The potential use of *moringa oleifera* pod extract in softening hard water

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Abstract- Natural substances that is locally, readily available and often considered as waste was potentially found to be good in water treatment. This paper investigated the hardness removal efficiency of *Moringa oleifera* pod extract for softening high hard water. The turbidity removal efficiency was investigated with 3% (w/v) and 6% (w/v) stock solution concentrations of *Moringa oleifera* pod, using jar test. Results obtained revealed that 540mg/L dose of the two stock solution concentrations gave the highest turbidity removal efficiency of 48% and 57% respectively. This study demonstrated the potential of using *Moringa oleifera* pod for softening high hard water.

Index Terms- Stock solution, Hard water, Softening, *Moringa oleifera*, Coagulation, and Flocculation.

I. INTRODUCTION

Water is an important component of human life and is needed in every activity in human life. Surface and ground water are the main source of water that we use for many purposes in domestic, agricultural, industrial and recreational purposes. Human activities increase due to increase in modern technologies, pollution and population, which results to contamination of human food chain and water sources. Water contamination by these microorganisms is inevitable. About billion people across Asia, Africa, and Latin America are estimated to rely on untreated surface water sources for their daily water needs. Of these, some two million are thought to die from diseases caught from contaminated water every year, with the majority of these deaths occurring among children under five years of age [1].

In some communities where surface water is difficult to access, groundwater is used for day to day life activities. The groundwater used is usually hard water that contains salts of calcium and magnesium principally as bicarbonates, chlorides, and sulfates. Ferrous iron may also be present; oxidized to the ferric form, it appears as a reddish brown stain on washed fabrics and enameled surfaces. Water hardness that is caused by calcium bicarbonate is known as temporary, because boiling converts the bicarbonate to the insoluble carbonate; hardness from the other salts is called permanent. Calcium and magnesium ions in hard water react with the higher fatty acids of soap to form an insoluble gelatinous curd, thereby causing a waste of the soap and scale formation in hot water pumps, boilers and pipes. Hardness is expressed in terms of $CaCO_3$ and is divided into temporary and permanent hardness [2].

Softening is the removal of ions which cause hardness in water. Hardness is caused mainly by calcium and magnesium ions, or at times, by iron, manganese, strontium, and aluminum ions. Hardness causes excessive soap consumption and scale formation in hot water pumps, boilers and pipes. Public water supplies should not exceed 300 to 500mg/l of hardness; although, aesthetically, a hardness greater than 150mg/l is unacceptable. Because the cost of chemicals for softening is high, local materials are being considered as substitutes. *Moringa oleifera* seed extract has been identified as a potential softening agent [3]. *Moringa oleifera* is a tropical plant which belongs to the family *Moringa*ceae. The plant is one of the most widely cultivated species of the genus *Moringa*. *Moringa oleifera* is a fast growing evergreen, deciduous plant found in the tropical and sub-tropical countries of Asia and Africa. It is highly valued and provided with incredible nutritious components. In Northern Nigeria, the fresh leaves are used as a vegetable, roots for medicinal purposes and branches for demarcation of property boundaries and fencing. The dry seed is known to be a natural coagulant and coagulant aid as well as bacterial reduction agent. The softening property of *Moringa oleifera* which was accidentally discovered in that study is the only one documented to date. The present study was therefore carried out to explore further the potential of this multipurpose tropical plant as a new method for use in the softening of hard groundwater [4].

II. RESEARCH METHODOLOGY

A. Methods

i. Sample collection

The fresh matured *Moringa oleifera* pods were obtained from Mr. Musa's farm at Garko local government area, Kano state. The pods were allowed to naturally dry under shade. The dried pods were ground into powder using mortar and pestle, the powder was sieved through 150µm BS test sieve to obtain a fine powder. The sample was stored in an enclosed plastic container prior to use.

ii. Preparation of the sample

A. Preparation of Moringa oleifera stock solution of 3.0% (W/V)

3.0g of the fine powder of pod was added to a beaker containing 100ml of tap water to give a solution with approximate concentration of 30000mg/l. The solution was stirred using a magnetic stirrer for ten minutes to promote the extraction of the active components of *Moringa oleifera*, the resulting suspension was filtered through a filter paper.

B. Preparation Moringa oleifera stock solution of 6.0% (W/V)

6.0g of the fine powder of pod was added to a beaker containing 100ml of distilled water to give a solution with approximate concentration of 60000mg/l. The solution was stirred using a magnetic stirrer for ten minutes to promote the extraction of the active components of *Moringa oleifera*, the resulting suspension was filtered through a filter paper.

iii. Preparation of Hard Water Sample

Synthetic hard water was prepared with powdered calcium carbonate and tap water. The volume of the calcium carbonate solution to substitutes the same volume out of 250ml of tap water and results hardness of about 500 CaCO3 was determined in quick test.

iv. Quick test

0.5g of the fine powder was weighed using weighing balance and then dissolved in 100ml of tap water to give a solution. Firstly, hardness of the tap water was tested and found to be 178 $CaCO_3$. At the end of many trials which were done by substituting some little quantity of the tap water with the same quantity of prepared solution of $CaCO_3$ in 250ml of tap water, 2.6ml was found to results in hardness of about 500 of $CaCO_3$.

v. Determination of temperature

Thermometer was set in a vertical position and the lower end of it was carefully clean with cotton wool. The sample to be tested was shaken and poured in a clean beaker; the mercury end of the thermometer was inserted and holds firmly while observing the rise in mercury level until it become stable. The mercury level was recorded as the temperature of the sample and then the thermometer was removed from the sample and cleans with cotton wool. The procedure was followed for all the samples and all the temperature values were determined both before and after the Jar test.

vi. Determination of pH of the samples

The electrode of the pH meter was first rinsed with distilled water, and then carefully placed up to the maximum immersion level in the beaker containing the water sample to be tested, the stable reading on the pH mater was observed and recorded. The electrode was then removed from the sample and rinsed with distilled water. Using a soft cotton wool, the electrode was wiped and cleaned to dryness. The procedure was followed for all the samples and all the pH values were determined both before and after the Jar test.

vii. Conventional jar test

Investigations of treatment performance were undertaken using the conventional jar test [5]. The jar test carried out for this research was carried using a flocculator (Model: PEF, Serial No. PEF003/11, Spain) that consists of six propellers. Under each propeller, a 500ml capacity beaker was placed containing 250ml of hard water with same hardness. Different dosages of the *Moringa oleifera* were added to five of the beakers with the last beaker served as control beaker without adding any dose, prior to the addition of the different dosages, the same volume to be added was removed from each beaker containing hard water so as to maintain 250ml in each beaker. The varying dosages are 0.5ml, 1.5ml, 2.5ml, 3.5ml, and 4.5ml for 3.0%(W/V) stock solution and 0.25ml, 0.75ml, 1.25ml, 1.75ml, and 2.25ml for 6.0%(W/V) stock solution. The flocculator was then started, and allowed to mix the content of the beaker for about 30 minutes. After 5 minutes of rapid agitation at 125 rpm, the mixing speed was then lowered to 20 rpm for 25 minutes, this allowed the flocs to form. The flocculator was then stopped and the sample was allowed to stand at near quiescent condition for one hour. After 1h, the sample of the supernatant was collected from each beaker, and its residual hardness, turbidity, temperatures were measured as well as their pH. The dosage that gave the lowest residual hardness value was taken as the optimum dose. For the purpose of obtaining reliable results, the experiments were carried out in duplicate and the averages were taken.

viii. Determination of turbidity

Calibration of turbidity meter (Portable Turbidity, Model: SGZ-200BS, England):

The standard solution of 100 NTU was used to calibrate the instrument; the detection range selected for the adjustment was 1000 NTU. Distilled water first added to the sample cell up to the vertical mark and was wiped gently using cotton wool. The sample cell was then inserted in to the turbidity meter and the dial cap placed. Using the set zero knobs, the reading on the turbidity meter was adjusted to zero. The distilled water was then discarded and a standard solution of 100 NTU was added to the sample cell up to the vertical mark and wiped gently with soft cotton wool. The sample cell was inserted in to the turbidity meter and covered with the cap. The stable reading on the turbidity meter was then observed. If the reading was not 100 NTU, using the calibration knob, the reading was adjusted to 100 NTU. The procedure was repeated until the distilled water and the standard solutions gave zero and 100 NTU respectively. The instrument was then ready for used.

ix. Testing of water sample

The water to be measured was added to the sample cell up to the vertical mark, the cell was wiped gently with cotton wool and inserted in to the turbidity meter, the dial cap was placed and the stable reading observed and recorded as the turbidity of that water sample. Turbidity removal efficiency of the coagulants was calculated in percentage using the relationship below;

Turbidity removal efficiency = $\left(\frac{Ci-Cf}{Ci}\right) \times 100\%$........................(1)

Where C_i and C_f are the initial and final turbidity of the raw water respectively.

x. Determination of Hardness of the sample

A. Hardness test

50ml of the supernatant was measured into the beaker, 0.5ml of 0.1N HCL was added to it and heat was applied to boil it, in order to expel CO_2, the boiled solution was allowed to cool to 50°C. 2ml of the buffer solution (pH 10) was added after which two drops of Erichrome T indicator was added. The solution was then titrated with EDTA until the colour changes from wine red to blue and the volume of EDTA was recorded. The procedure was followed for all the samples. Hardness was determined using this formula below;

Hardness as mg/l $CaCO_3$ = ml of EDTA titrant x f x 1000 x 0.1 x 17.8/ ml of sample……………………………………………..(2)

Where $f = 1$

Hardness removal efficiency = $\left(\frac{hi-hf}{hi}\right) \times 100\%$ ……………………………………………………………....(3)

Where h_i and h_f are initial and final hardness of the sample respectively.

III. RESULTS AND DISCUSSIONS

The jar test experiments were conducted for the two stock solutions each with varied dosages. The synthetic hard water was made to have hardness of 500CaCO3. After the tests with different dosages of the two stock solutions of the *Moringa oleifera* pod extracts, the hardness removal efficiencies were determined using equation 3. The last dose that corresponds to the lowest residual hardness represents the highest dosage and the stock solution with the highest removal efficiency represents the highest stock solution. The initial and final temperature, pH, and turbidity for all the dosages were determined.

A. Highest Dosage of the Stock Solutions

i. Stock solution 1: 3% (w/v)

Figure 1 shows the relationship between dosages and the hardness removal efficiencies from 3% (w/v) stock solution

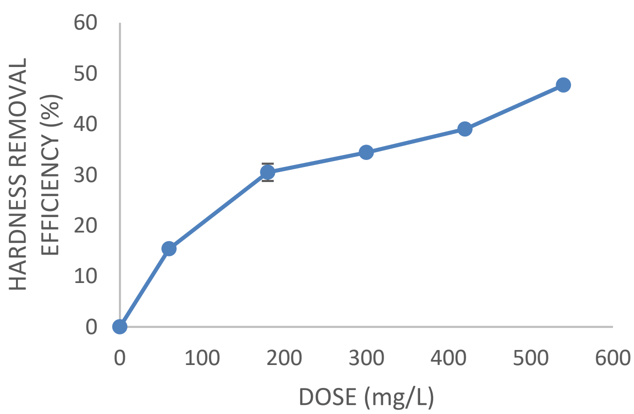

Fig. 1. Hardness removal efficiency against dose of 3% (w/v) stock solution.

Figure 1 explain the results obtained when the hard water of 500caco3 was treated with doses of 0, 60, 180, 300, 420 and 540mg/L of 3% (w/v) stock solution. The residual hardness after the test with the dosages was determined to be 0, 500, 423, 348, 328, 305 and 262caco3 respectively. The corresponding hardness removal efficiencies were 15, 31, 34, 39 and 48% respectively. The result shows that the hardness decrease with increase in dosage and the hardness removal efficiency of 48% was achieved at dose of 540mg/L which is taken as the highest dosage of 3% (w/v) stock solution.

x. Stock solution 2: 6% (w/v)

Figure 2 shows the relationship between dosages and the hardness removal efficiencies from 6% (w/v) stock solution.

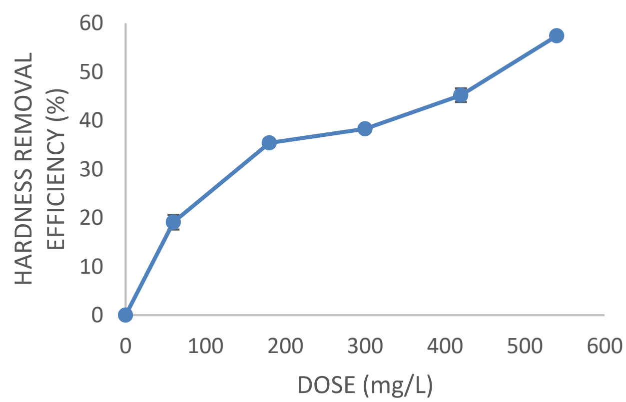

Fig. 2. Hardness removal efficiency against dose of 6% (w/v) stock solution

Figure 2 explain the results obtained when the hard water of 500caco3 was treated with doses of 0, 60, 180, 300, 420 and 540mg/L of 6% (w/v) stock solution. The residual hardness after the test with the dosages was determined to be 500, 405, 323, 309, 274 and 213caco3 respectively. The corresponding hardness removal efficiencies were 0, 19, 35, 38, 45 and 57% respectively. The result shows that the hardness decrease with increase in dosage and the hardness removal efficiency of 57% was achieved at dose of 540mg/L which is taken as the highest dosage of 6% (w/v) stock solution.

B. Highest Stock Solution

From the results above, 48% was determined as the highest hardness removal efficiency that corresponds to the 540mg/L dose of 3% (w/v) stock solution and 57% was determined as the highest hardness removal efficiency that corresponds to the 540mg/L dose of 6% (w/v) stock solution. By comparing the highest efficiencies of the 3% (w/v) and 6% (w/v) stock solutions which were 48% and 57% respectively, it can be seen that 6% (w/v) stock solution have the greater efficiency of 57% therefore 6% (w/v) stock solution is taken as the highest stock solution.

C. pH results

i. Stock solution 1: 3% (w/v)

The average initial pH of the six set of beakers before the jar test were determined to be 7.31 which after the jar test decreases with increase in dosages. The average final pH of the six beakers were determined to 7.31, 6.93, 6.85, 6.83,6.80 and 6.76 corresponding to 0, 60, 180, 300, 420 and 540mg/L dosages respectively.

ii. Stock solution 2: 6% (w/v)

The average initial pH of the six set of beakers before the jar test were determined to be 7.31 which after the jar test decreases with increase in dosages. The average final pH of the six beakers were determined to 7.31, 6.91, 6.84, 6.81, 6.76 and 6.74 corresponding to 0, 60, 180, 300, 420 and 540mg/L dosages respectively.

C. Relationship between pH and hardness removal efficiency

i. Stock solution 1: 3% (w/v)

Figure 3 shows the relationship between hardness removal efficiency and pH.

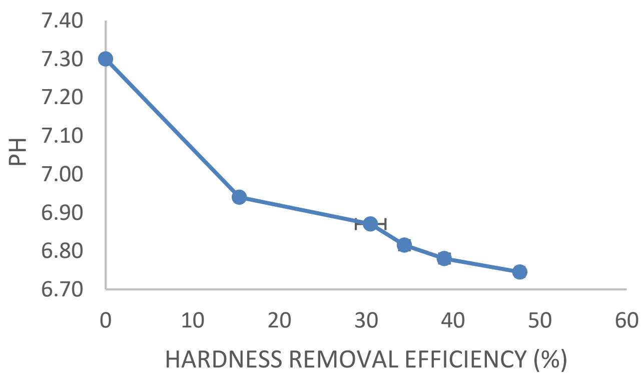

Fig. 3. pH against hardness removal efficiency

The figure above also indicated that hardness removal efficiency increases with the increase in pH.

ii. Stock solution 2: 6% (w/v)

Figure 4 shows the relationship between hardness removal efficiency and pH. It revealed that hardness removal efficiency increases with the increase in pH.

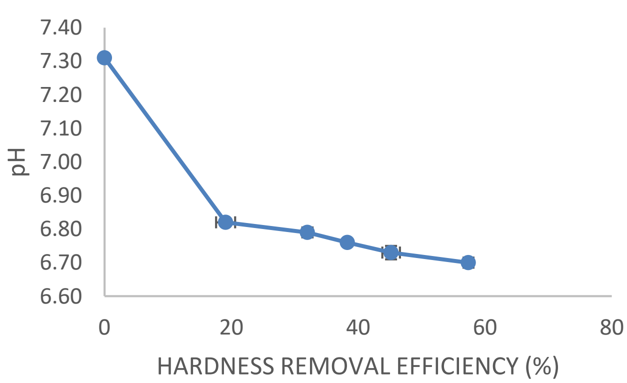

Fig. 4. pH against hardness removal efficiency

D. Temperature

Throughout the tests, initial and final temperature was measured. The temperature during the tests ranges from 25 to 30^{O}C. As pH decreases with increase in temperature, so the increase in temperature might have also contributed in the decrease in pH of the water.

E. Turbidity

The initial turbidity of the sample was 4NTU which after the tests was also determined as shown in the figures below.

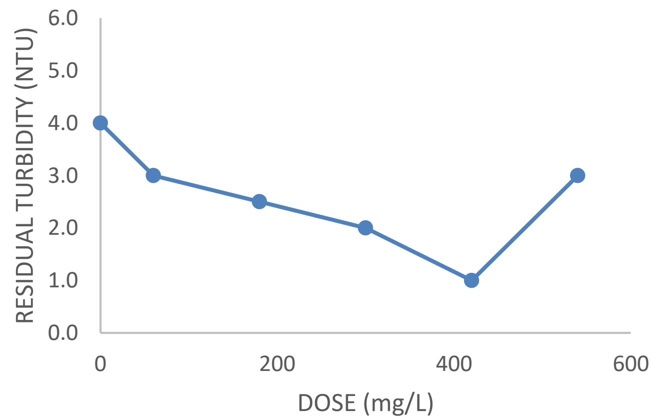

Fig. 5. Residual turbidity against dose of 3%

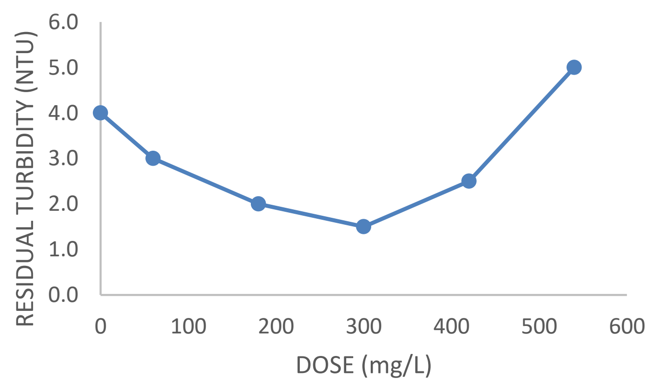

Fig. 6. Residual turbidity against dose of 6% (W/V)

From the result shown in figure 5, turbidity was decreasing with dosages except for the last dose where the turbidity increased to 3NTU and from figure 6, turbidity was also decreasing with dosages except with the last two dosages where turbidity increased to 5NTU which is due the color of the *moringa olifera* pod extracts as noted by[6] that since *Moringa oleifera* is a polyelectrolyte, It may not be effective as a primary coagulant for low/medium turbid water because such waters contain low concentration of colloidal particles, with a low rate of inter particle contact in such systems.

IV. CONCLUSION

The results for 3% (w/v) and 6% (w/v) stock solutions were obtained using various dosages and hardness removal efficiency was found to increase with increasing dosage of *Moringa* *oleifera* pod extract, hence it was investigated to be suitable in softening hard water. *Moringa oleifera* pod extract could be utilized in softening hard water as it was found from the stock solutions used in this research, hardness was reduced by 48% and 57% with 3% and 6%(W/V) stock solutions respectively. Hence *Moringa oleifera* pod could reduce the need to spend on chemical for softening hard water. Dosage of 540mg/L both from the stock solutions was found to reduced hardness the most by 48% and 57%. Therefore, its determined to be the highest dosage within the scope of this research.

The 6%(W/V) Stock solution was determined to reduced hardness the most, with its highest dosage of 57%. Hence it is found to be the highest stock solution in softening hardness. Furthermore, there is need for clarification of the treated water as the residual hardness were still at the range of higher hardness. *Moringa oleifera* pod is recommended for use in softening hard water especially in rural areas where hard water is mostly used for their activities. As coliforms might be present, treatment on disinfection of the treated water is needed. It is recommended that research work should be carried out on combining *Moringa oliefera* pod and *Moringa oleifera* seed in various ratios to investigate the suitability as well as the best combined ratio in softening hard water.

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