PRODUCTION TECHNIQUE OF NATURAL COAGULANT FROM *MORINGA OLEIFRA* SEEDS

Eman N. Ali[1], Suleyman A. Muyibi[2], Hamzah M. Salleh[2], Md Zahangir Alam[2], and Mohd Ramlan M. Salleh[2]

1) Ph.D. Candidate, Bioenvironmental Engineering Research Unit (BERU) Biotechnology Engineering Department, Faculty of Engineering, International Islamic University Malaysia, P.O. Box 10, 50728 Kuala Lumpur, Malaysia
E-mail: iman129@yahoo.com
2) Bioenvironmental Engineering Research Unit (BERU) Biotechnology Engineering Department, Faculty of Engineering, International Islamic University Malaysia, P.O. Box 10, 50728 Kuala Lumpur, Malaysia

ABSTRACT

The synthetic coagulants are available worldwide in different types for water treatment. These coagulants create many problems that need to be solved. Natural coagulant consider safe and more economical alternative for developing countries where the plant is available. Many researchers have worked to find production technique, but most of these research works showed high cost and complicated techniques.

This paper presents the production methodology of natural coagulant from *Moringa oleifera* seeds. It is produced by cost effective technique (oil extraction, salt extraction, and microfiltration through 0.2 μm). The turbidity removal was 94.82% by adding a dosage of 0.8 mg/L of processed *Moringa oleifera* seeds to river water with initial turbidity of 44.2 NTU.

The product can contribute to the water treatment industry in many countries where the plant is indigenous. It can be produced locally and exported worldwide.

Keywords: *Moringa oleifera* seeds, Microfiltration, Natural coagulant, Salt extraction

1. INTRODUCTION

Developing countries are facing potable water supply problems because of inadequate financial resources. The cost of water treatment is increasing, and the quality of river water is not stable due to a suspended and colloidal particle load caused by land development and high storm runoff during the rainy season such is experienced in a country like Malaysia and other countries. Due to many problems created by using the synthetic coagulants such as aluminium sulphate which is used worldwide, there is a high demand to find an alternative coagulant which is preferable to be a natural coagulant.

Naturally occurring coagulants are usually presumed safe for human health. Many researchers have reported on *Moringa oleifera* various uses and as a coagulant specifically for the last 25 years (Jahn, 1984 & 1988; Sutherland et al. 1992; Gassenschmidt et al. 1995; Muyibi & Okuofu, 1995; Muyibi & Evison 1995 and 1996; Ndabigengesere et al. 1995; Ndabigengesere & Narasiah 1998; Okuda et al. 1999; Muyibi & Evison 1999; Diaz et al. 1999; McConnachie et al. 1999; Muyibi et al. 2001, 2002, 2003; Muyibi & Alfugara 2003; Birima et al. 2003, Kebreab et al. 2005) they have found that the Moring*a oleifera* seed is non-toxic and good coagulant in water treatment. It is recommended to be used as a coagulant in developing countries. Encouraged results of these studies, many developing countries have turned to use this plant as a viable coagulant in water and wastewater treatment on a small scale (Ndabigengesere et al. 1995).

Usually, the aluminium sulphate is the most used coagulant in water treatment for coagulation-flocculation process. Aluminium sulphate is usually imported and this adds extra cost to the water treatment industry. The lime for pH adjustment is added to the water treatment process, which is considered as an additional cost for water treatment companies. Therefore, this paper is focused on presenting the developed, efficient and cost effective processing technique for *Moringa oleifera* seed to be used for drinking water treatment.

2. MATERIALS AND METHODS

Good quality dry seeds of *Moringa oleifera* were selected from the pods that was collected from Serdang), Selangor Darul Ehsan, Malaysia (Figure 1). The pods collected were allowed to completely dry on the tree (the brown colour pods) because the green pods do not possess any coagulation activity (Ndabigengesere et al. 1995). The seeds coat and wings were removed manually. The seeds were grounded and sieved through sieve 250 µm (Gassenschmidt et al. 1995). The powder with < 250 µm was used in this research work.

Fig. 1 *Moringa oleifera* pods and seeds

2.1 Process Scheme

The proposed production method for natural coagulant from *Moringa oleifera* seed is shown in Figure 2. It represent process details starting from harvesting the pods, grinding, sieving of the seeds, oil extraction using hexane, salt extraction with 1 M NaCl, microfiltration using the filter size of 0.2 µm, and freeze drying of the permeate, which is the natural product in dry form.

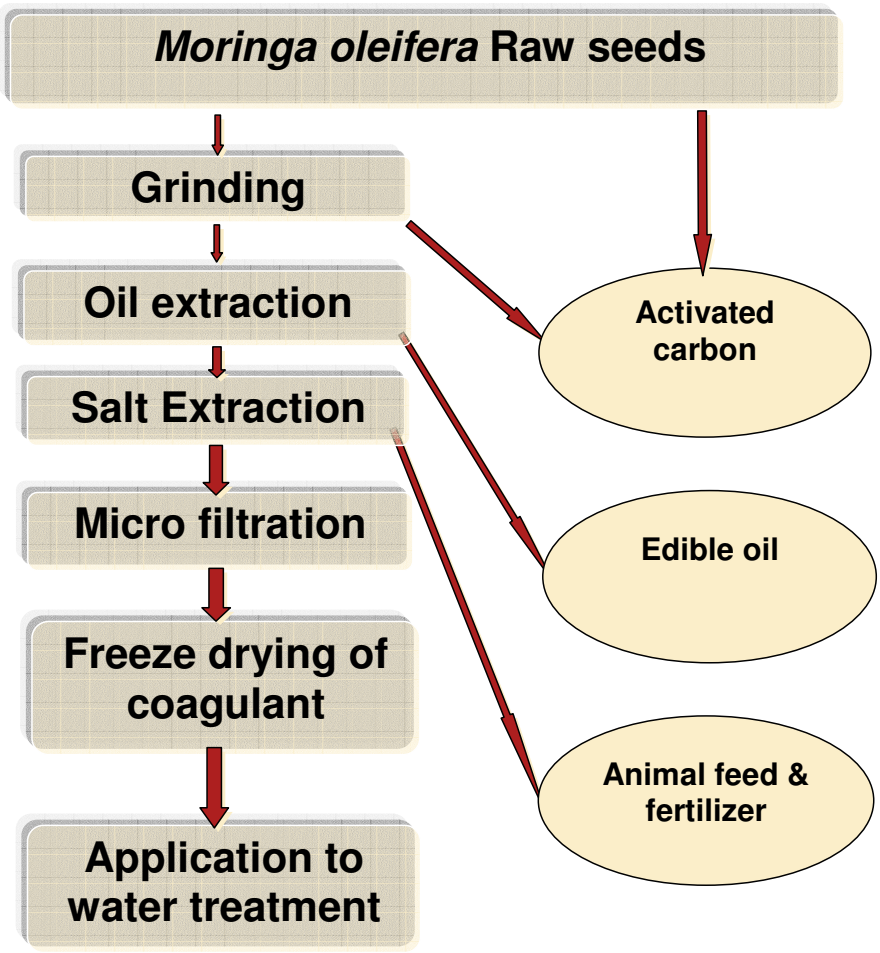

Fig. 2 Proposed method for processed *Moringa oleifera* seed production

2.2 Oil Extraction

Oil extraction from *Moringa oleifera* seed was carried out to remove the oil from the seed. Oil extraction was done by adding hexane to the seed powder. Electro Thermal Soxhlet apparatus was used and the procedure was as follows: Weighing of 10 gm of *Moringa oleifera* seed powder and setting it in the thimbles of the electro thermal soxhlet extraction chamber. Adding 170 ml of hexane in the heating chamber; Evaporating of hexane within three cycles each for 30 min to ensure the extraction of

oil from the seeds (until the hexane became colourless); Drying of *Moringa oleifera* cake residue from the soxhlet thimbles and weighing the dry sample (Muyibi et al. 2003). The oil content was 35% of the seed weight. The *Moringa oleifera* cake residue stock after oil extraction was used in this research work.

2.3 Salt Extraction of Bio-Active Constituents

Extraction of bio-active constituents by sodium chloride (NaCl) was done by adding 1 Molar NaCl. Five grams of the *Moringa oleifera* cake residue stock after oil extraction was added to 1 litre of 1 M NaCl and mixed for 30 minutes using the magnetic stirrer. The solution then filtered with Whatman filter paper # 1, and the clear solution then applied to microfiltration cartridge.

2.4 Cross Flow Filtration

2.4.1 Cross Flow Filtration (microfiltration)

Cross flow filtration (QuixStand Benchtop System) with peristaltic pump Xampler was used for this process. The microfiltration cartridge (CFP-2-E-3MA) was used for sample filtration with pore size of 0.20 µm, which have fibre ID 1 mm, membrane area 110 cm^2, and nominal flow path length of 30 cm. It is a polysulfone membrane which is operated in a vertical orientation complete process fluid drainage and maximum product recovery can be achieved. The sample extracted by salt and filtered in section 2.3 above was applied to the microfiltration cartridge. The permeate was collected and injected to the ultrafiltration cartridge. The protein concentration was measured by protein assay method (Bradford MM, 1976). The conventional jar test was performed and the dosage of processed *Moringa oleifera* was added according to the protein concentration.

2.4.2 Cross Flow Filtration (ultrafiltration)

The Xampler ultrafiltration cartridge (UFP-1-C-3M) was used for bioactive constituents separation with cutoff of 1000 NMWC with fiber ID 0.5 mm, membrane area 140 cm^2, and nominal flow path length 30 cm, the type of membrane is polysulfone hollow fiber type (GE Healthcare Bio-Science Corp. USA).

2.5 Freeze Drying

The freeze drying of processed *Moringa oleifera* results in awhite powder, which it totally soluble in water. The powder solution has a high coagulation activity. The product was dried by freezing by using (LABCONCO, Labconco Corporation 8811, Prospect Avenue, Kansas City, Missouri 64132, USA).

2.6 Evaluation of bioactive constituent's efficiency by Jar Test

The produced natural coagulant was evaluated by performing the conventional jar test. The processed *Moringa oleifera* seed was applied to river water samples and the residual turbidity was measured, and the turbidity removal percentage was calculated.

3. RESULTS AND DISCUSSION

The results of this research work showed that the processed *Moringa oleifera* seed is a natural coagulant of high efficiency, it was possible to treat river water with low initial turbidity of 44.2 NTU. The processed *Moringa oleifera* seed was added to river water sample and residual turbidity was measured. In the same time, other test were carried out to compare between the use of aluminium sulphate (the most common coagulant), and the natural coagulant (processed *Moringa oleifera* seeds).

3.1 Jar test using aluminium sulphate

Aluminium Sulphate [Al_2 $(SO_4)_3.18H_2O$] used in this research work is laboratory grade. Five grams of aluminium sulphate was added to 100 ml of tap water to get 5% w/v solution of aluminium sulphate stock solution. The jar test was carried out to treat the river water with initial low turbidity of 44.2 NTU and pH 6.08 with different dosages of aluminium sulphate. The method applied was according to (Muyibi et al. 2003) with rapid mixing of 125 rpm for 4 minutes, followed by slow mixing of 40 rpm for 25 minutes for the flocculation process, and settling time of 1 hour. The jar test equipment contains six paddles rotating in a set of six beakers. The residual turbidity was measured for the supernatant of each beaker in the jar test. The results are shown in Figure 3. An additional tests were carried out which is important in water treatment such as; chemical oxygen demand (COD), pH, and Conductivity. The results are shown in Table 1.

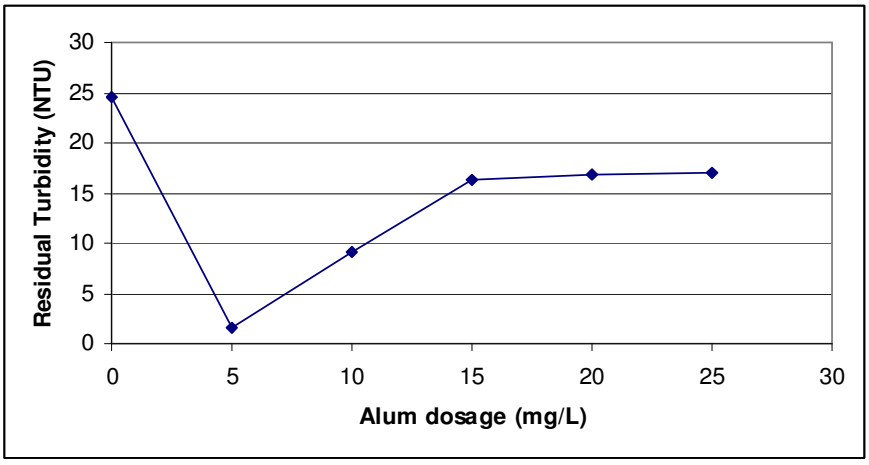

Fig. 3 Residual turbidity using aluminium sulphate

3.2 Jar test using microfiltered Moringa oleifera seed

The jar test was performed by adding of different dosages of processed *Moringa oleifera* seed (after microfiltration) to river water. The residual turbidity was measured; results are shown in Figure 4. Other tests were carried out for the supernatant water after settling for 1 hour. The results are shown in Table 1.

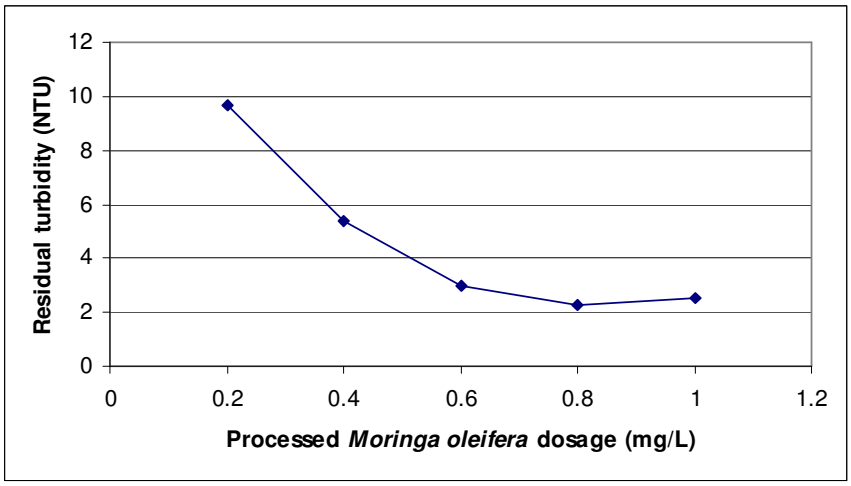

Fig. 4 Residual turbidity using microfiltered *Moringa oleifera*

3.3 Jar test using ultrafiltered *Moringa oleifera* seed

The jar test was performed by adding of different dosages of processed *Moringa oleifera* seed (after ultrafiltration) to river water. The residual turbidity was measured; other tests were carried out for the supernatant water after settling for 1 hour. The results are shown in Table 1.

Table 1 Comparison between using alum, microfiltered *Moringa oleifera,* and ultrafiltered *Moringa oleifera*

Alum dosage (mg/l)	Residual Turbidity (NTU)	Removal percentage (%)	COD (ppm)	Conductivity (µs/cm)	pH
5	1.63	96.31	8	57.4	5.81
Jar test for sample microfiltered with 0.2 µm					
Dosage (mg/l)	**Residual Turbidity (NTU)**	**Removal percentage (%)**	**COD (ppm)**	**Conductivity (µs/cm)**	**pH**
0.8	2.29	94.82	13	296	7.03
Jar test for sample ulrafiltered with 1 kD					
0.8	2.17	95.1	14	263	6.79

The results of this research work showed that the processed *Moringa oleifera* seed can be used for river water treatment. A dose of 0.8 mg/L of processed *Moringa oleifera* seed was enough to get residual turbidity of 2.29 NTU for microfiltered and 2.17 NTU for ultrafiltered *Moringa oleifera* seed, while 5 mg/L of aluminium sulphate is needed to treat the same turbidity. The residual turbidity was less than the standard drinking water turbidity of less than 5 NTU according to World Health Organization (WHO). The pH of treated water is very important as the potable water should have pH between 6.5-8.5 according to (WHO). The pH for water treated with processed *Moringa oleifera* seed was 7.03 for microfiltered and 6.79 for ultrafiltered *Moringa oleifera* seed, which is within the standard range, while it was 5.81 for water treated with aluminium sulphate. Therefore, it is important to add the lime to adjust the pH and this is an additional cost for water treatment industry. The conductivity and COD are within the standard limits which are acceptable in potable water in both cases by using aluminium sulphate and processed *Moringa* oleifera seeds.

It was observed that the microfiltered *Moringa oleifera* was good enough and the turbidity removal was 94.82%, and there is no much improvement by using ultrafiltration process which adds more production cost with an increase in turbidity removal of 0.28% only.

4. CONCLUSIONS

The produced *Moringa oleifera* is of high efficiency and the turbidity is removed by using very low dosages. The processed *Moringa oleifera* is performing well with low dosages compared to the aluminium sulphate. The coagulant has a very good coagulating activity in the turbidity removal for water with low turbidity which was difficult to be achieved by most researchers who have studied the application of *Moringa oleifera* seed in water treatment.

Moringa oleifera is recommended to be an alternative coagulant to aluminium sulphate for water treatment not only in Malaysia (where the plant considered indigenous) but, worldwide.

ACKNOWLEDGMENTS

The author would like to appreciate the financial support from Ministry of Science, Technology and Innovation (MOSTI), Malaysia under project IRPA (09-02-08-10002-EAR) headed by Prof. Dr. Suleyman A. Muyibi.

REFERENCES

[1] Birima, A.H., Muyibi, S.A., Mohammed, T. A., Noor, M.J.M.M., Ghazali, A.H., and Yusuf, B. (December 2003). *Comparative studies between*

conventional treatment of surface water and direct filtration using Moringa oleifera seed extract as primary coagulant. IWA Conf. on Environmental Biotechnology/ Advancement on Water and Wastewater Applications in the Tropics. Kuala Lumpur, Malaysia, 2003.

[2] Bradford, M.M. (1976). Rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal Biochem.*, Vol. 72, pp. 248-254.

[3] Diaz, A., Rincon, N., Escorihuela, A., Fernandez, N. Chacin, E., and Forster, C.F. (1999). A preliminary evaluation of turbidity removal by natural coagulants indigenous to Venezuela. *Process Biochemistry*, Vol. 35, pp. 391-395.

[4] Gassenschmidt, U., Jany, K.D., Tauscher, B., and Niebergall, H. (1995). Isolation and Characterization of a flocculating protein from *Moringa oleifera* Lam. *Biochemica et Biophysica Acta.*, Vol. 1243, pp. 477-481.

[5] Jahn, S.A.A. (1984). Effectiveness of Traditional Flocculants as Primary Coagulants and Coagulant aids for the Treatment of Tropical Waters with more than a Thousand Fold Flocculation in Turbidity. *Water Supply*, 2 (3/4) Special Subject (6), pp. 8-10.

[6] Jahn, S.A.A. (1988). Using *Moringa oleifera* seeds as coagulant in developing countries. *J. Am. Wat. Wks Ass.*, Vol. 6, pp. 43-50.

[7] Kebreab, A.G., Gunaratna K.R., Henriksson H., Brumer H., and Dalhammar G. (June 2005). A simple purification and activity assay of the coagulant protein from *Moringa oleifera* seed. *Water Research,* Vol. 39, pp. 2338-2344.

[8] McConnachie, G.L., Folkard, G.K., Mtawali, M.A., and Sutherland, J.P. (1999). Field Trials of Appropriate Hydraulic Flocculation Processes. *Wat. Res.*, Vol. 33 (6), pp. 1425-1434.

[9] Muyibi, S.A. and Alfugara, A.M.S. (December 2003). Treatment of surface water with *Moringa oleifera* seed extract and Alum – A comparative study using A Pilot scale water treatment plant. *International Journal of Environ. Studies*, Vol. 60, No. 6, pp. 617-626.

[10] Muyibi, S.A. and Evison L.M. (1995). Optimizing Physical Parameters affecting coagulation of turbid water with *Moringa oleifera* seeds. *Wat. Res.*, Vol. 29 (12), pp. 2689-2695.

[11] Muyibi, S.A., Abbas, S.A., Noor, M.J.M.M., Ahmadon, F.R. (2003). Enhanced coagulation efficiency of *Moringa oleifera* seeds through selective oil extraction. *International Islamic University Malaysia Engineering Journal*, Vol. 4, No. 1, pp. 1-11.

[12] Muyibi, S.A., and Evison, L.M. (1996). Coagulation of turbid water and softening of hardwater with *Moringa oleifera* seeds. *Int. J. Environ. Studies*, Vol. 49, pp. 247-259.

[13] Muyibi, S.A., and Evison, L.M. (1999). Flocs settling characteristics of turbid water coagulated with *Moringa oleifera* seeds. *International J. Environ. Studies*, Vol. 56, pp. 483-495.

[14] Muyibi, S.A., and Okuofu, C.A. (1995). Coagulation of low turbidity surface water with *Moringa oleifera* seeds. *Int. J. Environ. Studies*, Vol. 48, pp. 263-273.

[15] Muyibi, S.A., Mohammed, A.H.B., Mohammed T.A., and Noor, M.J.M.M. *Direct Filtration for Removal from Surface Water with Moringa oleifera seed Extract as Primary Coagulant*. Proceedings of Int. Conf. on Chemical and Bioprocess Engineering. University Malaysia Sabah, Kota Kinabalu, Malaysia, 2003.

[16] Muyibi, S.A., Noor, M.J.M.M, Ong, D.T., and Kai, K.W. (2001). *Moringa oleifera* seeds as a flocculant in waste sludge treatment. *International J. Environ. Studies*, Vol. 58, pp. 185-195.

[17] Muyibi, S.A., Noor, M.J.M.M., Leong, T.K., and Loon, L.H. (2002). Effect of oil extraction from *Moringa oleifera* seeds on coagulation of turbid water. *Environ. Studies*, Vol. 59, No. 2, pp. 243-254.

[18] Ndabigengesere, A., and Narasiah, K.S. (1998). Quality of water treated by coagulation using *Moringa oleifera* seeds. *Wat. Res*., Vol. 32, No. 3, pp. 781-791.

[19] Ndabigengesere, A., Narasiah, K.S. and B.G. Talbot (1995). Active agents and mechanism of coagulant of turbid waters using *Moringa oleifera*. *Water Research*, Vol. 29, No. 2, pp. 703-710.

[20] Okuda, T., Baes, A.U., Nishijima, W., and Okada, M. (1999). Improvement of extraction method of coagulation active components from *Moringa oleifera* seed. *Water Res*., Vol. 33, No. 15, pp. 3373-3378.

[21] Sutherland, J.P., Folkard, G.K., and Grant, W.D. (1992). *Natural coagulants as pilot scale*. 18th WEDC Conf. Proceedings, pp. 55-58.