Moringa oleifera as coagulant for batik effluent treatment*)

Hefni Effendi[1)], Raden Delima Sari[1)], Sawarni Hasibuan[2)]

[1)] Centre for Environmental Research, Bogor Agricultural University, Indonesia
[2)] Djuanda University, Bogor, Indonesia

Traditional batik industrial wastewater is not well treated so far. The waste is simply dumped into the surrounding water bodies. Raw wastewater quality characteristics of batik small and medium enterprises (SMEs) included pH (6.05), turbidity (1306 NTU/Nephelometric Turbidity Unit), TSS/Total Suspended Solid (1248 mg/l) and COD/Chemical Oxygen Demand (3712.5 mg/l).

M. oleifera seed powder coagulant addition and deposition length as well as their interactions in batik effluent treatment significantly (0.01) affected turbidity decrease. Interaction of *M. oleifera* seed powder coagulant addition (4000 mg/l) and deposition length (180 minutes) showed the lowest turbidity decline namely 59.25 NTU (95.5% reduction).

M. oleifera seed powder coagulant addition significantly (0.01) affected TSS reduction. Deposition length and the interaction between the coagulant addition and deposition length did not significantly affect the TSS. Treatment of 5000 mg/l *M. oleifera* seed coagulant and 60 minutes precipitation gave the best results with the lowest TSS of 156.00 mg/l (87.5% reduction).

In general, the best treatment combination was shown by treatment of 5000 mg/l coagulant addition and 180 minutes long deposition which eventually produced turbidity of 61 NTU and TSS of 170 mg/l. However further investigation need to be carried out to treat the remaining high COD.

Key words: *Moringa oleifera*, batik, turbidity, TSS, COD.

INTRODUCTION

After gaining recognition from UNESCO as a world heritage in 2009, the batik industry in Indonesia has been growing rapidly. At the end of 2010, batik small and medium enterprises (SMEs) in Indonesia numbered 55778 units with total labor force of 916783 people (Juzri and Idris, 2012).

Traditionally batik industrial wastewater is not treated. The waste is simply dumped into the surrounding water bodies. One way to treat batik wastewater that would reduce the concentration of pollutants in the wastewater of batik is a method of coagulation and flocculation through the use of *Moringa oleifera* seed powder as a natural coagulant.

M. oleifera seeds contain proteins that have active coagulation properties and are being used for turbidity removal in many countries (Sotheeswaran *et al.* 2011). *M. oleifera* seeds are also used as a primary coagulant in drinking water clarification and waste water treatment due to the presence of a water-soluble cationic coagulant protein able to reduce turbidity of the water treated (Madrona *et al.* 2012; Saduzaman *et al.* 2013; Susheela *et al.* 2014). Plant materials such as extracts from *M. oleifera* seeds *Cactus latifaria* and *Prosopis juliflora* are natural coagulants used in the treatment of water for human consumption (Santos *et al.* 2012).

Antimicrobial factor (rhamnosyloxy benzyl-iso thiocyanate) found in *M. oleifera* seed could remove coliforms bacteria from water (Bina, 1991; Muyibi *et al.* 1995)

*) A paper presented at IAIA 15 (International Association for Impact Assessment) conference, 20-23 April 2015 in Florence, Italy.

The study aimed to determine the effect of natural coagulant of *M. oleifera* seed powder and deposition length on the decreament of turbidity, TSS, and COD in the wastewater treatment process of traditional batik SMEs.

MATERIALS AND METHOD

Liquid waste was taken from one of the batik SMEs in Bogor, Indonesia. *Moringa oleifera* seed were blended into a powder, then dried in an oven at 105°C for 30 minutes.

Various concentrations of coagulant *M. oleifera* seed powder [30000 mg/l (A1) , 40000 mg/l (A2), and 50000 mg/l (A3)] in 200 ml of batik liquid waste samples were stirred rapidly (100 rpm) for 3 minutes and slowly (40 rpm) for 12 minutes. Samples were then precipitated 60 minutes (B1), 120 minutes (B2), and 180 minutes (B3). Analysis of turbidity, TSS, COD, and pH (APHA, 2005) was performed on all samples.

Data were analyzed by analysis of variance (ANOVA) at significance level α=0.05 and α=0.01, then analyzed with least square different test (LSD) to determine differences among treatments.

RESULTS AND DISCUSSION

Turbidity

Comparison of raw batik effluent quality and raw textile effluent quality including pH, turbidity, TSS, COD is presented at **Table 1**.

Table 1. Characteristic of raw small scale batik effluent.

No	Parameter	Raw Batik Liquid Effluent	Raw Textile Effluent (Muralimohan *et al.* 2014)
1	pH	6.05	11.65
2	Turbidity (NTU)	1306	175
3	TSS (mg/l)	1248	1348
4	COD (mg/l)	712.5	1990

Turbidity of raw batik effluent is very high when compared to that of raw textile wastewater. Turbidity of batik wastewater treated with coagulant *M. oleifera* seed powder and precipitation showed a substantial decline. Pre-treatment turbidity levels of 1306 NTU fell to an average turbidity range of 59.25-114 NTU (**Table 2**). Turbidity removal is one of the important steps in water treatment process and generally is achieved by coagulation – flocculation – sedimentation process. Common coagulants like alum and iron salts have been widely used in conventional water treatment processes (Giddle *et al.* 2012).

Table 2. Average turbidity (NTU) of batik liquid waste after treatment.

No	*M. oleifera* coagulant concentration treatment	B1 (60 minutes deposition)	B2 (120 minutes deposition)	B3 (180 minutes deposition)
1	A1 (30000 mg/l)	114.00	76.75	61.75
2	A2 (40000 mg/l)	89.75	66.50	59.25 (95.5% reduction)
3	A3 (50000 mg/l)	80.50	64.00	61.00
4	Control (0 mg/l)	1306		

Treatment of batik wastewater with coagulant of *M. oleifera* seed powder, deposition length, and their interaction affected turbidity decrease significantly (0.01). Treatment A3 (50000 mg/l) showed the best results with the average turbidity of 68.50 NTU.

Turbidity (68.50 NTU) at treatment A3 (5000 mg/l) was significantly different (0.01) with the average turbidity of 84.17 NTU at treatment A1 (30000 mg/l), but not significantly different with the average turbidity of 71.83 NTU at treatment A2 (40000 mg/l).

The best deposition length was shown at B3 (180 minutes) which was significantly different (0.01) with B1 (60 minutes) and B2 (120 minutes). *M. oleifera* seed powder coagulant concentration of 40000 mg/l and 180 minutes deposition length produced lowest turbidity of 59.25 NTU. Decrease in turbidity was due to deposition of suspended or colloidal solids in wastewater by natural coagulant of *M. oleifera* seeds as illustrated in **Figure 1**.

Figure 1. Turbidity of batik effluent before and after treatment with 40000 mg/l coagulant of *M. oleifera* seeds and deposition length of 180 minutes.

The extract of *M. oleifera* seed removes 60% to 70% of hardness as well as 99% of effectiveness of water turbidity (Muyibi *et al.* 1995). The mechanism of coagulation with the seeds of *M. oleifera* consists of adsorption and neutralization of the colloidal positive charges that attract the negatively charged impurities in water (Sotheeswaran *et al.* 2011).

The extract of *M. oleifera* seed had higher efficiency in removing high turbidities in comparison with low turbidities (Yarahmadi *et al.* 2009). The best efficiency was obtained in turbidity of 50 NTU and pH of 7 as well maintenance time of 15 days and optimum dose of 20 mg/l (Yarahmadi *et al.* 2009).

The *Moringa* coagulant dose (seeds suspension) of 25 g/l reduced 78% turbidity of slaughterhouse wastewater (Avelino1 *et al.* 2009). *Moringa* reduced turbidity of abattoir waste water from 218.4 NTU to 68 NTU being 68.86% reduction (Lagasi *et al.* 2014).

Result of this research has shown a remarkable reduction of turbidity reaching 95% with treatment of 50000 mg/l *M. oleifera* coagulant under 180 hours deposition.

Total Suspended Solid (TSS)

TSS after coagulation ranged from 156 to 274 mg/l, while initial TSS was 1248 mg/l (**Table 3**). The addition of *M. oleifera* seed coagulant affected TSS with a high degree of significance (0.01) affected TSS. Deposition length as well as interaction of coagulant concentration and deposition length had no significant effect on TSS.

Table 3. Average TSS (mg/l) of batik liquid waste after treatment.

No	*M. oleifera* coagulant concentration treatment	B1 (60 minutes deposition)	B2 (120 minutes deposition)	B3 (180 minutes deposition)
1	A1 (30000 mg/l)	270.50	274.00	266.00
2	A2 (40000 mg/l)	204.00	210.00	222.00
3	A3 (50000 mg/l)	156.00 (87.5% reduction)	180.00	170.00
4	Control (0 mg/l)	1248		

The lowest TSS using at *M. oleifera* seeds coagulant treatment of 50000 mg/l was significantly different (0.01) than TSS at coagulant treatment of 30000 mg/l and 40000 mg/l. The greater the concentration of coagulant, the greater the TSS excluded. Sharmila *et al.* (2013) found that *M. oleifera* extract could reduce total solid of domestic wastewater from 80 mg/l to 51.2 mg/l, meaning 36% reduction. Our experiment found that *M. oleifera* seed coagulant was able to reduce 87.5% TSS reduction.

The isolated *Moringa* flocculants show that the basic polypeptides with molecular weights ranging from 6000 to 16000 Daltons are the main causes of clarifiers (Sotheeswaran *et al.* 2011). The seed kernels of *Moringa* contain significant quantities of series of low molecular weight and water soluble protein, which carries positive charge to the solution. The protein is considered to act similar to a synthetic and positively charged polymer coagulant. When this protein is added to raw water, it binds with the predominantly negatively charged particulate making the raw water turbid (Gidde *et al*. 2012). *M. oleifera* seeds contains a flocculating protein that works as a clarifying agent of turbid water (Gassenschmidt *et al.* 1995).

Chemical Oxygen Demand (COD)

Treatment of coagulant addition and deposition length as well as interaction of both treatments did not significantly affect COD. COD continued to increase after the treatment (**Table 4**). Initial COD was 3712.5 mg/l, while COD at *M. oleifera* seed coagulant treatment (50000 mg/l) increased to 9652.5 mg/l.

Table 4. Average COD (mg/l) of batik liquid waste.

No	*M. oleifera* coagulant concentration treatment	B1 (60 minutes deposition)	B2 (120 minutes deposition)	B3 (180 minutes deposition)
1	A1 (30000 mg/l)	4900.00	5594.50	7425.00
2	A2 (40000 mg/l)	6682.50	7227.00	9405.00
3	A3 (50000 mg/l)	7720.50	8217.00	9652.50
4	Control (0 mg/l)	3712.50		

Kazi1 and Virupakshi, 2013 found that *M. oleifera* coagulants not only removed turbidity of 82.02%, but also reduced COD up to 83.3% of tannery wastewater.

COD of dairy wastewater was drastically reduced from 1440 mg/l to 640 mg/l and 800 mg/l for 425µm and 212µm particle size of *Moringa* coagulant indicating a removal efficiency of 55.6% and 44.4% respectively (Pallavi and Mahesh, 2013).

However in this experiment, *M. oleifera* seed powder could not reduce COD of batik effluent. The increase of COD in batik effluent after *M. oleifera* seed treatment can be caused by *M. oleifera* seed powder itself which is an organic material.

pH

Average pH of batik liquid waste at *M. oleifera* seed coagulant addition ranged 5.98 - 6:07 (**Table 5**). Coagulant addition and deposition length as well as their interaction did not significantly affect the pH. pH values showed no significant change from the control pH of 6.05. The extract of *Moringa oleifera* seed had a minimal effect on pH of water (Yarahmadi *et al.* 2009).

Table 5. Average pH of batik liquid waste after treatment.

No	*M. oleifera* coagulant concentration treatment	B1 (60 minutes deposition)	B2 (120 minutes deposition)	B3 (180 minutes deposition)
1	A1 (30000 mg/l)	5.98	6.04	5.98
2	A2 (40000 mg/l)	5.94	6.05	6.03
3	A3 (50000 mg/l)	6.03	6.07	6.07
4	Control (0 mg/l)	6.05		

The blended coagulant of *M. oleifera* : $Al_2(SO_4)_3$ of 50:50 dosage ratio gives better removal efficiencies with respect to turbidity, TSS, TDS, COD and BOD and appears to be suitable for textile waste water treatment (Muralimohan *et al.* 2014).

M. oleifera seeds as natural absorbent is also used as environmentally friendly antimicrobial agent for purification of ground water for drinking purpose. *Moringa* coagulant of 150 mg/l reduced bacteria of groundwater from 1600 MPN/100 ml to 5 MPN/100 ml (Mangale *et al.* 2012).

The optimum dosage of *M. oleifera* aqueous extract for synthetic water samples containing heavy metal concentrations of 5 mg/l was 2 g/l and the removal efficiencies were 95%, 93%, 76% and 70% of copper, lead, cadmium and chromium respectively (Ravikumar and Sheeja, 2013). Treatment of palm oil mill effluent with *M. oleifera* resulted in 99.2% suspended solids removal and 52.5% COD reduction (Othman *et al.* 2008).

CONCLUSION

Result of this research has shown that *M. oleifera* seed powder might be applied as a natural coagulant in treating batik wastewater instead of using chemical coagulant commonly used. However, optimation of doses usage needs to be pursued.

M. oleifera seed powder coagulant addition and deposition length as well as their interactions in batik liquid waste treatment significantly (0.01) affected turbidity decrease. Interaction of *M. oleifera* seed coagulant addition (4000 mg/l) and deposition length (180 minutes) showed the lowest turbidity decline namely 59.25 NTU (95.5% reduction).

M. oleifera seed coagulant addition significantly (0.01) affected TSS reduction. Deposition length and the interaction between the coagulant addition and deposition length did not significantly affect the TSS. Treatment of 5000 mg/l *M. oleifera* seed coagulant and 60 minutes precipitation gave the best results with the average TSS of 156.00 mg/l (87.5% reduction).

M. oleifera seed coagulant addition and deposition length as well as their interaction had no significant effect on COD. An increase in COD was caused by organic substances of *M. oleifera* seed itself.

In general, the best treatment combination was shown by treatment of 5000 mg/l coagulant addition and 180 minutes long deposition which eventually produces turbidity of 61 NTU and TSS of 170 mg/l. However further investigation need to be carried out to treat high COD.

ACKNOWLEDGEMENT

Thanks are due to Centre for Environmental Research, Bogor Agricultural University, for financing the author to join this conference in Italy.

REFERENCES

Avelino, F.D.M. Novelo, R.M. and Dávila, M.T. 2009. Treatment of slaughterhouse wastewater using *Moringa oleifera* lam seeds as coagulant. *Tropical and Subtropical Agroecosystems* 10: 523 – 529.

Bina, B. 1991. Investigation into the use of natural coagulants in the removal of bacteria and bacteriophage from turbid waters. PhD Thesis. University Newcastle upon Tyne. UK.

Gassenschmidt, U. Jany, K.D. Tauscher, B. and Niebergall, H. 1995. Isolation and characterization of a flocculating protein from *Moringa oleifera* Lam. *Biochim. Biophys. Acta* 1243:477–481.

Gidde1, M.R. Bhalerao, A.R. and Malusare, C.N. 2012. Comparative study of different forms of *Moringa oleifera* extracts for turbidity removal. *International Journal of Engineering Research and Development* 2(1):14-21.

Jusri, M. and Idris, M. 2012. Indonesian batik as a culture tradition. Ministry of Industry. Jakarta (In Indonesian).

Kazil, T. and Virupakshi, A. 2013. Treatment of tannery wastewater using natural coagulants. *International Journal of Innovative Research in Science, Engineering, and Technology* 2(8):4061-4068.

Lagasi, J.E. Agunwamba, J.C. and Aho, M. 2014. Comparative studies on the use of ordinary and de-oiled *Moringa oleifera* in the treatment of abattoir waste water. *The International Journal of Engineering And Science* 3(2):01-07.

Madrona, G.S. Branco, I.G. Seolin, V.J. Filho, B.D.A. Klen, M.R.F. and Bergamasco, R. 2012. Evaluation of extracts of *Moringa oleifera* Lam seeds obtained with NaCl and their effects on water treatment. *Acta Scientiarum* 34(3): 289-293.

Mangale, S.M. Chonde, S. G. and Raut P.D. 2012. Use of *Moringa oleifera* (drumstick) seed as natural absorbent and an antimicrobial agent for ground water treatment. *Research Journal of Recent Sciences* 1(3):31-40.

Muralimohan, N. Palanisamy, T. and Vimaladevi, M.N. 2014. Experimental study on removal efficiency of blended coagulants in textile wastewater treatment. *International Journal of Research in Engineering & Technology* 2(2):15-20.

Muyibi, S.A. and Evison, L.M. 1995. *Moringa oleifera* seeds for softening hardwater. *Water Research* 29(4):1099-1104.

Othman, Z. Bhatia, S. and Ahmad, A.L. 2008. Influence of the settleability parameters for palm oil mill effluent (pome) pretreatment by using *Moringa oleifera* seeds as an environmental friendly coagulant. *International Conference on Environment* 1-9 p.

Pallavi, N. and Mahesh, S. 2013. Feasibility study *of* *Moringa oleifera* as a natural coagulant for the treatment of dairy wastewater. International Journal of Engineering Research 2(3): 200-202.

Ravikumar, K. and Sheeja, A.K. 2013. Heavy metal removal from water using *Moringa oleifera* seed coagulant and double filtration. *International Journal of Scientific & Engineering Research* 4(5):10-13.

Saduzaman, M. Sharmila, S. and Jeyanthi, R.L. 2013. Efficacy of leaf extract of *Moringa oleifera* in treating domestic effluent. *Journal of Chemical and Pharmaceutical Research* 5(2):139-143.

Santos, A.F.S. Paivab, P.M.G. Teixeiraa, J.A.C. Britoa, A.G. Coelhob, L.C.B.B. and Nogueiraa, R. 2012. Coagulant properties *of* *Moringa oleifera* protein preparations: application to humic acid removal. *Environmental Technology* 33(1): 69–75.

Sharmila, S. Jeyanthi, R.L. and Saduzzaman, M. 2013. Domestic waste water treatment using leaf extract of *Moringa oleifera*. *Research Journal of Pharmaceutical, Biological and Chemical Sciences* 4(2):833-839.

Sotheeswaran, S. Nand, V. Matakite, M. and Kanayathu, K. 2011. *Moringa oleifera* and other local seeds in water purification in developing countries. *Research Journal of Chemistry and Environment* 15(2):135-138.

Susheela, P. Sri, R.B. and Radha, R. 2014. Effectiveness of *Moringa oleifera* seeds in the phytoremediation of pond water. *Scrutiny International Research Journal of Agriculture, Plant Biotechnology and Bio Products* 1(2):34-42.

Yarahmadi, M. Hossieni, M. Bina, B. Mahmoudian, M.H. 2009. Application of *Moringa oleifera* seed extract and polyaluminum chloride in water treatment. *World Applied Sciences Journal* 7 (8): 962-967.