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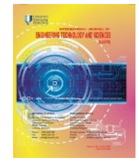

Colour and Ammonia Nitrogen Removal from Stabilised Leachate Using Two Stages Coagulation: Tapioca coagulant and Electrocoagulation

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Abstract- Leachate produced in municipal solid waste landfills is known to have very high concentrations of organic and inorganic pollution substances that could contaminate the surrounding. Degradation of leachate pollutants by coagulation was done conventionally by using single chemical coagulation. The application of natural coagulants, together with electrocoagulation (EC) is still at an uncertain stage. The purpose of this study was to investigate the ability of two stages of coagulation (TSC) consisting of coagulation (tapioca starch coagulant) and EC in removing colour and ammonia nitrogen from stabilising leachate under the influence of dose, leachate pH, duration, and electric current. Coagulation of tapioca starch without EC, removed 24% and 18% of colour and ammonia nitrogen, respectively. However, combining EC with coagulation at the optimum duration (20 minutes), a dose of TF (2.5 g/L), leachate pH (7), and electric current (0.15 A) achieved 37% and 61% removal of colour and ammonia nitrogen, respectively. The enhancement of colour and ammonia nitrogen were recorded by TSC. Therefore, TSC is proven able to improve colour and ammonia nitrogen removal from stabilised leachate.

Indexed Terms- Natural coagulant, dual coagulation, electricity, landfill leachate, solid waste

I. INTRODUCTION

Solid waste generated each day brings a negative impact to the environment if not properly managed. The generation of solid waste is the source of several types of pollution, such as air, soil, and water pollution. It not only affects the environment, but solid waste also can affect social and human health. A mitigation action is important in controlling these pollutions. One of the mitigation aspects that is crucial to be focused on is leachate treatment.

Leachate is the liquid that drains or 'leaches' from a landfill [1]. Leachate may produce in various compositions based on the age of landfill and the type of waste contains [1-2]. Leachate from landfill usually contains extracted, dissolved, and suspended materials, some of which may be harmful [2-3]. The ineffectiveness of leachate management can lead to water pollution to the nearby river or groundwater. Leachate will cause a severe threat to the environment, surrounding soil, and underlying groundwater if the spread of contamination content found in landfill leachate is allowed. The infiltrations of contamination into the soil increase the risk of degradation of human health since groundwater is the major source of drinking water worldwide [4]. Therefore, treatment of leachate is essential.

One of the conventional methods in treating leachate in the primary treatment stage is coagulation. Conventional coagulation is a process of mixing the coagulant with wastewater, which produced floc that is settled by gravity. Most of the coagulant used was chemical coagulant [4]. The natural coagulant is less exploited in this system, as it is not as good as a chemical coagulant and most of the natural coagulant study is just in the laboratory stage [5]. Even though chemical coagulant has a negative effect on the health of people compared to natural coagulant, a chemical coagulant is still widely accepted.

Another way of coagulating and flocculating pollutants in wastewater is EC. EC is a common process in treating industrial wastewaters because of the versatility and environmental compatibility [6-7]. Besides having a short reaction retention period, EC processes have no chemical addictive and have a lesser amount of precipitate or sludge, as Jotin et al. [8] concluded in their study. Furthermore, Mohd-Amdan et al. [6] also found that EC requires no filters, no daily maintenance, and removes any size of suspended solids, oil, grease, and heavy metals.

Based on previous studies [9-13], most of the coagulation treatments were only focusing on separate treatment, whether coagulation, chemical coagulation, or EC. Also, most previous studies only focusing on chemical coagulants instead of natural coagulants. Hence, in this study, TSC (a combination of coagulation (TF coagulant) and EC) was conducted to investigate the ability of this combination technique under the influence of dose of TF, leachate pH, duration, and electric current in removing colour and ammonia nitrogen from stabilised leachate.

II. MATERIALS AND METHODS

Leachate sample was collected from Simpang Renggam landfill (1°53'41 "N 103°22'35" E). This landfill is validated to generate stabilised leachate [1, 14]. The sampling and preservation of the samples were made according to the Standard Method for the Examination of Water and Wastewater [15].

Coagulation experiments were performed in a conventional jar-test apparatus (VELP-Scientifica, Model: J LT6, Italy). The operating conditions of the jar test were listed in Table 1. The volume of the leachate sample used in the study was 500 mL. In the jar test of the coagulation process, two varied factors tests were a dose of TF and leachate pH. The pH of the leachate sample was altered by using 1N hydrochloric acid (HCl) and 1N sodium hydroxide (NaOH).

After obtaining the optimum pH and TF dose from the coagulation experiment, the experimental work was continued with the TSC, which consisted of coagulation and EC. The variables considered for the determination of optimum condition for this combined method were duration and electric current following Zailani et al. [14] and Mohd-Amdan et al. [16]. The coagulation process in rapid mixing was conducted as usual while the EC took place in the slow mixing. A pair of iron plates with a dimension of 200 mm × 50 mm × 1 mm with an effective area of 45 cm^2 were dipped into the sample. The spacing between the electrodes is 9.5 cm. The electrode is connected to the electric source using the wire and crocodile clip. The laboratory DC power supply was used to adjust the electric current. Leachate was firstly added with TF and stirred at 200 rpm for 4 minutes to allow the floc to grow large enough for removal without any current flow. Then, the electrodes were connected to the power source to begin the EC process. After the EC process was completed, the sample was allowed to settle for 30 minutes. Supernatant samples were withdrawn and sent for analysis. The removal of colour and ammonia nitrogen were calculated by using Equation 1.

$$\text{Removal (\%)} = \frac{Initial\ concentration - Final\ concentration}{Initial\ concentration}\ x\ 100 \qquad (1)$$

III. RESULTS AND DISCUSSION

The optimum dose of TF was determined using different dose values of coagulant between 1.6-3.2 g/L, as shown in Figure 1. The removals have an increment with the addition of TF until 2.5 g/L of TF. Beyond 2.5 g/L, decrement trends were recorded for colour and ammonia nitrogen. Therefore, the optimum dose of TF was 2.5 g/L. At this optimum dose, removal for colour and ammonia nitrogen were 21% and 26%, respectively. Shaylinda et al. [10] show better removal of colour and lower removal of ammonia nitrogen compared to this study. Probably, different characteristic of leachate influences the removal ability of TF.

Figure 2 shows the effect of pH on removing colour and ammonia at a 2.5 g/L dose of TF. The values of pH tested were between 3-8. Based on the removal trends for colour and ammonia nitrogen, better removals were recorded at an alkaline pH range. At pH 8, the removals of ammonia nitrogen and colour had the same percentage removal, i.e., 30%. However, pH 7 was selected as the fixed leachate pH for the next experimental work to maintain the natural pH, and the removal of colour and ammonia nitrogen at leachate pH 7 was not significantly different from pH 8.

The effect of EC duration was investigated in the range of 5-25 minutes for the TSC. 2.5g/L dose of TF was mixed with pH 7 of leachate at 200 rpm for 4 minutes. Then, the electric current was supplied at 0.02A according to the duration needed. The removals of colour initially increased, then fluctuate as duration increased. However, the best removal of colour was obtained at 20 minutes with 38% removal. As for ammonia removal, a significant increment was recorded as the EC duration increased (Figure 3). The highest removal was recorded at 25 minutes, with 52% removal. Nevertheless, 20 minutes of EC is the duration value that satisfied both colour and ammonia nitrogen removals.

The optimum electric current for the TSC was examined by varying the current between 0.02-0.35A. Different values of electric current were applied for 20 minutes after the completion of TF addition and 4 minutes of rapid mixing. Figure 4 showed that the best electric current flow was 0.15A. At this optimum electric current, 37% and 61% of colour and ammonia nitrogen were removed, respectively. A single electrocoagulation study by Zailani et al. [14] recorded lower removal (37%) of ammonia from leachate. Thus, based on overall experimental work, TSC exhibits better removal compared to coagulation without EC. The removal of colour increased from 21% to 37%. A significant improvement was recorded for ammonia nitrogen removal as 61% removal was recorded by TSC compared to just 26% recorded by TF coagulation.

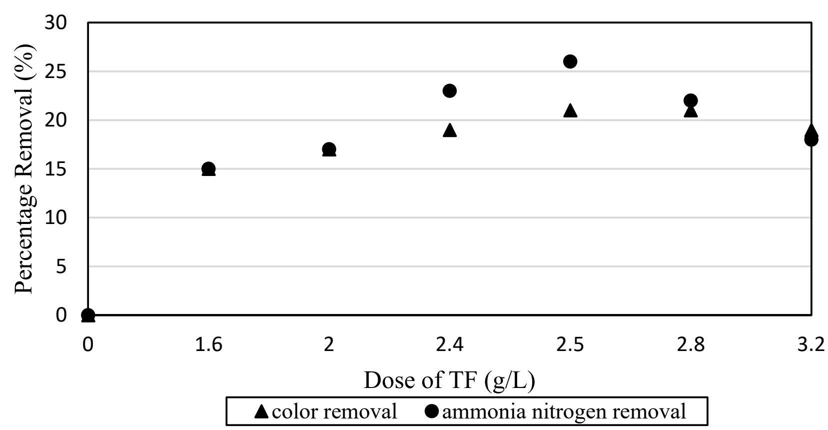

Figure 1: Coagulation under the influence of TF dose

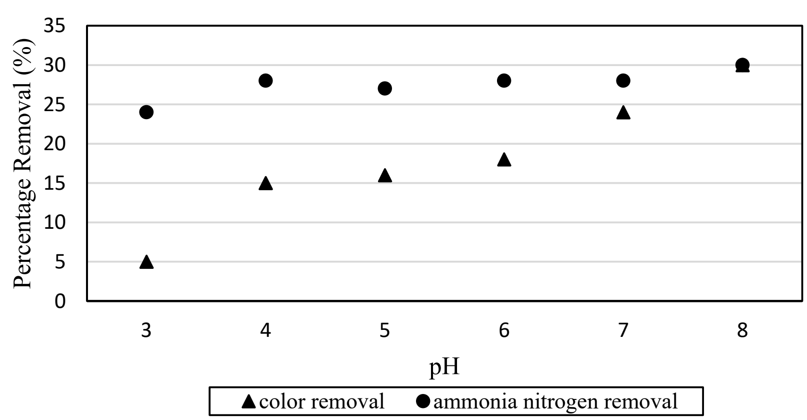

Figure 2: Coagulation under the influence of leachate pH.

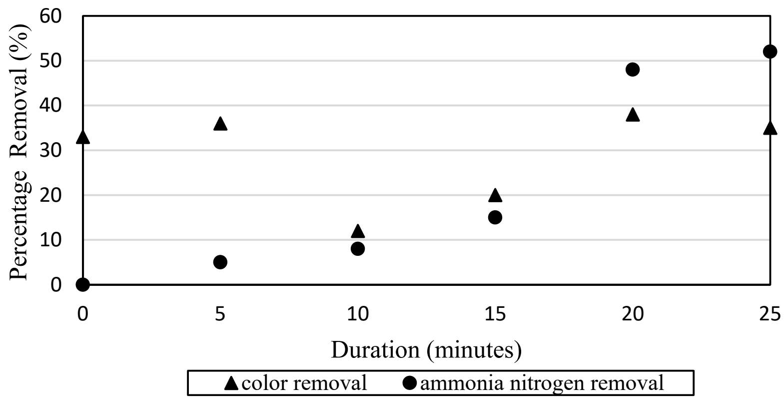

Figure 3: Two stages of coagulation under the influence of duration.

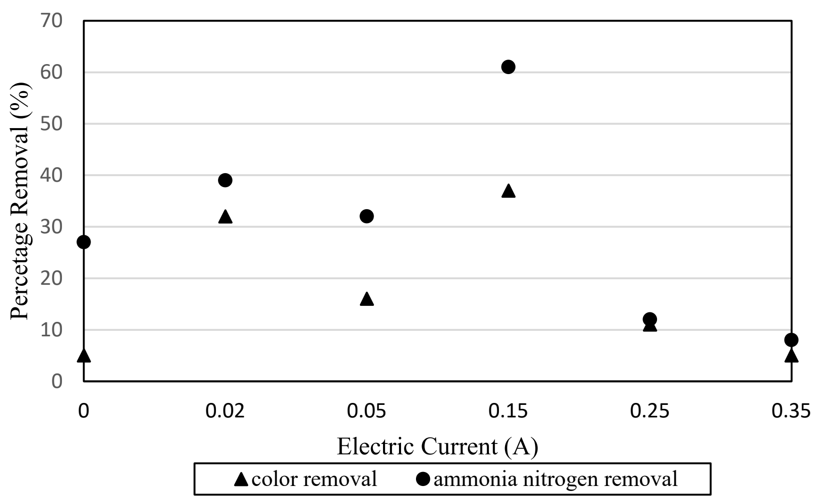

Figure 4: Two stages of coagulation under the influence of current.

IV. CONCLUSIONS

It could be concluded that leachate pH 7, 2.5 g/L of TF dose, 20 minutes of EC, and 0.15A electric current were the optimum values for colour and ammonia nitrogen removal by TSC (coagulation and EC). EC after coagulation significantly improved the removal efficiency, especially for ammonia nitrogen removal. The results of this study suggested that TSC consist of coagulation (TF coagulant), and EC can be a feasible method in removing colour and ammonia nitrogen from stabilised leachate.

Nomenclature:

A	Ampere
cm	centimetre
g/L	gram per litre
mm	millimetre
mL	millilitre
rpm	revolutions per minute
%	percentage

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