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Effect of Modified Micro-Sand, Poly-Aluminium Chloride and Cationic Polymer on Coagulation-Flocculation Process of Landfill Leachate

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ABSTRACT

Sanitary landfill leachate is considered as highly polluted wastewater, if without any treatment and discharge into water system will affect water quality. This study was carried out to assess the treatability of the semi-aerobic landfill leachate via coagulation-flocculation using poly-aluminum chloride (PAC), cationic polymer and modified micro sand. Leachate was collected from Pulau Burung Sanitary Landfill located in Penang, Malaysia. Coagulation-flocculation was performed by using jar test equipment and the effect of pH, dose of coagulant and polymer toward removal of chemical oxygen demand (COD), color and suspended solid (SS) were examined. Micro sand also had been used in this study to compare settling time between coagulation-flocculation process with and without the aid of micro sand. The optimum pH, dose of coagulant (PAC) and dose of polymer (cationic) were achieved at 7.0, 1,000 mg/L and 8 mg/L, respectively. The dose of micro sand used for the settling time process is 300 mg/L. Results showed 52.66 % removal of COD, 97.16% removal of SS and 96.44% removal of color were obtained under optimum condition. The durations of settling time to settle down the sludge or particle that formed during coagulation-flocculation process were recorded at 1 minute (modified sand), 20 minutes (raw micro sand) and 45 minutes (without micro sand).

1. INTRODUCTION

Water pollution had been one of the major problems that need to be managed properly. Major problems such as diseases and death occurred due to uncontrolled water pollution, lack of clean drinking water and expensive water treatment due to high concentration of pollutants. One of the sources that cause water pollution is discharge of wastewater either from industrial or landfill into water system. The wastewater discharge from landfill known as leachate usually consists of high concentration of organic and inorganic matter such as chemical oxygen demand (COD), bio-chemical oxygen demand (BOD), suspended solid (SS), ammonia nitrogen (NH3-N) and heavy metals [1]. The composition of the leachate depends on several factor such as moisture content, type of landfill, volume of waste produce, type of waste, age of the landfill and climate condition [2, 3]. Without any treatment, contamination of leachate into water system will not only cause water pollution, but also threaten the surrounding ecosystem [4].

Physical, biological treatment or physical-chemical treatment such as anaerobic and/or aerobic biological degradation, chemical oxidation, coagulation-precipitation, activated carbon adsorption, photo-oxidation and membrane process can be used to treat wastewater [5, 2, 6]. Leachate from stabilized landfill involves more than ten years which has low biodegradability due to large amounts of non-biodegradable organic compounds with high molecular weight [1]. These criteria lead to less effectiveness of biological treatment to treat stabilized landfill leachate. To overcome this problem, physical-chemical water treatment has been applied to treat leachate from the stabilized landfill. One of the commonly used physical-chemical treatments applied in wastewater treatment is coagulation-flocculation. Coagulation process followed by flocculation process was said to be more effective in organic pollutant removal [6]. The efficiency of coagulation-flocculation process depends on several factors such as type and dosage of coagulant/flocculant, pH, mixing speed and time, temperature and retention time [7, 8, 9, 10].

Coagulation-flocculation is a simple process that involves the use of inorganic metal salts such as aluminum sulfate (alum), ferric chloride (FeCl3) and poly-aluminum chloride (PAC) [11]. Several studies have been done using alum and PAC as a coagulant in wastewater treatment by comparing their parameter such as COD, turbidity, color and SS. Overall, the result showed that PAC was very effective for the removal of physical parameters such as color, turbidity and SS but less effective in COD removal compared to alum [11]. However, during coagulation-flocculation process, the settle down of the sludge or particle produced is rather slow. To enhance the settle down process, micro sand has been used to provide a surface area that enhances the flocculation and acts as a weight to settle down the sludge or particle [12]. The aim of this study is to examine the effectiveness of coagulation-flocculation process in landfill leachate treatment using combination of poly-aluminium chloride (PAC), cationic polymer and chemically modified micro-sand in term of chemical oxygen demand (COD), total suspended solid (TSS) and color removal.

2. Materials & Method

2.1 Leachate Sampling and Characterization

Samples of leachate were collected from leachate collection ponds at Pulau Burung Sanitary Landfill (PBSL). PBSL is situated within the Byram Forest Reserve in Penang, Malaysia and the total area of the landfill site is 23.7 hectares [13]. PBSL has been operated semi-aerobically since year 1991 by employing a controlled tipping technique and has been upgraded to leachate circulation system in year 2001 [14]. Leachate samples were collected in plastic container and transported to laboratory. The samples were stored at 4°C and the characterization of the raw leachate samples from PBSL was carried out according to the Standard Method for the Examination of Water and Wastewater [15]. The characteristic of raw leachate samples are shown in the Table 1. Parameters of leachate samples that were analyzed on site were pH, dissolved oxygen (DO), temperature, and conductivity; while measurement of color, chemical oxygen demand (COD), biochemical oxygen demand (BOD5), suspended solid (SS) and ammonia nitrogen (NH3-N) were performed immediately upon return to the laboratory.

Table 1 Characteristic of raw leachate sample

Parameter	Unit	Value
Temperature	°C	29.1 – 31.2
pH	-	8.32 – 8.60
COD	mg/L	1450 – 1520
BOD_5	%	179 – 188
Color	Pt-Co	3450 – 3630
NH_3-N	mg/L	790 - 810
TSS	mg/L	164 – 181

2.2 Coagulation-Flocculation

Coagulation-flocculation experiment on leachate was carried out by using jar test equipment (VELP-Scientific, Model: JLT6, Italy) that consist of six paddle rotors (2.5 cm x 7.5 cm) and six beakers (500 mL). Coagulant and polymer applied in this study were poly-aluminium chloride

(PAC) and cationic polymer. Leachate samples were subjected to jar test after pH adjustment had been done by using sodium hydroxide (NaOH) and hydrochloric acid (HCl). This coagulation-flocculation process involves 3 distinct steps: (i) rapid mixing stage which aim to mix the coagulant with leachate to maximize the effectiveness of the destabilization of colloidal particles; (ii) slow mixing stage where the suspension is slowly stirred to increase contact or collision between coagulating particles to produce large flocs; (iii) settling time stage where the mixing is terminated and the flocs are allowed to settle down. The sample was immediately stirred at a constant speed of 200 rpm for 2 minutes followed by a slow stirring at 40 rpm for 10 minutes [16]. Initial settling time in this experiment was 30 minutes. Later, by using the optimum condition gained, samples were observed at minute of 0, 0.5, 1, 5, 10, 15, 20, 30, 45 and 60 to compare settling time between coagulation-flocculation process with and without micro sand and modified micro sand. Modified micro sand used in this study was prepared by dissolving the sodium aluminium and sodium hydroxide in distilled water with micro sand.

3. Results & Discussion

3.1 Effect of pH

pH is one of the important parameters in the coagulation-flocculation process since it controls hydrolysis species. Different pH values were applied to perform the coagulation-flocculation process. The ranges of pH examined were from 2 – 10 as shown in the Fig. 1. From Fig. 1, coagulation-flocculation process was more efficient in removal of COD, TSS and color at the ranges of pH from 6 – 7. The higher percentage removal for COD, SS and color were at 49.46%, 99.19% and 93.53%, respectively. After pH adjustment to pH 4 and 9, some flocs were already appeared even without coagulant. The color intensity gradually reduced as the pH approached the optimum pH which from dark brown to light yellow.

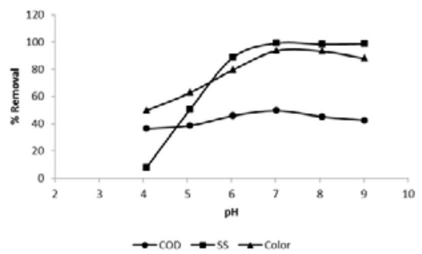

Fig. 1 Effect of pH toward percentage removal of COD, TSS and color

3.2 Effect of Cationic Polymer

Cationic polymer usually added in the coagulation-flocculation process to improve the settling characteristic. The different dose of cationic polymer was applied to determine the optimum dose of cationic polymer. Fig. 2 shows that the optimum dose of cationic was 8 mg/L with the higher percentage removal obtained for COD, TSS and color were 58.99%, 95.68% and 94.41%, respectively. There were a slightly increase and decrease in the percentage of removal for COD from 6 mg/L to 10 mg/L of cationic polymer.

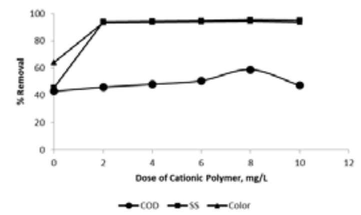

Fig. 2 Effect of cationic dose toward percentage removal of COD, TSS and color

3.3 Effect of PAC

One of the commonly use coagulant in coagulation-flocculation process was PAC. Different doses of coagulant have been applied in this study. The ranges of coagulant dose examined were from 500 mg/L – 2,500 mg/L. The percentages removal of COD, TSS and color are shown in the Fig. 3. Optimum doses of PAC observed in this study were ranges between 500 to 1,000 mg/L. The higher percentage removal of COD, TSS and color were obtained at 52.66%, 97.16% and 96.44%, respectively.

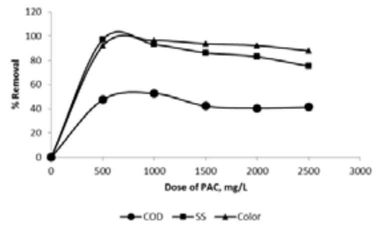

Fig. 3 Effect of PAC toward percentage removal of COD, TSS and color

3.4 Application of Modified Microsand

Micro sand was used in the coagulation-flocculation process to enhance the flocculation process and settle down the sludge or particles that formed during the process. The dose of micro sand and modified micro sand used was 300 mg/L as optimum dose as shown in the Fig. 4. In this study, the settling time recorded to settle down the sludge and particle formed during coagulation-flocculation process were 1 minute with modified micro sand, 20 minutes with raw micro sand and 45 minutes without micro sand (Fig. 5). The results indicate that the settling time in coagulation-flocculation process of landfill leachate was accelerated by chemically modified microsand

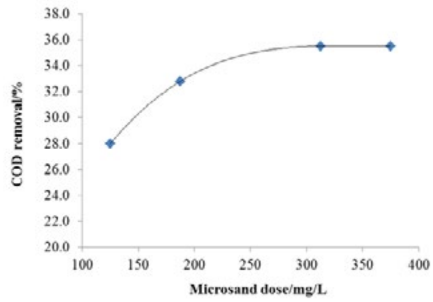

Fig. 4 Effect of modified micro sand dosage to COD removal in coagulation-flocculation process

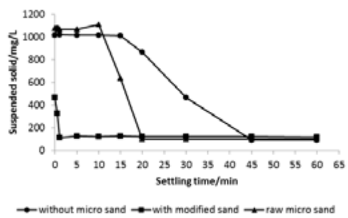

Fig. 5 Comparison of settling time between coagulation-flocculation process with raw micro sand, modified micro sand and without micro sand

4. Conclusion

In the present study, the application of coagulation-flocculation process to treat landfill leachate collected from PBSL was examined. The efficiency of PAC and cationic polymer in removing COD, TSS and color as well as the use and efficiency of micro sand and modified micro sand to settle down sludge and particles formed during coagulation-flocculation process were also investigated. We found that the highest percentage removal of COD, TSS and color can be observed at pH 7 with the optimum dose of PAC was 1,000 mg/L and optimum dose of cationic polymer was 8 mg/L. Micro sand and modified micro sand were shown to be more efficient to settle down sludge and particles that formed in coagulation-flocculation process. With the addition of polymer, the removal process of COD, TSS and color can be improved.

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