

Evaluation of the Use of Moringa Oleifera Seed Extract and Maize Starch as Coagulant Aids to Aluminium Sulphate in Water Treatment

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ABSTRACT

The major technique used in water treatment around the world is chemical coagulation using aluminium salts. Aluminium residual in drinking water has been found to be associated with various health problems and hence the need to source for locally available plant based materials as substitutes or aids to aluminium salts in water treatment. In this study, the effectiveness of powder extracted from mature-dried Moringa oleifera seeds, and maize starch as coagulant aids to aluminium sulphate (alum) in the treatment of water from Ahmadu Bello University waterworks, Zaria was determined. The quality of treated water with and without the coagulant aids were analysed and compared; as well as the quality of sludge produced. An optimum alum dose of 40mg/l was used with different concentrations of the coagulant aids and their results compared to that of half the concentration of the optimum dose (i.e. 20mg/l of alum) with increased concentration of coagulant aids in order to determine the possibility of reducing the amount of alum dose by substituting it with the coagulant aids. The results obtained showed that 20mg/l of moringa oleifera seed extract 70mg/l of maize starch and 10mg/l of a combination of both moringa oleifera seed extract and maize starch gave 2.35NTU, 2.38NTU and 3.79NTU as optimum turbidity values respectively when used as coagulant aids to half of the optimum dose of alum. Findings from this study indicate that both Moringa oleifera seed extract and maize starch are potentially viable coagulant aids to alum in the treatment of water in order to reduce aluminium residual in water.

Keywords: aluminium sulphate, coagulant aid, moringa oleifera , water treatment, optimum dose

INTRODUCTION

Safe water and adequate sanitation are basic to the health of every person on the planet, yet many people especially in Africa and Asia do not have access to this fundamental need (Bartram et al. 2005). An important step towards resolving this global crisis is to understand its magnitude: how many people lack access to safe drinking water and sanitation (WHO and UNICEF, 2000). Despite widespread recognition of the importance of improved water and sanitation and heavy investment by international donors and government in developing countries in extending water supply systems, more than half the population of rural areas still lack access to drinking water (Ron dinelli, 1991).

Due to this distressed situation people in rural areas are forced to use traditional sources that are polluted (WHO and UNICEF, 2000). Contaminated drinking water and inadequate supplies of water for personal hygiene and poor sanitation are responsible for about four billion cases of diarrhoea each year that cause 2.2 million deaths, mostly among children under the age of five (WHO, 2003).

Conventional water treatment processes involve coagulation, flocculation, settling and filtration. Presently, the most widely used coagulant in water treatment plants is sulphate of aluminium ($AlSO_4$) also known as alum because of its proven performance and cost effectiveness. The use of alum as a coagulant in the treatment of drinking water increases the aluminium concentration in finished water (Barnett et al., 1969).

It has been reported that the use of aluminium salts as primary coagulants in water treatment may result in increased residual aluminium which may be deposited in the water distribution system. Agitation of these deposits leads to increased aluminium levels resulting in undesirable colour and turbidity. (WHO, 1996). Also, aluminium residual in drinking water has been found to be associated with various health problems. Some minor symptoms that have been reported in literature resulting from high concentrations of aluminium in drinking water include nausea, vomiting, diarrhoea, mouth and skin ulcers, rashes and arthritic pain.(WHO, 2003). It was also stated in the Environmental Health Criteria document for aluminium (WHO, 1997) that there is possible linkage between aluminium in drinking water and Alzheimer disease.

An approach to reduce concentration of residual aluminium in finished water is to use a naturally occurring polyelectrolyte as a coagulant aid with primary coagulant alum. The coagulant aid reduces the requirement of alum and improves the physical characteristics of flocs which result in better quality of treated water. Toxicity of any polyelectrolyte has to be checked before it can be used as coagulant aid (CPHEEO 1991). Because most of the naturally occurring polyelectrolytes are of plant origin and are generally nontoxic in nature, these are given more importance by several workers (Bulusu et al. 1968). Studies on such material have been restricted to only finding the optimum dose required for clarification after settling and comparing the results to that of alum.



This study therefore seeks to determine the effectiveness of two natural polyelectrolyte materials- moringa oleifera seed extract and maize starch as coagulant aids and to determine whether or not the quantity of alum required can be reduced by the use of the coagulant aids under study.

MATERIALS AND METHODS

Natural Source Water

The natural source water was obtained from the Kubani dam, which is located at the southern part of the Ahmadu Bello University Zaria, Kaduna State main campus, close to the Water Treatment facility of the institution. Water was obtained and transported to the laboratory where it was stored at 4°C until tested. The experiments were performed within 3 weeks of collecting the source water.

Coagulant

Aluminium Sulphate ($AlSO_4$) also regarded to as Alum was used as the primary coagulant, it was obtained from the Samaru market Zaria, Kaduna State of Nigeria. Five grams of powered aluminium sulphate was weighed and dissolved in 100ml distilled water.

Coagulant aid preparation

Preparation of starch from maize

The process involved softening the kernel in steep water for two (2) days until the maize became soft for smooth grinding. The maize was smoothly ground and fine sieved to eliminate fibre from the starch (contains about 4-5% gluten). The sieved starch stood in a container for some time until was distinct supernatant water above and the settled starch below. Fractions were separated by taking advantage of differences in the physical properties including density and particle size of the fractions. The starch was dried and pounded in a mortar and piston until very fine grains attained and fine sieved again. Five grams of the starch was weighed. 100ml distilled water was added, mixed and filtered.

Preparation of Seed Extract from *Moringa Oleifera* Seeds

The *moringa oleifera* seeds used were dried, the pods were unshelled and the seeds removed. The seeds were later ground into powder and kept in a container with a cover. Five grams of seed powder was weighed. 100ml distilled water was added, mixed and filtered.

Jar Test for Coagulation

One litre of raw water was poured into 5 beakers each and placed under a special multiple stirrer rigs. The prepared solution of alum was added at concentrations of 2, 4, 6, 8 and 10ml. The coagulant concentrations were added simultaneously. The set up were stirred thoroughly with a glass rod to enable total dispersal of coagulant. Samples were then flocculated for 30 minutes and allowed to stand in a quiescent condition for 60 minutes on a work bench. Supernatant was decanted and examined for pH, colour and turbidity and the optimum coagulant dosage was obtained. The jar test experiment was carried out using standard Methods. A laboratory Jar test equipment manufactured by Peterson Candy

International Limited, England was used to carry out the coagulation on the water samples.

The procedure was repeated with the addition of the coagulant aids (*moringa oleifera* seeds extract, maize starch and also a mixture of the two respectively) and the optimum coagulant dosage obtained as in the step above.

Physicochemical Measurements of the Raw Water Sample

Turbidity

Turbidity value of the raw water decreased from 322NTU when treated with varying concentrations of alum until the lowest turbidity of 4.58NTU was reached at 40mg/l which implied that optimum alum dose was 40mg/l.

The raw water sample was then treated using the optimum alum dose (40mg/l) with varying concentrations of *moringa oleifera* seed extract, maize starch and a combination of both *moringa* and maize starch as coagulant aids with the alum.

Analysis of Quality of Sludge Produced after Coagulation

The sludge that was produced from the coagulation process using alum, *moringa oleifera* seed extract, maize starch and the mixture of the two as coagulant aids were tested and analysed in the laboratory in order to determine their NPK values.

RESULTS AND DISCUSSION

Physical Properties of Raw Water

The physical properties of the raw water sample obtained from the Kubanni reservoir are as given in Table 1. The table shows that the raw water sample is highly turbid and slightly acidic.

Table 1: Physical Properties of Raw Water Sample obtained from the Kubanni Reservoir

Physical properties	Value
Turbidity	322 NTU
pH	6.8
Colour	70

Physical Properties of Maize Starch, *Moringa Oleifera* Seed Extract and Alum

The Maize Corn was yellowish in colour and of the family *Zea mays*. The Starch produced from the Maize Corn was fine and yellowish in colour. The Alum (Aluminium Sulphate) was white in colour and in powdered form while the *Moringa Oleifera* seed extract prepared was white in colour, fine and properly stored. The paste was freshly made each time it was to be used.

Quality of Effluent After coagulation using only alum

The effluent turbidity from coagulating with Alum (coagulant) gave the optimum results at a dose of 40mg/l as shown in Table 1, with turbidity reduction from 322 to 4.58 NTU. The pH and colour reduced from 6.8 and 70 to 6.5 and 5 respectively and then remained constant for all the doses of alum used.



Table 2: Physical parameters of effluents after coagulation using only alum

Coagulant dose (mg/l)	Turbidity (NTU)	pH	Colour
0	322	6.8	70
20	9.22	6.5	5
40	4.58	6.5	5
60	6.57	6.5	5
80	12.2	6.5	5
100	11.8	6.5	5

Effect of Coagulant Aids on the Turbidity of the Treated Water Sample

The turbidity results of the raw water sample using optimum alum dose (40mg/l) with varying concentrations of *moringa oleifera* seed extract, maize starch and a combination of both *moringa* and maize starch as coagulant aids are as shown in Table 2.

The turbidity of effluent with alum and 40mg/l of *moringa oleifera* as coagulant aid gave an optimal turbidity value of 2.13 NTU, the optimum turbidity of 3.14 NTU was obtained with alum and 50mg/l of maize starch while the combination of *moringa oleifera* and maize as coagulant aid resulted in an optimal turbidity value of 5.19NTU using only 60mg/l of the coagulant aids mixture. This result indicate that the *moringa oleifera* was able to aid coagulation better than the maize as a lesser quantity was required to give almost the same results with the use of starch. However, the combination of the two coagulant aids had an optimum dose of 5.19 NTU which is slightly higher than the recommended standard turbidity for drinking which according to WHO should not be greater than 5NTU.

Table 3: Turbidity values of water samples using 40mg/l alum with the coagulant aids

Coagulant aid dose (mg/l)	Turbidity (NTU) mor	Turbidity (NTU) mai	Turbidity (NTU) mor&mai
0	322	322	322
10	10.7	11.13	8.88
20	7.13	10.9	11.0
30	7.06	6.21	6.65
40	2.13	7.27	5.96
50	10.2	3.14	8.82
60	7.48	12.0	5.19
70	6.07	9.13	6.84
80	6.77	14.0	11.8
90	5.55	8.48	9.77
100	14.2	9.68	7.58

Mor – *moringa oleifera*

mai- maize

Effect of 50% Reduction of Alum with Coagulant aids on Quality of Effluent

The effect of 50% reduction in the optimum dose of alum on the quality of the effluent was investigated to determine whether or not the coagulant aids can make up for the reduction in alum dosage. The Table 4 shows the

percentage reduction in turbidity of the water sample on coagulating using 50% optimum alum dose with the coagulant aids.

Table 4: Turbidity values of water samples using half the optimum dose of alum with the coagulant aids

Coagulant aid dose (mg/l)	Turbidity (NTU) mor	Turbidity (NTU) mai	Turbidity (NTU) mor&mai
0	322	322	322
10	6.25	5.69	3.79
20	2.35	5.47	7.89
30	5.34	3.95	4.99
40	5.69	2.92	5.96
50	15.1	2.53	13.7
60	17.0	2.44	8.86
70	37.0	2.38	5.80
80	55.4	2.98	15.0
90	46.6	4.36	14.3
100	77.9	3.06	8.33

The turbidity results of the raw water sample using half of the optimum alum dose i.e. 20mg/l with varying concentrations of *moringa oleifera* seed extract, maize starch and a combination of both *moringa* and maize starch as coagulant aids are as shown in Table 4.

The turbidity of effluent with alum and 20mg/l of *moringa oleifera* as coagulant aid gave an optimal turbidity value of 2.35 NTU, the optimum turbidity of 2.38 NTU was obtained with alum and 70mg/l of maize starch while the combination of *moringa oleifera* and maize as coagulant aid resulted in an optimal turbidity value of 3.79 using only 10mg/l of the coagulant aids mixture. This result indicate that the *moringa oleifera* was able to aid coagulation better than the maize as a lesser quantity was required to give almost the same results with the use of starch. However, the combination of the two coagulant aids was able to give a value of 3.79 NTU which although was a bit higher than the optimal values obtained using *moringa oleifera* and maize separately, it was able to attain with only 10mg/l of the mixture and the turbidity value obtained still falls within the recommended standard turbidity for drinking which according to WHO should not be greater than 5NTU.

Quality of sludge produced using alum only and alum as coagulant with the various coagulant aids

The quality of sludge produced during the coagulation process using alum as coagulant with various coagulant aids was determined by testing the sludge obtained in order to find out which of the obtained sludge can be used as fertilizer. The use of sludge as fertilizer will also help reduce the disposal difficulty of the sludge produced during coagulation.

The results obtained from the different sludge produced are given in table 5.



Table 5: Analysis of sludge produced from the coagulation process.

SLUDGE SAMPLE	NITROGEN (%)	PHOSPHORUS (%)	POTASSIUM (%)
Alum	1.313	0.137	0.148
Alum and <i>MoringaOleifera</i>	1.663	0.156	0.133
Alum and Maize starch	1.225	0.156	0.103
Alum, <i>Moringa</i> and Maize starch	1.580	0.176	0.130

From the Table 5, sludge obtained after coagulation with alum and *moringa oleifera* seed extract as coagulant aid has the highest percentage of nitrogen and potassium. This suggests that *moringa oleifera* seed extract improves the quality of sludge produced and can therefore enhance its use as fertilizer thereby reducing disposal difficulty of the sludge produced from water treatment plants.

CONCLUSION

This study has shown that *Moringa oleifera* seed extract and maize starch are effective natural coagulant aids which can be used in improving the turbidity of water during water treatment and the quantity of aluminium sulphate used in water treatment can be reduced by the use of these coagulant aids. Also, the quality of sludge produced from the treatment process is better with the use of coagulant aids (*Moringa oleifera*) than with alum alone.

References

- Barnett P.R., Skorrstad M.W., Miller K.J.(1969). Chemical characterization of a public water supply. J. Am. Water Works Assoc. 61:61–67.
- Bartram, F. G., Fewtrell, L., Prüss-Üstün, A and Bos R.(2005). Water, sanitation and hygiene: quantifying the health impact at national and local levels in countries with incomplete water supply and sanitation coverage. World Health Organization, Geneva.
- Bulusu K.R., Thergaonkar V.P., Kulkarni D.N., Pathak B.N. (1968). Natural polyelectrolytes as coagulant aid. Indian J. Environ. Health 10:239–264
- CPHEEO (1991). Manual on water supply and treatment. Ministry of Urban Affairs and Employment, New Delhi.
- World Health Organization and UNICEF. (2000). Global water supply and sanitation assessment 2000 report. World Health Organisation/United Nations Children's Fund, Geneva/New York.
- World Health Organization (1996). Guidelines for drinking-water quality, 2nd ed. Vol. 2. Health criteria and other supporting information. Geneva, World Health Organization.
- WHO (1997) Aluminium. Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 194).
- World Health Organization (2003a). "Managing water in the home: Accelerated gains from improved water supply."
- World Health Organization(2003b). Aluminium in Drinking-water: Background document for development of WHO Guidelines for Drinking-water Quality, 2003.

