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Moringa Oleifera Seed Powder as an Alternative to Alum Powder for Water Purification

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ABSTRACT

Clean water availability is a major issue, particularly in developing nations like Nigeria where chemical coagulants like alum render traditional treatment techniques unsuitable. The study evaluates the effectiveness of *Moringa oleifera* seed powder as a natural coagulant in comparison with alum powder for water purification. Specifically, it investigates the impact of varying dosages on physicochemical parameters (pH, turbidity), and microbiological quality (coliform reduction) of water sourced from Oganaji River, Ayingba, Kogi State.*Moringa oleifera* seed were obtained, the kernels were ground into a fine powder using a mortar and pestle and then sieved to a very fine powder. The efficacy of *Moringa oleifera* seed powder was verified by biochemical testing, including turbidity, jar, and pH tests. The loading doses of 0.4g/l, 0.6g/l, 0.8g/l, 1.0g/l, and 1.2g/l of the powder made from *Moringa oleifera* seed powder, Aluminum sulphate (alum) powder and control were used as coagulants. The best dosages for the coagulants were obtained by applying 1.2g/l of *Moringa oleifera* seed powder and alum powder treatments. The pH readings for alum were below the World Health Organization (WHO)'s permissible limit (acidic), whereas the pH values for *Moringa oleifera* seeds were between the recommended ranges. To ascertain the antibacterial efficiency, microbiological tests such total coliform counts were also carried out. *Moringa oleifera* seed powder is a valuable source for water purification (reducing waterborne bacterial disease) because it shows a notable decrease in coliform levels. A natural coagulant called *Moringa oleifera* seed powder may be a good alternative to alum powder in water treatment.

Keywords: *Moringa oleifera*, seed, Alum, Water, Coagulation

INTRODUCTION

Water is essential to human life, and since it directly affects health, the cleanliness of the water used is significant. One of the most fundamental human needs is a sufficient quantity of "clean" water. The importance of water purity for ecosystem and human health cannot be over-emphasized (Lin *et al*., 2022).

According to Tunggolu and Payus (2017), poorly treated water cause waterborne diseases that kill people every day while others suffer from its side effects. Waterborne illnesses are caused by harmful microorganisms that are directly transferred through tainted drinking water. To reduce the possible risk to public health, systematic monitoring of water quality is necessary. Therefore, it is important to treat drinking water to remove impurities and bacteria in order to meet the quality guidelines which satisfy 5 Nephelometric Turbidity Units (5NTU) for drinking water requirement according to (WHO, 2006).Water borne diseases are one of the major problems in developing countries, about 1.6 million people are compelled to use contaminated water and more than a million people (of which two million are children) die from diarrhea each year (Amagloh and Benang, 2009).

Despite the role of synthetic and inorganic coagulant in water purification, they are associated with several neurotoxic and carcinogenic effects due to the leftover residues left in the water such as Alum. (Abdulsalam *et al*., 2007). Aluminum sulphate also acidified water hence the use of plant based coagulant to replace synthetic coagulant. The organic (natural) coagulants are regarded to as safe for human. When compared to inorganic coagulants, *Moringa oleifera* seeds have been found to be the most effective natural coagulant for water purification (Ghebremichael *et al*., 2005). The seeds are harmless for the environment, very therapeutic, and biodegradable. Furthermore, the coagulation activity of the seed has been testified on industrial scale for industrial waste water treatment such as palm oil effluents (Pome) and has a high effluent reduction (Chaudhuri *et al*., 2009). In addition, *Moringa oleifera* seeds possess other effects such as antimicrobial, buffering capacity (Dalenn *et al*., 2009) and also contain natural antioxidant compounds which are essential to the human system (Mohammed and Faziah, 2015) *Moringa oleifera* powder has the capability of reducing low and high turbidity values in water (Blix, 2011). In order to ascertain the efficacy of *Moringa oleifera* seeds as a natural coagulant for water filtration, this study was conducted. The goals are to assess and compare the performance and efficacy of *Moringa oleifera* seed powder as an alternative to alum in water treatment, review the ideal coagulant dosage using the Jar test, assess the pH of water treated with *Moringa oleifera* seed and alum, and perform a bacterial examination on the water treated with *Moringa oleifera* and alum.

MATERIALS AND METHODS

Sample Collection and Preparations

500ml of Water fetched from Oganaji River in Ayingba Kogi State was dispensed into 5 beakers. Each beaker held 100 milliliters of the sample. Weighing 0.4, 0.6, 0.8, 1.0g, and 1.2g of *Moringa oleifera* seed powder and alum individually into a beaker with 100 ml of distilled water allowed us to generate five different quantities of the stock solutions for the loading dose. To get a clear solution, the liquids in the beakers were agitated with a glass rod. The control was 100 milliliters of distilled water devoid of alum and *Moringa* powder. (Muhammed *et al*., 2018). The seeds of *Moringa oleifera* were obtained from fruits. After the fruits were picked, they were cracked to extract the seeds, which were then allowed to air dry for three days. Similar to the alum, the kernels were ground into a fine powder using a mortar and pestle and then sieved to a very fine powder using a sieve with a size of 2.5 mm2. The powder was kept at room temperature in a sterile bottle. Petroleum ether was used to extract the powdered sample. 250 milliliters of petroleum ether were used to soak

50 grams of powdered *Moringa oleifera* seed. It was kept for 48hrs (2 days) and oven-dried Beakers, Petri plates, and reagent vials were sterilized in a hot oven box at 160℃ for an hour. Glassware such as test tubes and conical flasks were autoclaved for 15 minutes at 121℃ to disinfect them. Before being used, inoculating loops were disinfected by being heated to red hot in a gas flame and then cooled.

Turbidity Test
This was done using a direct reading spectrometer on the supernatants that were left over after the treatments were added to the beakers holding the pond water. First, a 25 ml cuvette was filled with distilled water and placed inside the spectrophotometer. The instrument was calibrated after pressing the calibration button. A 25 ml cuvette was filled with each sample that needed to be read, and it was then placed inside the spectrophotometer. The device's LCD panel showed the samples' turbidity in Nephelometric Turbidity Units (NTU). Before using the spectrophotometer on the subsequent sample, it was calibrated once more using distilled water following each reading (Raja *et al*., 2019).

Jar Test
A beaker with 1000 ml of water was filled with 3 ml of each of the different concentrations, including the control of all the loading dosages created. To help with coagulant production, the solutions were quickly mixed for two minutes and then gently mixed for ten minutes with a glass rod. For one hour, the suspensions were not disturbed. Since there is no set procedure for doing the jar test, this is the approach used. After being decanted, the resulting supernatants were tested for turbidity and pH (Amagloh and Benang, 2009).

pH Test
A calibrated Crison pH meter Basic C20 was used to determine the sample's pH. Making ensuring the pH meter probe did not come into contact with the beaker, it was placed into the beakers holding the treatment and the control. Once it had stabilized, the pH reading was obtained from the LCD display (Naceradska *et al*., 2019).

Microbiological Analysis of Samples
250mls of the sample of Oganaji River water collected was dispensed into 3 bottles each. The bottles were labeled sample *Moringa oleifera* seed powder ,Aluminum sulphide (Alum) and Control was not treated with neither *Moringa oleifera* seed powder nor Aluminum sulphide (Alum) powder and left for 48hrs (2 Days).The samples were analyzed and submitted for bacteriological test. Samples were diluted ten-fold (serial dilution) until dilution 10^{-6} was obtained. 1ml of 10^{-5} and 10^{-6} of the dilutions were inoculated into Nutrient media (containing *Moringa oleifera* seed powder), MacConkey Agar (Aluminum sulphide (Alum) and Eosin Methylene blue (containing Control) in petri-dishes and labeled appropriately. After allowing the infected media to solidify, the plates were incubated for 24 hours at 35℃. After a 24 hours incubation period, Colony Forming Units (CFU/mls) on Nutrient Agar and MacConkey Agar were counted.Gram staining was carried out for microscopic identifications. Hekton enteric agar, MacConkey Agar, Eosin methylene blue agar, and selective and differential media were subcultured for further identification (Delelegn *et al*., 2018).

Biochemical Characterization
Catalase test, Citrate utilization test, Triple sugar iron agar test, Gas formation test and Hydrogen sulphide test were conducted to presumptively identify the bacterial colonies.

Catalase Test: The slide agglutination method was adopted for the catalase test. A 24 hours old culture of the test bacterium was combined with a drop of hydrogen peroxide (H_2O_2) on a wire loop. A favorable response was shown by the bubbles that emerged from the culture.

Citrate Utilization Test: By streaking the slope, the test isolates were introduced into Simon citrate agar slants. After being inoculated, tubes were incubated at 35℃ for 48 hours. A favorable response was signified by the medium changing from green to blue.

Triple Sugar Iron Test: The triple sugar iron test agar was prepared as agar slants for test for the utilization of sucrose, glucose and lactose. The formation of gas and hydrogen sulphide production by the bacteria isolates were streak on the slope and stabbed in the bolt. Reactions were observed after 48 hours inoculation. The colour of the slope and bolt were recorded. Gas formation was noted by the presence of cracks and bubbles in the tubes and blackening of the medium was an indication of hydrogen sulphide production.

Statistical Analysis
Samples were subjected to one-way Analysis of Variance (ANOVA) to determine significant differences among the different concentrations of *Moringa oleifera* seed powder and alum powder. Means were separated using Duncan's Multiple Range Test (DMRT) at a 95% confidence level ($p < 0.05$).

RESULTS AND DISCUSSION
Turbidity Level of *Moringa oleifera* seed Powder as Coagulant
Table 1 presents the turbidity level decreased when the concentration of *Moringa oleifera* seed powder was raised from 0.4g/l to 0.6g/l.

Table 1: Effectiveness of the Different *Moringa Oleifera* Seed Powder Concentrations on the Turbidity Level

***Moringa oleifera* seed powder Concentrations**	**Turbidity (NTU)**
0.4g/l	325.00 ± 2.00^{d}
0.6g/1	348.00 ± 1.00^{e}
0.8g/1	288.00 ± 1.50^{c}
1.0g/1	277.50 ± 0.50^{b}
1.2g/1	245.00 ± 0.50^{a}

Values are Mean ± SD, Values with different superscript letter down the column are significantly different at $p < 0.05$ using Duncan Multiple range test (DMRT)

Turbidity Level of Alum Seed Powder as Coagulant
The turbidity level decreased when the alum concentration was raised from 0.4g/l to 0.6g/

Table 2: Effectiveness of the Different Alum Powder Concentrations on the Turbidity Level

Alum powder Concentrations	Turbidity (NTU)
0.4g/l	33.50 ± 0.50^{e}
0.6g/l	32.50 ± 0.50^{d}
0.8g/l	25.50 ± 0.50^{c}
1.0g/l	22.50 ± 0.50^{b}
1.2g/l	19.50 ± 0.50^{a}

Values are Mean ± SD, Values with different superscript letter down the column are significantly different at p <0.05 using Duncan Multiple range test (DMRT)

Effectiveness of *Moringa oleifera* seed powder and Alum powder

Table 3 compares the effect of the different concentrations of *Moringa oleifera* seed powder on the turbidity level and concentrations of alum powder on the turbidity level.

Table 3: Comparison of the Effectiveness of *Moringa Oleifera* Seed Powder and Alum Powder Concentrations

Concentrations	*Moringa oleifera* seed powder	Alum powder	p-value	Remarks
0.4g/l	325.00 ± 2.00^{b}	33.50 ± 0.50^{a}	0.000	S
0.6g/l	348.00 ± 1.00^{b}	32.50 ± 0.50^{a}	0.000	S
0.8g/l	288.00 ± 1.50^{b}	25.50 ± 0.50^{a}	0.000	S
1.0g/l	277.50 ± 0.50^{b}	22.50 ± 0.50^{a}	0.000	S
1.2g/1	245.00 ± 0.50^{b}	19.50 ± 0.50^{a}	0.000	S

Values are Means ±SD, Values with same superscript across the rows are significantly different (P>0.05) using independent Sample t-test

pH Values of *Moringa Oleifera* Seed Powder and Alum Powder Concentrations

Alum powder produce variations in the pH values obtained and the degree of acidity rose as the concentration of alum powder increased, with 1.2g/l of alum yielding 3.40 pH values when the pH rises as the concentration of *Moringa oleifera* seed powder increases, the opposite is seen.

Table 4: Comparison of the pH Values of *Moringa Oleifera* Seed Powder and Alum Powder Concentrations

Concentrations	*Moringa oleifera* seed powder	Alum powder	p-value	Remarks
0.4g/l	6.00 ± 0.10^{b}	3.50 ± 0.10^{a}	0.001	S
0.6g/l	6.40 ± 0.15^{b}	3.50 ± 0.10^{a}	0.002	S
0.8g/l	6.30 ± 0.13^{b}	3.60 ± 0.10^{a}	0.001	S
1.0g/l	6.40 ± 0.14^{b}	3.50 ± 0.12^{a}	0.001	S
1.2g/l	6.50 ± 0.20^{b}	3.40 ± 0.10^{a}	0.001	S

Values are Means ±SD, Values with different superscript across the rows are significantly different (P>0.05) using independent Sample t-test.

Bacterial Count in the Treated Water Samples and Control

Table 5 illustrates bacterial (colony) count in the treated water samples and control after incubation. *Moringa oleifera* seed powder has lesser colony counts on the two growth Medias of Nutrient agar and MacConkey agar. Control has higher colony counts on the growth Medias. This suggests the effectiveness of *Moringa oleifera* seed powder in the removal of bacteria in water.

Table 5: Bacterial Count in the Treated Water Samples and Control

Samples	Nutrient Agar (CFU/ml)	MacConkey Agar (CFU/ml)
Moringa oleifera seed powder	$1.9*10^{6}$	$6.0*10^{4}$
Alum powder	$3.2*10^{5}$	$2.6*10^{5}$
Control	$8.43*10^{5}$	$8.29*10^{5}$

Cultural and Biochemical Identification of Microorganisms in the Samples

Table 6 illustrate the different tests conducted (catalase test, Citrate test, Triple sugar iron test, Gas formation test, Hydrogen sulphide production test, the physical characteristics and various presumptive organisms identified. Three presumptive organisms were identified in *Moringa oleifera* seed powder. Three presumptive organisms were identified in sample Alum powder. Eight presumptive organisms were found in sample Control. This shows the effectiveness of *Moringa oleifera* seed powder compared to alum powder in the removal of bacteria in water.

Table 6: Cultural and Biochemical Identification of Microorganisms in the Samples

Samples	Gram's Reaction	Morphology	Catalase Test	Citrate Test	Triple Sugar Iron Test	Gas Formation	Hydrogen Sulphide production (H2S)	Presumptive organism identified
Moringa oleifera seed powder								
Isolate 1	+	Fat rods	+	+	-	-	-	*Bacillus spp*
Isolate 2	+	Long rods	+	-	+	-	-	*Lactobacillus spp*
Isolate 3	-	Cocci chain	+	+	+	+	-	*Escherichia spp*
Alum powder								
Isolate 1	+	Cocci cluster	+	+	+	+	-	*Enterococcus spp*
Isolate 2	+	Rods with central	+	+	-	-	-	*Bacillus spp*
Isolate 3	-	Cocci chain	+	+	+	+	-	*Escherichia spp*
Control								
Isolate 1	-	Cocci	+	-	+	+	+	*Salmonella spp*
Isolate 2	+	Slender rods	+	-	-	-	-	*Bacillus spp*
Isolate 3	-	Cocci chains	+	+	+	-	-	*Escherichia spp*
Isolate 4	+	Fat rods	+	+	-	-	-	*Bacillus spp*
Isolate 5	+	Long rods	+	-	+	-	-	*Lactobacillus spp*
Isolate 6	-	Cocci	+	+	+	-	-	*Pseudomonas spp*
Isolate 7	-	Cocci	+	+	-	+	+	*Shigella spp*
Isolate 8	+	Diplococci	+	+	+	-	-	*Micrococcus spp*

+= Present -=Absent

Discussion

Moringa oleifera seed powder has proven to be a potent natural coagulant, capable of enhancing key water quality parameters. Its application contributes to improvements in physicochemical properties such as pH balance, turbidity reduction, and microbial control, making it a valuable alternative in water treatment practices.

According to the study *Moringa oleifera* seed powder works well as a coagulant to remove bacteria from water and raise pH levels. (Ali *et al*., 2018). *Moringa oleifera* kernel extracts have the potential to remove turbidity, according to earlier studies (Gaikwad and Munavalli, 2019; Ayegba *et al*., 2023) *Moringa oleifera* seeds can lower high turbidity because they contain an active bio-coagulation ingredient (Hamid *et al*., 2014). It was shown that when coagulant dosages rose, turbidity removal effectiveness gradually increased. The turbidity unit exceeded the 5 Nephelometric Turbidity Unit (5NTU) permissible limit threshold. Re-suspended bottom sediments may be the cause of the increased turbidity. This could be explained by the flocculants' free positioning charged molecules repelling one another, which causes the flocs to float or suspend in the water (WHO, 2008;WHO 2016).

However, because aluminum sulphate shows more suspended bottom particles than *Moringa oleifera* seed powder, it was a better purifier (in terms of turbidity levels).

The turbidity level decreased when the concentration of *Moringa oleifera* seed powder was raised from 0.4g/l to 0.6g/l. Similarly, the turbidity level decreased when the alum concentration was raised from 0.4g/l to 0.6g/l. In other words, increase in concentration results in decrease in the turbidity levels. The concentration at1.2g/l had the lowest turbidity levels for both. World Health Organization's (WHO) recommended pH range for drinking water is 6.0-8.5. Because the coagulant consumes alkalinity during hydrolysis, the pH of aluminum sulphate is below the allowed range for drinking water. The results are consistent with Liberty and Taurai (2015) assertion that aluminum sulphate is more acidic. These studies suggest that employing alum powder produce variations in the pH values obtained and the degree of acidity rose as the concentration of alum powder increased, with 1.2g/l of alum yielding 3.40 pH values (which are severely acidic).When the pH rises as the concentration of *Moringa oleifera* seed powder increases, the opposite is seen. It works because the seed powder contains water-soluble cationic proteins. The pH values of 6.00, 6.40, 6.30, 6.40, and 6.50 that were obtained are within the acceptable range for drinking water. The ideal dosage is 1.2g/l at a pH of 6.50.

Moringa oleifera seed powder and alum powder had lower bacterial counts in the water samples, while the control had greater bacterial counts. The antibacterial properties of *Moringa oleifera* seed powder have been demonstrated. The antibacterial qualities of *Moringa oleifera* seed powder were verified by Ferreira *et al*. (2011). Microorganism growth was inhibited by alum and powdered *Moringa oleifera* seeds. Three presumed microorganisms were detected in the powdered *Moringa oleifera* seeds, three in the powdered alum, and eight in the control. This demonstrates that *Moringa oleifera* seed powder is more effective than alum at eliminating bacteria.

CONCLUSION

Moringa oleifera seed powder is an effective natural coagulant which can be used in improving the physicochemical properties of water such as pH, turbidity and microbiological characteristics. The study revealed that the powder from seed of *Moringa oleifera* seed powder contains some coagulating properties with optimal dosage of 1.2g/l. *Moringa oleifera* seed powder present available alternative coagulant to alum in treating water for people since it is

environmentally friendly and cheaper. It is sustainable, appropriate, effective water treatment means.

i. Powder proportion studies should be conducted to establish their effectiveness in treating water.
ii. Further research on coagulation is necessary to identify the elements responsible for the process, with the aim of extracting them for use in the production of water guard.
iii. Exploration of plant-based coagulants should be expanded to discover additional natural alternatives for water treatment.
iv. *Moringa oleifera* seed powder in water purification is recommended due to its promising potential.
v. A combination treatment of alum and *Moringa oleifera* in continuous flow form is recommended as a practical approach for future water treatment applications.

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