Treatment of Wastewater From Car Washes Using Natural Coagulation and Filtration System

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ABSTRACT
Wastewater generated from carwash is one of the main wastewater resources, which contribute effectively in the increasing of environmental contamination due to the chemical characteristics of the car wastes. The present work aimed to develop an integrated treatment system for carwash wastewater based on coagulation and flocculation using Moringa oleifera and Ferrous Sulphate (FeSO₄·7H₂O) as well as natural filtration system. The carwash wastewater samples were collected from carwash station located at Parit Raja, Johor, Malaysia. The treatment system of car wash wastewater was designed in the lab scale in four stages included, aeration, coagulation and flocculation, sedimentation and filtration. The coagulation and flocculation unit was carried out using different dosage (35, 70, 105 and 140 mg L⁻¹) of M. oleifera and FeSO₄·7H₂O, respectively. The efficiency of the integrated treatment system to treat carwash wastewater and to meet Environmental Quality Act (EQA 1974) was evaluated based on the analysis of pH, dissolved oxygen (DO), chemical oxygen demand (COD) and turbidity (NTU). The integrated treatment system was efficient for treatment of raw carwash wastewater. The treated carwash wastewaters meet EQA 1974 regulation 2009 (Standards A) in the term of pH and DO while, turbidity and COD reduced in the wastewater to meet Standards B. The integrated treatment system designed here with natural coagulant (M. oleifera) and filtration unit were effective for primary treatment of carwash wastewater before the final disposal or to be reused again for carwash process.

Keywords: Coagulation, flocculation, filtration, sedimentation, moringa oleifera, ferrous sulphate.

1. Introduction
Among several types of wastewater, the carwash wastewater represents one of the heavily contaminated wastes with high impurities. It was due to presence of sand and particles, oil and grease, surfactants, detergent, phosphates and hydrofluoric acid [1]. Therefore, the direct disposal for wastewater into the drainage exacerbates the natural water pollution [2,3,4]. On the other hand, the discharge of the car washes wastewater directly into sewerage network might effect negatively on the efficiency of the treatment processes of sewage due to presence of heavy metals or at least represent a burden on the sewage treatment plant.

Further, the treatment of wastewater at the resource point might be easier and more effective than that if they have collected into one treatment plant. This is because, the individual treatment process will take sufficient time to remove most impurities and contaminants. Indeed, the treatment of small amount of wastewater does not require a complicated treatment system to produce high quality of treated wastewater. Moreover, the simple treatment system might be more efficiency to produce good quality of treated wastewater suitable for car wash again [5]. There are no quality regulations for the water, which are used for car wash. Therefore, the wastewater generated from car washes with high turbidity might be treated using coagulation and flocculation methods and reused again, both methods are efficient for turbidity and economic [6]. In order to improve the water quality characteristics, an integrated treatment system might be provided.

The coagulation and flocculation treatment are one of the important stage in the wastewater treatment processes. Several of chemical substances such as ferric sulphate, ferrous sulphate, ferric chloride and ferric chloride sulphate are used as coagulant and flocculants. However, the new direction is to use the natural substances. The application of these substances included free toxic by-products such as carcinogenic
compounds and low cost. The utilisation of natural coagulants provides an alternative way to lower the coagulants and flocculants cost and to improve the water quality characteristics for safe utilization [7]. In previous study, [8] investigated the efficiency of Moringa oleifera and Strychnospotatorum seeds as natural coagulant compared with synthetic common coagulants for treating car wash wastewater. The study indicated that both M. oleifera and S. potatorum seeds contain coagulating substances capable of removing turbidity, chemical oxygen demand (COD), Biochemical oxygen demand (BOD) and Total suspended solids (TSS).

In the present study, a treatment process of car wash wastewater was designed based on the previous study [7,8]. The treatment process was enhanced with an integrated system comprises aeration, coagulation and flocculation, sedimentation and filtration unit to produce high quality of treated wastewater. The coagulant used was M. oleifera and ferrous sulphate (FeSO$_4$.7H$_2$O). The efficiency of the integrated treatment system to treat carwash wastewater and to meet Environmental Quality Act 1974 was evaluated based on the analysis of pH, dissolved oxygen (DO), chemical oxygen demand (COD) and turbidity (NTU).

2. Material and Methods

2.1 Collection of carwash wastewater samples

The carwash wastewater samples were collected from a Pusat Cuci Kereta Automatic Parit Raja. The car wash station is located at the Jalan Manis 1/2, 86400 Parit Raja, Johor, Malaysia (103°10’019) (Figure 1). The samples were collected weekly during the period from January to March 2015. The samples were collected between 9 and 11 am, where high number of vehicles were coming for the washing process based on the data collected from the station management. The samples were taken using grab sampling technique into the plastic bottles (2 L) and transported to the laboratory according to [9].

![Figure 1. Location Map of Pusat Cuci Kereta Automatik Parit Raja (retrieved from Google map on November 3, 2014) Analysis of wastewater samples](image)

The wastewater samples were tested for pH, Turbidity, Chemical Oxygen Demand (COD), and Dissolved Oxygen (DO). pH value of the sample was determined using a calibrated pH meter (EC Probe Meter). Turbidity of the wastewater sample was tested using the Attenuated Radiation Method (Method 3750, HACH DR 6000). COD were determined using Reactor Digestion Method (Method 8000, HACH DR 6000), finally, DO was tested using DO meter (EC Probe Meter). All the analysis was carried out according to [9].
2.2 Preparation of Moringa oleifera and ferrous sulphate
Moringa oleifera seeds (Figure 2) were purchased from a local market and was dried under the sunlight to improve level of polyelectrolyte presented in the kernels [10]. Then, the seeds were grounded into fine particles (0-0.20 mm) and dried at 100°C for 24 hrs. The dried seeds were milled into fine powder by using domestic blender and then passed through 50-mesh sieve according to coagulant-method [11]. Ferrous sulphate (FeSO₄·7H₂O) salts (CAS:7782-63-0, Fisher Scientific) was supplied from Tai’an Ming Chen Chemical Import and Export Co. Ltd, China.

![Figure 2. Moringa oleifera seeds](image)

2.3 Design of integrated treatment system
The treatment system used in this study is presented in Figure 3. It consists of four stages included aeration, coagulation and flocculation unit, sedimentation and filtration unit.

![Figure 3. Schematic diagram of the integrated flocculation carwash wastewater system.](image)

In this system, a volume of one litre of wastewater sample was transported manually into the aeration tank (25cm×17cm×18cm), and aerated for 30 min. The wastewater was pumped into the flocculation and
coagulation tank using a water pump (Shanda), 120V. The flocculation and coagulation tank was made of High-density polyethylene (HDPE) transparent bottle (14cm×20cm×14cm) 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. A weight of 35 mg of M. oleiferra was added into the flocculation and coagulation tank. The wastewater sample was mixed for one hour. Thereafter, the supernatant was pumped slowly into sedimentation tank and allowed to settle for one hour. The supernatant was then filtrated using a natural filtration system consisted of sand and gravel. The treatment process was repeated with different doses of M. oleiferra and FeSO₄·7H₂O (70, 105 and 140 mg, respectively) According to [7,8]. The treated wastewater was analysed for pH, turbidity, DO and COD parameters.

3. Results and discussion

3.1 Characterization of raw carwash wastewater

The mean of pH, turbidity, DO and COD of raw car wash wastewater are illustrated in Table 1.

| Parameter                     | Raw car washes wastewater | Effluent Standard by Environmental Quality Act 1974 |
|-------------------------------|---------------------------|-----------------------------------------------------|
| pH                            | 6.96                      | 6-9                                                 |
| Turbidity (NTU)               | 275.1                     | <5                                                  |
| Dissolved Oxygen (DO) (mg/L)  | 2.55                      | >7                                                  |
| Chemical Oxygen Demand (COD) (mg/L) | 220                     | <50                                                 |

Its appeared that the turbidity, DO and COD were higher than the standards limits of Environmental Quality Act 1974. While, pH was within the standards limits. These results are in agreement with those reported by [12] in Malaysia and [13] in India. However, they were differed from that reported in previous study [8]. Turbidity in carwash wastewater in this study was more than that in the last study. In contrast, COD concentrations was less than that recorded in the previous study. These differences would be related to the source carwash wastewater and type of vehicles.

The high value of turbidity is due to the presence dirt, mud and brake particles in wastewater which are washed off from vehicles and are comparatively large molecule size of pollutants [12]. The increasing the turbidity of wastewater indicated that the wastewater has high concentrations of total suspended solid (TSS) [1]. However, TSS is not investigated in the current study. The high concentration of COD might be related to the presence of detergents utilized during the washing process, which cause oxidation process of organic compound and then increasing COD [14]. It can be indicated that the parameters of raw carwash wastewaters are higher than the standards limits required for disposal process. Therefore, these wastes should be treated to improve their characteristics and prevent contamination of the environment.

3.2 Efficiency of integrated treatment system

The efficiency of the integrated treatment system design here for treating of carwash wastewater was evaluated based on pH, turbidity, DO and COD as described in section materials and method. The characteristics of wastewater treated with different doses of M. oleiferra and FeSO₄·7H₂O are presented in Table 2.
It can be noted that pH, and DO of treated wastewater reduced to meet EQA 1974, Regulation 2009 [15]. The maximum value of pH was recorded with 70 mg L\(^{-1}\) of \textit{M. oleifera}. In contrast, pH was decreased with increasing of FeSO\(_4\cdot\text{H}_2\text{O}\) to pH 3.93 with 140 mg L\(^{-1}\). These results indicated that the natural coagulant is more efficient to adjust pH value of wastewater than chemical coagulant ones. These findings were similar to that recorded by [8]. However, in that study the author reported that the alum and FeSO\(_4\) was better as coagulant because little or no further addition of chemical would be required to correct the finished water pH. Conversely, this study demonstrated that \textit{M. oleifera} is the best as coagulant because the pH value still within the standards limits 6-9 even at high concentrations, while it decreased to pH 5.65 at the low concentrations of FeSO\(_4\).

The coagulation using \textit{M. oleifera} increased of wastewater DO from 2.55 to 7.22 mg L\(^{-1}\) with 105 mg L\(^{-1}\), while FeSO\(_4\cdot\text{H}_2\text{O}\) increased it to 6.78 at same concentrations. Thus, in the term of DO, only carwash wastewater treated with \textit{M. oleifera} has met EQA 1974, Regulation 2009 (Standard A).

Both coagulants were effective for reducing turbidity from 275.1 NTU to 8.42 and 18.3 NTU respectively at 140 mg L\(^{-1}\) of concentrations. The turbidity concentration still more than the EQA 1974, Regulation 2009 (Standard A). However, the wastewater treated with \textit{M. oleifera} was almost near to meet the standards limits (<5 NTU), the removal percentage was >97%. [16] also showed that the coagulation of wastewater with \textit{M. oleifera} reduced turbidity by more than 99%.

COD exhibited less response for both coagulant substrates; it reduced from 220 mg L\(^{-1}\) to 143 and 169 mg L\(^{-1}\) with 140 mg L\(^{-1}\) of \textit{M. oleifera} and FeSO\(_4\cdot\text{H}_2\text{O}\) respectively. However, the wastewater meet the regulations required for Standards B. The maximum reduction of COD was 35 and 23.1% recorded at 140 mg L\(^{-1}\) of \textit{M. oleifera} and FeSO\(_4\), respectively. This removal percentage is less than that reported by [7] where 60% of reduction for COD was observed at 60 mg L\(^{-1}\) of \textit{M. oleifera}. These differences might be due to the turbidity concentrations of raw carwash wastewater, 275.1 NTU in this work comparing to 39-173 NTU in the study conducted by [7]. Therefore, in the current study the interaction between turbidity and COD removal was analyzed at p<0.05. It was noted that the turbidity concentration and COD removal correlated significantly with R\(^2\)=0.96.

In general, \textit{M. oleifera} was more effective in the treatment of raw carwash of pollutants than FeSO\(_4\cdot\text{H}_2\text{O}\) at different concentrations investigated in this study. These differences might be related to nature of \textit{M. oleifera} as adsorbent for H\(^+\) ions and TSS and has the ability to neutralization of solution [17]. Thus, the turbidity in the wastewater treated with \textit{M. oleifera} was less than that treated with FeSO\(_4\cdot\text{H}_2\text{O}.

In addition to efficiency of \textit{M. oleifera} compared to FeSO\(_4\cdot\text{H}_2\text{O}, it is a natural product, low cost and eco-friendly since no chemical additive is needed or toxic by-product is generated from the coagulation process.

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**Table 2. Characteristics of carwash wastewater treated with different doses of \textit{M. oleifera} and FeSO\(_4\cdot\text{H}_2\text{O}.)**

| Dose (mg L\(^{-1}\)) | pH     | Turbidity (NTU) | DO (mg L\(^{-1}\)) | COD (mg L\(^{-1}\)) |
|----------------------|--------|-----------------|---------------------|---------------------|
|                      | \textit{M. oleifera} | FeSO\(_4\cdot\text{H}_2\text{O}\) | \textit{M. oleifera} | FeSO\(_4\cdot\text{H}_2\text{O}\) | \textit{M. oleifera} | FeSO\(_4\cdot\text{H}_2\text{O}\) | \textit{M. oleifera} | FeSO\(_4\cdot\text{H}_2\text{O}\) |
| 0                    | 6.96   | 275.1           | 2.55                | 220                 |
| 35                   | 6.89   | 5.65            | 39.7                | 4.19                | 3.6                 | 215                 | 217                 |
| 70                   | 7.03   | 4.83            | 23.5                | 5.89                | 4.91                | 200                 | 213                 |
| 105                  | 6.29   | 4.13            | 14.3                | 7.22                | 6.78                | 160                 | 180                 |
| 140                  | 6.17   | 3.93            | 8.42                | 7.13                | 6.38                | 143                 | 169                 |
| Standards (A)        | 6-9    | <5              | >7                  | 50                  |
| Standards (B)        | 5.5-9  | 50              | 5 – 7               | 100                 |
4. Conclusion
It can be concluded that the integrated treatment system designed here with natural coagulant \(M. \text{oleifera}\) and filtration unit was effective for primary treatment of carwash wastewater. \(M. \text{oleifera}\) was effective as coagulant for treatment of raw car washes wastewater. The wastewater treated with low concentrations of \(M. \text{oleifera}\) meet the regulation required Standard A in the term of pH and DO. The reduction of turbidity and COD reduced to meet EQA 1974 regulation 2009 (Standards B). Moreover, the parameters of treated car washes wastewater is appropriate to be reused again for car washing processes.

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