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EFFICACY OF *MORINGA OLEIFERA* SEED AS SUSTAINABLE OPTION IN WATER TREATMENT FOR SAFE DRINKING

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Abstract
The production process of Aluminum sulphate commonly used for water purification comes with environmental hazards, among other drawbacks associated with the use of alum as coagulating agent. Therefore, this study seeks to investigate the efficacy of Moringa oleifera seed as a viable option for alum in rural water treatment. Proximate analysis of the Moringa oleifera seed was first conducted. The coagulants of varying concentrations were prepared by weighing 0.5, 1.0, 1.5, 2.0 and 2.5g of Moringa oleifera seedpowder into five beakers containing 1000 ml of distilled water, and another separate set of five concentrated solution prepared for alum with the same measurements as Moringa oleifera. A control sample (water from River Landzun without alum and Moringa treatments) was also kept for the experiment. The turbidity, pH, conductivity and total coliform were determined for all the samples.The proximate profile shows that the seed contains 8.2 % ash, 34.1 % crude protein, 3.6 % crude fiber, and 18.6 % total carbohydrate. With the initial 30 NTU turbidity of raw water, higher concentrations of Moringa oleifera powder of 2.0 g/l and 2.5 g/l loading dose reduced the turbidity to 5 NTU and 3 NTU respectively, which is within the maximum permitted limit set by World Health Organization (WHO) for safe drinking water. The pH values of the treated water increases slightly within the range of 7.60 to 7.75 as the Moringa oleifera dose increases and this falls within the recommended range set by WHO. Moringa oleifera seed made 70 % reduction of bacteria load of the treated water while alum reduced 16 %. It can be inferred from this study that Moringa oleifera seed can serve as a substitute for alum in water treatment.

Keywords: Alum, *Moringa oleifera*, water, dosage

Introduction

Water is an indispensable basic human need just as food and shelter, and its level of purity determines its importance for both industrial and domestic use. The level of purity of water for consumption by human is crucial as it has direct or indirect impact on human well-being. ButKumari *et al*. (2005) found that sources of water are being polluted through various means such as the use of fertilizers, chemicals used for agricultural purposes, and other human

activities. Therefore water treatment, before consumption, is paramount to improvement of availability of good and safe water, environmental, health and life quality (Rodríguez-Núñez et. al., 2012).About 1.6 million people living in the developing nations are exposed to contaminated water and thus are commonly faced with cases of water borne diseases such as diarrhoea, cholera, dysentery and typhoid (Amagloh & Benang, 2009). The need for water treatment keeps increasing due to environmental strain, population explosion and urban migration (Liew *et al*., 2006).

The conventional way of water purification using inorganic coagulants such as aluminum sulphate (alum) and calcium hypochlorite and also chlorine are financially implicating as they are either imported or manufactured with lots of energy inputs, and also the complexity in the management of sewage sludge which is high in aluminum sulphate content (Rodríguez-Núñez et. al., 2012). Therefore in the rural areas in the developing countries it is costly to treat water, and so no option left other than to drink from ponds, river, streams, and even ditches. Recent studies reveal that diseases like Alzheimer and pre-senile dementia and other related health issues are connected to residual aluminium and iron salts in treated water (Yang, *et al*., 2010; Dalen *et al*., 2009). Alum as a coagulating agent is not effective on cold water; it also changes the alkalinity of the water, reducing the water pH and the coagulant effectiveness further reduces (Muyibi, & Alufugara, 2003). The process of manufacturing Aluminium sulphate poses an environmental hazard by changes being made to the pH of the surrounding watercourses. So all the discharged effluent, which is the major potential environmental hazard posed by this process, cause changes to the pH of surrounding watercourses, and so all effluent and close water sources are monitored for pH and level of suspended solids (http://nzic.org.nz/ChemProcesses/production/1F.pdf).

A possible substitute to inorganic coagulants is *Moringa oleifera* seed, which is natural and sustainable as it reduces the environmental impact and cost effective from the source, and presumed to be safe for human health. *Moringa oleifera* is a tropical tree with diverse purposes and applications ranging from food supplement to medicine (Katayon *et al*., 2006). However, it has been previously investigated that *Moringa oleifera* seed is one of the most effective primary coagulant for waste water treatment and can be comparable to alum (Schwarz, 2000). It also finds its purpose as softening agent and anti-bactericidal agent (Pritchard, *et al*., 2010). The kernels of *Moringa oleifera* is embedded with certain amount of positively charged water-soluble proteins (polypeptide), which act as a cationic polyelectrolyte and attracts negatively charged particles (clay, silk, and other toxic particles) in the water (Arnoldsson *et al*., 2008). Treating water with *Moringa oleifera* results in significant removal of 90 to 99 % of bacteria; this is quite possible owing to the fact that bacteria is normally attached to solid particles, and *Moringa oleifera*, in ground state, constitutes the particles in the water (Schwarz, 2000; Amagloh and Benang, 2009; Futi *et al*., 2011).Owing to the organic nature of *Moringa oleifera* the noticeable drawback of using the seed as coagulant results in the increase in concentration of nutrients and COD (chemical oxygen demand) in the treated water (Arnoldsson *et al*., 2008).

To this end, there have been reports from different studies that revealed that parts of *Moringa oleifera* tree serves different purposes, including the seed having the property for water purification. Therefore the present study investigates the efficacy of *Moringa oleifera* seed, as natural and renewable coagulant, and its potential as alternative to alum in the treatment of a river water for safe drinking.

Methodology

Preparation of the Seed Powder: Matured and dried *Moringa oleifera* seeds were collected from a farm in Bida, Niger State. The seeds were then shelled to obtain the seed kernels, which were crushed into powder using laboratory mortar and pestle. The powder was sieved by 0.8 mm mesh to get a finer powder particle. Various analyses including moisture, ash, minerals, total carbohydrate, lipids and protein content were conducted on the powered seed sample.

Moisture Content and Dry Matter Determination: Air oven method was used in determining the moisture content. Petri-dish was initially weighed and cooled and then 5g of the seed powdered sample was measured into the dish. The dish and the content were moved into an air oven to dry at 105 ^{0}C for 2 hours. The sample was removed from the oven and taken into desiccator and left there to cool for 15 minutes after which it was removed and re-weighed again. The process was repeated until a constant weight was obtained. The difference in the weight (weigh loss) was considered as moisture content, and the percentage moisture content in the sample was calculated using equations (1) and (2) respectively.

$$\text{Percentage moisture content} = \frac{wt\ loss \times 100}{wt\ of\ sample} \quad (1)$$

$$\%\ \text{total solid (dry matter)} = 100 - \%\ \text{moisture} \quad (2)$$

Ash Content Determination: After taking the weight of a crucible dish, a 5 g of sample was measured out on the crucible. It was then taken into the furnace for ashing via furnace rack, where the temperature was set at 450 ^{0}C for 15 hours until complete ashing of sample happened. The crucible dish and the ash in it was removed from the furnace and placed in desiccator to cool. After cooling the crucible dish and the ash, their weights were retaken. Equation (3) was used to calculate the percentage ash content of the sample.

$$\text{Percentage ash} = \frac{Total\ wt\ of\ extracted\ ash \times 100}{wt\ of\ sample} \quad (3)$$

Fat Content Analysis: Soxhlet solvent extraction method was used to extract oil from the ground *Moringa oleifera* seed sample. The soxhlet extractor was set up with a reflux condenser and 500 ml round bottom flask. An empty extraction dish was weighed out (W1). 10 g of the milled sample was weighed into the fat-free thimble that has been previously oven dried and then stoppered with cotton wool and placed in the extraction dish containing 300 ml of solvent (petroleum ether). The soxhlet apparatus were assembled and allowed to reflux for 6hours until

the barrel of the extracting dish is almost empty. The thimble was removed carefully and the condenser also detached. The solution contained in the extracting dish was then placed in an oven at 105 – 110 ^{0}C for 30minutes, the period for which all the solvent and possible moisture would have evaporated.

The dish was then removed and placed in desiccator to cool after which it was weighed (W2). The percentage fat content of the sample was then calculated using equation (4).

$$\text{Percentage fat} = \frac{wt\ of\ \ fat\ extracted\ \times 100}{wt\ of\ \ sample} \quad (4)$$

Crude Protein Determination: A known weight (1g) of the *Moringa oleifera* powdered sample was weighed out and poured into kyeldahl flask. 0.5 g catalyst system comprising of an hydrous Selenium dioxide, $CuSO_4$ and Na_2SO_4 in the ratio of 1:1:98 respectively was weighed and added to the sample in the flask. To this, 10 ml of concentrated H_2SO_4 was added and the mixture (the flask and its content) then heated gently until reduction in floating was observed. This was then left to cool and later transferred into 100 ml flask and diluted with distilled water to 100 ml. 20 ml of the solution was collected and dissolved with 30 ml of 40 % NaOH and placed in the Markehan still. The mixture was then steam distilled, and to the distillate, 30ml of 2 % boric acid was added. This was then titrated with acid (0.1 N HCl) to end point with the use of methyl orange indicator. A blank was also determined concurrently. The percentage nitrogen was computed using the relationship shown in equation (5).

$$\text{Percentage nitrogen (N)} = \frac{14(\text{V - B}) \times \text{M} \times 100 \times 100}{1000 \times 10 \times wt\ of\ \ sample} \quad (5)$$

(Dalem *et al*., 2009)

The result obtained in equation (5) was used to compute the percentage crude protein as shown in equation (6).

$$\text{Percentage crude protein} = \text{N} \times 6.25 \quad (6)$$

Where B is the Blank, V is the volume of acid used, M is the molarity of H_2SO_4, and 6.25 is the conversion factor.

Sample Preparation for Laboratory Analysis

Five Concentrated solutions each of alum and *Moringa oleifera* seed powder were prepared for the loading dosage. This preparation was carried out by weighing 0.5, 1.0, 1.5, 2.0 and 2.5 g of alum into five beakers containing 1000 ml of distilled water, and another separate set of five concentrated solution prepared for *Moringa oleifera* seed powder with the same measurements as alum. Each of the solution mixture in the beakers were stirred thoroughly using a glass rod to get a clearer solution.

Laboratory Analyses

Water from River Landzunin Bida, Niger state, Nigeria was used as raw water sample for analysis. From the prepared solutions, 5 ml was fetch into a beaker containing 500 ml of the

river water, for each of the prepared solutions of varying concentrations. The solutions were mixed gently for 15 minutes and thereafter left to stand without disturbance for 1hour so that the flocs formed to sediment. The resulted supernatants were decanted and subjected to various analyses which include pH, conductivity, turbidity, and total bacteria and coliforms count measurements. A control sample, 1000 ml of raw sample water containing neither alum nor *Moringa oleifera* seed powder, was kept and also subjected to these analytical tests.

Turbidity Measurement

Determination of turbidity was done by Nephelometric technique using a turbidimeter on water samples.

Conductivity Measurement

Crison Conductimeter Basic C30 was used. The conductivitimeter probe was placed in the center of beaker container sample water, and ensuring that it did not have contact with the beaker. After the instrument stabilized in the water, the reading was taken from the displayed LCD.

Total Dissolve Solid (TDS)

The total dissolve solid was calculated using the value of conductivity in micro siemens per centimeter by the formula;

Total dissolve solid = Conductivity (µs/cm) x 0.666

pH Measurement

Calibrated Crison pH meter Basic C20 was used to measure the pH. The pH meter probe was placed in the center of beaker container water sample, and ensuring that it did not have contact with the beaker. After the instrument stabilized in the water, the reading was taken from the displayed LCD.

Microbial Analysis of the Sample Water for Total Bacteria Count

Total bacterial and coliform counts of the raw water were estimated by serial dilution using the pour plate method. 28 g of the nutrient agar was suspended in 1 Lt of distilled water, the dissolve nutrient agar was sterilized by autoclaving at 121 ^{0}C for 15 min, after which it was cooled to molten in water bath. Serial dilution of 10^{-1}, 10^{-2}, 10^{-3} were made, the melted nutrient agar and the 1ml of the serial dilution was poured into Petri dish, rotated and allow to solidify, the medium was allowed to set before inverting to incubate at 37 ^{0}C for 24 hrs and 48 hrs.

Results and Discussions

Table 1: Chemical Composition of Crude Powder of *Moringa oleifera*

Composition of seed (%)	Obtained values	Reported values[a]	
		1	*2*
Dry matter	95.0	92.1	Nd
Moisture content	5.0	7.9	Nd
Ash content	8.2	6.5	3.8
Crude Protein	34.1	38.3	36.7
Crude fiber	3.6	4.5	4.8
Total Carbohydrate	18.6	16.5	17.8
Fat/oils	30.5	30.8	41.7

nd, not determined.

a(1) Abdulkarim et al., (2005) (2)Makkar and Becker (1997).

Table 1 represents the proximate composition of undefatted *Moringa* o*leifera* seed. The result shown herein is compared with the work presented by Abdulkarim *et al*, (2005), and Makkar and Becker, (1997). The difference in the values, most especially for lipids, protein and carbohydrate, can be attributed to geographic region of cultivation and the cultivation conditions of the plant (Okuda *et al*., 1999). Also extraction efficiency and experimental method employed for their determination can also be responsible for the variations in the result (Muyibi and Alufugara, 2003).

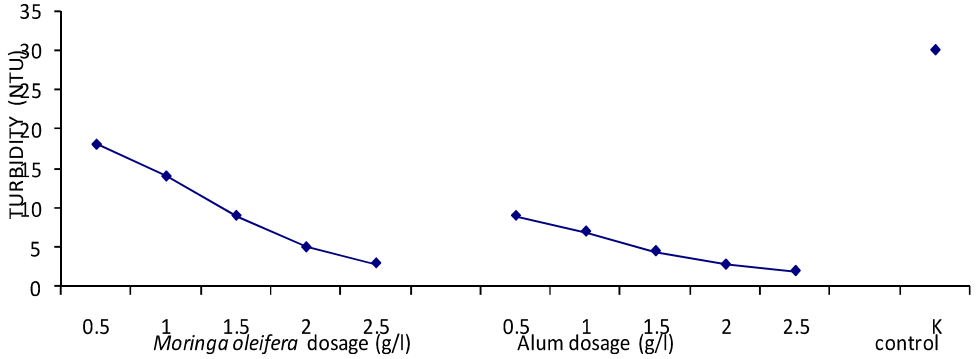

Figure 1: Turbidity Test of the Water Samples at Varying Concentrations of the Coagulants

From Figure 1 above, Alum removes quite significant turbidity of the sample water as compared to *Moringa oleifera*. This river water was quite turbid in the time (July – August) of this experimental work as a result of more influx of mud and other particles from heavy and continuous rainfall of the period. The declared WHO guideline for turbidity provided for safe drinking water is 5 NTU (WHO, 2006). It is clearly seen that higher concentrations of *Moringa oleifera* powder of 2.0 g/l and 2.5 g/l loading dose as coagulant gives similar effect on turbidity

(5 NTU and 3 NTU) compared with alum of loading doses of 1.5 g/l, 2.0 g/l and 2.5 g/l which reduces the water turbidity to 4.5 NTU, 2.8 NTU and 2 NTU respectively. These dosages reduced the turbidity of water to that which is acceptable according to the WHO (2006) guideline for drinking water. The initial turbidity was 30 NTU. The values of turbidity obtained for the *Moringa oleifera* dosage in this work is similar to those reported by Futi *et al*., (2011) who mentioned 17.4 NTU for 0.5 g/l *Moringa oleifera* dosage at the initial turbidity of 33.1 NTU.

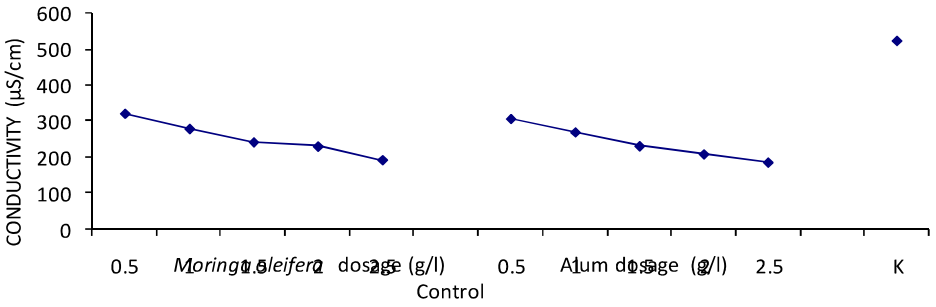

Figure 2: Conductivity Test of the Water Samples at Varying Concentrations of the Coagulants

Conductivity of water differs to some extent with different geographical areas due to differences in solubility of minerals (Amagloh and Benang, 2009). The maximum allowable conductivity for safe drinking water is 1000 µS/cm (WHO, 2006). The various dosages (Figure 2) of alum and *Moringa oleifera* treatments gives conductivity values that are acceptable according to the WHO guideline for drinking water but high levels of it in drinking water may be objectionable to consumers. The conductivity ranges from 183 to 320 µS/cm for all the various loading dosages used. The higher the concentrations of both the alum and *Moringa oleifera,* the lower the conductivity of the treated sample waters.

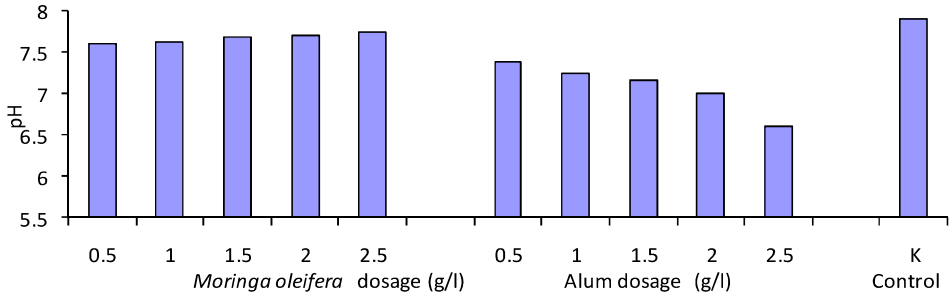

Figure 3: pH Test of the Water Samples at Varying Concentrations of the Coagulants

As can be seen in Figure 3, the treated sample waters gave a pH range of 6.3 to 7.6 for all the coagulum used. These fall within the range (6.0 – 8.0) recommended by WHO, 2006. For *Moringa oleifera*, the pH of the treated water increases slightly as the concentrations of the dosing solutions are increased, while for the alum the pH reduces sharply as alum dosing concentration increases. A similar trend was also observed by Arnoldsson *et al*. (2008) and Futi *et al*. (2011) where the treatment with *Moringa oleifera* had no effect on the pH of the treated water. Also from the previous studies by kemira (2003) and Amagloh & Benang (2009) the alum effect on treated water gave a lower pH of the water, and this is a generic situation world-wide whenever aluminium sulphate is used for water treatment (Arnoldsson *et al*., 2008). Alum in the treatment process formed sulphuric acid which dropped the pH levels. *Moringa oleifera* contains some proteins whose amino acids accept a proton from water to form hydroxyl group, thus making the water basic and hence the slight increase in pH of the treated water.

Table 2: Microbial analysis of water samples

Bacteria Count (cfu/ml) (x 10^3)	*Moringa oleifera* dosage (g/l)					Alum dosage (g/l)					Control
	0.5	1.0	1.5	2.0	2.5	0.5	1.0	1.5	2.0	2.5	K
24 hours	2.0	2.0	1.5	1.0	1.0	4.4	4.4	4.4	3.9	3.9	4.5
48 hours	2.0	2.0	1.7	1.2	1.2	4.4	4.4	4.4	3.9	3.9	5.0

Moringa oleifera coagulant has antibacterial activity against bacteria and this is an added advantage as it reduces microbial load of the water being treated. From Table 2, the bacteria load on the samples treated with *Moringa oleifera* was observed to give an average value of 1.5 x 10^3 and 1.62 x 10^3 for the 24 and 48 hours respectively while the alum treatment recorded an average value of 4.2 x 10^3 for both 24 and 48 hours. The control (initial microbe count) had the highest counts of 4.5 x 10^3 and 5.0 x 10^3. There is quite significant reduction of microbial load when water is treated with *Moringa oleifera* seed as compared with alum. This is supported by Amagloh and Benang (2009) in their study, and also a similar observation was made by Shekhar *et al*. (2000) where extracts of *Moringa oleifera* showed activity against *E. coli* only.

Conclusion and Recommendation

The present study demonstrates how efficient *Moringa oleifera* seed is as coagulant for treating water for safe drinking. Although the turbidity removal by *Moringa oleifera* is not as efficient as that of alum, however, the turbidity of the treated water using *Moringa oleifera* falls within the acceptable limits for safe drinking water set by WHO (5 NTU); particularly at the higher dosage of 2 to 2.5 g/l of the crushed seed. The use of *Moringa oleifera* is beneficial as that the alkalinity and conductivity of the water are not significantly affected in comparison with using alum. It is also observed that *Moringa oleifera* has antimicrobial properties which when used as coagulant reduces the microbial load of the water. However, for the fact that *Moringa oleifera* can be sourced locally and at low cost and a renewable material, and having demonstrated its

efficacy as a coagulant, it should be considered a viable and sustainable option in water purification, particularly for the rural folks.

It is hereby recommended that a further study be conducted on the effect of high dosing of *Moringa oleifera* seeds in the water at longer sedimentation time owing to the fact that the seed is an organic material which is liable to decomposition.

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