between synthetic polymers vs plant-based flocculants.



	Sr. No	Weight of gel(ml)	% Solution	RPM	Dosing(PPM)	Consumption	pH	TSS(mg/l)	TDS(mg/l)	Temperature©	COD(mg/l)	NH3-N(mg/l)	Conductivity(PPM)	Sedimentation time (min)
Series4	3	1000	0.1	150	200	20	6.87	18	403	24.5	403	22	181	30
Series3	3	1000	0.1	150	200	20	6.87	18	403	24.5	403	22	181	30
Series2	2	1000	0.1	180	150	15	6.86	49	582	25.1	582	27.3	422	20
Series1	1	1000	0.1	200	100	10	6.91	66	622	25.7	623	29	625	10

Graph 9: Comparison of Cost of Synthetic Poly Electrolyte vs Bio-Flocculant

Okra gel exhibited superior flocculation behavior compared to commercial flocculants such as polyelectrolyte (cationic) flocculant. When used in biologically treated wastewater, Okra at smaller dosages produced greater turbidity reductions (80% to 90%). Okra presents a potentially significant alternative for the flocculation of portable water and effluent treatment due to its performance and biodegradability. The aforementioned findings demonstrate that natural flocculants can efficiently treat wastewater and water. The sludge generation is 30% higher than with synthetic polyelectrolyte. According to the experimental study, we found that sludge dewatering obtained 1.2MT per 10 KL of sludge, whereas with polyelectrolyte, it was observed at 900kg per 10 KL of effluent.

The sludge is disposed of in a secure landfill according to standard storage and transportation practices. The overall cost of disposing of the sludge is the same compared to other flocculants used. However, the sludge generation capacity is relatively higher than with other chemicals [4-15]. Therefore, by using Okra gel, we can generate more sludge from primary waste sludge.

Conclusion

According to the results of the experiment, we have found that Okra gel has good potential to function as a natural polymer in the primary coagulation-flocculation process. Due to their high viscosity, these biopolymers appear to be suitable for replacing chemical polymers in effluent treatment. At a dose of 15ml of alum, Okra gel produces a highly efficient effect. The study indicates that the application of bioflocculants meets all water quality standards as defined by the pollution control board. For the applicability of this bioflocculant, appropriate pilot studies are required to ensure its performance, identify the actual cost of treatment, and assess the long-term applicability of the plant. The future scope of study includes exploring the physical form of Okra gel as a powder for further research work. The cost of synthetic polymer is approximately 450 Rs/kg, while the cost of Okra is maximum 20 to 30 Rs/kg. Therefore, based on this experimental work, the future research focus will be on determining the actual quantity of Okra powder required to achieve efficient industrial purposes. Characteristics of the effluent suggest that a site-specific test is advised to check long-term applicability and determine the real cost of the process [16-23]. Conducting a site-specific test based on effluent characteristics is recommended to ascertain the true cost of the procedure and ensure its long-term application.

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