

# Efficiency of *Moringa oleifera* Seeds for Treatment of Laundry Wastewater

Al-Gheethi AA<sup>1</sup>, Mohamed RMSR<sup>1\*</sup>, Wurochekke AA<sup>1</sup>, Nurulainee NR<sup>1</sup>, Mas Rahayu J<sup>1</sup>, Amir Hashim MK<sup>1</sup>

<sup>1</sup>Micro-pollution Research Centre (MPRC), Department of Water and Environmental Engineering, Faculty of Civil & Environmental Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia

**Abstract:** Laundry wastewater has simple characteristics in which the detergents compounds are the main constituents. But these compounds have adverse effects on the aquatic organisms in the natural water bodies which received these wastes without treatment. Few studies were conducted on these wastes because it represents a small part of the total wastewater generated from different human activities. Moreover, the coagulation process for laundry wastewater might be effective to remove of detergents compounds. Therefore, in the present study, the efficiency of coagulation process by using chemical (ferrous sulphate) and natural coagulants (*Moringa oleifera* seeds) were investigated. The raw laundry wastewater samples were collected from laundromat located at Taman Universiti, Parit Raja. The characteristics of these wastes were determined and then the wastewater was subjected for the treatment process consisted of three units including aeration, coagulation and sedimentation process. The chemical and natural coagulants were used with four dosages (30, 60, 90 and 120 mg L<sup>-1</sup>) and the coagulation process was carried out at room temperature (25±2°C) for one hour. The results revealed that the laundry wastewater have high concentrations of turbidity (57.8-68.1 NTU) and Chemical Oxygen Demand (COD) (423-450 mg L<sup>-1</sup>) with pH value between 7.96 and 8.37. *M. oleifera* seeds exhibited high efficiency for removal of turbidity (83.63%) with 120 mg L<sup>-1</sup> of dosage, while 30 mg L<sup>-1</sup> of FeSO<sub>4</sub> was the best for removal of COD (54.18%). However, both parameters still more than Standard B for wastewater disposal suggesting the need to increase the period of coagulation process with *M. oleifera* seeds or to subject of the treated effluents for a secondary coagulation process with natural coagulant products to improve the characteristics of laundry wastewater without a secondary products as that generated with the chemical coagulants.

## 1 Introduction

Detergent compounds are classes of the organic micro-pollutants (OMPs) in the laundry wastewater. The disposal of these compounds into the natural water bodies lead to

---

<sup>1</sup> Corresponding author: maya@uthm.edu.my

aesthetic losses due to the foam which can also cause adverse effects on ecosystems and biodiversity [1,2]. Detergents compounds in the laundry wastewater are biodegradable compounds and they have a short persistence time in the environment. Nevertheless, the main hazard for these compounds are associated with their concentrations which might be very active and poisonous directly for the organisms within a short exposure time. The indirect effect of the detergent for aquatic life lies by lowering the surface tension of the water. Besides, the chemical composition of the laundry wastewater such as high chemical oxygen demand (COD) and total suspension solids (TSS) as well as pH might change the natural water characteristics and induce the occurrence eutrophication phenomenon. Therefore, these parameters have to be reduced in the laundry wastewater to the minimum concentrations. Among several technologies used for the treatment and reduction of organic compounds in the wastewater, the coagulation process represent the most potent technique for improving the characteristics of wastewater before the disposal into the environment. The coagulants substances used might be chemicals such as ferrous sulphate or natural such as *Moringa oleifera*. Nonetheless, natural coagulant have more advantages than chemical substances in term of toxicity and efficiency as well as the cost. The toxicity of chemical coagulants have reported in the literature, the correlation between the availability of ferrous sulphate (above 200 mg L<sup>-1</sup>) in the treated water and Alzheimer's and neuro-degenerative diseases has revealed by Bhatia et al. [3].

*Moringa oleifera* is known as a tropical plant with high contents of oil and water soluble molecules in their seeds [4]. *M. oleifera* seeds are used in the coagulation process due to the biodegradable characterize of their compounds. One advantages more of *M. oleifera* is the biological activity against bacteria which has demonstrated by the authors. *M. oleifera* has the potential to reduce cloudiness, clay and bacterial content of water in comparison to aluminium salts. Therefore, it represent an alternative and future technology for the wastewater treatment. Two process included absorption and neutralization of the colloidal charges are explained the mechanism of coagulation with *M. oleifera*. *M. oleifera* is non-toxic and biodegradable substrates, eco-friendly and unlike alum, has no effect on the pH and conductivity of the treated wastewater. Moreover, less amounts of sludge are generated when *M. oleifera* are used in the coagulation of wastewater in comparison to alum [5].

*M. oleifera* seeds extracts has exhibited an efficiency in the reduction of surfactant such as sodium lauryl sulphate from aqueous solutions, where 80% of the reduction has recorded [1]. It has been reduced TSS by 92%, total coliform by 89.6% and faecal coliform by 98.1% with 10 mL L<sup>-1</sup> (v/v) of seeds concentrations [6]. However, the maximum reduction recorded for BOD and COD were 32 and 48% respectively. *M. oleifera* seeds have used for treatment different types of wastewater such as tapioca starch wastewater. Suhartini et al. [7] used a system consisted of two-stage clarifier tanks filled with sand or coconut fiber and *M. oleifera* seeds. The system occurred high reduction of BOD, COD and TSS to meet the Indonesian standards limits of tapioca starch wastewater discharge. Laundry wastewater has a different composition to the domestic and agriculture wastewater. These differences lies the quality of the chemical characteristics rather than their quantity. Therefore, the potential of natural coagulant for the treatment of these wastes need to be investigated in order to give an evaluation for their role in the reduction of physical and chemical parameters in these wastes before the final disposal into the environment and this is the focus of the current work.

This study aimed to examine the efficiency of *M. oleifera* seeds as coagulant of laundry wastewater in comparison to the commercial coagulant such as ferrous sulphate. The potential of *M. oleifera* seeds in improving the quality of laundry wastewater

was evaluated based on the reduction of COD, TSS, turbidity and pH which represent the main parameters of the laundry wastewater.

## 2 Materials and methods

### 2.1 Study area and sampling

The laundry wastewater samples (5 L) were collected from laundromat located at Taman Universiti, Parit Raja (Latitude 1°51'3.12"N and longitude 103° 4'29.63"E). The laundromat was selected because it's a self-service laundromat where different types of detergents with different dosages are used and thus represent a good model to test the efficiency of natural coagulants. The samples were collected from discharge point (Fig. 1) in a plastic bottle (5 L) and then transported into the laboratory in ice box and subjected for the chemical and physical tests within two hours to prevent the degradation of detergents compounds. The characteristics of laundry wastewater including pH, turbidity, COD and TSS were determined according to APHA [8].



**Fig. 1.** Laundry wastewater discharge point

#### 2.1.1 Preparation of *M. oleifera* seeds and ferrous sulphate

*M. oleifera* seeds were obtained from a local market at Parit Raja. The seeds were dried in order to improve level of polyelectrolyte presented in the kernels [9]. Thereafter, they were grounded into fine particles less than 0.20 mm of size and dried again at 100°C for 24 hrs [10]. The dried seeds were milled into a fine powder by using domestic blender and then passed through 50-mesh sieve according to coagulant-method [3]. Ferrous sulphate ( $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ ) salts (CAS: 7782-63-0, Fisher Scientific) was supplied from Tai'an Ming Chen Chemical Import and Export Co. Ltd, China.

### 2.2 Coagulation studies

The raw laundry wastewater were treated by using a treatment system consisted of three units included aeration, coagulation and sedimentation tank. The aeration process was carried out in order to remove carbon dioxide and oxidize soluble iron and manganese as well as to reduce hydrogen sulphide and ammonia. The coagulation process were performed with four concentrations of *M. oleifera* seeds and ferrous sulphate in order to determine the optimal concentrations required to achieve high removal percentage of the

main parameters of laundry wastewater. The sedimentation tank was used to separate solid materials resulted from the coagulation process and clarified wastewater.

A fixed volume of (1 L) of laundry wastewater sample was stored in the aeration tank (25×17×18 cm) at room temperature (25±2 °C) for 30 min. The wastewater was pumped into the coagulation tank using a water pump (Shanda), 120V. The coagulation tank made up of High-density polyethylene (HDPE) transparent bottle (14 cm×20 cm×14 cm) and Direct Current motor (DC Geared Motor, DC12V) with 1.1 watt, 103 rpm, 410 mA, 127.4 mN and 8 mm of shaft diameter [10]. Four concentrations [30, 60, 90 and 120 mg L<sup>-1</sup> (w/v)] of *M. oleifera* seeds and ferrous sulphate were investigated separately. The wastewater sample was mixed with each concentration for one hour. At the end of the coagulation process, the wastewater was pumped slowly into sedimentation tank to settle for one hour. The supernatant generated from the sedimentation tank was used to determine pH, turbidity, COD and TSS according to APHA [8]. The control samples were conducted without chemical or natural coagulant. The removal efficiency was calculated according to the following equation;

$$Removal\ (%) = \frac{C_i - C_f}{C_i} \times 100 \quad Removal\ (%) = \frac{C_i - C_f}{C_i} \times 100 \quad (1)$$

where,  $C_i$  is the initial parameter concentration (mg L<sup>-1</sup>),  $C_f$  is the remaining parameter concentration (mg L<sup>-1</sup>)

### 3 Results and discussions

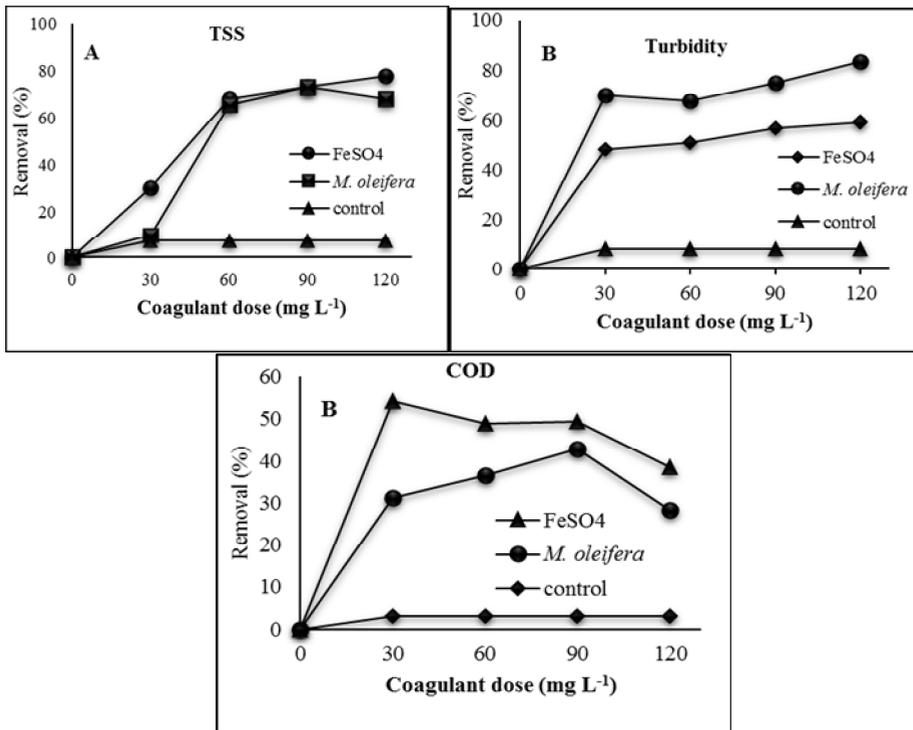
The characteristics of laundry wastewater demonstrated that these wastes have high concentrations of COD (423-450 mg L<sup>-1</sup>) and turbidity (57.8-68.1 NTU) more than the standards limits recommended by Environmental Quality Act, 1974 (sewage and Industrial effluents, Regulation 2009). These standards are used for sewage and industrial wastewater, but it can be used for discharging laundry wastewater due to absence a specific regulation of these wastes. The high concentrations of COD might be due to the presence of detergents compounds, which lead to increase of chemical reaction level between organic substances. Laundry wastewater has high impurities due to the presence of sand and particles, oil and grease, surfactants, detergent and phosphates [11]. Despite, TSS and pH values were within the standards range, pH of these waste was more than pH 7.5, which might be related to the presence detergents compounds that include wide range of amphoteric, anionic and cationic compounds. Laundry water contains detectable concentrations of TSS, salts, nutrients, organic matter and pathogens raised from the clothes, laundry detergents and fabric softener residues [12]. Moreover, the detergents are the most abundant organic chemicals in these wastes [13]. Therefore, removal of these compounds is required before the discharge into the environment.

The efficiency of chemical and natural coagulant in the removal of TSS is presented in Fig. 2 a. TSS was within the standard limits of wastewater disposal regulated by Environmental Quality Act, 1974 (sewage and Industrial effluents, Regulation 2009). Moreover, *M. oleifera* seeds and ferrous sulphate exhibited an efficiency to reduce it by 73 and 78% at 90 and 120 mg L<sup>-1</sup> of both coagulants respectively. It has revealed that *M. oleifera* seeds contain significant quantities of proteins with high molecular weight and water soluble protein, which carries a positive charge to the solution. These flocculating protein works as a clarifying agent of turbid water [4].

*M. oleifera* seeds and ferrous sulphate have recorded a significant reduction in the turbidity in comparison to the control (without coagulant) (Fig. 2 b). The maximum removal was noted with the high concentrations (120 mg L<sup>-1</sup>) of both coagulant.

However, *M. oleifera* seeds exhibited high efficiency in the turbidity removal than ferrous sulphate (83.63 vs. 59.02%). The efficiency of *M. oleifera* seeds in removal of turbidity might be related to the presence of water soluble cationic proteins which indicate for electronic charge and enhance coagulation and flocculation [14]. In contrast, FeSO<sub>4</sub> exhibited more efficiency in the removal of COD, the reduction was 54.18% with 30 mg L<sup>-1</sup> for FeSO<sub>4</sub>, and 42.72% at 90 mg L<sup>-1</sup> of *M. oleifera* (Fig. 2 c). These findings might be due to the nature of chemical reaction between FeSO<sub>4</sub> and organic constitutes in the wastewater which might occur more than that between *M. oleifera* components and the organic compounds. However, it has to mention that the reduction of COD with the addition of FeSO<sub>4</sub> take place due to the chelating process that bind to the organic matter with FeSO<sub>4</sub>. This process relied on the equilibrium between the substrates during the coagulation process. The high concentrations of FeSO<sub>4</sub> has decreased the removal; percentage of COD, due to the decreases in the affinity of organic compounds to adsorb of Fe ions. Besides, coagulation process with chemical chelating agents is accomplished with the generation of sludge. On the other hand, the efficiency *M. oleifera* seeds in the reduction of COD take place by the degradation of organic matter by using their compounds which have the degradation potential. The high ability of *M. oleifera* to degrade the organic compounds relate to the presence of protein in the *M. oleifera*. The binding of proteins to the organic compounds facility their consumption by the microorganism as carbon sources by using hydrolyses enzymes. But the degradation process need more time to cause a significant reduction in COD. In the present study the coagulation process was conducted for one hour which might be sufficient for the chelating process but not for the degradation process. It has demonstrated that even with high concentrations of *M. oleifera* seeds the reduction in COD might still limited [15]. Nonetheless, it can be indicated that the *M. oleifera* still better than FeSO<sub>4</sub> for reducing COD, because less sludge is produced with the natural coagulants as revealed by previous studies in literature [16] and the produced sludge is a degradable substances and has no toxicity characteristics. The absence of toxicity of produced sludge related to the nature of *M. oleifera* seeds which have no toxicity and they are used for the medical applications.

In all case, the results recorded here indicated that the final concentrations of COD and turbidity still more than the standard A and B required for the disposal of wastewater (Table 1). These findings indicate that the treatment system has to be conducted for more than one hour rather than to increase the concentrations of coagulants. This is because the increasing in these concentrations correlated with the reduction in pH value the minimum pH value recorded was pH 5.77 with 120 mg L<sup>-1</sup> of both *M. oleifera* and FeSO<sub>4</sub>, this value is most close to the minimum pH required by Standard B (pH 5.5), therefore, the addition more coagulant dose might lead to decrease pH value to less than the standards. Hence, in order to achieve more reduction of COD and turbidity the coagulation period might be extended to more than one hour. However, the results for the coagulation with FeSO<sub>4</sub> noted that the maximum reduction of COD was observed with 30 mg L<sup>-1</sup> while the increasing of concentrations to more than 30 mg L<sup>-1</sup> associated with decreases in the removal percentage which indicating that the increasing of coagulation period might effect negatively on the chemical coagulation. In contrast the increasing of removal percentage with increasing of *M. oleifera* dose indicating that the increasing of time might also achieve high efficiency based on the concept of equilibrium between substrates and produces. The alternative way to achieve more reduction in both COD and turbidity is by perform a secondary coagulation process of supernatant results from the first coagulation process. The increasing in the coagulant dose or settling time might achieve the reduction levels required for the disposal process while, the adjusting pH of laundry wastewater might be unacceptable in terms of reduction of chemical additives for the treatment of wastes.



**Fig. 2** Removal percentage of the main laundry wastewater during the coagulation process using chemical and natural coagulant; A) TSS; B) Turbidity; C) COD

**Table 1.** Characteristics of laundry wastewater coagulated with different doses of *M. oleifera* and  $\text{FeSO}_4$

Dose ( $\text{mg L}^{-1}$ )	pH		Turbidity (NTU)		COD ( $\text{mg L}^{-1}$ )		TSS ( $\text{mg L}^{-1}$ )	
	<i>M. oleifera</i>	$\text{FeSO}_4$	<i>M. oleifera</i>	$\text{FeSO}_4$	<i>M. oleifera</i>	$\text{FeSO}_4$	<i>M. oleifera</i>	$\text{FeSO}_4$
0	7.96-8.37		57.8-68.1		423-450		0.38-0.44	
30	6.14	6.42	19	32.5	300	200	0.37	0.25
60	7.01	6.02	20.5	30.9	277	223	0.14	0.13
90	6.52	6.09	15.8	27.3	250	222	0.11	0.11
120	5.77	5.7	10.3	25.8	313	269	0.13	0.09
Standards (A)	6-9		<5		50		50	
Standards (B)	5.5-9		50		100		100	

COD (Chemical Oxygen Demand); TSS (Total suspension solids)

## 4 Conclusions

The results of COD, turbidity, pH and TSS indicate that the laundry wastewater have a different characteristics due to the presence of detergent compounds which lead to increase COD and pH values. *M. oleifera* seeds exhibited high efficiency for the removal of turbidity but not for the COD in comparison to FeSO<sub>4</sub>. However, *M. oleifera* seeds is eco-friendly since the sludge generated is consist of degradable substances. Both COD and turbidity still more than the standards A and B for the disposal of wastewater, but the increase the period of coagulation with *M. oleifera* seeds or the subsection for a secondary coagulation process might contribute in their reduction of these parameters to be within the standards limits. Nevertheless, these suggestion need to be investigated to confirm their effectiveness.

The authors gratefully acknowledge Research, Innovation, Commercialization, Consultancy Management (ORICC), UTHM for Financial support of this work

## References

- [1] J. Beltrán-Heredia and J. Sánchez-Martín, Removal of sodium lauryl sulphate by coagulation/flocculation with *Moringa oleifera* seed extract. J. Hazard Materials, **164**(2), 713-719, (2009)
- [2] J. K. Braga and M. B. Varesche, Commercial laundry water characterisation. Am J Anal Chem., **5**(1), 8, (2014)
- [3] S. Bhatia, Z. Othman and A. L. Ahmad, Coagulation–flocculation process for POME treatment using *Moringa oleifera* seeds extract: optimization studies. Chem. Eng. J., **133**(1), 205-212, (2007)
- [4] K. A. Ghebremichael, K. R. Gunaratna, H. Henriksson, H. Brumer and A. Dalhammar, simple purification and activity assay of the coagulant protein from *Moringa oleifera* seed. Water Res., **39**(11), 2338-2344, (2005)
- [5] A. Ndabigengesere, K.S. Narasiah and B. G. Talbot, Active agents and mechanism of coagulation of turbid waters using *Moringa oleifera*. Water Res., **29**(2), 703-710, (1995)
- [6] M. A. Ashmawy, M. S. Moussa, A. K. Ghoneim and A. Tammam, Enhancing the efficiency of primary sedimentation in wastewater treatment plants with the application of *Moringa oleifera* Seeds and Quicklime. J Am. Sci., **8** (2), (2012)
- [8] S. Suhartini, N. Hidayat and E. Rosaliana, Influence of powdered *Moringa oleifera* seeds and natural filter media on the characteristics of tapioca starch wastewater. Int. J. Rec. Org. Waste Agr. **2**(1), 1-11 (2013)
- [9] APHA, American Public Health Association, Inc. Standard methods for the examination of water and wastewater (21st Ed.). New York. USA, (2005)
- [10] R. Nirmala and M. V. Jadhav, Enhancing filtrate quality of turbid water incorporating seeds of *Strychnos potatorum*, pads of *Cactus opuntia* and mucilage extracted from the fruits of *cocciniaindica* as coagulants. J. Environ. Res. Dev. **7** (2), 668-674 (2012)
- [11] A. A. Al-Gheethi, R. M. Mohamed, M. Afaiz Ab. Rahman, J. Mas Rahayu and H.K. Amir, Treatment of wastewater from car washes using natural coagulation and filtration system, *Int. Conf. On Sustainable Environment & Water Research (ICSEWR 2015)*, 25-26 Oct. 2015, Johor Baru, Malaysia, (2015)

- [12] R.S. Mandac, B. Bogunović, D. Žagar and J. Faganeli, Riverine impact on the thermohaline properties, turbidity and suspended solids in a shallow bay (Bay of Koper, northern Adriatic Sea). *Acta Adriatica*, **55** (2), 195 – 212, (2014)
- [13] E. R. Howard, R. Misra, Loch, and N. Le-Minh. *Laundry grey water potential impact on Toowoomba soils*-final report. National Centre for Engineering in Agriculture Publication 1001420/2, USQ, Toowoomba, Australia. (2005)
- [14] M. Abu-Zreig, R.P. Rudra and W. T. Dickinson, Effect of application of surfactants on hydraulic properties of soils. *Biosys. Eng.*, **84**(3), 363-372 (2003)
- [15] K. H. Lee, K. Y. Park, S. K. Khanal and J. W. Lee, Effects of household detergent on anaerobic fermentation of kitchen wastewater from food waste disposer. *J. Hazard. Mat.*, **244**, 39-45 (2013)
- [16] N. Muralimohan, T. Palanisamy and M.N. Vimaladevi, Experimental Study on removal efficiency of blended coagulants in textile wastewater treatment. *IMPACT: Int. J. of Research in Engineering & Technology.*, **2**, 2347-4599, (2014)
- [17] R.M. Mohamed, A.I. Kutty, N. Mariam, M. Kassim, A. Hashim, Efficiency of using commercial and natural coagulants in treating car wash wastewater treatment. *Aus. J. Basic Appl. Sci.*, **8**(16), 227-234, (2014)