Effect of Moringa Seed Powder on Blue Nile Water Purification as Compared to Poly Aluminum Chloride

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Abstract: ***The high cost of treated water makes most people in the rural communities to resort to readily available water sources which are normally of low quality exposing them to waterborne diseases. This work was carried out at Wad Medani Waterworks to compare the efficiency of Moringaoleifera seed and PAC as coagulants. Four samples (raw water, water treated with Moringaoleifera seed powder, powder of Moringaoleifera seed extracted by hexane, and water treated with PAC) were subjected to physical and chemical analysis. The comparison was drawn between the Moringa seeds coagulants efficiently to purify water. This was also compared to efficiently of PAC using the Jar test method. The Cake of Moringa seeds extracted by hexane, from which 50ppm reduced the turbidity from (1650NTU-6.36NTU) was found to be better than the Moringa whole seeds of which (50ppm) reduced the same water turbidity to12.8ppm. and unlike(PAC), does not significantly affect the pH and conductivity of the water after the treatment. The concentration of chloride in water increased if purification was by PAC, but when usingMoringa seeds the concentration of chloride did not change. So, as a coagulant, Moringaoleifera seed may be a potentially valuable substitute to (PAC). Application of this low-cost Moringaoleifera seeds is recommended for eco-friendly, nontoxic, simplified water treatment where rural and peri-urban people living in extreme poverty.***

Keywords: MoringaOleifera, Water Treatment, Seed Extract, Electric Conductivity and Total Dissolved Solids

1. Introduction

Moringaoleifera is a perennial tree, still considered as among underutilized plant and falls under *Moringa*ceae family. The plant is also known as Drumstick, Sahjan or Sohanjana in India. All plant parts are having remarkable range of some functional and nutraceutical properties make this plant diverse biomaterials for food and allied uses [1].

Moringaoleifera is rich in compounds containing the simple sugar, rhamnose and a fairly unique group of compounds called glucosinolates and isothiocyanates [2,3]. The stem bark has been reported to contain two alkaloids, namely moringine and moringinine [4]. Vanillin, β-sitosterol, β-sitostenone, 4-hydroxymellin and octacosanoic acid have been isolated from the stem of *Moringaoleifera* [5]. Purified, whole-gum exudate from *Moringaoleifera* has been found to contain L-arabinose, -galactose, -glucuronic acid, and L-rhamnose, -mannose and -xylose, while a homogeneous, degraded-gum polysaccharide consisting of L-galactose, -glucuronic acid and L-mannose has been obtained on mild hydrolysis of the whole gum with acid [6]. Flowers contain nine amino acids, sucrose, D-glucose, traces of alkaloids, wax, quercetin and kaempferat; the ash is rich in potassium and calcium [7]. They have also been reported to contain some flavonoid pigments such as alkaloids, kaempherol, rhamnetin, isoquercitrin and kaempferitrin [5, 8]. Antihypertensive compounds thiocarbamate and isothiocyanate glycosides have been isolated from the acetate phase of the ethanol extract of *Moringa* pods [9]. The cytokinins have been shown to be present in the fruit [10].

Moringa seeds are one of the best natural coagulants discovered so far [11]. Crushed seeds are a viable replacement of synthetic coagulants [12]. In Sudan, seed crude extract is used instead of alum by rural women to treat the highly turbid Nile water because of a traditional fear of alum causing gastrointestinal disturbances and Alzheimer's disease [13, 14, 15, 16]. *Moringa* seeds are very effective for high turbidity water and show similar coagulation effects to alum [17]. The coagulation effectiveness of *Moringaoleifera* varies depending on the initial turbidity and it has been reported that *Moringaoleifera* could reduce turbidity by between 92% and 99% [17]. Moringa seeds also have softening properties in addition to being a pH correctant (alkalinity reduction), as well as exhibiting a natural buffering capacity, which could handle moderately high to high alkaline surface and ground waters. The *Moringa* seeds can also be used as an antiseptic in the treatment of drinking water [18]. Ongoing research is attempting to characterize and purify the coagulant components of *Moringa* seeds [19, 20]. It is believed that the seed is an organic natural polymer [21]. The active ingredients are dimeric proteins with a molecular weight of about 1300 Da and an iso-electric point between 10 and 11 [22]. The protein powder is stable and totally soluble in water. *Moringa* coagulant protein can be extracted by water or salt solution (commonly NaCl). The amount and effectiveness of the coagulant protein from salt and water extraction methods vary significantly. In crude form, the salt extract shows a better coagulation erformance than the corresponding water extract [23]. This may be explained by the presence of a higher amount of soluble protein due to the salting-in phenomenon. However, purification of the *Moringaoleifera* coagulant protein from the crude salt extract may not be technically and economically feasible.

2. Materials and Methods

2.1 Preparation of Sample Water

Moringaoleifera seeds were obtained from the Center of *Moringaoleifera* near Gezira Club, Wad Medani City. The turbid water samples to be treated were taken from the Blue Nile, during the flood season 2012.

2.2 Comparative Performance between Moringa seed and PAC

All the laboratory tests were carried out using Phipps & Bird multiple stirring devices (Jar tester), equipped with stirring paddles and provisions for control mixing .The floc size and its settle ability were observed with the illuminating device at the base of the apparatus, Figure 1.

Figure 1: Jar Test

2.3 Preparation of various solid moringa seed doses

Before crushing the *Moringaoleifera* seeds, the wings and brown coats were removed from each seed as well as any kernel that shows any signs of damage. The seeds were then crushed in a blender into a fine powder. Three different samples (50grams each) were taken from the powder. The first sample was left as it is, the second was extracted with hexane to remove oils and the third was extracted with water and the residue of each sample was taken for the test. Different weights (50, 100, 150 and 200mg) were used for each sample. Each weight was placed in a small cloth, which was then dropped into a beaker containing the turbid water (1 liter) to promote coagulation and flocculation, using the jar testing method.

2.4 Preparation of dose forPoly Aluminum Chloride (PAC)

1% solution of (PAC) was freshly prepared on daily basis. Samples (1liter) of turbid water were also treated by 24, 26 and 28 ppm of PAC by jar test.

2.5 Test Conditions

Measured volumes of raw water samples (1000ml) in beakers were flocculated using the jar test apparatus using one liter beakers. The beakers were placed in position in the jar tester, the motor of the stirrer paddles was started after addition of coagulant in each beaker simultaneously, and rapid mix was maintained at 200±10 rpm for 3 minute followed by slow mix for the turbid samples at 50±5 rpm for 10 minute, except PAC the rapid mix was maintained at 150±10 rpm for 3 minute followed by slow mix for the turbid samples at 35±5 rpm for 10 minute. After the end of stirring period, the beakers were slowly removed from the jar tester platform and the content of the beakers were allowed to settle for 60 minutes. For each series the criteria used for the evaluation of the efficiency of the coagulants were: settled water turbidity, OH and measured as done before to water samples. About 250 ml from each of the above treatments were drawn from the clean water and analyzed physically and chemically.

2.6 Water Quality Analysis

The desired water quality parameters pH, turbidity, EC, TDS and COD were measured by using the standard method [24].

3. Result and Discussion

3.1 Effect of Seed Extracts on pH

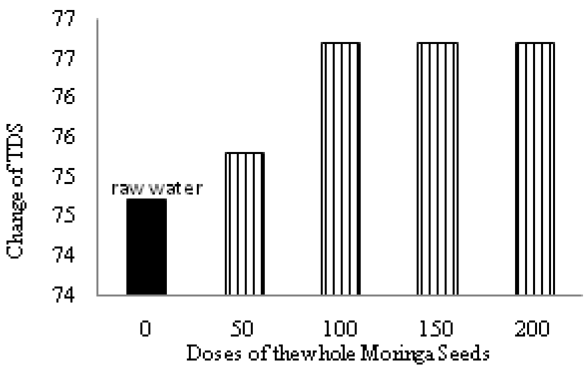
The use of *Moringaoleifera* whole seeds , *Moringaoleifera* seeds powder extracted with hexane (ppm), *Moringaoleifera* seeds powder extracted by water (ppm)and PAC might have an effect on the pH of the treated water of blue Nile river. The results of the effects are shown in Table 1 and 2. After using *Moringaoleifera* whole seeds, *Moringaoleifera* seeds powder extracted with hexane (ppm), *Moringaoleifera* seeds powder extracted by water, pH varied within the range of 7.8 - 8. Consequently for 24 ppm, 26 ppm and 28 ppm use of PAC showed an almost similar range of pH change 7.65 – 7.90.Ndabigengesere et al. reported that the action of M. oleifera as a coagulant lies in the presence of water-soluble cationic proteins in the seeds. This suggests that in water, the basic amino acids present in the protein of *Moringaoleifera* would accept a proton from water resulting in the release of a hydroxyl group making the solution basic. This accounted for the basic pH values observed for *Moringaoleifera*seeds treatments compared with PAC treatments [25]. The change of pH after coagulation treatment was found within the permissible limit for the drinking as well as domestic water quality set by the WHO and Sudanese Standard and Metrology Organization SSMO [26, 27]. It was observed that the change of pH was random but not in any extreme level either acidic or basic.

3.2 Effect of Seed Extracts on Turbidity

Results for the removal of turbidity using various doses of *Moringaoleifera* seeds are shown in Table1. Whole *Moringaoleifera* seeds were able to achieve 99.2 % turbidity removal at an optimum dosage of 50 ppm for 12.8 NTU while for 15.3, 22.7 and 39.6 NTU turbidity the dosage were 100, 150 and 200 ppm respectively and percentage turbidity removal was 99.07 %, 98.7 % and 97.6 % respectively. Whereas seeds powder of *Moringaoleifera* extract by hexane was able to achieve 99.8 % turbidity removal at an optimum dosage of 50 ppm for 6.36 NTU while for 7.5, 7.77, and 9.52 NTU turbidity the dosage were 100, 150 and 200 ppm respectively and percentage turbidity removal was 99.8 %, 99.5 %, 99.5% and 99.4 % respectively. PAC was able to achieve 99.75 % turbidity removal at optimum dosage of 28 ppm for 4.07 NTU while for 4.82 and 4.27 NTU turbidity the dosages were 24 and 26 ppm respectively and percentage turbidity removal was 99.70 % and 99.74 respectively. The results obtained by using *Moringaoleifera* at every dose comply with the Sudanese drinking water standard and WHO guidelines [28, 29]. From the results, it is clear that the lower dose (50 ppm) was the best for control of turbidity compared to the higher doses (150 and 200 ppm).The turbidity after treatment by *Moringaoleifera* seed extract by hexane was better than *Moringaoleifera* whole seeds. The addition of dosage beyond optimum dose is shown slight increasing the turbidity.

3.3 Effect of Seed Extracts on TDS

Table 1, shows that the TDS value of the Blue Nile river water before and after treatment by the different form of seeds. The TDS of water sample treated by whole *Moringaoleifera* seeds falls between 75-76.7 ppm with an average value of 76.4 ppm, whereas that of water treated by seed powder of *Moringaoleifera* extract by hexane falls between 76.7 – 80 ppm with an average value of 78.4 ppm. For water sample treated by seeds powder of *Moringaoleifera* extracted by water the TDS fall between 82 – 84 ppm with an average value of 82.8 ppm. It was clear that after treatment the TDS value increase and the values were within the acceptable range for the use of domestic purposes according to WHO guideline [27]. Hence, the coagulation process has only very little on the concentration of TDS of the sample water. *Moringaoleifera* is known to be a natural cationic polyelectrolyte and flocculent with a chemical composition of basic polypeptides with molecular weights ranging from 6000 to 16,000 daltons, containing up to six amino acids of mainly glutamic acid, methionine, and arginine [30].



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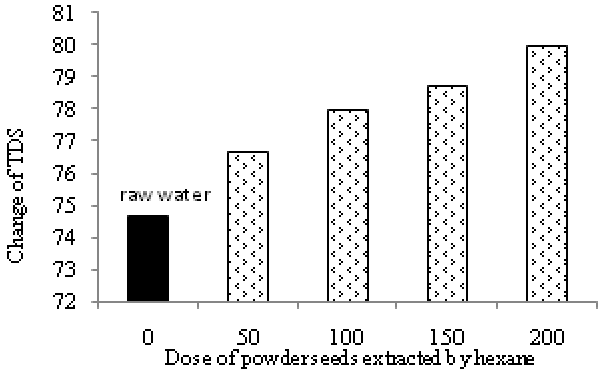

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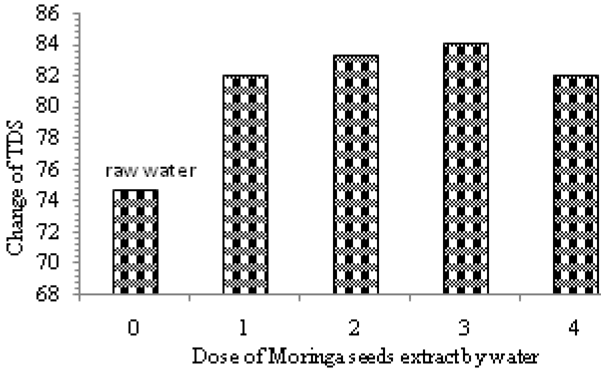

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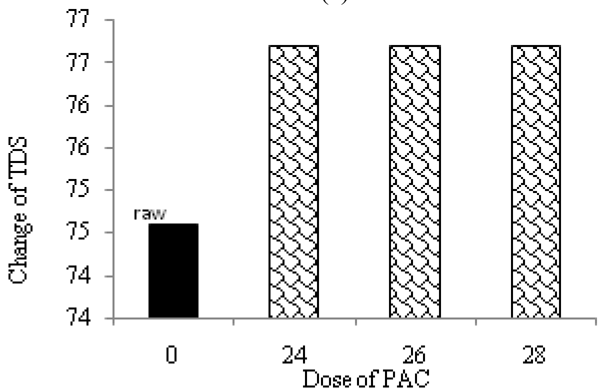

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Figure 2: Effect of *Moringaoleifera* seeds (a), *Moringaoleifera* seeds powder extract by hexane (b), Moringaoleifera seeds powder extract by water (c), PAC (d) on TDS of sample water.

3.4 Effect of Seed Extracts on Alkalinity

Alkalinity during the present study was observed to be 140 ppm. At various doses powder of*Moringaoleifera* seed, it was observed that the alkalinity reduced after the treatment at the different doses. The alkalinity observed was in the rangeof 95-100 mg/l which was within the limit. The slight decrease in alkalinity of all water samples may be due to precipitation of insoluble products of the reaction between the *Moringaoleifera* and the hardness causing ions similar to precipitation softening using lime/soda ash. The *Moringaoleifera*seed extract appears to have natural buffering capacity. The precipitates (solids / flocks) were light and did not settle easily. The chemical constituent of the precipitate is however not known, but it was found that alkalinity reduction in the coagulation of water sources using *Moringaoleifera* seeds [31].

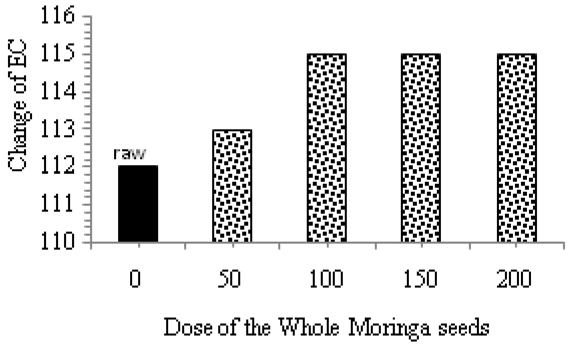
Table 1: Physico-chemical characters of Blue Nile river water before and after treatment with various doses of *Moringaoleifera* seed powder

Parameter		Doses of *Moringaoleifera* whole seeds (ppm)				Doses of *Moringaoleifera* seeds powder extracted with hexane (ppm)				Doses of *Moringaoleifera* seeds powder extracted by water (ppm)			
	Raw	50	100	150	200	50	100	150	200	1	2	3	4
T.B (NTU)	16.5	12.8	15.3	22.7	39.6	6.36	7.56	7.77	9.52	4.95	9.30	13	19.8
pH	8.05	7.95	8.0	8.0	8.0	7.8	7.8	7.8	7.8	7.95	8.0	8.1	8.05
EC (µs/cm)	112	113	115	115	115	115	117	118	120	124	125	126	123
T. A (ppm)	140	100	100	100	100	80	80	80	80	80	120	80	80
TDS (ppm)	74.7	75.3	76.7	76.7	76.7	76.7	78.0	78.7	80	82	83.3	84	82
T.H ($CaCO_3$ ppm)	68	72	68	68	68	68	68	68	84	68	68	68	68
Ca^{+2} (ppm)	16	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.6	16	17.6	20.8	16
Mg^{+2} (ppm)	7.84	7.84	6.72	6.72	6.72	6.72	6.72	6.72	11.2	7.84	6.72	4.48	7.84
Chloride (ppm)	8	8	10	10	10	8	8	8	8	8	10	8	8

Key: T. B:Turbidity, EC: Electric conductivity, T. A: Total Alkalinity, T.H: Total hardness

Table 2: Physico-chemical characters of Blue Nile river water before and after treatment with doses of PAC

Parameter	*Doses of PAC (ppm)*			
	Raw	*24*	*26*	*28*
Turbidity(NTU)	16.50	4.82	4.27	4.07
pH	8.05	7.65	7.80	7.90
Electric conductivity EC (µs/cm)	112	115	115	115
Total Alkalinity(ppm)	140	80	100	100
TDS(ppm)	74.7	76.7	76.7	76.7
Total hardness ($CaCO_3$ppm)	68	60	64	68
Ca^{+2}	16	16	16	16
Mg^{+2}	7.84	5.6	6.72	7.84
Chloride (ppm)	8	16	16	16



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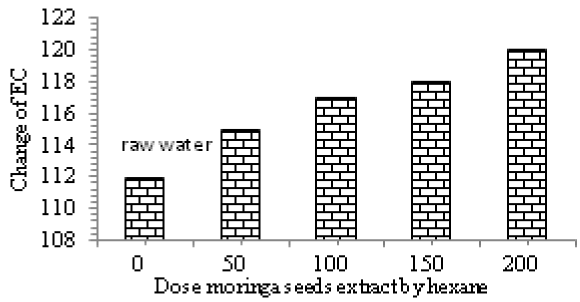

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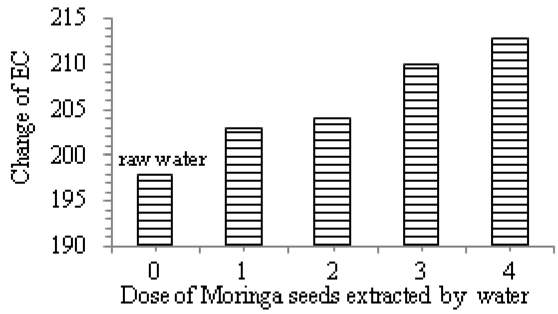

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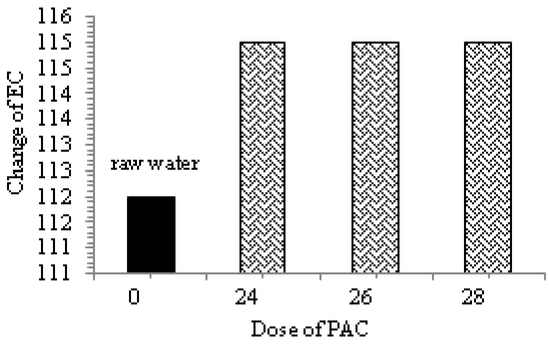
3.5 Hardness

Hardness ranges from 100-170 mg/l after treatment which is within the limits of WHO standards. As a polyelectrolyte it may therefore be postulated that *Moringaoleifera* removes hardness in water through adsorption and inter-particle bridging [32]. According to Muyibi and Evison, as a polyelectrolyte *Moringaoleifera* seed powder removes hardness in water through adsorption and inter-particle bridging. Secondly, with the observation that light and slow-settling solids/flocks were formed, precipitation reaction leads to the conversion of soluble hardness-causing ions to insoluble compounds would also be a good prediction of the reaction mechanism [33]. The higher value for the surface water samples is due to the fact that they contain hardness due to calcium, magnesium and other hardness causing substances. This implies that as the number of hardness increases, the required dosage of *Moringaoleifera* seed powder increases.

Chlorides initially were 8 ppm in the Blue Nile river water sample, but treatment with high doses of whole *Moringaoleifera* seed the chlorides concentration increase.

It was clear that after treatment by water and hexane extract of *Moringaoleifera*seed there were no significant change in chloride concentration. Chloride range was 5-9 mg/l in water samples and is within limits of drinking water standards. On the other hand when water treatment by PAC, the concentration of chloride increase two time of initial concentration of chloride.



(d)

Figure 3: Effect of Moringaoleifera seeds (a), Moringaoleifera seeds powder extract by hexane (b), Moringaoleifera seeds powder extract by water (c), PAC (d) on the EC of water sample

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