



Original Research Article

Effect of *Moringa Oleifera* as a Natural Coagulant in Treatment of Water

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Abstract: Access to adequate clean water is a global challenge, particularly in developing countries where rural populations rely on water from rivers, dams and streams that may contain pathogenic and toxic materials. This research investigates the effect of *Moringa oleifera* seeds as a natural coagulant in treatment of water. The experimental procedure involved preparing *M. oleifera* seeds solution at varying concentrations, identifying the optimal dosage (120 mg/L) based on the earliest flocculation and sedimentation after 30 minutes. Physico-chemical parameters were analyzed using standard methods, and data from Atomic Absorption Spectroscopy (AAS) were analyzed using t-test with a significance level of $p \leq 0.01$. Two-way ANOVA was applied to assess significant differences ($p < 0.05$) among the physico-chemical parameters. The results show significant reductions in electrical conductivity from (54.4 $\mu\text{S}/\text{cm}$ to 53.4 $\mu\text{S}/\text{cm}$), turbidity from (11.34 NTU to 8.45 NTU), total suspended solids (TSS) from (0.867 mg/L to 0.821 mg/L), total dissolved solids (TDS) from (198.6 mg/L to 196.3 mg/L), and chloride levels from (178.54 mg/L to 167.34 mg/L). The treatment also demonstrates selective effects on metal levels, significantly increasing Chromium concentrations (0.06 $\pm$ 0.01) to (0.27 $\pm$ 0.21), Nickel concentrations (0.38 $\pm$ 0.02) to (0.48 $\pm$ 0.02) while significantly reducing Copper levels (0.03 $\pm$ 0.20) to (0.013 $\pm$ 0.00) and having no significant effect on Cadmium and Cobalt levels. These findings suggest that the treatment process is effective in reducing heavy metal concentration in contaminated water and improving water quality. Further studies should explore the effectiveness of *M. oleifera* in combination with other coagulants to enhance its ability to remove broader range of heavy metals.

Keywords: *Moringa Oleifera*, Coagulant, Water, Treatment, Heavy Metals.

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INTRODUCTION

M. oleifera is native from India and adapted in tropical countries, *M. oleifera* is a medium-sized plant, resistant to water crises and productive throughout the year. This plant has several applications in pharmaceutical, cosmetics and food nutrition industries due to its properties. However,

for many years, several studies have been investigating the potential of its seeds and seed husks in drinking water treatment. (Gashi *et al.*, 2018; Ndabigengesere and Subba, 2016). The tree itself is very thin, with drooping limbs, and reaches a height of around 10m. To ensure that the pods and leaves are still within reach, it is normally pruned down

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yearly to a height of one meter or less and left to re-grow. *Moringa ceae* is a single genus family with 14 known species, the most popular and frequently utilized of these is *Moringa oleifera* Lam (syn).

M. oleifera originated from the sub-Himalayan areas of north-western India; today a native of many countries in Africa, Arabia, South East Asia, the Pacific and Caribbean Islands, and South America. *M. oleifera* is also called as "Zogale" in Northern Nigeria, which reflects the tree's significance around the globe. Coagulation/flocculation is the most investigated process involving the use of MO seeds, as results showed that it is a natural coagulant with high efficiency, low cost and environmentally friendly. However, in recent years, studies have been increasingly intensified to mainly understand how the coagulation mechanism occurs, identify the proteins that are coagulating agents, and isolation techniques. Moreover, new methods have been evaluated to enhance the removal of contaminants in coagulation/flocculation, such as functionalization with nanoparticles (Baptista *et al.*, 2015).

Due to the wide application of *M. oleifera* seeds for the above process, the other parts can be considered as waste; disposed of in landfills. In this sense, some studies report the use of these materials for other types of water treatments, such as adsorption, which report their use *in natural* and chemically or thermally modified to remove emerging pollutants, among them; heavy metals, dyes, pesticides, drugs among others. Many studies presented good removal of these pollutants, making *M. oleifera* an interesting precursor for the development of an adsorbent technology (Sulaiman *et al.*, 2019). The study was aimed to ascertain the effect of *Moringa oleifera* seeds as natural coagulant in the treatment of water.

MATERIALS AND METHODS

Study Area

This research was conducted at the Laboratory of Biological Sciences department of Federal University Gusau, Zamfara State, Nigeria. Gusau is located in the northwestern part of Nigeria, between latitude 12°10'12.18"N and longitude 60°39'50.83"E. The average temperature in Gusau ranges from 58°F to 100°F and is rarely below 54°F or above 105°F and annual rainfall of 868mm.

Collection and Preparation of Sampling Materials

The moringa seeds were collected from Nagwamatse Farm Limited in Gusau, Zamfara State, Nigeria. The raw water sample to be used for this experiment was collected from the Gusau Barrage, Zamfara State, Nigeria.

Preparation of Coagulant

Adopting the method of Ndabigengesere and Narasiah (1998), *M. oleifera* seeds were obtained and the seed pods were allowed to dry properly. Mature seeds that show no signs of discoloration, softening, or extreme desiccation were used. First, the seed coating was removed, and then the seed kernels were grounded into a fine powder using a mortar and pestle. The powder was then sieved through a 60-micrometer stainless steel sieve. The ground *Moringa oleifera* seed powder was used to prepare a stock solution for the treatment of the raw water.

Experimental Procedure

One gram (1g) of the seed powder of *Moringa oleifera* was weighed and transferred quantitatively into a 1000ml flask. Distilled water was then added to the flask, making it up to the mark, and it was vigorously shaken for 10 minutes. Next, five different clean beakers labeled A to E were placed on a working desk. Doses of 60, 90, 120, 150 and 180mg of the stock solution were measured and transferred into each respective beaker. Each beaker was made up to 1000ml with the water sample collected and they were placed on a mechanical shaker. The mechanical shaker was turned on and it performed a quick mixing for 1 minute at a speed of 120rpm, followed by a slow mixing for 15 minutes at 30rpm. Then, the optimum dosage of the sample that started flocculating and settling first among the labeled samples A to E after 30 minutes was recorded. The coagulation took place, and the precipitate settled at the bottom, leaving a transparent medium at the top due to the pressure of a water-soluble cationic coagulant protein. The transparent medium of the most optimally purified water at a dosage of 120 mg/L was transferred into a plastic container for further analysis.

Digestion Process

The transparent medium of the most optimally purified water at a dosage of 120 mg/L was transferred into a plastic container. A certain volume of nitric acid was added to the purified water, stirred thoroughly. Afterward, the container was placed on a hot plate and brought to a boil. Once boiled, it was allowed to cool down before filtering. The purified water was filtered using filter paper and taken for further or direct analysis.

Physico-Chemical Parameters

pH Test:

pH meter was calibrated and the electrode was inserted into the water samples in a beaker. When inserting the pH meter into the beaker, it was not allowed to touch the bottom of the beaker and was at the middle.

Determination of Electrical Conductivity (EC):

The conductivity meter cell was rinsed with one or more portions of sample. The temperature was adjusted to $25.0 \pm 0.1^\circ\text{C}$. Sample resistance was measured and the resistance or conductivity and the temperature was noted (WHO, 2007).

Determination of Total Suspended Solids (TSS):

A filter paper was dried, weighed until a constant weight was obtained. Then a 100/ml of water sample was measured and filtered through the paper (using conical flask and a funnel in which the filter paper was folded into the funnel) then the filter paper was dried at 105°C to constant weight, then the difference between initial and final weight was calculated and recorded. (WHO, 2007).

Total Dissolved Solids (TDS):

TDS was measured using a sensitive analytical balance to weigh residual dissolved solids from the water sample after filtration.

Turbidity:

The sample was shocked thoroughly, until air bubbles disappeared, and the sample was poured into a turbidimeter tube and was immersed in an ultrasonic bath for 1 to 2 seconds to ensure complete bubble release. A dilute sample with one or more volumes of turbidity-free water was seen until turbidity falls between 30 to 40 NTU, which was read directly from the scale (FAO 1997). Nephelometric turbidity units (NTU) Where: $A \times (B \times C)$
A= NTU found in diluted sample
B= Volume of dilution of water, ml
C= Sample volume taking for dilution

Temperature:

The thermometer was placed into each bottle of water that was collected at the various locations and each reading was taken at the point of collection.

Determination of Chloride:

Water of about 20 ml was transferred into a conical flask and 3 drops of potassium chromate was added in which a yellow coloration was obtained. It was titrated with, 0.1 molar (M) silver nitrate (AgNO_3) solution until a pink color endpoint was reached, noted and recorded (FAO, 1997).

Total Hardness:

A sample of about 50 ml was diluted with distilled water in a conical flask. 1ml of buffer solution, and Eriochrome black "T" indicator solution of 1 to 2 drops was added. A standard EDTA was

titrated slowly with continuous stirring until a reddish tinge disappeared from the solution, adding the last few drops at 3 to 5 seconds interval, the end point was blue under normal conditions (FAO, 1997).

Alkalinity by Indicator Method:

An undiluted 100ml sample of each of the water was transferred into an Erlenmeyer flask, while drops of phenolphthalein were added. It was titrated with standard acid solution while stirring to end point was recorded as P= (P= titration to pH 8.3 in ml). According to (7), drop of the methyl orange indicator solution were titrated to end point until the color changed to red wine (at pH 4.5). Where N= Normality of HCL (0.1 N) used.

Determination of Chloride:

Water of about 20ml was transferred into a conical flask and 3 drops of potassium chromate was added in which a yellow coloration was obtained. It was then titrated with, 0.1molar (M) silver nitrate (AgNO_3) solution until a pink color endpoint was reached, noted and recorded, (FAO, 1997).

Determination of Salinity:

A conductivity meter was used to measure the water's quality to conduct electricity, which correlates to the concentration of dissolved salts. The salinity was calculated using the formula:
 $\text{Salinity mg/L} = \text{KE} \times \text{EC}$

Where KE was the correlation factor (typically 0.55 to 0.8) and EC was the conductivity in μS .

Data Analysis

Atomic Absorption Spectroscopy (AAS) analyzed data were determined using a t-test. A P-value of ≤ 0.01 was considered as statistically significant. Two-way analysis of variance (ANOVA) was used to analyze the physico-chemical parameters results for significant difference ($p < 0.05$) between the means.

RESULTS

The physicochemical parameters of water sample (Raw and Treated water) is presented in Table 1, it was observed that the physic-chemical levels of raw water of pH EC, TSS, TDS, turbidity, temperature, chloride and hardness are all higher than purified water except Alkalinity which value of (21.23 ± 4.54) in purified water higher than raw water (21.23 ± 4.54) . Also, all the parameters are within the acceptable limit of WHO.

Table 1: Physico-chemical parameters of water sample (Raw and Treated water)

Parameters	Raw water (Mean $\pm$ SD)	Treated water (Mean $\pm$ SD)	WHO (2020)
pH	5.98 $\pm$ 0.14	5.91 $\pm$ 0.12	6.5-8.5
EC (μ S/cm)	54.4 $\pm$ 2.34	53.4 $\pm$ 3.54	1000
TSS (mg/l)	0.867 $\pm$ 0.23	0.821 $\pm$ 0.15	N/G
TDS (mg/l)	198.6 $\pm$ 6.98	196.3 $\pm$ 7.34	1000
Turbidity (NTU)	11.34 $\pm$ 0.79	8.45 $\pm$ 0.67	5
Temperature ($^{\circ}$ C)	28.66 $\pm$ 2.64	27.20 $\pm$ 2.45	N/G
Chloride (mg/l)	178.54 $\pm$ 14.32	167.34 $\pm$ 12.43	250
Hardness (mg/l)	8.45 $\pm$ 2.23	5.88 $\pm$ 1.08	100-500
Alkalinity (mg/l)	18.34 $\pm$ 0.38	21.23 $\pm$ 4.54	N/G
Salinity (mg/l)	41.55 $\pm$ 2.49	41.39 $\pm$ 2.48	600

TDS = Total dissolve solids, EC= Electrical conductivity, Temp. = Temperature, TSS= Total dissolve solid, NG= Not given, SD= Standard deviation

The heavy metals concentrations are presented in Table 2. The increase before the administration of treatment of Cadmium changing from (0.03 $\pm$ 0.01) to (0.04 $\pm$ 0.01) and Cobalt from

(0.16 $\pm$ 0.04) to (0.19 $\pm$ 0.01) respectively. But the increase was highly significant from Chromium to Nickel at $P \leq 0.01$.

Table 2: Heavy Metals Concentrations (Mean $\pm$ SD) in raw and treated water

Treatment	Cd	Co	Cr	Cu	Ni
Raw	0.03 $\pm$ 0.01	0.16 $\pm$ 0.04	0.06 $\pm$ 0.01	0.03 $\pm$ 0.20	0.38 $\pm$ 0.02
Treated	0.04 $\pm$ 0.01	0.19 $\pm$ 0.01	0.27 $\pm$ 0.21	0.013 $\pm$ 0.00	0.48 $\pm$ 0.02
p-value	0.442	0.214	0.01	0.01	0.01

$P \leq 0.01$ Cd (Cadmium), Co (Cobalt), Cr (Chromium), Cu (Copper), Ni (Nickel)

DISCUSSION

The electrical conductivity of treated water (53.4 μ S/cm) is lower than that of raw water (54.4 μ S/cm). This reduction indicates a decrease in the Lower EC values, often associated with improved water quality, as they suggest reduced salinity and contamination levels concentration of dissolved ions, which is a positive outcome of the purification process. Both treated water (pH 5.91) and raw water (pH 5.98) are slightly acidic, which is consistent with natural water bodies. Importantly, both values fall within the acceptable range (6.5-8.5) established by the World Health Organization (WHO, 2020). The slight difference in pH suggests that the purification process does not adversely affect the acidity of the water. The purification process effectively reduces TSS from 0.867 mg/l in raw water to 0.821 mg/l in treated water. Similarly, TDS levels decrease from 198.6 mg/l in raw water to 196.3 mg/l in purified water. Turbidity is significantly lower in treated water 8.45 NTU compared to raw water 11.34 NTU. This reduction in turbidity is critical, as high turbidity can harbor pathogens and reduce the effectiveness of disinfection processes. According to (El-Geed and Abdulsalam, 2023), the turbidity dropped from 3.32 NTU to 2.47 NTU after treatment with a dose of 120 mg/L of *M. oleifera* seed powder. The slight increase in temperature of raw water (28.66 $^{\circ}$ C) compared to treated water (27.2 $^{\circ}$ C) may be attributed to

environmental factors such as exposure to sunlight and ambient conditions. While this difference is minor, it is important to monitor temperature, as it can influence chemical reactions and biological activity in water. Chloride concentrations are higher in raw water (178.54 mg/l) than in treated water (167.34 mg/l), suggesting that the purification process effectively reduces chloride levels, which can contribute to taste and health issues at elevated concentrations. Similarly, hardness is reduced from 8.45 mg/l in raw water to 5.88 mg/l in treated water, indicating successful removal of calcium and magnesium ions, which can cause scaling and affect water quality.

Alkalinity is higher in treated water (21.23 mg/l) compared to raw water (18.34 mg/l). This increase suggests that the purification process may enhance the buffering capacity of the water, which is beneficial for maintaining stable pH levels in various applications, including drinking water and aquatic ecosystems. The salinity levels of both water types are nearly identical, with treated water at 41.39 mg/l and raw water at 41.55 mg/l. This indicates that the purification process does not significantly alter salinity. The treatment had varying effects on the metal levels. For Cadmium and Cobalt, the increases observed after treatment were not statistically significant ($P > 0.05$), with Cd levels changing from (0.03 $\pm$ 0.01) to (0.04 $\pm$ 0.01) and Co levels increasing

from (0.16 ± 0.04) to (0.19 ± 0.01) respectively. The treatment had a significant impact on Chromium, Copper, and Nickel levels ($P \leq 0.01$). Cr levels increased from (0.06 ± 0.01) to (0.27 ± 0.21) , indicating a strong positive effect of the treatment on chromium concentration. Cu levels decreased significantly from (0.03 ± 0.20) to (0.013 ± 0.00) , suggesting that the treatment effectively reduced Copper levels. Ni levels also increased significantly from (0.38 ± 0.02) to (0.48 ± 0.02) , further demonstrating the treatment's ability to enhance Nickel concentrations. In summary, the findings of this study demonstrate that the purification process effectively improves the physico-chemical properties, making it more suitable for human consumption. All measured parameters fall within the acceptable limits set by WHO standards. *M. oleifera*, which is well known for having many health and medicinal benefits in addition to its water purification ability. Many studies have been conducted on different species of Moringa. The *M. oleifera* species has been extensively studied to identify its coagulation efficiency. Historically, various seeds have been used for water coagulation, such as apricot seeds, peach seeds, and mango seeds (Ali *et al.*, 2008; Elmolla *et al.*, 2020). The coagulation process is an essential step in water and wastewater purification. It relies on converting suspended particles into larger flocs that can settle or be easily filtrated from water. This process involves the addition of certain chemicals called coagulants. These chemicals have the ability to aid in the flocculation of suspended particles in water (Sharma and Sanghi, 2012).

CONCLUSION

From this research findings, it can be concluded that *Moringa oleifera* seeds effectively improves water quality and significantly reduced turbidity and heavy metals concentration in contaminated water.

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