JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Marang (Artocarpus odoratissimus) Seeds As Biocoagulant For Drinking Water Treatment

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CHAPTER I
INTRODUCTION

1.1 Background of the Study

Water is one of the main sources to sustain life. It is very important for preserving life (Ozalemdar, 2019). As of 2015, around 87.7% of the total population had access to a secure water supply, indicating that 12.3% of the populace, equivalent to 12.40 million people, did not have access to safe water (NEDA, 2021). Efficiently managing water resources and ensuring access to safe water and sanitation are crucial for fostering economic growth and productivity. Additionally, they offer substantial support to ongoing investments in health and education. The environment, including forests, soils, and wetlands, plays a vital role in overseeing water availability and quality. This enhances watershed resilience and supplements investments in physical infrastructure, as well as institutional and regulatory frameworks for water access, utilization, and disaster readiness (UNEP, 2017).

Certain communities rely on surface water as their primary drinking water source, commonly drawn from creeks, rivers, and lakes. Obtaining drinking water from surface water sources is generally more accessible compared to groundwater sources. For example, the process of gathering water from a flowing river includes positioning a screened diversion pipe that faces upstream in the river. When the water moves downstream, it goes through the screen, enters the pipe, and proceeds towards a collection pond or basin. Likewise, communities have the option of extracting water from a lake by utilizing a screened intake pipe, pumping the water from the lake to a designated collection basin (Vigil, 2003).

Coagulation is a method aimed at uniting tiny particles into more substantial aggregates known as flocs.

Simultaneously, it involves the adsorption of dissolved organic matter onto these particle aggregates, facilitating the subsequent removal of these impurities through solid/liquid separation processes (Jiang, 2015). Major disadvantages of the chemical coagulants are the operational costs, pose threat to the environment, a substantial quantity of residual sludge is generated towards the conclusion of the procedure, and have severe effect on human health. One promising solution is the use of biocoagulants, which are natural, biodegradable, and safe for human health as an alternative to chemical coagulants.

In recent years, numerous research efforts have been undertaken to discover sustainable and eco-friendly biocoagulants as substitutes for inorganic and synthetic counterparts in drinking water treatment. Even though these coagulants demonstrate effective performance and cost efficiency, it is essential to make pH and alkalinity adjustments, result in the production of significant sludge volumes, and leave residuals like aluminum in treated water. These residuals have been associated with neurodegenerative conditions such as Alzheimer's, along with neurotoxic and carcinogenic effects (V. Rondeuet et al., 2002). Furthermore, aluminum, being non-biodegradable, can pose environmental challenges during the processing and disposal of the produced sludge. Hence, materials of natural origin are utilized for water clarification, particularly in treating waters with high turbidity levels (>100 NTU).

The use of chemical coagulants and flocculants carries the risk of environmental contamination and health issues, which can be mitigated by opting for biocoagulants as a viable alternative. Biocoagulants, being entirely organic and biodegradable, are derived from living organisms or their components, presenting minimal to no adverse effects on human health and the environment. Before incorporation into treatment processes, extensive research has been conducted on biocoagulants, demonstrating their efficacy as substitutes for the currently prevalent chemical coagulants. Some biocoagulants sourced from diverse origins have already undergone examination, confirming their effectiveness in treatment procedures.

This research investigates the effectiveness of powdered marang seeds as biocoagulant in the treatment of water particularly from Tumaga River located in Barangay Tumaga, Zamboanga City.

1.2 Statement of the Problem

In the context of water treatment facilities, there is a pressing challenge regarding the escalating costs associated with the procurement and utilization of chemical coagulants. This challenge is worsened by the increasing need for freshwater, more stringent environmental regulations, and the imperative for adopting sustainable approaches. Finding innovative solutions to reduce chemical usage while maintaining or improving water quality is imperative to ensure cost-effectiveness and environmental sustainability in water treatment operations.

In this context, undertaking this study involves exploring alternatives derived from marang seeds for water treatment. Currently, there is a lack of existing data on experiments or research involving the use of powdered marang seeds specifically for drinking water treatment in the City of Zamboanga. Concentrating efforts on this treatment method could bring about positive impacts and contribute significant value to the community.

1.3 Objective of the Study

This study aims:

1. To assess the efficiency of powdered marang seeds as a biocoagulant for purifying drinking water.
2. To assess the pH, turbidity, and total dissolved solids (TDS) of the samples, different concentrations (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L) of marang biocoagulants with aluminum sulfate serving as the control.
3. To compare the effectiveness of powdered marang seeds in enhancing water quality over alum.

1.4 Significance of the Study

The study holds significant promise for several compelling reasons. It examines the viability of marang seeds as a sustainable, affordable, and environmentally friendly alternative for chemical coagulants, providing a direction towards water treatment solutions that are more environmentally conscious. By directly addressing the specific water treatment challenges faced by Zamboanga City, this contributes significantly to the local community's essential need for access to safe drinking water. It resonates with global sustainability objectives by reducing reliance on chemical coagulants in water treatment processes, aligning with the urgent need for environmentally responsible practices. Ultimately, it aspires to shed light on the dosage requirements and potential advantages of harnessing marang seeds as a biocoagulant, providing valuable insights that can shape the future of water treatment practices.

1.5 Scope and Limitation

This study primarily focuses on assessing marang seeds as a potential substitute coagulant for the treatment of drinking water. The central aim is to evaluate the effectiveness of marang seeds in achieving the specified physical and chemical water quality standards outlined in Table B-1 of the 2017, Philippine National Standards for Drinking Water (PNSDW). The parameters for this study are pH, turbidity, and total dissolved solids (TDS). This comprehensive study is focused on the Tumaga River situated in Barangay Tumaga, Zamboanga City, serving as the designated area of analysis.

CHAPTER III
METHODOLOGY

3.1 Data Gathering

The secondary data and information for this research were compiled through an extensive review of literature from diverse sources, encompassing multiple libraries and offices. This encompassed pertinent government publications like DOH Administrative Order No. 2017-0010, along with academic and scientific literature considered essential for the successful culmination of this study.

3.2 Research Locale

The test for the parameters was conducted at the Zamboanga City Water District laboratory.

3.3 Preparation of Materials

To carry out this study, various materials, tools, and equipment were bought from different establishments in Zamboanga City. The specific materials, tools, and equipment needed for this study are outlined in Table 3.1

Table 3.1
Materials, Tools, and Equipment

Quantity	Product
6 pcs	Marang Fruit
1 pc	Mortar and Pestle
14 pcs	Clear/Glass Bottles
1 pc	Sieve Size 1 mm
1 pc	Weighing Scale
73 pcs	1 Liter Plastic Bottles

3.4 Powdered Preparation

To conduct the experiment for the development of marang as a biocoagulant, six (6) pieces of marang fruit were obtained from a fruit stall in Magay, Zamboanga City. The marang pulp was carefully removed from the seeds, and the seeds were weighed. The seeds have been air-dried for three days, with an average of two (2) to four (4) hours of drying per day. The air-dried seeds were pulverized using a mortar and pestle tool to obtain a consistent powder. The powdered seeds were kept in an airtight container to inhibit moisture ingress and maintain their effectiveness until the experiment was conducted.

3.5 Collection of Water Samples

The raw water samples for this study were collected from the Tumaga River, in Barangay Tumaga, Zamboanga City, as it was more convenient and practical. The study utilized synthetic raw water samples, each comprising one liter with 1 gram of soil from the same river, with a total of seventy-three (73) bottles collected from the Tumaga River. I utilized a synthetic raw water sample because the Tumaga River met the study's parameters. Therefore, I need a raw water sample that does not meet the parameters standards. After the collection, the collected water samples were transported to the laboratory of Zamboanga City Water District for analysis of initial parameters and the rest were used for treated and controlled water samples.

3.6 Jar Testing

Jar testing was conducted using the jar test apparatus in the laboratory of Zamboanga City Water District with six (6) clean beakers for six dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L) repeated for total of six (6) trials. Each beaker was filled with one liter of the synthetic raw water sample and added with the coagulant of different dosages. Powdered marang seeds and aluminum sulfate are utilized as coagulants, with varying dosages (50 mg/L, 100 mg/L, 200 mg/L, 250 mg/L and 300 mg/L) for both treatment and control.

A high precision weighing scale was used to ensure the accuracy of the weight of the samples. The samples were stirred at approximately 100 rpm for five (5) minutes, and then stirred at 40 rpm for twenty (20) minutes using the jar test apparatus. Following the mixing process, the sample undergone a one-hour (1) settling period. The water subjected to treatment was separated from the flocs through the decanting process and transferred into a new, uncontaminated glass container.

The dosage is aimed at determining the optimum level at which powdered marang seeds show maximum effectiveness. The objective of the jar test is to assess the efficacy of the biocoagulants in eliminating turbidity and color from the drinking water samples. The results of the jar test will provide valuable information on the potential use of these biocoagulants in drinking water treatment.

3.7 Laboratory Analysis

The seventy-three (73) liters of synthetic raw water samples were brought to the laboratory of Zamboanga City Water District in an ice-cooled container for subsequent laboratory analysis. To determine the initial concentration of pH, Turbidity, and TDS of the raw water samples, one (1) liter was analyzed with the use of turbidimeter and multimeter device.

On the other hand, seventy-two (72) coagulated water samples (aluminum sulfate and marang biocoagulant with varying dosages) were also analyzed to determine the concentrations of pH, turbidity, and total dissolved solids

(TDS). The purpose of these samples is to determine the effectiveness of the biocoagulants in removing turbidity and color of the water samples.

3.8 Data Analysis and Interpretation

The analysis and interpretation of laboratory results for synthetic raw water involved comparing control samples treated with aluminum sulfate to the treated concentration marang biocoagulant. The results from all the trials were put together and analyzed to find the optimum dosage based on the conducted experiment. By means determination, the most effective dosage was determined. Doing this helps smooth out any differences between the trials and gives us a reliable result. Then, factors such as efficacy, safety, and practicality were considered to determine the recommended dosage. Graphs and tables were employed to evaluate the efficiency of aluminum sulfate and marang seed biocoagulant removal. Welch T-test was utilized to identify significant differences between the two treatments at a 5% significance level. Additionally, interpretation of results was guided by the PNSDW 2017.

CHAPTER IV
RESULTS AND DISCUSSION

4.1 Synthetic Raw Water Characteristics

The seventy-three (73) liters of synthetic raw water samples used in this study were collected from the Tumaga River in Tumaga, Zamboanga City. Every one (1) liter bottle of the sample has one (1) gram of soil added from the same river. The collected water samples were put in a basin and mixed together to have an evenly distribution of soil particles. The synthetic raw water samples had a physical appearance that is turbid and brown in color.

Figure 4.1 was the collected synthetic raw water samples in a 1-liter bottles.

Figure 4.1
The Collected Synthetic Raw Water Samples

Table 4.1 in the next page shows the laboratory result in the analysis of synthetic raw water samples before treated.

Table 4.1

Results of Synthetic Raw Water Samples Analysis

Parameters	Test Method	Synthetic Raw Water
pH	HACH Sension 156 Combination	6.90
Turbidity	HACH 2100Q	838 NTU
Total Dissolved Solids	HACH Sension 156 Combination	213 mg/L

4.2 Jar Testing

During the jar testing, six (6) trials of synthetic raw water samples were added with different dosages of 50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, 300 mg/L of aluminum sulfate as control and powdered marang seeds as treatment respectively, to monitor the changes and its quality. The rapid mixing lasts for 5 minutes for immediate dissipation and followed by a slow mixing for 20 minutes to let formation of flocs. After the jar testing, the control and treatment samples were set aside to let it settle for an hour. After setting duration, the suspended particles and flocs became visible and settled at the bottom of the beaker. Upon completion, the parameters were tested right away with the use of turbidimeter and multimeter devices. After testing for the levels and concentrations, the treated synthetic water samples were pipetted and transferred to different labelled glass bottles.

Figure 4.2 in the next page shows that the sludge has settled in the bottom of the beakers after a 1-hour settling period with the use of aluminum sulfate.

Figure 4.2

Settled Sludge (Aluminum Sulfate)

Figure 4.3 shows that the sludge has settled in the bottom of the beakers after a 1-hour settling period with the use of marang biocoagulant.

Figure 4.3

Settled Sludge (Marang Biocoagulant)

4.2.1 Marang Coagulation Observation

Observable changes occurred in the physical appearance before and after the coagulation process at varying dosages. At 50 mg/L, 100 mg/L, 150 mg/L, shows the same results in appearance, the samples gradually became clearer with reduced cloudiness. While at 200 mg/L, 250 mg/L, 300 mg/L, the color lightened but still brown in color and cloudier than the first three dosages. However, the marang biocoagulant didn't fully dissolve in all dosages after jar testing.

The images from figure 4.4 to figure 4.9 show how the samples looked before they were treated. These pictures give a clear idea of what the samples were like initially, before any changes were made to them. They act as a starting point for comparing how the samples appear after they've been treated.

Figure 4.4

Marang Biocoagulant (50 mg/L)

Before the Treatment

Figure 4.5

Marang Biocoagulant (100 mg/L)

Before the Treatment

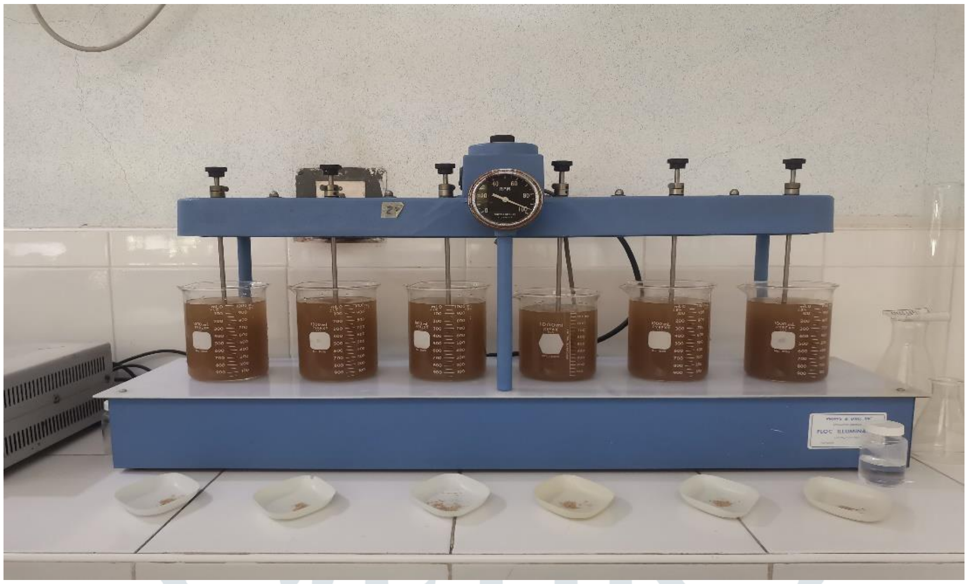


Figure 4.6

Marang Biocoagulant (150 mg/L)

Before the Treatment

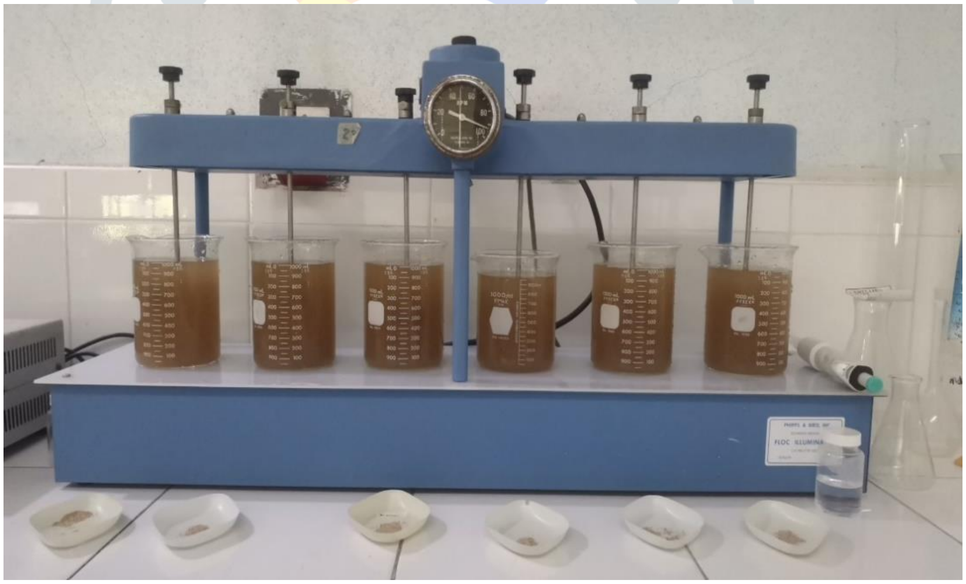
Figure 4.7

Marang Biocoagulant (200 mg/L)

Before the Treatment

Figure 4.8

Marang Biocoagulant (250 mg/L)



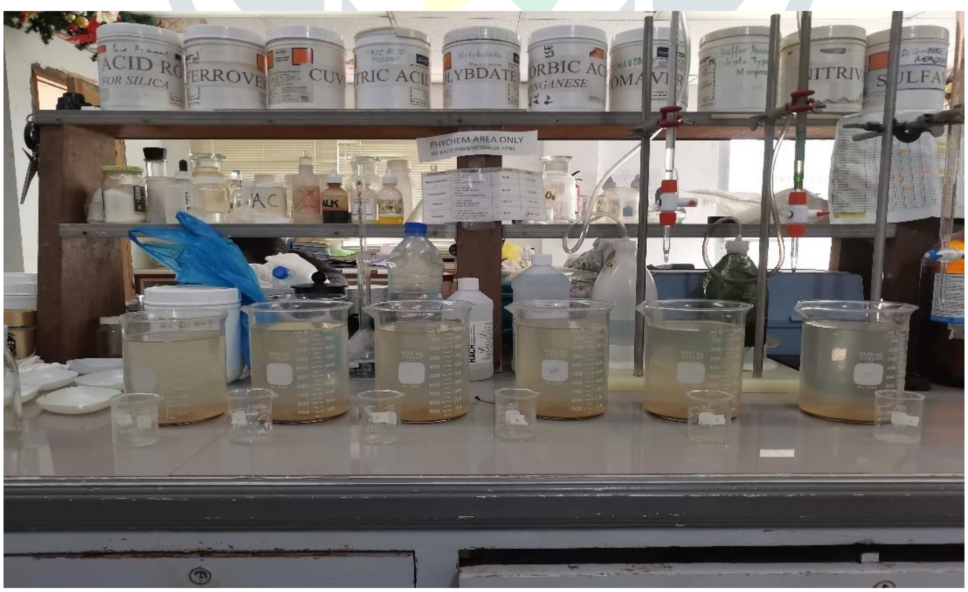
Before the Treatment

Figure 4.9
Marang Biocoagulant (300 mg/L)

Before the Treatment

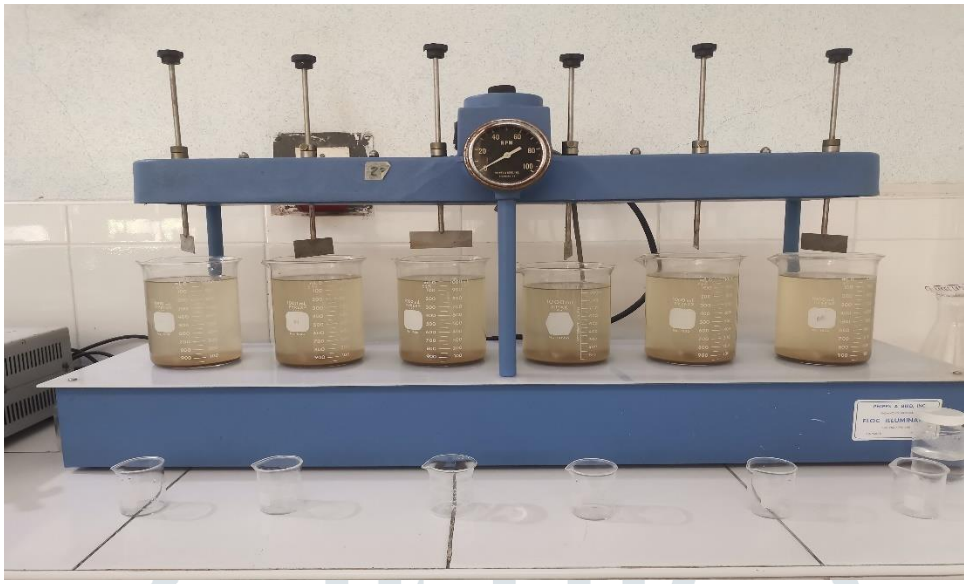
Figures 4.10 through 4.15 show samples treated with doses ranging from 50 mg/L to 300 mg/L with an interval of 50 mg/L. They illustrate the impact of different dosages on the samples.

Figure 4.10
Marang Biocoagulant (50 mg/L)



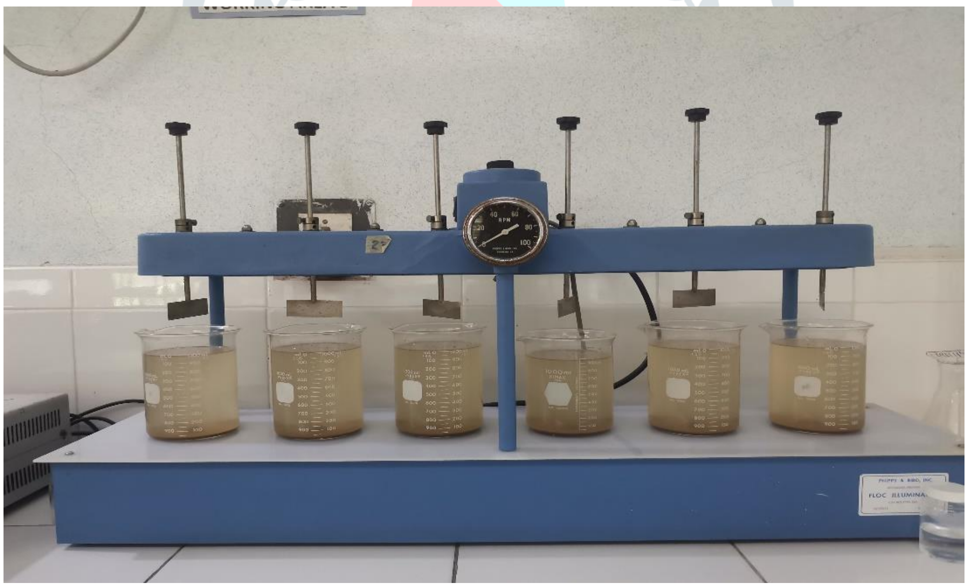
After the Treatment (1 hour Settling Duration)

Figure 4.11
Marang Biocoagulant (100 mg/L)



After the Treatment (1 hour Settling Duration).

Figure 4.12
Marang Biocoagulant (150 mg/L)



After the Treatment (1 hour Settling Duration)

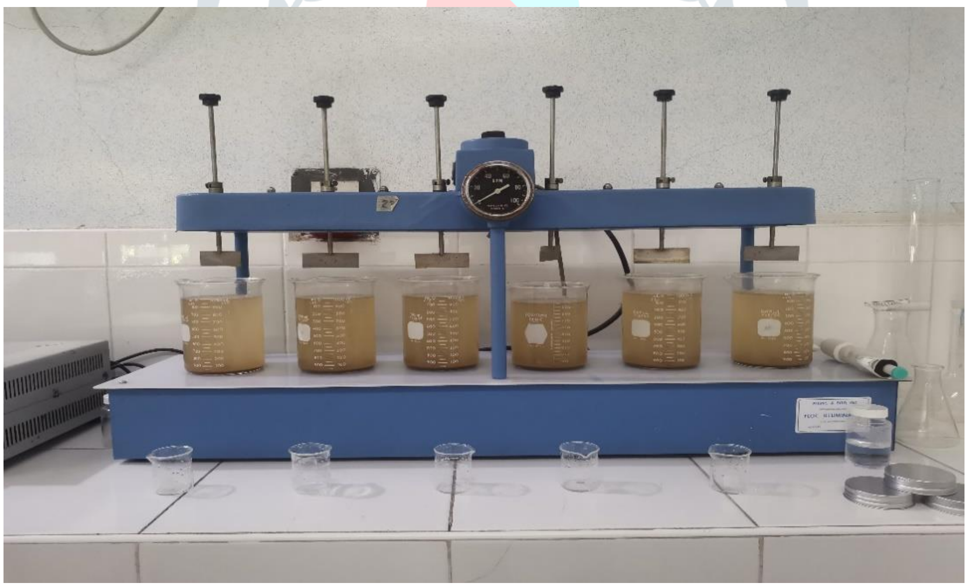
Figure 4.13

Marang Biocoagulant (200 mg/L)

After the Treatment (1 hour Settling Duration)

Figure 4.14

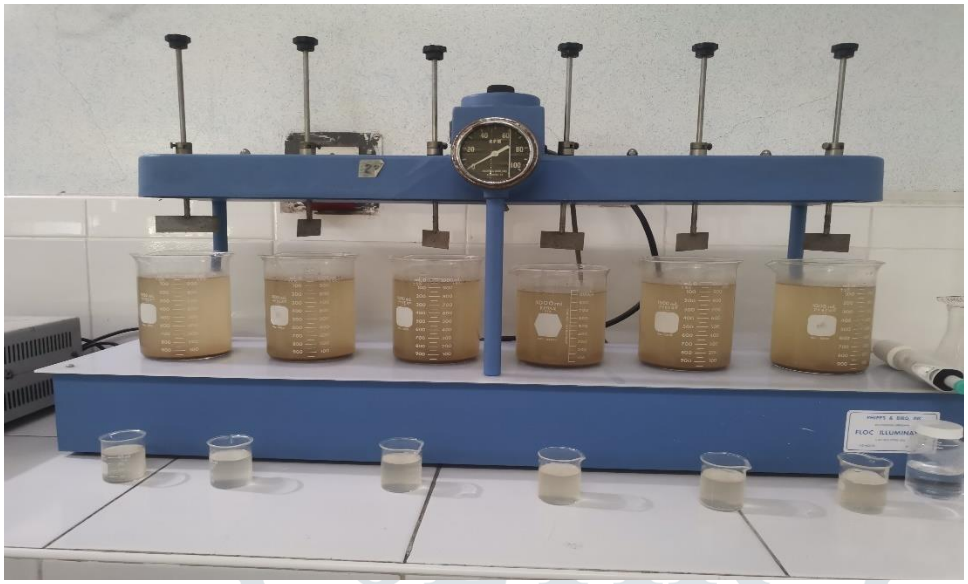
Marang Biocoagulant (250 mg/L)



After the Treatment (1 hour Settling Duration)

Figure 4.15

Marang Biocoagulant (300 mg/L)

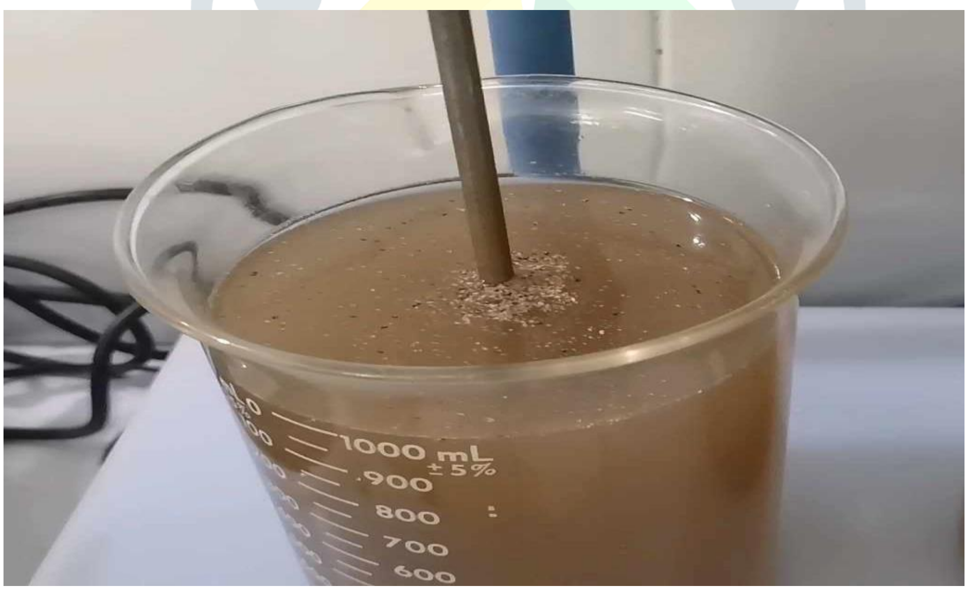


After the Treatment (1 hour Settling Duration)

Figure 4.16 shows there were traces of undissolved powdered marang seeds after the treatment.

Figure 4.16

Traces of Undissolved Marang Biocoagulant After 1 Hour Settling



4.2.2 Aluminum Sulfate Coagulation Observation

The synthetic water samples displayed noticeable changes in appearance before and after the coagulation process at varying dosages. All dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L) shows the same results in appearance which is, it improved clarity and reduced haziness in appearance.

The images from figure 4.17 to figure 4.22 show how the samples looked before they were treated. These pictures give a clear idea of what the samples were like initially, before any changes were made to them. They act as a starting point for comparing how the samples appear after they've been treated.

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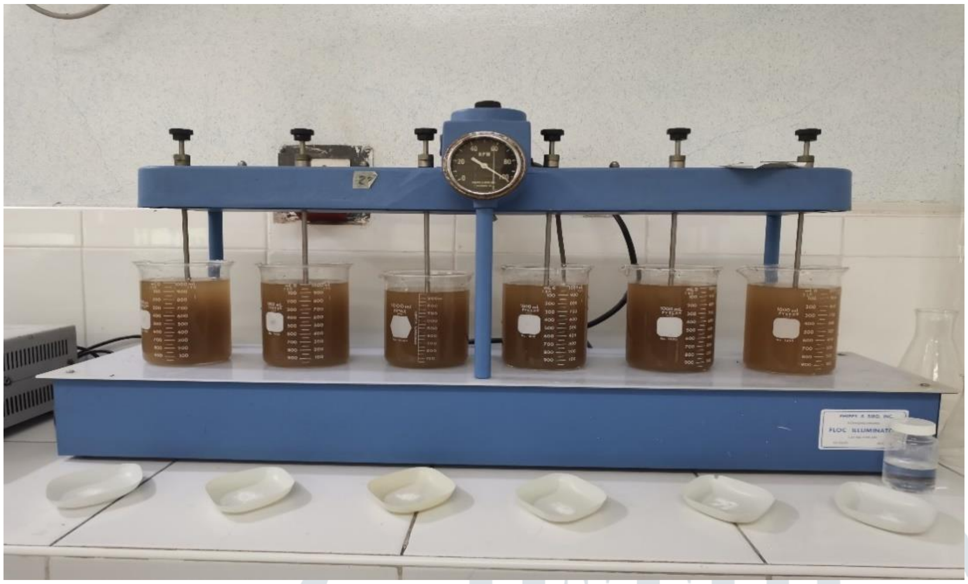
Figure 4.17

Aluminum Sulfate (50 mg/L)

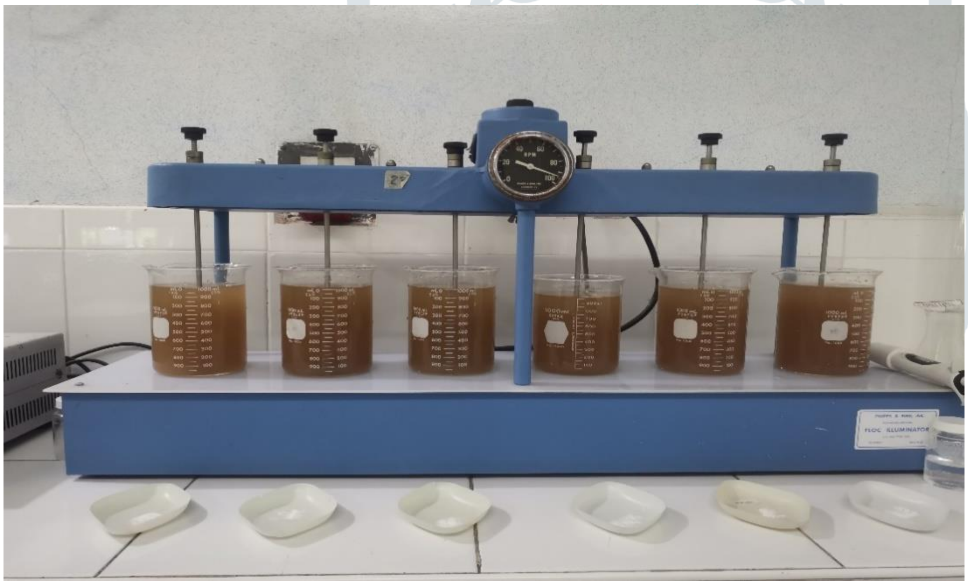
Before the Treatment

Figure 4.18
Aluminum Sulfate (100 mg/L)



Before the Treatment

Figure 4.19
Aluminum Sulfate (150 mg/L)



Before the Treatment

Figure 4.20

Aluminum Sulfate (200 mg/L)

Before the Treatment

Figure 4.21

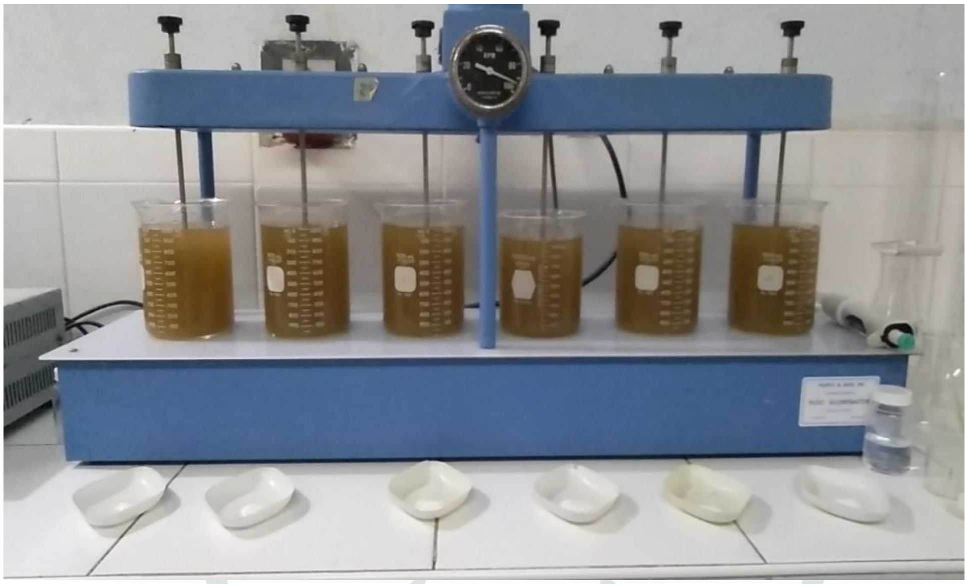
Aluminum Sulfate (250 mg/L)

Before the Treatment

Figure 4.22

Aluminum Sulfate (300 mg/L)

Before the Treatment



Figures 4.23 through 4.28 show samples treated with doses ranging from 50 mg/L to 300 mg/L with an interval of 50 mg/L. They illustrate the impact of different dosages on the samples.

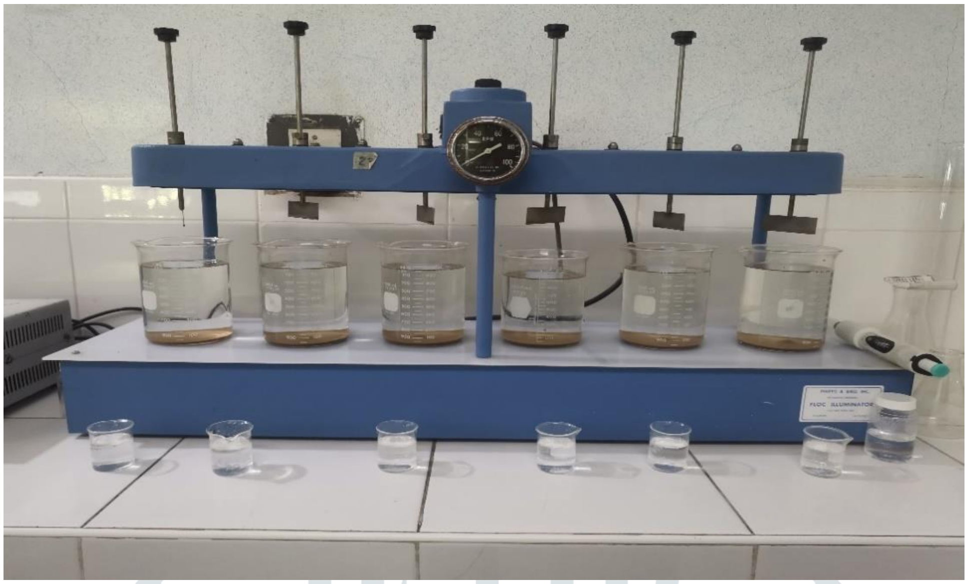
Figure 4.23

Aluminum Sulfate (50 mg/L)

After the Treatment (1 hour Settling Duration)

Figure 4.24

Aluminum Sulfate (100 mg/L)



After the Treatment (1 hour Settling Duration)

Figure 4.25

Aluminum Sulfate (150 mg/L)

After the Treatment (1 hour Settling Duration)

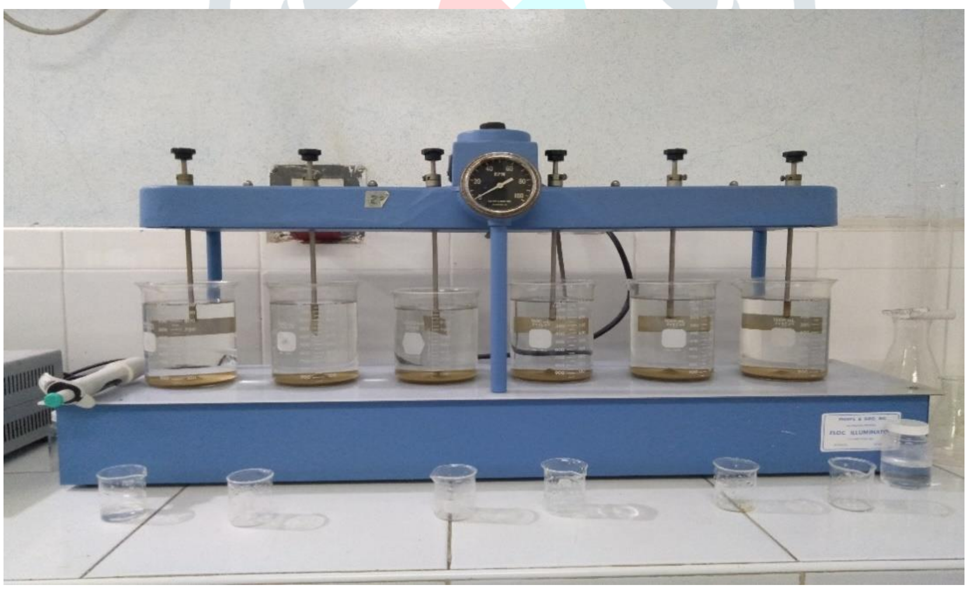
Figure 4.26

Aluminum Sulfate (200 mg/L)

After the Treatment (1 hour Settling Duration)

Figure 4.27

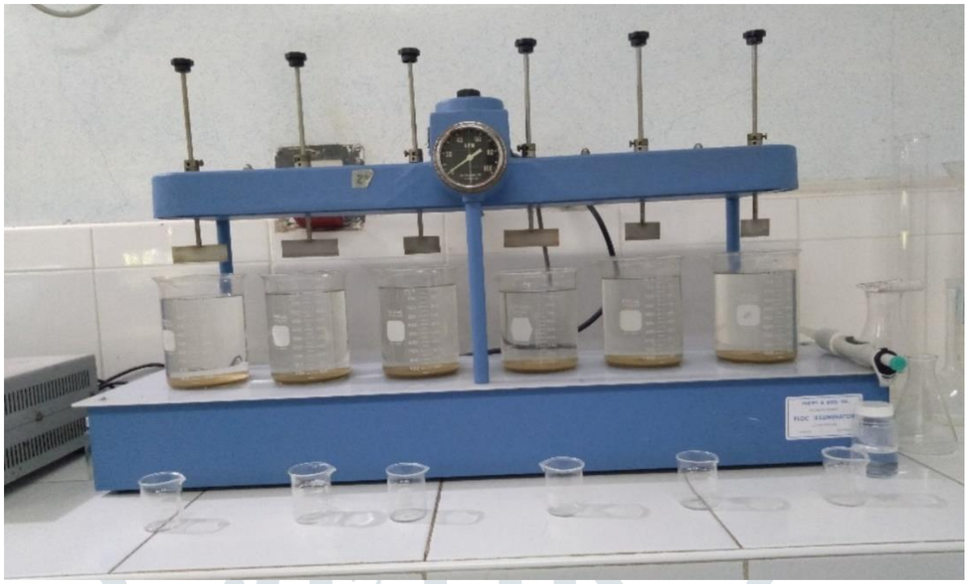
Aluminum Sulfate (250 mg/L)



After the Treatment (1 hour Settling Duration)

Figure 4.28

Aluminum Sulfate (300 mg/L)



After the Treatment (1 hour Settling Duration)

4.3 pH Levels of the Treated Synthetic Water Samples

Table 4.2 in the next page shows the marang biocoagulant pH results of the 6 trials of different dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). In all experiments conducted with varying dosages, fluctuations are observed.

Table 4.2

pH Results of Trials for Marang Biocoagulants

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total	Mean
50 mg/L	7.13	7.06	7.15	7.17	7.17	7.27	42.95	7.158
100 mg/L	6.95	6.94	6.96	6.99	7.01	7.05	41.9	6.983
150 mg/L	6.99	6.99	7.01	7.03	7.05	7.1	42.17	7.028
200 mg/L	7.09	7.08	7.07	7.09	7.08	7.09	42.5	7.083
250 mg/L	6.94	6.95	6.98	6.99	7.01	7.07	41.94	6.99
300 mg/L	6.97	7	7.01	6.99	7.02	7.06	42.05	7.008

Figure 4.29 illustrates the mean results of six trials using varying dosages of marang biocoagulant (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). The graph demonstrates fluctuations in results across different dosages. Initially, there is a decrease from 7.16 at 50 mg/L to 6.98 at 100 mg/L, followed by an increase to

7.03 and 7.08 at dosages of 150 mg/L and 200 mg/L, respectively. Subsequently, there is a decline to 6.99 at 250 mg/L before rising again to 7.01 at 300 mg/L. The optimal dosage for reducing pH levels appears to be 50 mg/L based on these findings.

Figure 4.29

pH Mean Results of Marang Biocoagulants of Different Dosages

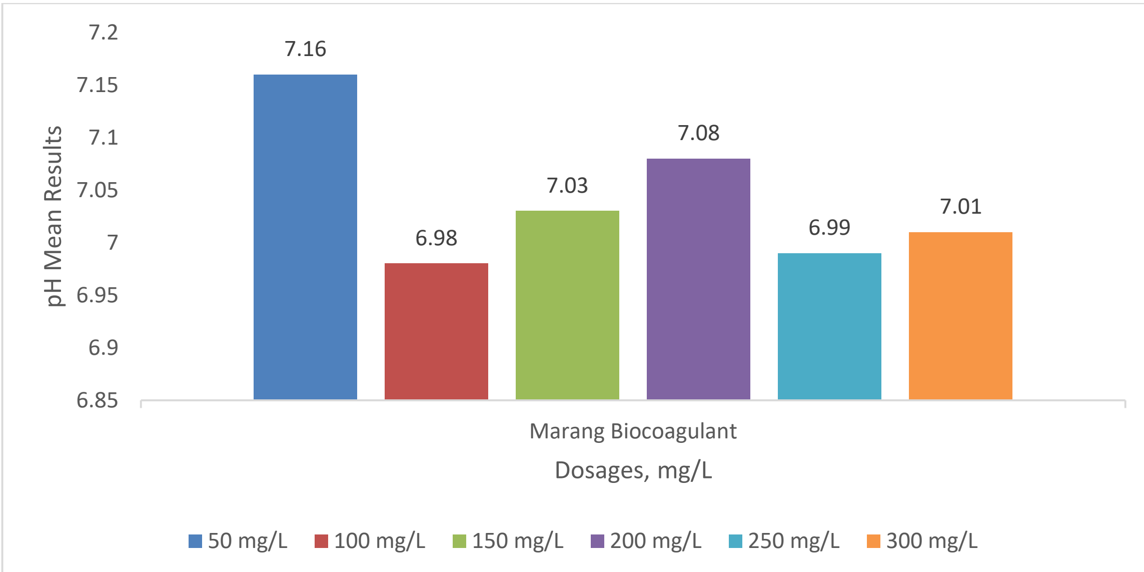


Table 4.3 displays the pH results of Aluminum Sulfate across six trials involving different dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). Across all these trials with varying dosages, fluctuations in pH levels are evident.

Table 4.3

pH Results of Trials for Aluminum Sulfate

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total	Mean
50 mg/L	6.67	6.62	6.63	6.66	6.65	6.69	39.92	6.653
100 mg/L	6.24	6.25	6.27	6.27	6.28	6.09	37.4	6.233
150 mg/L	6.12	6.05	6.3	6.12	6.11	6.14	36.84	6.14
200 mg/L	5.73	5.71	5.71	5.71	5.72	5.71	34.29	5.715
250 mg/L	5.92	5.93	5.91	5.87	5.93	5.96	35.52	5.92
300 mg/L	5.46	5.42	5.44	5.35	5.46	5.43	32.56	5.427

Figure 4.30 depicts the results of six trials using varying dosages of aluminum sulfate (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). The graph illustrates that as the dosage increases, the efficiency of

aluminum sulfate in reducing pH concentration decreases. However, at dosages of 200 mg/L and 250 mg/L, there are fluctuations observed. The optimal dosage in these trials appears to be 50 mg/L.

Figure 4.30

pH Mean Results of Aluminum Sulfate of Different Dosages

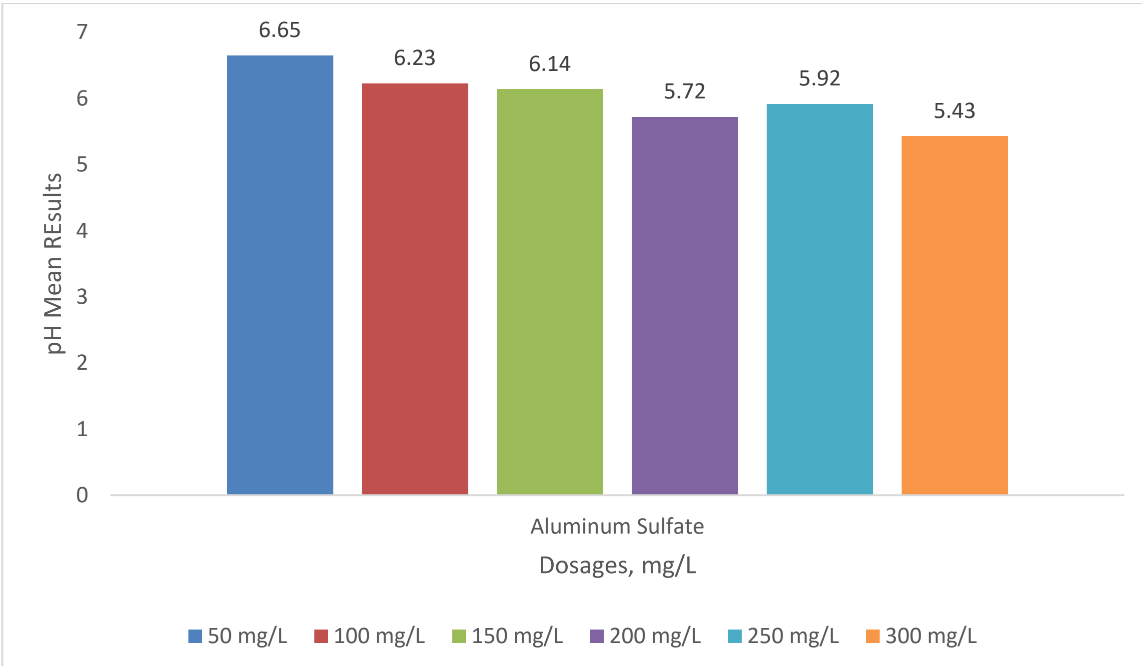


Table 4.4 displays the laboratory mean results for pH following the application of aluminum sulfate and marang biocoagulant. With aluminum sulfate, the pH levels decreased from 6.90 to 6.65, 6.23, 6.14, 5.72, 5.92, and 5.43 at dosages of 50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L, respectively. Conversely, with marang biocoagulant, the pH levels exhibited fluctuations but generally remained higher than the initial value of 6.90, increasing to 7.16, 6.98, 7.03, 7.08, 6.99, and 7.01 at dosages of 50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L, respectively.

Table 4.4

Mean Result of pH Analysis of different dosages

Coagulants	Test Method	Raw Samples	Dosages (mg/L)						PNSDW of 2017
			50	100	150	200	250	300	
			Results						
Marang Biocoagulant	HACH Sension 156 Combination	6.90	7.16	6.98	7.03	7.08	6.99	7.01	6.5 – 8.5
Aluminum Sulfate			6.65	6.23	6.14	5.72	5.92	5.43	

Figure 4.31 presents the efficiency of pH level reduction based on the mean data for each dosage and coagulant used. The graph illustrates that when using marang biocoagulant at dosages of 50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L, there were increases in pH data (-3.77%, -1.16%, -1.88%, -2.61%, -

1.30%, and -1.59%, respectively). Conversely, when using aluminum sulfate, there were reductions in pH levels of 3.62%, 9.71%, 11.01%, 17.10%, 14.20%, and 21.30% at the same respective dosages. This indicates that aluminum sulfate exhibits higher efficiency in reducing pH levels compared to marang biocoagulant.

The findings indicate that aluminum sulfate demonstrates a greater pH reduction compared to marang biocoagulant with increasing dosages. This is because aluminum sulfate, being a strong acid, is more effective at lowering pH levels by neutralizing alkaline compounds (Begley et al., 2012).

Figure 4.31

pH Level Reduction

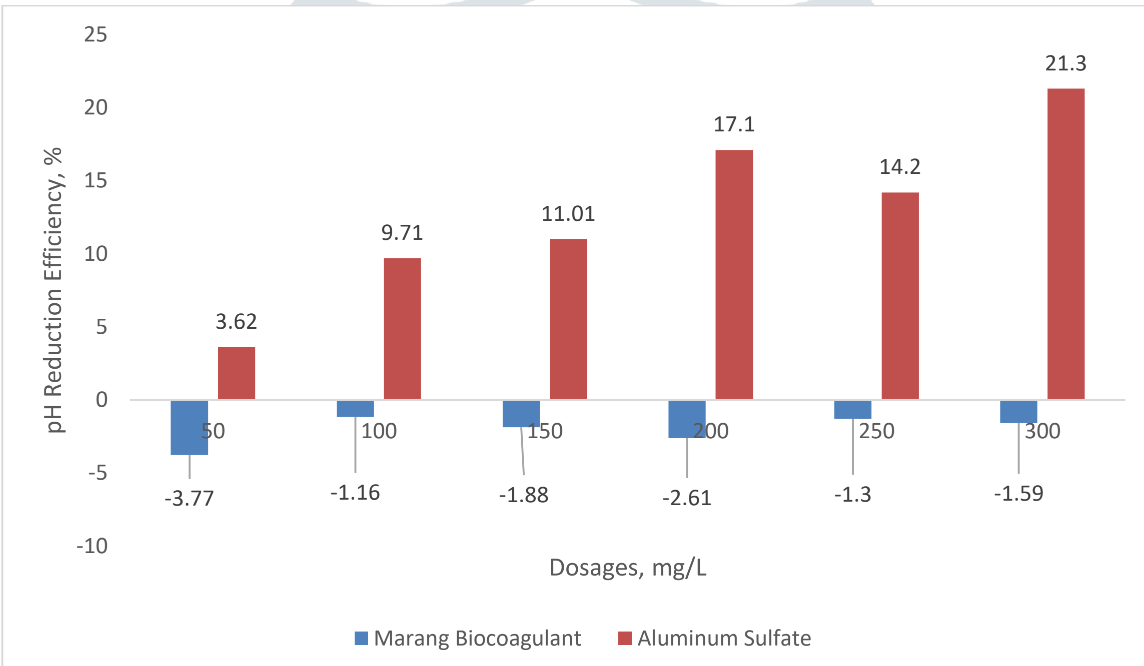


Table 4.5 utilizes Welch's T-test at a significance level of 0.50 to assess whether there is a significant difference in the effectiveness of marang biocoagulant compared to aluminum sulfate in pH removal. The findings suggest that there's no significant difference between marang biocoagulant and aluminum sulfate (p-value = 0.139 > 0.05 and p-value = 0.849 > 0.05), indicating that marang biocoagulant could serve as a substitute for aluminum sulfate. This highlights the crucial importance of dosage in pH reduction. Specifically, a dosage of 300 mg/L of aluminum sulfate decreases the pH from 6.90 to 5.43, whereas for marang biocoagulant, it consistently elevates the pH level across all dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, 300 mg/L).

Table 4.5

Welch T-test Results on pH Reduction

Group Name	Marang Biocoagulant	Aluminum Sulfate
Sample Average (x̄)	7.042	6.015
Sample Size (n)	6	6
Sample SD (S)	0.068	0.425
Skewness	1.251	0.161
Skewness Shape	pval = 0.139	pval = 0.849
Normality	0.325	1
Outliers	-	-
Outliers Count	-	-

4.4 Turbidity Laboratory Result and Removal Efficiency

Table 4.6 presents the turbidity results of marang biocoagulant across six trials involving different dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). While the trial at a dosage of 50 mg/L demonstrates significant success in reducing the pH level, the trials at the remaining dosages (100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, 300 mg/L) exhibit fluctuations.

Table 4.6

Turbidity Results of Trials for Marang Biocoagulants

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total	Mean
50 mg/L	47.1	46.1	43.2	42.4	40.1	33.6	252.5	42.0833
100 mg/L	77.3	73.3	70.6	72.3	72.3	71	436.8	72.8
150 mg/L	115	92.6	97.3	90.2	105	90.2	590.3	98.3833
200 mg/L	334	336	319	342	321	319	1971	328.5
250 mg/L	213	178	145	191	182	182	1091	181.833
300 mg/L	176	115	134	165	147	139	876	146

Figure 4.32 illustrates the mean results of six trials using various dosages of marang biocoagulant (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). The graph demonstrates that dosages of 50 mg/L, 100 mg/L, 150 mg/L, and 200 mg/L exhibit significant efficiency in reducing turbidity, whereas at dosages of 250 mg/L and 300 mg/L, the turbidity reduction efficiency decreases. The optimal dosage for reducing turbidity appears to be 200 mg/L based on these findings.

Figure 4.32

Turbidity Mean Results of Marang Biocoagulants of Different Dosages

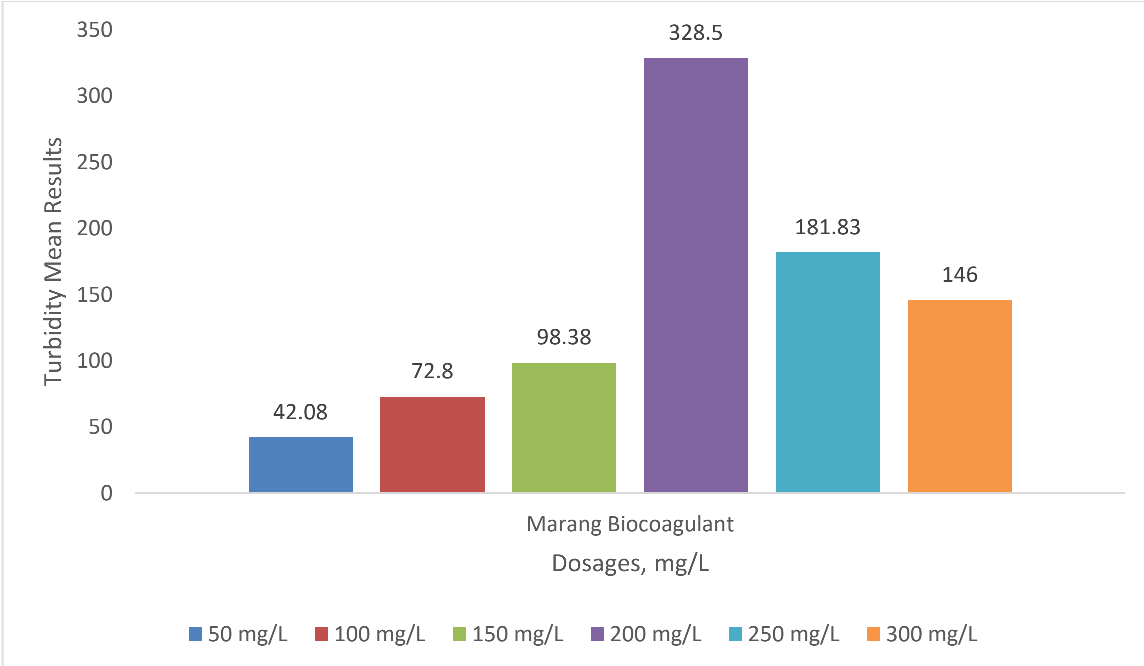


Table 4.7 presents the turbidity results of aluminum sulfate across six trials involving different dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). While the trial at a dosage of 50 mg/L shows considerable success in reducing turbidity, the trials at the other dosages (100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, 300 mg/L) display fluctuations.

Table 4.7

Turbidity Results of Trials for Aluminum Sulfate

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total	Mean
50 mg/L	2.49	1.94	1.85	1.76	1.64	1.49	11.17	1.862
100 mg/L	2.88	1.7	2.6	1.73	1.69	2.49	13.09	2.182
150 mg/L	4.02	5.7	3.06	2.08	3.05	3.23	21.14	3.523
200 mg/L	9.06	8.1	6.49	7.42	4.55	4.9	40.52	6.753
250 mg/L	7.41	10.6	9.56	6.9	7.65	8.89	51.01	8.502
300 mg/L	21	18.8	11.2	15.4	11	13.1	90.5	15.083

Figure 4.33 presents the mean results of six trials using varying dosages of aluminum sulfate (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). The graph illustrates that as the dosage increases, the effectiveness in reducing turbidity also increases. The optimal dosage for reducing turbidity appears to be 300 mg/L according to these results.

Figure 4.33

Turbidity Mean Results of Aluminum Sulfate of Different Dosages

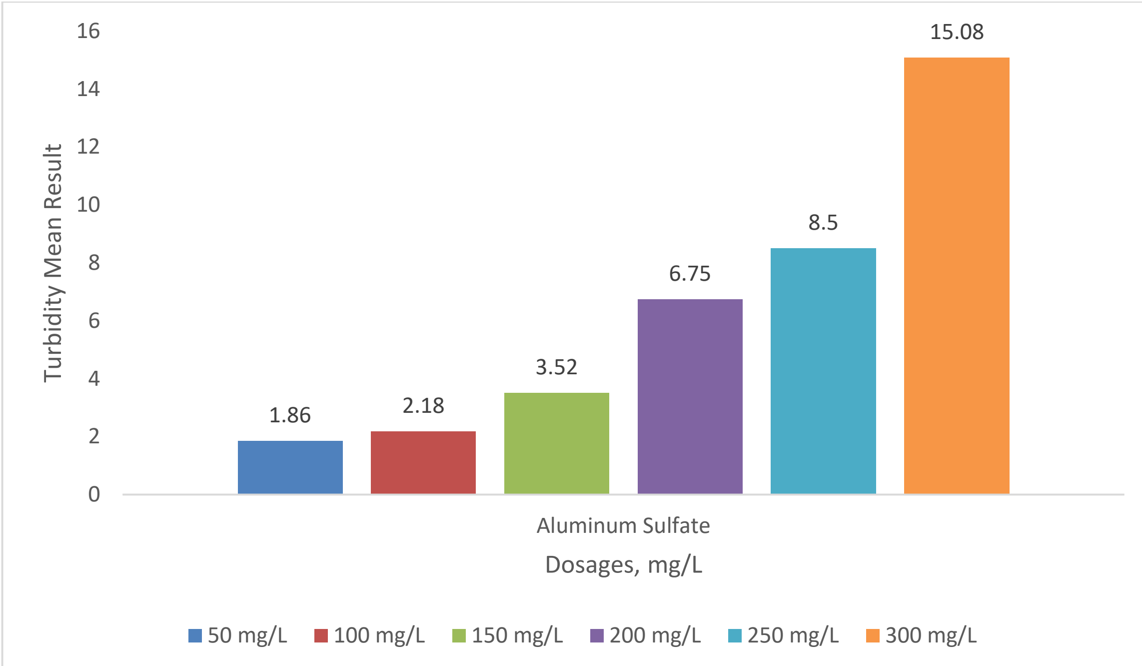


Table 4.8 presents the Turbidity laboratory results for aluminum sulfate and marang biocoagulant. with aluminum sulfate, turbidity decreased from 838 NTU to 1.86 NTU, 2.18 NTU, 3.52 NTU, 6.75 NTU, 8.5 NTU, and 15.08 NTU at 50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L dosages respectively. For marang biocoagulant, turbidity decreased from 838 NTU to 42.08 NTU, 72.8 NTU, 98.38 NTU, 328.5 NTU, 181.83 NTU, and 146 NTU at the same dosages as aluminum sulfate.

The results indicate that based on PNSDW of 2017 turbidity standard, the turbidity of synthetic raw and treated samples at varying dosages did not meet the standard. However, the control samples at 50 mg/L, 100 mg/L, and 150 mg/L dosages passed the standard while varying dosages 200 mg/L, 250 mg/L, and 300 mg/L did not pass.

Table 4.8

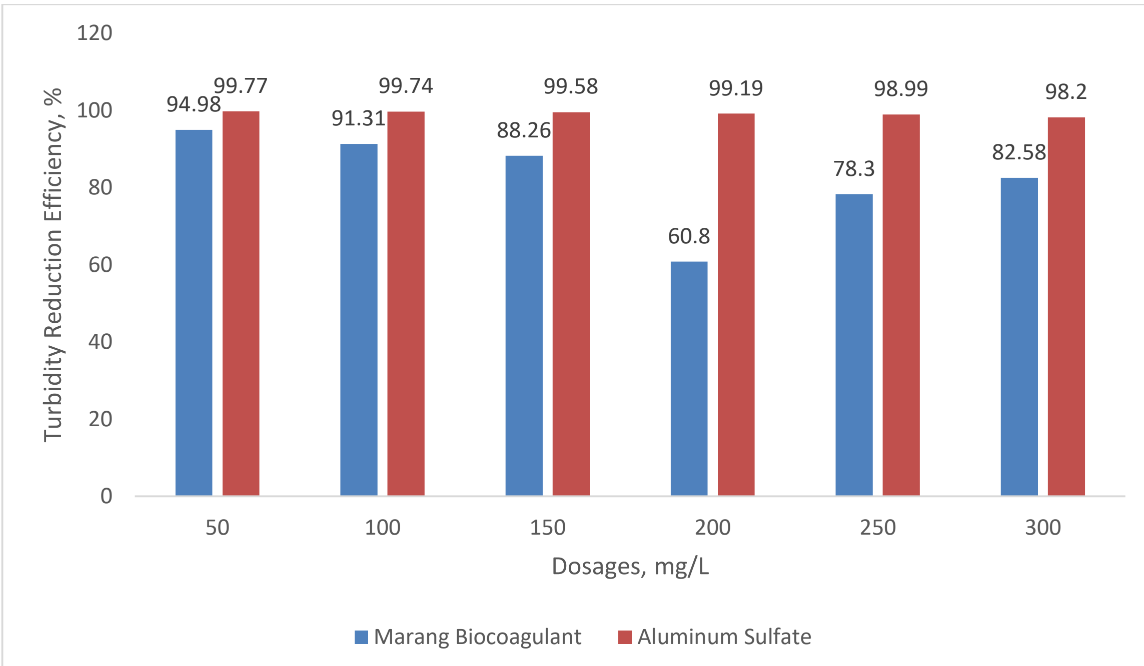
Mean Result of Turbidity Analysis

Coagulants	Test Method	Raw Samples (NTU)	Dosages (mg/L)						PNSDW of 2017
			50	100	150	200	250	300	
			Results						
Marang Biocoagulant	HACH 2100Q	838	42.08	72.8	98.38	328.5	181.83	146	5 NTU
Aluminum Sulfate			1.86	2.18	3.52	6.75	8.5	15.08	

In Figure 4.34, the effectiveness of two coagulants in removing turbidity is demonstrated. At a dosage of 50 mg/L, marang biocoagulant removed 94.98%, whereas aluminum sulfate achieved 99.77% removal. Increasing the dosage to 100 mg/L, marang biocoagulant achieved 91.31% removal compared to aluminum sulfate's 99.74%. The trend continued with diminishing removal efficiency for marang biocoagulant at higher dosages compared to aluminum sulfate, with values of 88.26%, 85.98%, 85.39%, and 85.16% at dosages of 150, 200, 250, and 300 mg/L, respectively, while aluminum sulfate maintained higher removal efficiencies at 99.58%, 99.84%, and 99.77% for the corresponding dosages.

Figure 4.34

Turbidity Reduction Efficiency



At 50 mg/L dosage, both aluminum sulfate and marang biocoagulant achieve a higher removal efficiency of 99.77 % and 94.98%. The graph indicates that marang biocoagulant's efficiency flactuates at different doses due to increased undissolved organic matter from Marang seeds. The granular form of Marang seeds does not fully dissolve during coagulation, leading to increased turbidity. for aluminum sulfate, the higher the dosage, the lower the removal efficiency.

Table 4.9 utilizes Welch's T-test with a significance level of 0.50 to compare marang biocoagulant and aluminum sulfate in turbidity removal. The findings indicate no significant difference between the two (p-value = 0.129 > 0.05 and p-value = 0.161 > 0.05), suggesting marang biocoagulant could substitute aluminum sulfate. This emphasizes the crucial role of dosage in reducing turbidity. For example, a dosage of 50 mg/L of aluminum sulfate achieved the standard turbidity levels, while marang biocoagulant reduced turbidity to 42.08 NTU from 838 NTU but still did not meet the standard.

Table 4.9

Welch T-test Results on Turbidity Reduction

Group Name	Marang Biocoagulant	Aluminum Sulfate
Sample Average ($\bar{x}$)	144.932	6.315
Sample Size (n)	6	6
Sample SD (S)	102.964	5.031
Skewness	1.251	0.161
Skewness Shape	pval = 0.129	pval = 0.161
Normality	0.4692	0.3132
Outliers	-	-
Outliers Count	-	-

4.5 Total Dissolved Solids (TDS) Laboratory Result and Removal Efficiency

Table 4.10 displays the total dissolved solids (TDS) results of marang biocoagulant across six trials with varying dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). Across all trials with different dosages, fluctuations are observed in the results.

Table 4.10

TDS Results of Trials for Marang Biocoagulants

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total	Mean
50 mg/L	215	217	217	216	217	218	1300	216.667
100 mg/L	207	208	207	208	208	207	1245	207.5
150 mg/L	164.6	164.6	164.5	164.8	164.3	164.7	987.5	164.583
200 mg/L	118.1	118	118.2	117.9	118.2	118	708.4	118.067
250 mg/L	212	212	213	213	212	211	1273	212.167
300 mg/L	164.6	164.5	164.3	164.8	164.6	164.4	987.2	164.533

Figure 4.35 shows the marang biocoagulant mean results of the 6 trials of different dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). The graph shows that at dosages 50 mg/L, 100 mg/L, 150 mg/L, and 200 mg/L there was a decrease of efficiency in reducing TDS concemtration while at dosages 250 mg/L shows that it increases and then dropped again at dosage 300 mg/L. At dosage 50 mg/L is the optimum dosage in reducing TDS.

Figure 4.35

TDS Mean Results of Marang Biocoagulant of Different Dosages

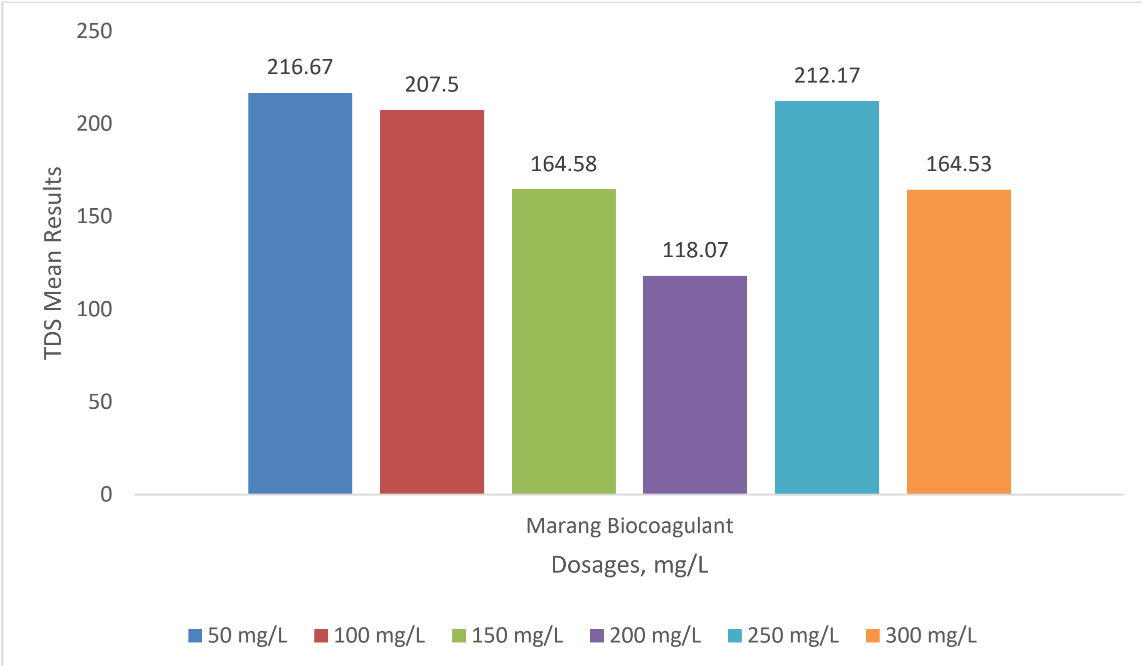


Table 4.11 shows the marang biocoagulant TDS results of the 6 trials of different dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). Table 4.11 presents the Total Dissolved Solids (TDS) outcomes for marang biocoagulant across six trials featuring various dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). Throughout all trials employing different dosages, fluctuations are evident in the results.

Table 4.11

TDS Results of Trials for Aluminum Sulfate

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total	Mean
50 mg/L	217	217	218	217	218	218	1305	217.5
100 mg/L	202	203	203	203	203	146.6	1160.6	193.433
150 mg/L	221	223	218	221	221	221	1325	220.833
200 mg/L	224	225	224	225	224	226	1348	224.667
250 mg/L	226	228	226	228	228	228	1364	227.333
300 mg/L	216	215	215	217	217	215	1295	215.833

Figure 4.36 shows the aluminum sulfate mean results of the 6 trials of different dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). The graph shows that at dosages 50 mg/L to 100 mg/L TDS

reduction efficiency dropped, at dosages 150 mg/L, 200 mg/L, and 250 mg/L there was a decreasing of efficiency in reducing TDS concemtration while at dosages 250 mg/L shows that it increases and then dropped again at dosage 300 mg/L. At dosage 250 mg/L is the optimum dosage in reducing TDS.

Figure 4.36

Turbidity Mean Results of Aluminum Sulfate of Different Dosages

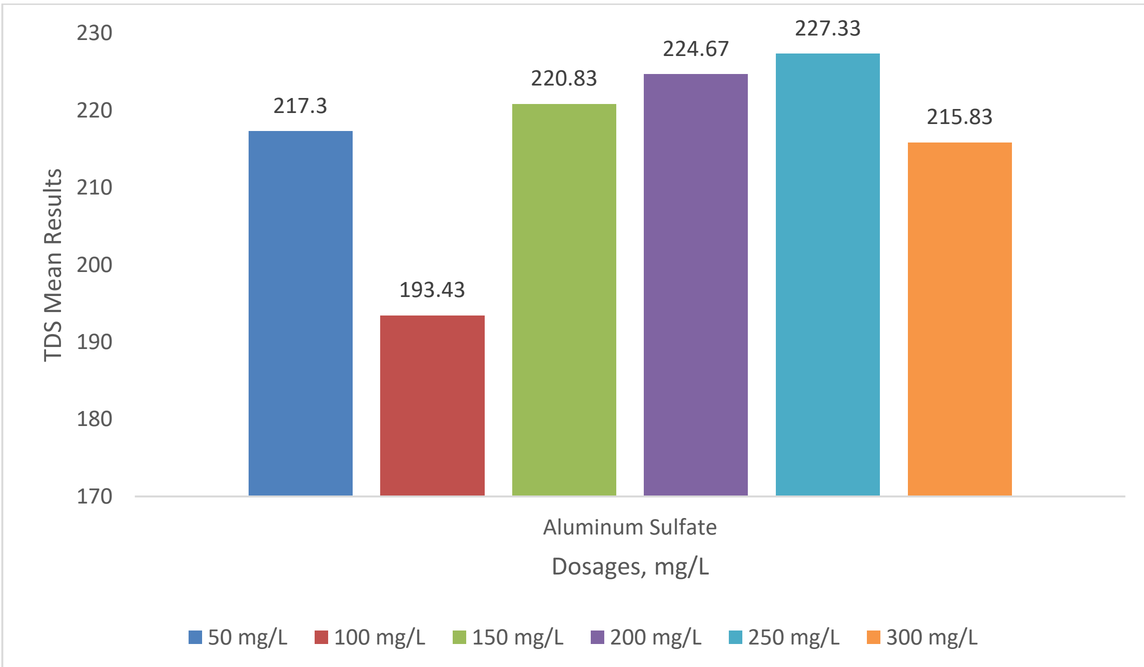


Table 4.12 shows the results of TDS for both aluminum sulfate and marang biocoagulant. After the jar test, the TDS level of marang biocoagulant at 50 mg/L of dosage increased however at 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L it decreases from 213 mg/L to 207.5 mg/L, 164.58 mg/L, 118.07 mg/L, 212.17 mg/L, and 164.53 mg/L. for aluminum sulfate, it only decreased at 100 mg/L of dosage resulted in 193.43 mg/L from 213 mg/L. The rest of the dosages (50 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L) obtained an increased in results of aluminum sulfate increased from 213 mg/L to 217.5 mg/L, 178.7 mg/L, and 191.4 mg/L, respectively. For marang biocoagulant, it increases to 155.8 mg/l, 156.3 mg/l, and 157.3 mg/l at too similar dosage as aluminum sulfate.

Laboratory results revealed that the TDS level of raw, control, and treated samples at varying dosage meet the standards based on PNSDW of 2017.

Table 4.12

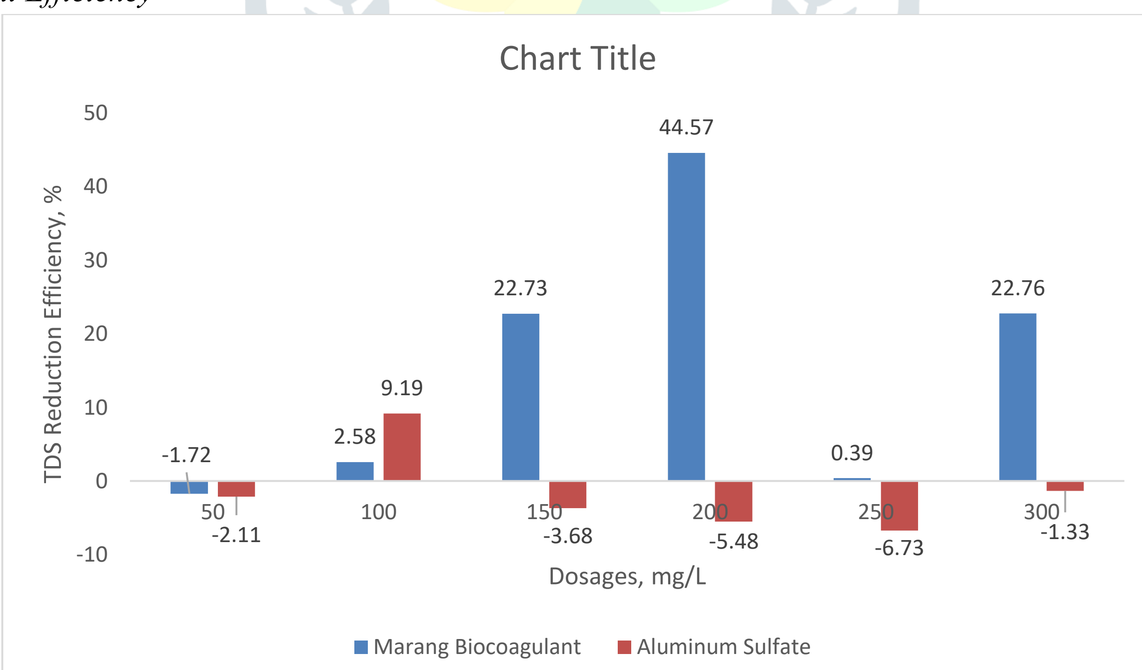
Mean TDS Result of Analysis

Coagulants	Test Method	Raw Samples (mg/L)	Dosages (mg/L)						PNSDW of 2017
			50	100	150	200	250	300	
			Results						
Marang Biocoagulant	HACH Sension 156 Combination	213	216.67	207.5	164.58	118.07	212.17	164.53	600 mg/L
Aluminum Sulfate			217.5	193.43	220.83	224.67	227.33	215.83	

Figure 4.37 depicts the TDS efficiency removal of aluminum sulfate and marang biocoagulant at different dosages (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L). At 50 mg/L, marang biocoagulant shows -1.72% efficiency, while aluminum sulfate demonstrates -2.11%. At 100 mg/L, marang biocoagulant exhibits 2.58% removal efficiency, while aluminum sulfate displays 9.19%. Finally, at 150 mg/L, Marang Biocoagulant has 22.73% removal efficiency, whereas aluminum sulfate indicates -3.68%. at 200 mg/l, marang biocoagulant shows 44.57% efficiency, while aluminum sulfate demonstrates -5.48%. at 250 mg/l, marang biocoagulant exhibits 0.39% removal efficiency, while aluminum sulfate displays -6.73%. finally, at 300 mg/l, marang biocoagulant has 22.76% removal efficiency, whereas aluminum sulfate indicates -1.33%.

Figure 4.37

TDS Removal Efficiency



In aluminum sulfate the removal efficiency fluctuates so as in the marang biocoagulant, but the graph shows that the marang biocoagulant has the potential to lower the TDS concentration than the aluminum sulfate.

Table 4.13 employs Welch's T-test at a significance level of 0.50 to compare the effectiveness of marang biocoagulant and aluminum sulfate in TDS removal. The results indicate significant difference between the two (p-value = 0.34 > 0.05 and p-value = 0.035 < 0.05), suggesting that aluminum sulfate has a better performance than marang biocoagulant in reducing TDS. It signifies that the dosage of coagulant, whether marang biocoagulant or aluminum sulfate plays an important part in TDS reduction. At a dosage of 100 mg/L, only aluminum sulfate succeeded in reducing the Total Dissolved Solids (TDS) concentration, while other dosages (50 mg/L, 150 mg/L, 200 mg/L, 250 mg/L, and 300 mg/L) resulted in an increase. On the other hand, marang biocoagulant showed an increase in TDS concentration only at the 50 mg/L dosage, whereas other dosage levels demonstrated efficiency in reducing TDS concentration. Notably, all outcomes complied with the Philippine National Standards for Drinking Water (PNSDW) of 2017.

Table 4.13

Welch T-test Results on Turbidity Reduction

Group Name	Marang Biocoagulant	Aluminum Sulfate
Sample Average ($\bar{x}$)	180.586667	216.598333
Sample Size (n)	6	6
Sample SD (S)	38.590685	12.135918
Skewness	-0.807004	-1.778837
Skewness Shape	pval = 0.34	pval = 0.035
Normality	0.2629	0.1051
Outliers	-	193.43
Outliers Count	0	1

The researcher observed fluctuations in pH, turbidity, and total dissolved solids (TDS) results when employing marang seeds as a biocoagulant for drinking water treatment. Several factors may contribute to these fluctuations. Firstly, variations in the composition and concentration of natural compounds within the marang seeds could influence their coagulation efficacy. Different batches of seeds may contain varying levels of coagulating agents, leading to inconsistencies in treatment performance.

Additionally, the environmental conditions during seed harvesting and storage may impact their effectiveness. Factors such as humidity, temperature, and exposure to light can affect the stability and potency of the coagulating agents present in the seeds, thereby influencing treatment outcomes.

Furthermore, the inherent variability in raw water quality could also contribute to the fluctuations observed. Natural variations in water chemistry, including the presence of organic matter, minerals, and suspended solids, can influence the coagulation process and subsequent treatment efficacy.

Moreover, the dosage and application method of marang seed extract can play a significant role in treatment performance. Variations in dosage levels and application techniques may lead to inconsistent coagulation and settling of impurities, resulting in fluctuations in pH, turbidity, and TDS levels.

As there were no previous studies found related to this study, all previously mentioned factors which have contributed to the fluctuations of the result are based on the observation and analysis of the researcher.

Overall, the fluctuations observed in pH, turbidity, and TDS results when using marang seeds as a biocoagulant highlight the complex nature of natural coagulants and the need for further optimization and standardization of treatment protocols to ensure consistent and reliable water treatment outcomes.