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Coagulation-Flocculation In Leachate Treatment By Using Micro Sand

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Abstract

Leachate was treated by using coagulation-flocculation. Coagulation-flocculation as a relatively simple physical-chemical technique was applied in this study. This study examined micro sand combination with coagulant and coagulant aids in treating a stabilized leachate, and compared the results in respect to the removal of suspended solid (SS), chemical oxygen demand (COD), color and ammoniacal nitrogen. The optimum pH for the tested coagulants was 7. The dosages were 2000 mg/L for PAC, alum and ferric chloride combination with 10 mg/L dose of polymer. the dose of micro sand were 1500 mg/L for PAC, 5000 mg/L for alum and 3000 mg/L for ferric chloride. The micro sand was sieved in 6 different particle sizes. Among the experiments, micro sand combination with PAC and cationic polymer showed the highest SS removal efficiency (99.5%), color removal efficiency (94.8%), COD removal efficiency (73%), ammoniacal nitrogen (65%) and with settling time for 30 minute.

Keywords—Leachate, coagulation-flocculation, coagulant micro sand

I. INTRODUCTION

Leachates are defined as the aqueous effluent generated as a consequence of rainwater percolation through wastes, biochemical processes in waste's cells and the inherent water content of wastes themselves. Leachate usually contain large amounts of organic matter, ammonia nitrogen, heavy metals, chlorinated organic and inorganic salts, which are toxic to living organisms and ecosystem (Zouboulis et al., 2008). Leachate composition depends on many factors such as the waste composition, site hydrology, the availability of moisture and oxygen, design and operation of the landfill and its age. Landfill leachate is generally characterized by a high strength of pollutants (Chen., 1996).

Leachate production starts at the early stages of the landfill and continue several decades even after closure of landfill. It is generated mainly by the infiltered water, which passes through the solid waste fill and facilitates transfer of contaminants from solid phase to liquid phase (Parkes et al., 2007). Due to the inhomogeneous nature of the waste and because of the differing compaction densities, water percolates through and appears as leachate at the base of the site.

Depending of the on the geographical and geological nature of a landfill site, leachate may seep into the ground and possibly enter groundwater sources. Thus it can be major cause of groundwater pollution (Cook & Fritz 2002; Mor et al., 2006).

Landfill leachate has an impact on the environment because it has very dangerous pollutants such as ammonium nitrogen, biodegradable and refractory organic matter and heavy matals. In fact, the ammonium concentration in leachtae found to be up to several thousand mg/L. in addition, leachate cause serious pollution to groundwater and surface waters. It is important to note that the chemical characteristic of leachate varies and as a function of a number of factors such as waste composition, the degradation degree of waste, moisture content, hydrological and climatic conditions (Sartaj et al., 2010).

Contamination of groundwater by landfill leachate, posing a risk to downstream surface waters and wells, is considered to constitute the major environmental concern associated with the measures to control leaking into the groundwater, and the significant resources spent in remediation, support the concern of leachtae entering the groundwater (Veli et al., 2008). Leachate treatment facility is required before discharging leachate into the environment and this depends on several factors such as the characteristics of leachate, costs, and regulations. Specific treatment techniques can be used to treat this hazardous wastewater in order to protect the ecosystem such as coagulation-flocculation (Abdulhussain et al., 2009).

Sand ballasted settling is a high rate coagulation/ flocculation/ sedimentation process that uses micro sand as a seed for particle formation. The micro sand provides a surface area that enhances flocculation and acts as a ballast or weight. The resulting particle settles quickly, allowing for compact clarifier designs with high overflow rates and short detention times (Achak et al., 2009).

II. CHARACTERIZATION OF THE LEACHATES

The leachates were collected from Pasir Gudang sanitary landfill that located at Johor, Malaysia. The Pasir Gudang sanitary landfill with largeness of 50 acres and average 350 tonnes of waste per day. The types of solid waste at Pasir Gudang sanitary landfill were housing, domestic, commercial, industry, institutions, market and construction.

Pasir Gudang landfill leachate has very high ammoniacal nitrogen in the range 1350 mg/L to 2150 mg/L. The average values of BOD_5 and COD were 131.5 mg/L and 2305 mg/L respectively, and the ratio of BOD_5/COD of raw leachate was about 0.05. Old or stabilized leachate are usually high in pH (>7.5) and NH_4-N (>400 mg/L) and low in COD (<3000 mg/L), BOD/COD ratio (<0.1) and heavy metal (<2 mg/L) (Ghafari et al., 2010, Neczaj et al., 2005, Bashir et al., 2011). Treatment of stabilized leachate from old landfill was more effective using the physic-chemical process (Durmusoglu & Yilmaz., 2006).

III. COAGULATION-FLOCCULATION

Coagulation-flocculation is widely used for wastewater treatment. This treatment is efficient to operate. It have many factors can influence the efficiency, such as the type and dosage of coagulant/flocculants, pH, mixing speed and time and retention time. The optimization of these factors may influence the process efficiency (Ozkan & Yekeler., 2004). Coagulation-flocculation is destabilizing the colloidal suspension of the particles with coagulants and then causing the particles to agglomerate with flocculants. After that, it will accelerate separation and thereby clarifying the effluents (Gnandi et al., 2005).

Ferric chloride ($FeCl_3$) and alum were chosen as coagulants for coagulation-flocculation. The experiments were carried out in a conventional jar test apparatus. For the jar test experiment, leachate sample were removed from the cold room and were conditioned under ambient temperature.

The jar test process consists of three steps which is the first rapid mixing stage; aiming to obtain complete mixing of the coagulant with the leachate to maximize the effectiveness of the destabilization of colloidal particles and to initiate coagulation. Second step is slow mixing; the suspension is slowly stirred to increase contact between coagulating particles and to facilitate the development of large flocs. After that, the third step settling stage; mixing is terminated and the flocs are allowed to settle (Choi et al., 2006; Wang et al., 2009).

Jar test was employed to optimize the variables including rapid and slow mixing, settling time, coagulant dose and pH. These variables were optimized based on the highest percentage removal of the leachate constituents. The leachate samples were adjusted to pH 7 before the addition $FeCl_3$ and alum. The amount SS, color, COD and ammoniacal nitrogen removal were determined after coagulation-flocculation. 10% solution of ferric chloride and alum were used as solution in the experiments.

IV. RESULTS AND DISCUSSION

A. Efficiency of micro sand combination with PAC and cationic polymer

It shows that the PAC was achieved higher removal percentage of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N). The results were 80 % above for SS and colour. There was no significant different compared using micro zeolite. Anyway, micro sand was lower efficiency in removal of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N) compared with micro zeolite.

The experiment results showed that the percentage removal of SS were 99% and 99.5% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentage of SS were not obvious different when micro zeolite replaced by micro sand. The results showed more than 90% which is the higher percentage was 99.5% and the lower percentage was 96%. The results for removal percentage of SS were showed in the Figure 4.88.

Furthermore, the removal percentage of colour were 89.8% and 94.8% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentages were majority around 90% and the results were no significant different among the 5 different doses of polymer which is 2 mg/L, 4 mg/L, 6 mg/L, 8 mg/L and 10 mg/L. The removal percentage was slightly decreased at 6 mg/L, 8 mg/L and 10 mg/L dose of polymer. The results for removal percentage of colour were showed in the Figure 4.89.

Otherwise, from the experiment showed that the removal percentages of COD were 61% and 73% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The percentages were increased with the increased of the particle size of micro sand. For example with particle size micro sand for 151µm to 180µm, it showed that 62% for 0 mg/L, 63% for 2 mg/L, 67% for 4 mg/L, 68% for 6 mg/L, 69% for 8 mg/L and 70% for 10 mg/L. The results for removal percentage of COD were showed in the Figure 4.90.

The NH_3N were achieved 51% and 65% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. For whole results, it was achieved from 42% to 65%. The removal percentages of NH_3N were increased slightly with started around 40% to 50%. After that, the results were increased to 60% and 60%

above for particle size of micro sand 151µm to 180µm and 181µm to 212µm. The results for removal percentage of NH_3N can refer to the Figure 4.91.

Finally, the experiment showed that the percentage removal using PAC combination with cationic polymer and micro sand (PAC + cationic polymer + micro sand) were slightly lower if compared with using PAC combination with cationic polymer and micro zeolite (PAC + cationic polymer + micro zeolite).

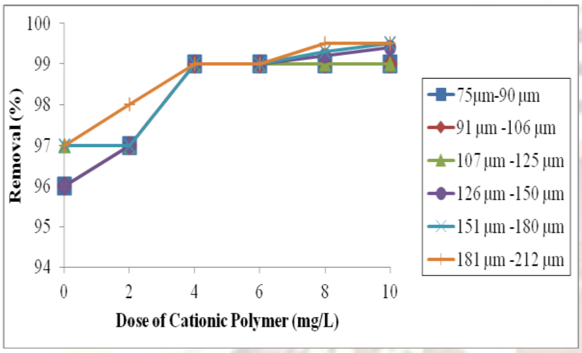

Figure 4.88: Removal percentage of SS for 1500 mg/L micro sand and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

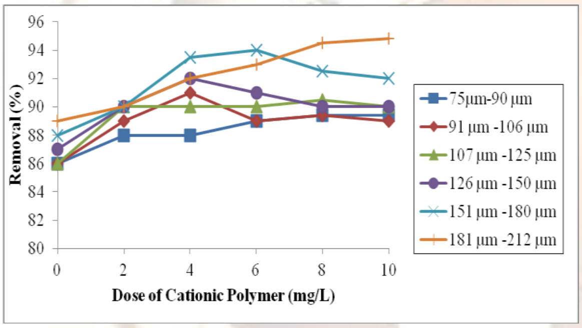

Figure 4.89: Removal percentage of colour for 1500 mg/L micro sand and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

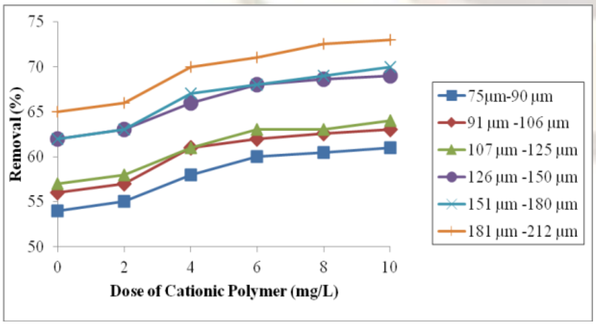

Figure 4.90: Removal percentage of COD for 1500 mg/L micro sand and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

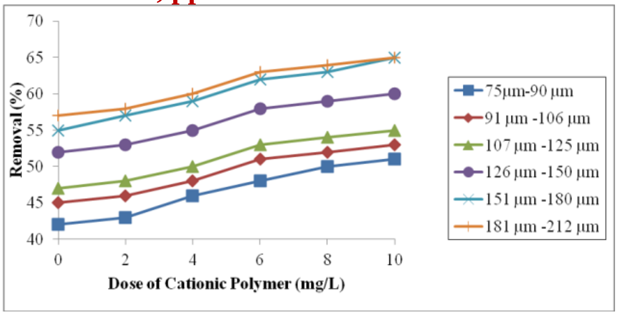

Figure 4.91: Removal percentage of NH_3-N for 1500 mg/L micro sand and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

B. Efficiency of micro sand combination with PAC and anionic polymer

It shows that the PAC was achieved higher removal percentage of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N). The results were 80 % above for SS and colour. There was no significant different for COD and ammoniacal nitrogen, which are the results was in between 40% - 60%.

From the experiment, the results showed SS was 99% with particle size of micro sand for 75µm – 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentages were also achieved 99% for other particle size of micro zeolite which is 91µm to 106µm, 107µm to 125µm, 126µm to 150µm and 151µm to 180µm. The results were 99% for whole particle size of micro zeolite but with 8 mg/L dose of polymer. For 6 mg/L doses of polymer, the percentage achieved 99% with particle size of micro zeolite 107µm to 125µm, 126µm to 150µm, 151µm to 180µm and 181µm to 212µm. The results for removal percentage was showed in the Figure 4.92.

Futhermore, the removal percentage of colour were achieved 90.4% and 94.4% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentages were majority whole more than 80% and the results were no significant different among the 5 different doses of polymer which is 2 mg/L, 4 mg/L, 6 mg/L, 8 mg/L and 10 mg/L. The results for removal percentage of colour were showed in the Figure 4.93.

Otherwise, from the experiment showed that the removal percentage of COD were 57% and 70% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The percentages were increased with the increased of the particle size of micro sand. For example with particle size of micro sand for 151µm to 180µm, it showed that 62% for 0 mg/L, 63% for 2 mg/L, 67% for 4 mg/L, 68% for 6 mg/L, 69% for 8 mg/L and 70% for 10 mg/L. the results for removal percentage of COD were showed in the Figure 4.94.

The NH_3N were achieved 46% and 62% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. For whole results, it was achieved from 42% to 62% compared with using PAC combination with cationic polymer and micro sand (PAC + cationic polymer + micro sand) was achieved similar from 42% but finally end with 65%. The removal percentage of NH_3N were increased slightly with started around 40% to 50%. After that, the results were increased to 60% and 60% above for particle size of micro sand 151µm to 180µm and 181µm to 212µm. The results for removal percentage of NH_3N showed in the Figure 4.95.

Finally, the experiment showed that the removal percentage of PAC combination with anionic polymer and micro sand (PAC + anionic polymer + micro sand) were slightly lower if compared with using PAC combination with anionic polymer and micro zeolite (PAC + anionic polymer + micro zeolite). Therefore, micro zeolite was more efficiency compared with micro sand when combination with PAC and anionic polymer.

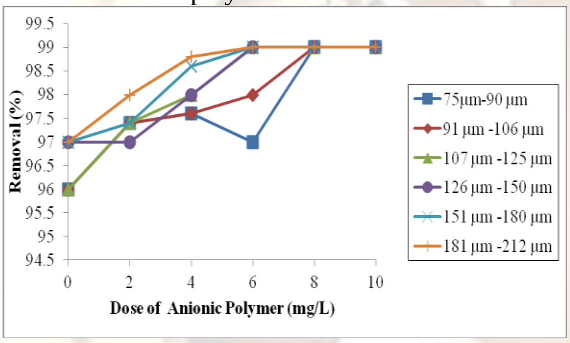

Figure 4.92: Removal percentage of SS for 1500 mg/L micro sand and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

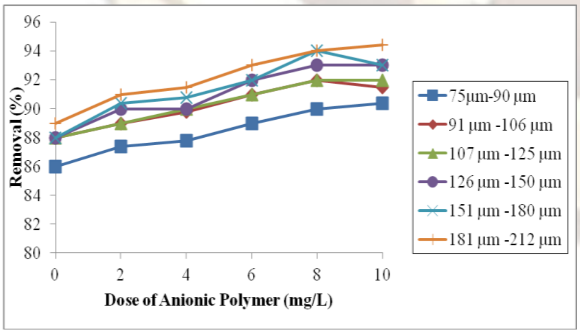

Figure 4.93: Removal percentage of colour for 1500 mg/L micro sand and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

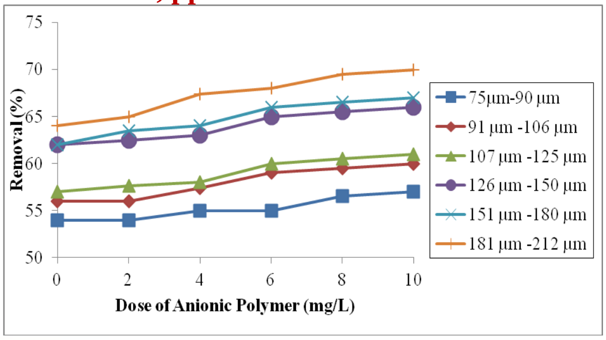

Figure 4.94: Removal percentage of COD for 1500 mg/L micro sand and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

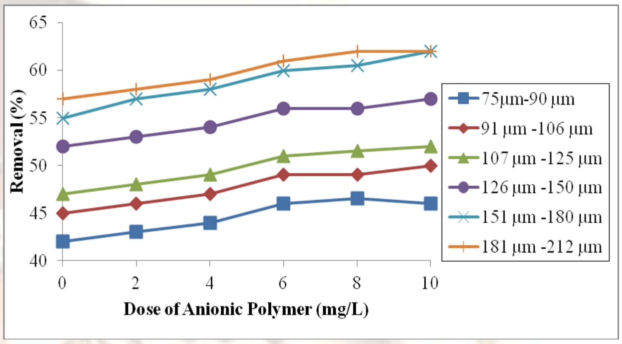

Figure 4.95: Removal percentage of NH_3-N for 1500 mg/L micro sand and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

C. Efficiency of micro sand combination with alum and cationic polymer

It shows that the alum was no significant in removal of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N). Therefore, the results were less than 80 % for SS and colour.

From the experiment, the removal percentages of SS were 72% and 84% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentage decreased when the PAC replace by alum. Anyway, the majority of percentage removals were achieved 60% above. It was slightly lower if compared with using micro zeolite. The results for removal percentage of SS were showed in the Figure 4.96.

The percentage removals of colour were around 50% to 60% which is in between 54% to 68%. The results achieved 70% when using the particle size of micro sand for 151µm to 180µm with 8 mg/L and 10 mg/L doses of polymer and 181µm to 212µm with 6 mg/L, 8 mg/L and 10 mg/L doses of polymer. The results for removal percentage of colour showed in the Figure 4.97.

Furthermore, the percentages of COD were achieved 51% and 70% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentage of COD were increased with the increased particle size of micro sand and doses of polymer. For example with particle size of micro sand for 151µm to 180µm, the percentage started from 45% for 0 mg/L, 47% for 2 mg/L, 48% for 4 mg/L, 49% for 6 mg/L, 51% for 8 mg/L and 60% for 10 mg/L. The results for percentage removal of COD were showed in the Figure 4.98.

Otherwise, the particle size of micro sand for 75µm to 90µm and 181µm to 212µm in NH_3-N were achieved 32% and 50% respectively with 10 mg/L dose of polymer. NH_3-N was the lower percentage in removal among 4 parameters which is suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3-N). The results for removal percentage of NH_3-N showed in the Figure 4.99.

From the experiment, it was showed that the alum was no significant in removal of leachate treatment, although the alum combination with cationic polymer and micro sand (alum + cationic polymer + micro sand). Nearly, the results for percentage of removal that using alum combination with cationic polymer and micro zeolite (alum + cationic polymer + micro zeolite) were find out almost similar efficiency with using alum combination with cationic polymer and micro sand (alum + cationic polymer + micro sand).

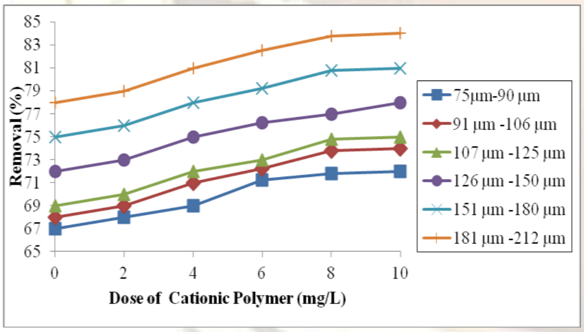

Figure 4.96: Removal percentage of SS for 5000 mg/L micro sand and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

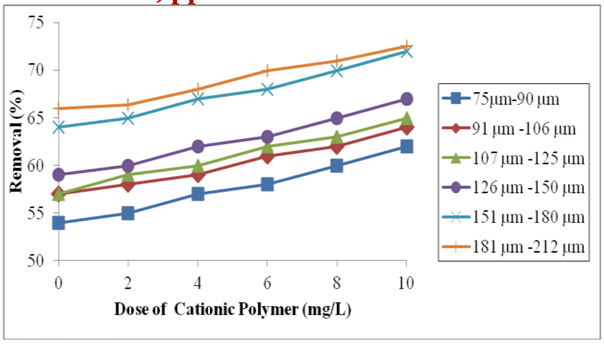

Figure 4.97: Removal percentage of colour for 5000 mg/L micro sand and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

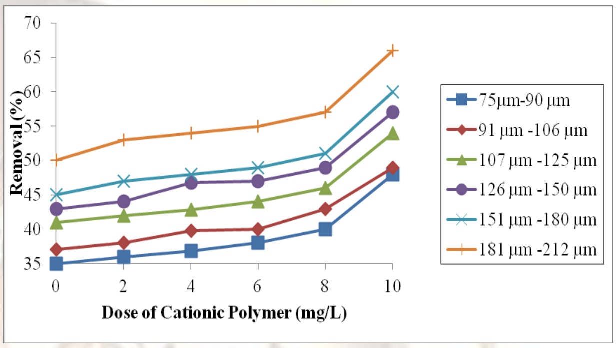

Figure 4.98: Removal percentage of COD for 5000 mg/L micro sand and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

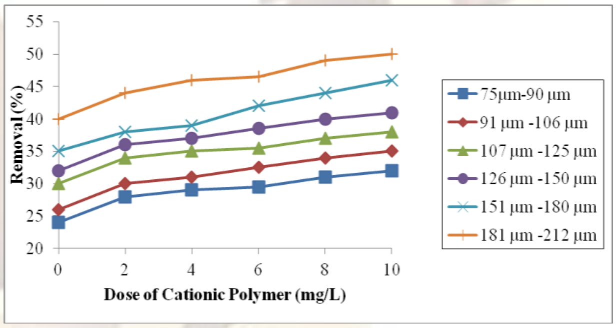

Figure 4.99: Removal percentage of NH_3-N for 5000 mg/L micro sand and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

D. Efficiency of micro sand combination alum anionic polymer

It shows that the alum was not significant in removal of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N). The results were less than 80 % for SS and colour.

From the experiment, the percentage of SS were 69.8% and 83% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentage decreased when the PAC replace by alum. Anyway, the majority of removal percentages were achieved 60% above. It was slightly lower if compared with using micro zeolite. The results for removal percentage of SS were showed in the Figure 4.100.

The percentage removals of colour were 61.2% and 72% with size particle micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The whole percentages were around 61.2% to 72% which is in between 55% to 72%. The results achieved 70% or above when using the size particle micro sand for 151µm to 180µm with 8 mg/L and 10 mg/L doses of polymer respectively . The removal percentages of colour were 70% or above for 181µm to 212µm with 6 mg/L, 8 mg/L and 10 mg/L doses of polymer respectively. The results for removal percentage of colour showed in the Figure 4.101.

Furthermore, the percentages of COD were achieved 38% and 56% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentages of COD were increased with the increased doses of polymer. For example with particle size of micro sand 181µm to 212µm, the percentage started from 51% for 0 mg/L, 52% for 2 mg/L and 4 mg/L, 54% for 6 mg/L, 54.8% for 8 mg/L and 56% for 10 mg/L. The results for removal percentage of COD were showed in the Figure 4.102.

Otherwise, the particle size of micro sand for 75µm to 90µm and 181µm to 212µm in NH_3-N were achieved 28% and 46% respectively with 10 mg/L dose of polymer. NH_3N was the lower percentage in removal among 4 parameters which is suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3-N). The results for removal percentage of NH_3-N showed in the Figure 4.103.

Finally, the experiment showed that alum combination with cationic polymer and micro sand (alum + cationic polymer + micro sand) were more effective if compared with alum combination with anionic polymer and micro sand (alum + anionic polymer + micro sand). Anyway, the results were not obviously different between the two polymer combination with alum and micro sand.

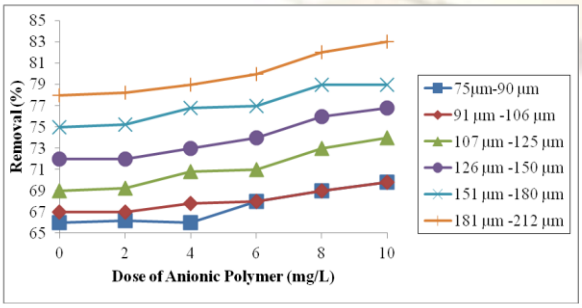

Figure 4.100: Removal percentage of SS for 5000 mg/L micro sand and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

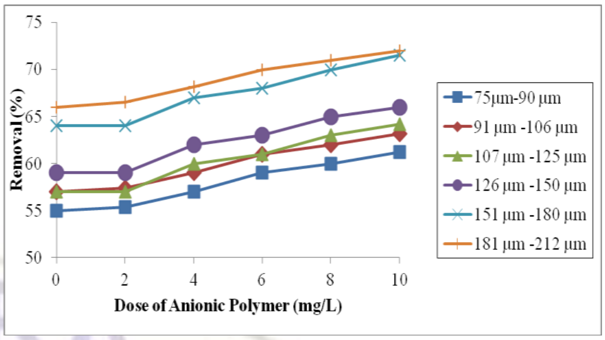

Figure 4.101: Removal percentage of colour for 5000 mg/L micro sand and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

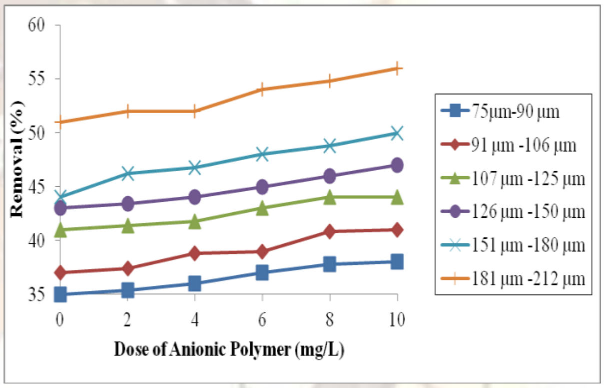

Figure 4.102: Removal percentage of COD for 5000 mg/L micro sand and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

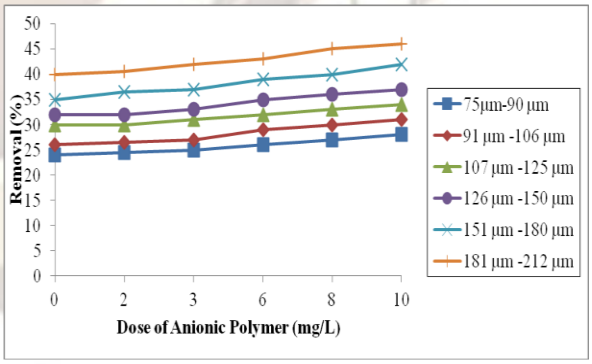

Figure 4.103: Removal percentage of NH_3-N for 5000 mg/L micro sand and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

E. Efficiency of micro sand combination with ferric chloride and cationic polymer

It shows that the ferric chloride was significant in removal of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3-N) compared with alum. The results were 80 % above for SS and colour.

The removal percentage of SS were 96% and 97% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The results were showed that majority 96% and 97% for whole percentages. For example with particle size of micro sand for 91µm to 106µm, it was 94% for started with 0 mg/L dose of polymer and then achieved 96% for 2 mg/L, 4 mg/L, 6 mg/L, 8 mg/L and 10 mg/L doses of polymer. The results for removal percentage of SS were showed in the Figure 4.104.

Furthermore, the removal percentage of colour were 88% and 94% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The whole percentages were around 80% to 90% which is in between 85% to 94%. The results achieved 90% or above when using the particle size of micro sand for whole the particle size of micro sand with 2 mg/L, 4 mg/L, 6 mg/L, 8 mg/L and 10 mg/L doses of polymer. The results for removal percentage of colour showed in the Figure 4.105.

The percentages of COD were achieved 48% and 64% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentage of COD were increased with the increased of particle size of micro sand and doses of polymer. For example with particle size of micro sand for 181µm to 212µm, the percentage started from 45% for 0 mg/L, 48% for 2 mg/L, 54% for 4 mg/L, 58% for 6 mg/L, 61% for 8 mg/L and 64% for 10 mg/L. The results for removal percentage of COD were showed in the Figure 4.106.

Otherwise, the particle size of micro sand for 75µm to 90µm and 181µm to 212µm in NH_3N were achieved 36% and 53% respectively with 10 mg/L dose of polymer. NH_3N was the lower percentage in removal among 4 parameters which is suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3-N). The results for removal percentage of NH_3N showed in the Figure 4.107.

Finally, the results for percentage in removal from this experiment showed that using ferric chloride combination with cationic polymer and micro zeolite (ferric chloride + cationic polymer + micro zeolite) was more effective if compared with using ferric chloride combination with cationic polymer and micro sand (ferric chloride + cationic polymer + micro sand).

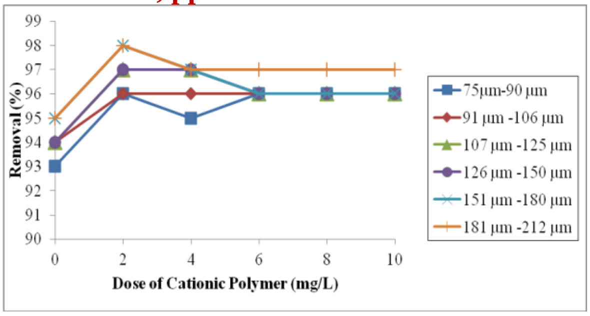

Figure 4.104: Removal percentage of SS for 3000 mg/L micro sand and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

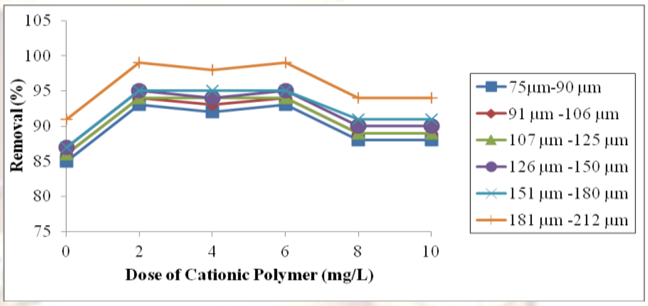

Figure 4.105: Removal percentage of colour for 3000 mg/L micro sand and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

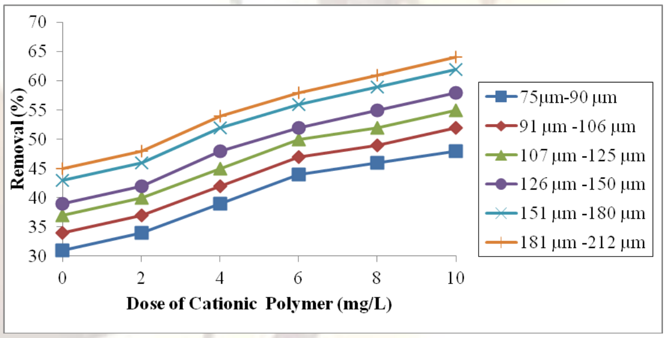

Figure 4.106: Removal percentage of COD for 3000 mg/L micro sand and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

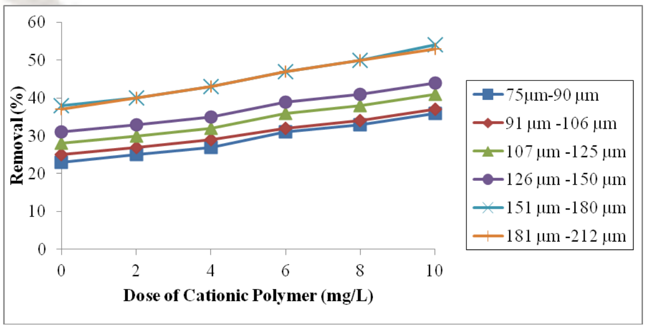

Figure 4.107: Removal percentage of NH_3-N for 3000 mg/L micro sand and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

F. Efficiency of micro sand combination with ferric chloride and anionic polymer

It shows that the ferric chloride was significant in removal of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N) if compared with alum. The results were 80 % above for SS and colour.

From the experiment, the percentage of SS were 94% and 96% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentage decreased slightly when the PAC replaces by ferric chloride. Anyway, the majority of removal percentages were achieved 90% above. It was slightly lower if compared with using micro zeolite (Bruch et al., 2011). The removal percentages were decreased slightly at 8 mg/L and 10 mg/L dose of polymer. The results for removal percentages of SS were showed in the Figure 4.108.

The removal percentages of colour were 83% and 89% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The whole percentages were around 80% to 90% which is in between 85% to 91%. The results achieved 90% or above when using the particle size of micro sand for 181µm to 212µm with 0 mg/L, 2 mg/L, 4 mg/L, 6 mg/L and 8 mg/L doses of polymer. The removal percentages were decreased slightly at 8 mg/L and 10 mg/L dose of polymer. The results for removal percentage of colour showed in the Figure 4.109.

Furthermore, the percentages of COD were achieved 46% and 61% with particle size of micro sand for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentage of COD were increased with the increased of particle size of micro sand and doses of polymer. For example with particle size of micro sand 181µm to 212µm, the percentage started from 45% for 0 mg/L, 49% for 2 mg/L and 53% for 4 mg/L, 55% for 6 mg/L, 58% for 8 mg/L and 61% for 10 mg/L. The results for removal percentage of COD were showed in the Figure 4.110.

Otherwise, the particle size of micro sand for 75µm to 90µm and 181µm to 212µm in NH_3-N were achieved 31% and 49% respectively with 10 mg/L dose of polymer. NH_3-N was the lower percentage in removal among 4 parameters which is suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3-N). The results for removal percentage of NH_3-N showed in the Figure 4.111.

Finally, the experiment showed that ferric chloride combination with anionic polymer and micro sand (ferric chloride + anionic polymer + micro sand) were lower efficiency if compared with ferric chloride combination with cationic polymer and micro sand (ferric chloride + cationic polymer + micro sand). Anyway, the results were not obviously different between two polymer combination with ferric chloride and micro sand.

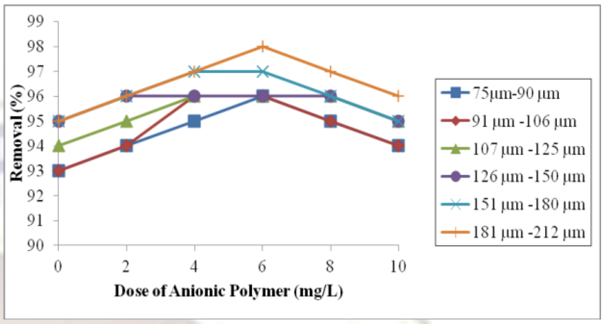

Figure 4.108: Removal percentage of SS for 3000 mg/L micro sand and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

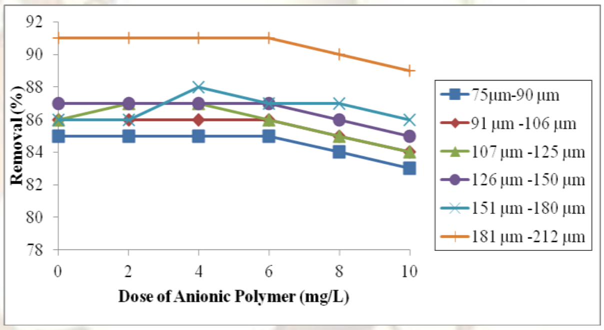

Figure 4.109: Removal percentage of colour for 3000 mg/L micro sand and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

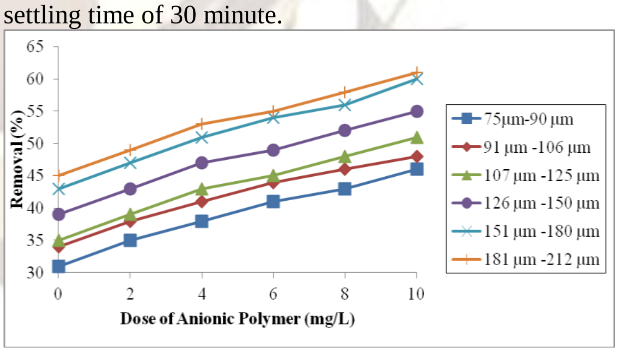

Figure 4.110: Removal percentage of COD for 3000 mg/L micro sand pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

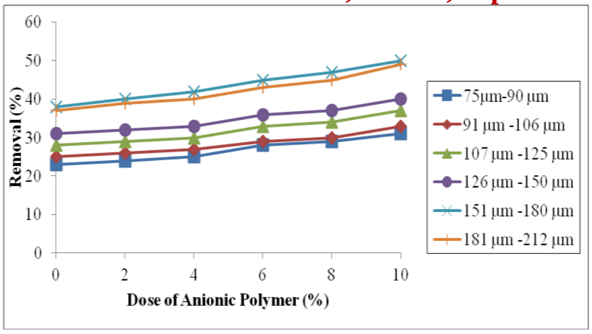

Figure 4.111: Removal percentage of NH_3-N for 3000 mg/L micro sand and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

V. CONCLUSION

Results showed that the PAC was more effective in leachate treatment compared with alum and ferric chloride when combination with polymer and micro sand. Alum was categories as low efficiency in leachate treatment. However, alum was achieved higher percentage removal in colour.

The results showed the percentage change in the removal of suspended solid (SS), colour, COD, and ammoniacal nitrogen in the sample of leachate treated by using 2000 mg/L alum and 2000 mg/L ferric chloride for optimum pH 7. The highest percentage of removal in SS, colour, COD and ammoniacal nitrogen are 99.5%, 94.8%, 73% and 65% for PAC, combination with cationic polymer and micro sand. Among the 6 categories, 181 µm -212 µm was achieved the higher percentage removal in suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N). The percentage of PAC, alum and ferric chloride were increased until achieved optimum dose and decrease slowly after that. PAC provides the highest percentage of removal in SS, colour, COD and ammoniacal nitrogen compared with alum and ferric chloride.

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