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Original research

The Utilization of Moringa Oleifera as a Sustainable Coagulant in Water Purification

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Abstract:

For a variety of uses, safe and clean water is ensured through the crucial process of water treatment. In this work, we investigate The potential application of Moringa oleifera seeds as a natural substitute for alum, a common coagulant, in water treatment. Several concentration ratios were considered in order to find the percentage of Moringa oleifera seeds that work best for treating water. This research aims to find the concentration that would yield the lowest turbidity, an important indicator of water clarity. For this Regard, this study focused into making a Moringa oleifera solution for water treatment using the seeds of Moringa oleifera. Before processing, the seeds were deoiled and the husks removed. A water sample from the intake of New Thebes City Water Purification Station in Luxor-Egypt, which had an initial turbidity. The water sample had a turbidity of 2.85 NTU. To achieve the desired turbidity of 50 NTU, it was necessary to add a specific amount of soil, 4 grams of soil per liter of water. Moringa oleifera seeds were used in a range of concentrations (60, 50, 40, 30, 20, and 10 mg/L), and tests for turbidity, pH, bacterial count, total coliform, fecal coliform, iron, and manganese were conducted. Furthermore, the effects of Aluminum sulfate and polyalmonium chloride (Pac) were investigated, both separately and in conjunction with the Moringa oleifera solution. A minimum turbidity rate of 20 mg/L was obtained when combined Moringa oleifera seeds with either alum or polyammonium chloride. Thus, this study is an important step toward developing sustainable and effective water treatment technologies that contribute to human health and environmental protection, as it found that Moringa with Alum or Polyammonium Chloride reduces turbidity significantly.

Keywords: Water turbidity, Moringa oleifera seeds, Polyammonium chloride, Alum, Coagulation.

1- Introduction

Everyone has the right to safe, clean drinking water for a healthy life and better healthcare. Still, in countless parts of the world, particularly in developing regions, getting enough clean drinking water is a real issue because of financial issues, poor infrastructure and frequent waterborne diseases. To solve these challenges, researchers are considering new methods to clean water that are sustainable, efficient and less expensive (Shukla, 2016; Hoa et al., 2018; Diver et al., 2023).

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Natural coagulants from plants are one of the methods that appear most promising. Moringa oleifera, often called the "miracle tree," has received a lot of interest. The plant is able to reduce turbidity because proteins in its structure attract and hold negatively charged particles in the water (Patchaiyappan et al., 2023; Elsergany et al., 2023). Because of these water-soluble proteins, Moringa can be used as a natural replacement for aluminum and iron salts as coagulants. People have done studies on Moringa seed extracts and seen that both how much is used and the time it sits can influence how cloudy the water becomes. Using the recommendation of 150 mg/L seed powder to treat water, researchers found the turbidity was reduced from 337 NTU to 13 NTU (Sudarmin et al., 2019; Yamaguchi et al., 2021; Stephen et al., 2022; Amin et al., 2022; Kusumawati et al., 2020; Pandey et al., 2020). Moringa shows the best results when treating highly turbid water, but does not perform as well in situations with little turbidity. When the turbidity is high, its usefulness comes close to that seen with aluminum-based coagulants (Elsergany et al., 2023).

Attention has been growing in recent years toward using environmentally friendly natural coagulants over synthetic chemicals in making water safe for public useEven though they perform very well, these technologies still run into problems such as having to adjust their pH and alkalinity, producing extra sludge and having tiny amounts of materials left in treated water. Some of these residues have been associated with problems in the brain and an increased risk of cancer, as well as a link to Alzheimer's disease (Pandey et al., 2020). A research team led by Ng and published in 2021 evaluated how Moringa oleifera seeds did in different conditions of pH, contact period, agitation rate and doses. It was found that the best conditions for turbidity removal involved a pH of 4, variable contact times of 60 to 3000 seconds for flocculation and coagulation, 30 and 300 RPM for agitation and 10 grams of dosage. Plant-based coagulants were less effective on very alkaline water, showing that small changes can matter in wastewater treatment. Researchers also examined whether Moringa seed oil showed antimicrobial and antifungal properties. By using ethanol extraction and GC-MS, substances with robust antifungal properties were found to work well against both Candida albicans and Rhizopus stolonifera. Using the extract in this way, they later produced antifungal soap and used the remaining pectin for purifying water (Ojewumi et al., 2021). Adding MoCP to the Opa Reservoir's water sample reduced turbidity, lowered organic material and reduced the presence of coliform bacteria. Molecular weights of 14.2 kDa (for the subunit) and 30.3 kDa (for the native protein) were measured by SDS-PAGE. MoCP possesses both coagulation and antibacterial capabilities as good as those seen in aluminum sulfate (Taiwo et al., 2020). While there are other plant-based coagulants, Moringa has gotten the most research attention so far. Experts point out that while these coagulants have potential, they also have challenges when it comes to being used on a large scale and being consistent. A number of studies have suggested changing the chemistry of natural coagulants to boost their effectiveness as well as their chance of succeeding in the market (Nimesha et al., 2021). The treatment of acidic and basic wastewater by Moringa seed powder worked very well in rural areas. A range of doses from 0.1 to 0.6 grams was used and it was shown that 0.4 grams worked best to remove turbidity and color, with over 99.5% and 97.7% improvements. Up to 65.82% was achieved in COD reduction. They found that using RSM is valid for optimizing the process and that the best outputs resulted from conditions with pH ranging from 7 to 9 (Desta et al., 2021). Another method to address commercialization challenges in natural coagulants was to try cooperative effects of Moringa, Cactus Opuntia and aluminum sulfate in water treatment. With the help of a simplex lattice approach, 13% alum, 42.6% Moringa and 44.4% Cactus were determined to be the best components, using a total dose of 45 mg/L. After the treatment, the water had reduced turbidity of 2.7 NTU, a pH of 6.99, 308 µS/cm for conductivity and an alkalinity of 137.7 mg/L, according to Gandiwa et al. According to Andrade et al. (2021), aqueous extracts of Moringa seeds are suitable for tertiary treatment of domestic wastewater by techniques including sedimentation, flocculation, coagulation and filtration. Still, they pointed out that making these proteins safer through purification would cut down on the amount of organic material in water after purification.

Although there is plenty of research showing Moringa oleifera can be used as a natural coagulant, scientists still need to focus on better combining it with chemicals and checking its effects on water. Though each study has presented good news on Moringa's own ability, it don't fully comprehend how Moringa works in combination with regular coagulants. While many studies have examined natural or chemical substances by themselves or together, the current work is different for several reasons. At the start, various combinations of natural and chemical substances were used at a studied concentration which has never been tested in such detail. Following this, by expanding the analysis approach, the study uncovered additional new interactions and results that were not found elsewhere. Additionally, the study aims to design solutions that can really be applied in the field which was missing in many other theoretical studies. Therefore, this paper works to produce a coagulant from Moringa oleifera seeds that have had the husk and oil removed and test its ability to treat water at the New Thebes City Water Station in Luxor. The study applies varying concentrations (10–60 mg/L) to evaluate their effects on turbidity, pH, bacterial count, total coliform, and fecal indicators.

1. Comparative Overview of Coagulant Agents in Water Treatment

It describes the types of materials and tools used during testing, including alum ($Al_2(SO_4)_3 \cdot nH_2O$), polyammonium chloride and Moringa oleifera. Alum is a white, powdered chemical that dissolves in water which makes it easy to use in treatment processes. Its chemical process means particles lose their charge, allowing fine particles in the water to gather and then be easily removed as presented in Figure 1. Yet, the amount of organic matter leached out by it is not much and some worries about the impact of remaining aluminum exist. Because of its water solubility and being colorless, polyammonium chloride is commonly used for coagulating biochemicals. While it works well in removing suspended particles, its efficiency for organic waste is not very strong. It causes less harm to the environment than some other traditional chemicals, although the formation of chloramines should still be carefully considered during planning treatment.

This vegetable is sold in dried leaf or powder form and works by coagulating, with active substances that dissolve in water. Its main proteins which are positively charged, allow the water to clump easily and form flocs. Also, the antimicrobial qualities in Moringa help stop bacteria from growing which makes it a great eco-friendly product.

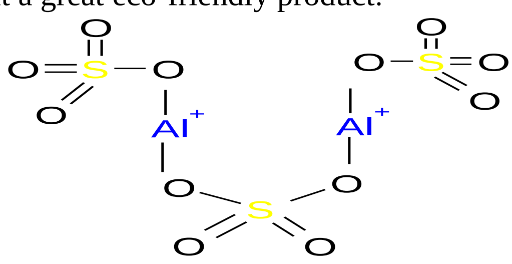

Fig. 1. Chemical structure of Alum

2. Materials and Methods

This section illustrates the methodology of this study. It Moringa Solution Preparation Stages, additionally, it presented the procedures for conducting turbidity, pH, bacterial count, total coliform, fecal coliform, iron, and manganese tests using different apparatuses.

2.1 Moringa Solution Preparation Stages

Moringa oleifera seeds were purchased from a local herbal supplier. The seeds were shelled, ground into fine powder, and used to prepare aqueous extracts. The extract was freshly prepared for each experiment to preserve coagulation properties. Figure 2 shows the stages of preparing Moringa powder. Figure 2.a illustrates the hulled moringa seeds, Figure 2.b shows grinding process of hulled seeds of Moringa, and Figure 2.c presents the Moringa powder.

Moringa Solution Preparation Stages are as following: -

- Carefully peel the Moringa leaves.
- After peeling, the seeds are ground well until they become a fine powder.
- Add an appropriate amount of ethanol to the Moringa powder. Ethanol is used to remove the oils and fats present in the leaves, which helps in concentrating the active compounds. The ratio was about 3:1 (ethanol: powder) for best results.
- The mixture is mixed well and left to dry, then the mixture is filtered to obtain the pure liquid.
- Then, a 1 molar sodium hydroxide solution is added to the extracted liquid. Sodium hydroxide helps adjust the pH and improve the chemical stability of the solution.

(a) (b) (c)

Fig. 2. Stages of preparing Moringa powder.

2.2 Analytical Procedures for Water Quality Assessment

The procedures for conducting turbidity, pH, bacterial count, total coliform, fecal coliform, iron, and manganese tests using different apparatuses are as following: -

- Turbidity Test is carried out using HACH TU5200 according to ISO 7027. The sample cell is filled with the water sample then it is inserted into the turbidimeter. The turbidity measurement is in nephelometric turbidity units (NTU).
- pH Test is carried out using HACH HQ411d according to ASTM D1293. After Calibration the pH meter using appropriate pH buffer solutions, the pH electrode is immersed into the water sample. After stabilizing the reading, the pH value displayed on the pH meter is recorded.
- Bacterial Count Test using HACH HQ411d is applied according to ISO 6222 by preparing a sterile agar plate suitable for bacterial growth. A sterile pipette is used to transfer a known volume of the water sample onto the agar plate. The agar plate is incubating at the appropriate temperature and duration required for bacterial growth (e.g., 37°C for 24-48 hours). After incubation, count the number of bacterial colonies that have grown on the agar plate.
- Total Coliform Test is carried out according to ISO 9308-1 by preparing a selective culture medium suitable for total coliform growth. The water sample is inoculating into the prepared medium using a sterile pipette. The medium is incubating at the appropriate temperature and duration required for total coliform growth (e.g., 35-37°C for 24-48 hours). After incubation, the growth of colonies is observing and recording.
- Fecal Coliform Test is according to ISO 9308-1 Standard by placing the filter on the prepared selective medium and incubates at the appropriate temperature and duration (e.g., 44-45.5°C for 24 hours). After incubation, count the number of fecal coliform colonies that have grown on the membrane filter.
- For Iron and Manganese Tests according to ISO 6332 and ISO 6332 respectively, the sample and reagents are mixing thoroughly and allowing them to react for the specified time, then measuring the color intensity of the resulting solution using the spectrophotometer at the appropriate wavelength specified. The iron concentration is measured by compare the measured color intensity with a calibration curve or standard.
- The study looked at the effects of the Moringa oleifera solution alone as well as the effects of mixing the solution with two coagulants that are frequently used in water treatment procedures: polyammonium chloride and alum. Using coagulants is intended to help particles in water aggregate and become easier to remove throughout the treatment process. The outcomes showed that additional turbidity reductions in the water sample were achieved when the 20 mg/L concentration of Moringa oleifera solution was mixed with either alum or polyammonium chloride. This suggests that the treatment method was more effective when the coagulants and Moringa oleifera solution were combined. Water clarity increased as a consequence of the coagulants' probable synergistic effects with the Moringa oleifera solution, which encouraged the aggregation and settling of suspended particles

A water sample from the New Thebes City Water Station in Luxor, which had an initial turbidity of 50 NTU, was used for the experiment. To reach 50 NTU turbidity, it was necessary to add approximately 4 grams per liter of soil which is standard in water treatment studies for making synthetic turbid water (Ndabigengesere & Narasiah, 1998). The soil was sifted, completely dried and mixed evenly to ensure it could be replicated. I do not yet have details on how it was made, since it was originally gathered from local farmland topsoil. All chemical specifications and test procedures are now found together in the “Materials” and “Analytical Methods” sections. Moringa oleifera seeds were used in a range of concentrations (60, 50, 40, 30, 20, and 10 mg/L), and tests for turbidity, pH, bacterial count, total coliform, fecal coliform, iron, and manganese were conducted.

Table 1 provides information about various parameters measured in the turbid water sample, including turbidity, pH, total bacterial count, total coliform count, iron concentration, and manganese concentration. Turbidity is a measure of the cloudiness or haziness of the water, which is caused by suspended particles. the turbidity of the water sample is 50 NTU, the total bacterial count is 183 CFU/mL. Total coliform count is 41 CFU/100 mL. While, the fecal coliform count is 53 CFU/100 mL. Fe represents the concentration of iron in the water sample is 0.13 mg/L, which is below the recommended limit of 0.3 mg/L. The manganese concentration is 0.06 mg/L, which is below the recommended limit of 0.4 mg/L.

Table 1. The Properties Measured for Turbid Water Sample

	Unit	Turbid water sample	Limit
Turbidity	**NTU**	**50**	**<1**
PH	**PH**	**7.34**	**6.5-8.5**
Account bas	**cell/ML**	**183**	**50/ML**
T.CF	**cell/100ML**	**41**	**2/100ML**
F.CF	**cell/100ML**	**53**	**Empty**
Fe	**MG/L**	**0.13**	**<0.3**
Mn	**MG/L**	**0.06**	**<0.4**

To find out how well Moringa oleifera seeds treated water, this study conducted an experiment with varying doses of the seeds. A total of 60, 50, 40, 30, 20 and 10 mg/L were examined. To assess the effectiveness of the treatment, a number of water quality metrics were evaluated during the trial. Turbidity, pH, bacterial count, total coliform, faecal coliform, iron, and manganese were among these characteristics.

3 .Results and Discussion

The study looked at the effects of the Moringa oleifera solution alone as well as the effects of mixing its solution with two coagulants that are frequently used in water treatment procedures: polyammonium chloride and alum. Using coagulants is intended to help particles in water aggregate and become easier to remove throughout the treatment process. The outcomes showed that additional turbidity reductions in the water sample were achieved when the 20 mg/L concentration of Moringa oleifera solution was mixed with either alum or polyammonium chloride. This suggests that the treatment method was more effective when the coagulants and Moringa oleifera solution were combined. Water clarity increased as a consequence of the coagulants' probable synergistic effects with the Moringa oleifera solution, which encouraged the aggregation and settling of suspended particles. Six samples were tested for turbidity at different concentrations (10, 20, 30, 40, 50, and 60 mg/L) and reapated at least three time. The results values optained showed that the following order of substances caused the most turbidity at a concentration of 10 mg/L: alum, moringa, and polyammonium chloride. Furthermore, turbidity was higher when alum and Moringa oleifera were combined than when polyammonium chloride and Moringa oleifera were combined. Likewise, the following sequence of substances showed the highest turbidity at a concentration of 20 mg/L: moringa, alum, and polyammonium chloride. When alum and Moringa oleifera were combined, the turbidity was higher than when polyammonium chloride and Moringa oleifera were combined.

3.1 Effect on Turbidity

The order in which the maximum turbidity was seen at a concentration of 30 mg/L was moringa, alum, and finally the combination of alum and Moringa oleifera. Reduced turbidity was the outcome of both Moringa oleifera and polyammonium chloride. The highest turbidity was found at 40 mg/L for the following concentration order: moringa, polyammonium chloride, and alum. When alum and Moringa oleifera were combined, the turbidity was higher than when polyammonium chloride and Moringa oleifera were combined. The order in which the maximum turbidity was seen at a concentration of 50 mg/L was moringa, alum, and finally the combination of alum and Moringa oleifera. The turbidity of polyammonium chloride was lower than that of alum and Moringa oleifera. Finally, the highest turbidity was found at a concentration of 60 mg/L in the following order: moringa, alum, and finally, alum combined with Moringa oleifera. The turbidity of polyammonium chloride was lower than that of alum and Moringa oleifera as showing in Figure 3.

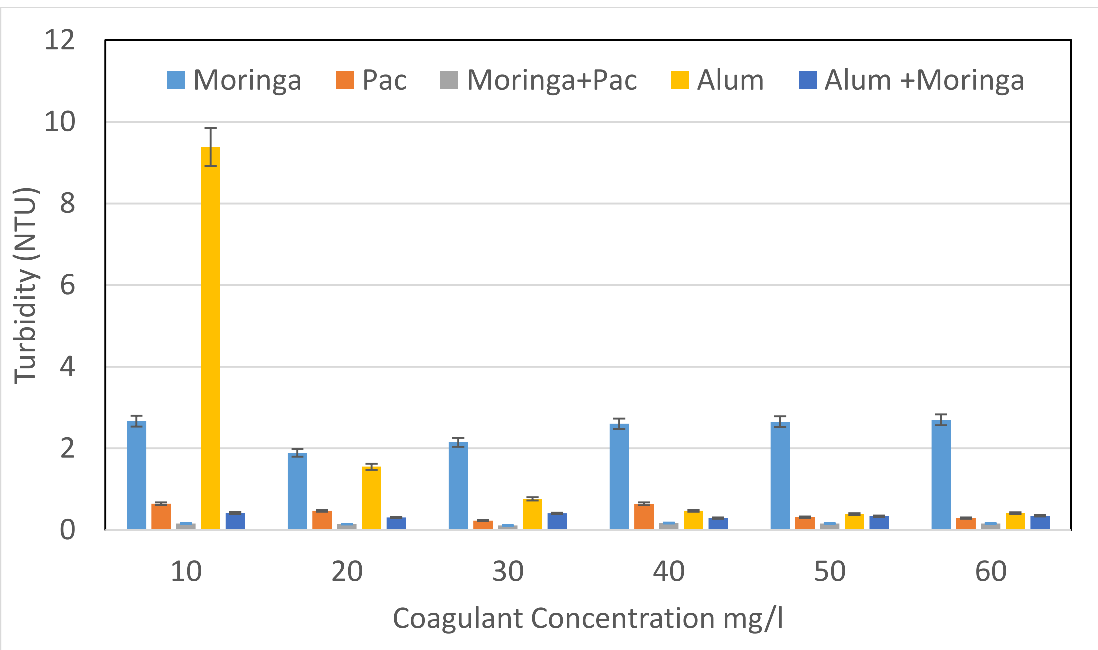

Fig 3. The turbidity results for different coagulants concentrations.

3.2 Effect on T.CF

Total coliform was measured, and the results for polyammonium chloride and Moringa oleifera at different concentrations were 0. Maximum counts of total coliform were noted at various alum concentrations: 10, 20, 30, 40, 50, and 60 mg/L as showing in Table 2. these show that when used alone, alum achieved the highest turbidity reduction (T.CF) effectiveness at all concentrations of polyammonium chloride (PAC) used. Results for alum alone showed a significant reduction in turbidity at all concentrations, with T.CF values remaining relatively high. Using Moringa alone showed a slight improvement in turbidity reduction at 10 mg/L, but its effect became very weak as the concentration increased. The Moringa-Alum combination showed a slight improvement in turbidity reduction compared to alum alone at 10 mg/L, but its effect became very weak as the concentration increased. The Moringa-PAC combination showed a slight improvement in turbidity reduction at 10 mg/L, but its effect became very weak as the concentration increased.

Table 2. The T.CF measured results for Moringa, Pac, Moringa with Pac, Alum, and Alum with Moringa.

Concentration mgl/l	T.CF				
	Moringa	Pac	Moringa+Pac	Alum	Alum+Moringa
10	16	13	0	39	11
20	15	2	0	35	9
30	6	0	0	33	4
40	6	9	0	31	4
50	3	0	0	21	2
60	12	0	0	30	7

3.3 Effect on total coliform counts

When measuring (T. Basic Calculation), the results showed that alum alone shows a significant decrease in turbidity at all concentrations, with T. Basic Calculation values remaining relatively high. While when using Moringa alone, it shows a slight improvement in reducing turbidity at a concentration of 10 mg/L, but its effect becomes very weak with increasing concentration. The combination of Moringa with alum or with PAC shows a slight improvement in reducing turbidity compared to alum alone at a concentration of 10 mg/L, but its effect becomes very weak with increasing concentration. The measurements for polyammonium chloride mixed with Moringa oleifera at concentrations of 10, 20, 30, 40, 50, and 60 mg/L were 3, 0, 3, 6, 5, and 2 as a result of the assessment of the total coliform levels. When alum was used, the highest total coliform counts at various doses were noted as showing in Table 3.

Table 3. The T.account bas measured results for Moringa, Pac, Moringa with Pac, Alum , and Alum with Moringa.

Concentration mg/l	T.account bas				
	Moringa	Pac	Moringa+Pac	Alum	Alum+Moringa
10	160	123	3	176	73
20	81	2	0	163	67
30	70	1	3	154	63
40	44	35	6	136	43
50	55	15	5	125	54
60	65	2	2	131	61

3.4 Effect on total coliform counts

After measuring the pH levels, the following results were obtained for the concentrations of alum (10, 20, 30, 40, 50, and 60 mg/L): 6.98, 7.2, 6.94, 6.88, 6.87, and 6.83. On the other hand, the pH levels that were found at various concentrations were connected to polyammonium chloride as showing in Figure 5 and Table 5. When measuring pH, the results showed that alum alone achieved a significant reduction in pH at all concentrations, with values remaining below 7.0 in all cases. While when using Moringa alone, a slight effect on pH was observed, with values remaining close to 7.5. However, when mixing Moringa with alum or with PAC, it showed a slight effect on pH, with values remaining close to 7.5 (See Table 4).

Table 4. The PH bas measured results for Moringa, Pac, Moringa with Pac, Alum, and Alum with Moringa.

concentration mgl/l	PH				
	Moringa	Pac	Moringa+Pac	Alum	Alum+Moringa
10	7.37	7.56	7.31	6.98	7.65
20	7.59	7.65	7.34	7.2	7.57
30	7.61	7.7	7.39	6.94	7.44
40	7.62	7.74	7.37	6.88	7.4
50	7.62	7.75	7.26	6.87	7.19
60	7.77	7.74	7.22	6.83	7.1

3.5 *Results of Iron, Manganese, and Fecal Coliform Concentration Measurements*

This study results show manganese (**MN**) measurements for a variety of substances (Moringa, Pac, Moringa with Pac, alum, and alum with Moringa) at different concentrations (10, 20, 30, 40, and 60 mg/L). For Moringa, the manganese values range from 0.018 to 0.013, decreasing as the concentration increases from 10 mg/L to 60 mg/L. For Pac, the values range from 0.031 to 0.064, with a slight increase in values as the concentration increases. For Moringa with Pac, the values range from 0.034 to 0.071, with varying patterns as the concentration increases. For Alum, the values range from 0.028 to 0.056, with a consistent increase in values as the concentration increases. For alum with Moringa, the values range from 0.029 to 0.066, with varying patterns as the concentration increases as showing in Table 5.

Table 5. The MN bas measured results for Moringa, Pac, Moringa with Pac, Alum, and Alum with Moringa

Concentration Mg/L	MN				
	Moringa	Pac	Moringa+Pac	Alum	Alum+Moringa
10	0.018	0.031	0.034	0.028	0.029
20	0.024	0.036	0.035	0.032	0.03
30	0.024	0.044	0.045	0.039	0.041
40	0.023	0.048	0.057	0.042	0.052
50	0.023	0.06	0.061	0.053	0.055
60	0.013	0.064	0.071	0.056	0.066

The results show the measurements of iron concentrations (**FE**) for a variety of substances (Moringa, Pac, Moringa with Pac, alum, alum with Moringa) at different levels (10, 20, 30, 40, and 60 mg/L). The range of values observed for Moringa suggests that the iron concentration remains constant at 0.02 mg/L for all tested doses. The range of readings for Pac is 0.03 to 0.02;

the iron concentration varies somewhat across the tested ranges. The range of readings for iron concentrations over the investigated levels can be seen in the Moringa with Pac values, which span from 0.02 to 0.05. Alum readings vary from 0.02 to 0.03; iron concentrations are consistently 0.02 mg/L at lower levels and somewhat higher at higher ones, at 0.03 mg/L. The Alum with Moringa readings shows a variety of iron concentrations across the tested levels, ranging from 0.02 to 0.04. These findings imply that the iron content changes according to the substance under investigation. While the concentration of Moringa remains constant, that of Pac and Alum varies slightly, and the mixture of the two substances (Moringa with Pac and alum with Moringa) displays a greater range of concentrations as showing in Table 6.

Table 6 The FE bas measured results for Moringa, Pac, Moringa with Pac, Alum and Alum with Moringa.

Concentration Mg/L	FE				
	Moringa	**Pac**	**Moringa+Pac**	**Alum**	**Alum+Moringa**
10	0.02	0.03	0.02	0.02	0.02
20	0.01	0.03	0.02	0.03	0.02
30	0.02	0.03	0.02	0.03	0.02
40	0.02	0.02	0.02	0.03	0.03
50	0.03	0.02	0.02	0.02	0.03
60	0.02	0.02	0.05	0.02	0.04

The results show the measures of fecal coliform (**F.CF**) concentrations for a variety of compounds (Moringa, Pac, Moringa with Pac, alum, alum with Moringa) at different levels (10, 20, 30, 40, and 50 mg/L). The fecal coliform concentration present during the usage of Moringa is indicated by the values, which range from 3 to 5. There is some fluctuation in the values among the tested levels. The data for Pac show the concentration of fecal coliform at the time of use, ranging from 6 to 0. There is diversity in the values throughout the tested levels as well. The results show that the combination of Moringa and Pac did not produce any detectable fecal coliform presence at any of the tested doses. The values for Moringa with Pac are consistently 0. The readings for alum, which show the concentration of fecal coliform when Alum was used, range from 48 to 29. With an increase in concentration, the values exhibit a trend toward decrease. The concentration of fecal coliform when Alum and Moringa were combined is indicated by values for Alum with Moringa, which range from 3 to 0. There is some fluctuation in the values among the tested levels. These findings imply that the various drugs' effects on the amount of fecal coliform vary. While there is considerable variance between Moringa and Pac, when Moringa and Pac are combined, there is no fecal coliform found. Fecal coliform concentrations are greater in Alum and get lower as the concentration rises. The fecal coliform content varies somewhat when Alum and Moringa (or Alum with Moringa) is combined. (See Table 7).

Table 7 .The F.CF bas measured results for Moringa, Pac, Moringa with Pac, Alum, and Alum with Moringa

Concentration mg/l	F.CF				
	Moringa	Pac	Moringa+Pac	Alum	Alum+Moringa
10	3	6	0	48	3
20	4	0	0	45	2
30	2	0	0	39	2
40	10	2	0	34	4
50	5	0	0	29	1
60	5	0	0	31	0

Based on the test results, Moringa oleifera added with PAC or Alum outperforms other systems by greatly enhancing the quality of water metrics such as turbidity, total and fecal coliform counts and concentrations of Mn and Fe. Treating drinking water with Moringa + PAC successfully removed all the fecal coliforms at 30 mg/L and greatly lessened turbidity (typically by more than 95%) while maintaining a near neutral pH. Our findings agree with those by Rai et al. (2022), who found that membrane filtration in combination with Moringa oleifera made coagulation more effective, reducing the amount of turbidity and harmful pathogens. They pointed out that Moringa oleifera has the potential to lower water turbidity by over 96% after treatment. Potential acceptance as a safe treatment confirms Moringa's better environmental properties than alum, based on the acidic effect and increased aluminum found in treated water by Tetteh and Rathilal (2021). In addition, adding Moringa to treated water with PAC or Alum played a role in decreasing iron and manganese, both important standards for drinking water. This research points out that Moringa-based hybrid coagulants are both efficient and environmentally friendly, so they are well suited to decentralized water treatment units in areas with few resources (See Table 8).

Table 8 The Comparison between current study and recently studies

Coagulant Treatment	Optimal Dosage (mg/L)	Turbidity Removal (%)	Fecal Coliform Removal (%)	pH Stability	Reference
Moringa + PAC	30	>95	100	Neutral	Current Study
Moringa + Alum	30	>90	100	Neutral	
Moringa oleifera	50	81.4	Not specified	Neutral	Abouzied et al., 2023
Moringa oleifera	50	96.2	Not specified	Neutral	Rai et al., 2022
Alum	20	~90	70	Acidic	Tetteh & Rathilal, 2021

4 Conclusion

This study sought to minimize turbidity, a critical measure of water purity, by figuring out the ideal concentration of Moringa oleifera solution for water treatment. In order to accomplish this, the researchers concentrated on utilizing the plant's seeds to create a Moringa oleifera solution. The seeds were deoiled and the husks removed before processing. A water sample from the New Thebes City Water Station in Luxor was used in the experiment; the water's original turbidity level was 50 NTU (Nephelometric Turbidity Unit). Several seed concentrations of Moringa oleifera (60, 50, 40, 30, 20, and 10 mg/L) were studied in order to evaluate the efficacy of the plant. Turbidity, pH, bacterial count, total coliform, fecal coliform, iron, and manganese were among the many characteristics that were assessed. The effects of employing polyammonium chloride and alum alone as well as in conjunction with the Moringa oleifera solution were also investigated in this investigation. The least amount of turbidity was produced by a minimum concentration of 20 mg/L of Moringa oleifera solution, according to the data gathered. When this concentration was mixed with either polyammonium chloride or alum, the turbidity was significantly reduced. These results suggest that Moringa oleifera can successfully increase water clarity and the water treatment process. The study's conclusions have a significant impact on how water is treated, especially in places with limited access to traditional chemical coagulants. It has been demonstrated that moringa oleifera seeds are a workable substitute for turbidity removal from water, which is necessary to provide safe and pure drinking water. Communities may be able to lessen their reliance on pricey and perhaps hazardous chemical coagulants by using this natural coagulant.

References

Amin, A. A., Soliman, H. A., & Hashem, K. S. (2022). Moringa oleifera seeds extract improves the quality of treated wastewater of Byad-Elarab plant, Beni-Suef, Egypt. Egyptian Journal of Chemistry, 65(132), 887-894.

Andrade, P. V., Palanca, C. F., de Oliveira, M. A. C., Ito, C. Y. K., & dos Reis, A. G. (2021). Use of Moringa oleifera seed as a natural coagulant in domestic wastewater tertiary treatment: Physicochemical, cytotoxicity and bacterial load evaluation. Journal of Water Process Engineering, 40, 101859.

Desta, W. M., & Bote, M. E. (2021). Wastewater treatment using a natural coagulant (Moringa oleifera seeds): optimization through response surface methodology. Heliyon, 7(11).

Diver, D., Nhapi, I., & Ruziwa, W. R. (2023). The potential and constraints of replacing conventional chemical coagulants with natural plant extracts in water and wastewater treatment. Environmental Advances, 100421.

Elsergany, M. (2023). The Potential Use of Moringa peregrina Seeds and Seed Extract as a Bio-Coagulant for Water Purification. Water, 15(15), 2804.

Gandiwa, B. I., Moyo, L. B., Ncube, S., Mamvura, T. A., Mguni, L. L., & Hlabangana, N. (2020). Optimisation of using a blend of plant based natural and synthetic coagulants for water treatment:(Moringa Oleifera-Cactus Opuntia-alum blend). South African Journal of Chemical Engineering, 34, 158-164.

Hoa, N. T., & Hue, C. T. (2018). Enhanced water treatment by Moringa oleifera seeds extract as the bio-coagulant: role of the extraction method. Journal of Water Supply: Research and Technology—AQUA, 67(7), 634-647.

Kusumawati, E., Widyanti, E. M., & Waluya, F. (2020, December). Production of Powdered Bio-coagulant from Moringa oleifera Seeds Using Vacuum Drying Method. In International Seminar of Science and Applied Technology (ISSAT 2020) (pp. 365-370). Atlantis Press.

Ng, M. H., & Elshikh, M. S. (2021). Utilization of Moringa oleifera as natural coagulant for water purification. Industrial and Domestic Waste Management, 1(1), 1-11.

Nimesha, S., Hewawasam, C., Jayasanka, D. J., Murakami, Y., Araki, N., & Maharjan, N. (2021). Effectiveness of natural coagulants in water and wastewater treatment.

Ojewumi, M. E., Alagbe, E. E., Abinusawa, A. P., John, A. N., Taiwo, S. O., & Bolade, O. P. (2021, February). Moringa oleifera as natural coagulant in water treatment and production of antifungal soap. In *IOP Conference Series: Earth and Environmental Science* (Vol. 655, No. 1, p. 012007). IOP Publishing.

Pandey, P., Khan, F., Mishra, R., & Singh, S. K. (2020). Elucidation of the potential of Moringa oleifera leaves extract as a novel alternate to the chemical coagulant in water treatment process. Water Environment Research, 92(7), 1051-1056.

Patchaiyappan, A., & Devipriya, S. P. (2022). Application of plant-based natural coagulants in water treatment. In Cost effective technologies for solid waste and wastewater treatment (pp. 51-58). Elsevier.

Shukla, P. (2016). Natural coagulants for water purification: an ecofriendly approach Word Journal of Pharmaceutical Research, 5(5), 1177-118

STEPHEN, A., & LAL, A. (2022). Phyto-Chemical Studies Of Moringa Oleifera L. Seeds As A Source Of Bio-Coagulant Agent For Water Purification.

Sudarmin, S., Kurniawan, C., Puji, N., & Nurul, I. (2019). The implementation of chemical project learning model integrated with Ethno-stem approach on water treatment topic using kelor (moringa oleifera) seed extract as bio-coagulant. KnE Social Sciences, 492-501.

Taiwo, A. S., Adenike, K., & Aderonke, O. (2020). Efficacy of a natural coagulant protein from Moringa oleifera (Lam) seeds in treatment of Opa reservoir water, Ile-Ife, Nigeria. Heliyon, 6(1).

Yamaguchi, N. U., Cusioli, L. F., Quesada, H. B., Ferreira, M. E. C., Fagundes-Klen, M. R., Vieira, A. M. S., ... & Bergamasco, R. (2021). A review of Moringa oleifera seeds in water treatment: Trends and future challenges. Process Safety and Environmental Protection, 147, 405-420.

Ndabigengesere, A., & Narasiah, K. S. (1998). Quality of water treated by coagulation using Moringa oleifera seeds. Water Research, 32(3), 781–791. https://doi.org/10.1016/S0043-1354(97)00295-9

Abouzied, A. H., et al. (2023). Applying Moringa oleifera Extract in Water Treatment as a Natural Coagulant to Remove Turbidity and Algae. Egyptian Journal of Aquatic Biology & Fisheries, 27(5), 1121-1131.

Rai, A., et al. (2022). A Synergistic Effect of Moringa oleifera-Based Coagulant and Ultrafiltration for the Wastewater Treatment. Journal of Environmental and Public Health, 2022, 1285011.

Tetteh, E. K., & Rathilal, S. (2021). Sustainable water purification using plant-based coagulants: A review. Environmental Technology Reviews, 10(1), 56–70.