Coagulation-Flocculation In Leachate Treatment By Using Micro Zeolite

Lee Mao Rui, Zawawi Daud, and Abd Aziz Abdul Latif

*F. A. Author is with the Civil Engineering Department, University of Tun Hussein onn, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.

**S. B. Author, was with Civil Engineering Department, University of Tun Hussein onn, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.

***T. C. Author is with the Civil Engineering Department, University of Tun Hussein onn, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.

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 zeolite 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 zeolite were 1000 mg/L for PAC, 4000 mg/L for alum and 2000 mg/L for ferric chloride. The micro zeolite was sieved in 6 different of particle size. Among the experiments, micro zeolite combination with PAC and cationic polymer showed the highest SS removal efficiency (99.7%), color removal efficiency (96%), COD removal efficiency (76%), ammoniacal nitrogen (68%) and with settling time for 30 minute.

Keywords—Leachate, coagulation-flocculation, coagulant, micro zeolite

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).

Zeolite is commercially attractive because of their unusual crystalline structures that give them unique chemical properties. Zeolite is seen as a potential adsorbent for natural gas/methane due to the ability of the micro porous structure to adsorb molecules selectively, depending upon the size of the pore window. Zeolite frameworks are also flexible and the degree of flexibility is a function of a structure of the framework as the presence of extra-framework cations and molecules (Shah et al., 1997).

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).

Polyaluminium chlorides (PAC), 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 zeolite combination with PAC and cationic polymer

The results were achieved 80 % above for SS and colour. The results achieved higher efficiency in COD and NH_3-N when the leachate was treated with coagulant and micro zeolite. It described a second phase in the treatment of leachate using micro zeolite (Ulusoy & Simsek., 2005).

The experiment was achieved 99.2% and 99.7% for SS with particle size of micro zeolite for 75µm to 90 µm and 181µm to 212µm respectively with 10 mg/L dose of cationic polymer. Removing of SS was become the higher efficiency among 4 parameters. The results for removal percentage of SS showed in the Figure 4.64.

The results from the experiment for colour were 93% and 96% in fixed dose of micro zeolite with particle size of micro zeolite for 75µm to 90 µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. Anyway, the results showed that no significant different for the removal percentage among 6 categories of particle size micro zeolite which is 94% for size particle 91µm to 106µm, 96% for particle size 151µm to 180µm and 95% for particle size 107µm to 125µm and 126µm to 150µm. The results for removal percentage of colour showed in the Figure 4.65.

Furthermore, removal percentage of COD increased with increasing for dose of polymer (Sun et al., 2011). It resulted 64% and 76% of COD removals in 10 mg/L cationic polymer with particle size of micro zeolite for 75µm to 90 µm and 181µm to 212µm respectively. The removal percentage of COD was increased slightly with increased doses of cationic 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 COD showed in the Figure 4.66.

Otherwise, NH_3-N was the lower removal percentage achieved among the 4 parameters which is SS, colour, COD and NH_3-N. It was 53% and 68% removals were obtained from the experiment for NH_3-N with particle size of micro zeolite for 75µm to 90 µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The results for removal percentage of NH_3N showed in the Figure 4.67. The micro zeolite with particle size 181µm to 212µm has performed much better among 6 categories of particle size of micro zeolite.

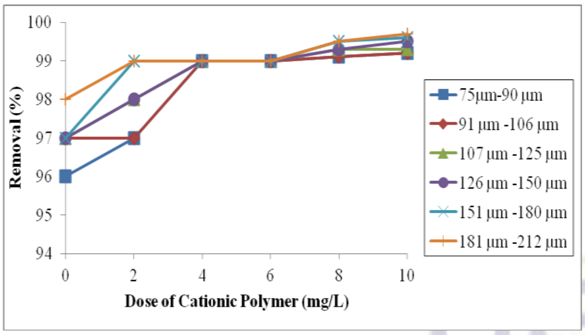

Figure 4.64: Removal percentage of SS for 1000 mg/L micro zeolite and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

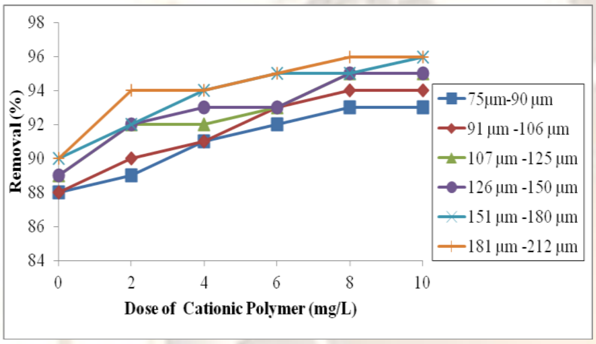

Figure 4.65: Removal percentage of colour for 1000 mg/L micro zeolite and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

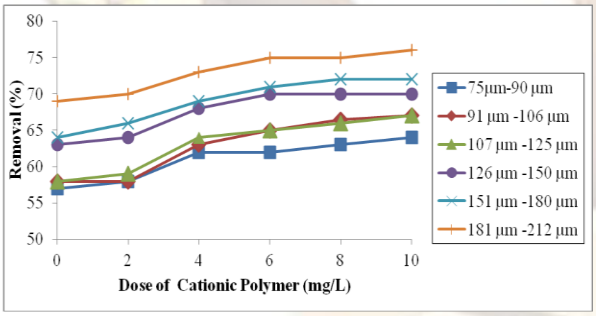

Figure 4.66: Removal percentage of COD for 1000 mg/L micro zeolite and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

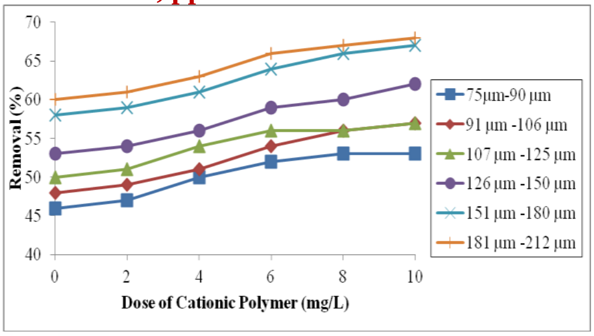

Figure 4.67: Removal percentage of NH_3-N for 1000 mg/L micro zeolite and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

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

From the graph, it shows the removal percentage of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N). The results were achieved 80 % above for SS and colour. The experiment using micro zeolite and anionic polymer with PAC indicated that the leachate treatment was very good and in high removal percentage. Anyway, the results from the experiment showed that the lower percentage if compared with using micro zeolite and cationic polymer with PAC (PAC + cationic polymer + micro zeolite). Therefore, cationic polymer was more effective if compared with anionic polymer when combination with PAC and micro zeolite.

The removal percentage of SS was achieved 99% and 99.6% with size particle micro zeolite for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The results showed that the majority of percentage removal achieved 98% above. It was the very good efficiency among the 4 parameters which is SS, colour, COD and NH_3N. The results for removal percentage of SS showed in the Figure 4.68.

Furthermore, the removal percentage of colour was achieved excellent results which is majority 90% above. The results were 93% and 95% with particle size of micro zeolite for 75µm to 90 µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The results for removal percentage of colour showed in the Figure 4.69.

Besides that, the experiment showed the resulting in removal of COD which is 61% and 75% with particle size of micro zeolite for 75µm to 90 µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentage of COD was achieved 50% above. The results for removal percentage of COD showed in the Figure 4.70.

Similarly, NH_3N was achieved 51% and 65% with particle size micro zeolite for 75µm to 90 µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The percentages of NH_3N were increased if compared with using PAC alone or PAC combination with anionic polymer. Therefore, it was more effective when the process added by micro zeolite. The results for removal percentage of NH_3N showed in the Figure 4.71.

From the experiment, it were concluded that micro zeolite combination with PAC and cationic polymer (PAC + cationic polymer + micro zeolite) were more effective than micro zeolite combination with PAC and anionic polymer (PAC + anionic polymer + micro zeolite).

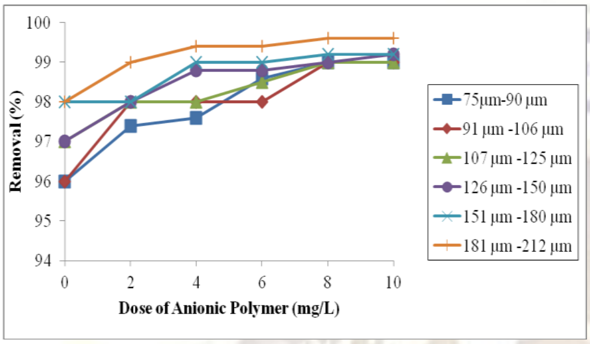

Figure 4.68: Removal percentage of SS for 1000 mg/L micro zeolite and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

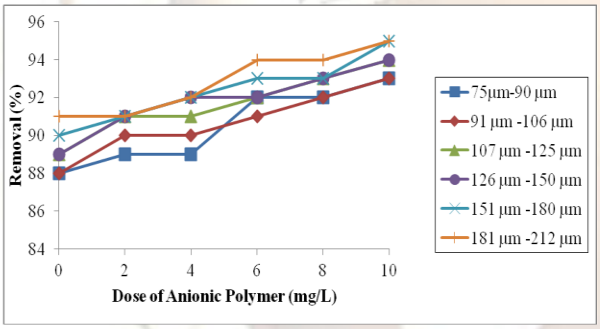

Figure 4.69: Removal percentage of colour for 1000 mg/L micro zeolite and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

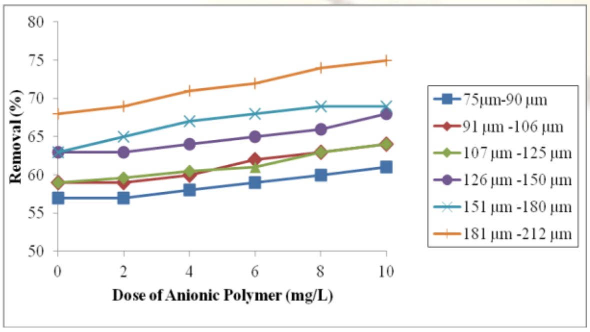

Figure 4.70: Removal percentage of COD for 1000 mg/L micro zeolite and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

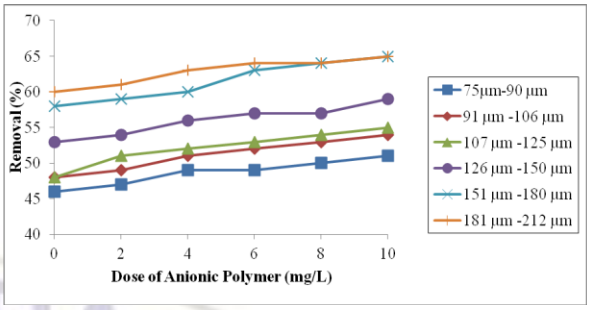

Figure 4.71: Removal percentage of NH_3-N for 1000 mg/L micro zeolite and pH 7, by using 2000 mg/L PAC, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

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

In alum coagulation, it shows the alum was no significant in removal of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N) if compared with PAC. The results were less than 80 % for SS and colour.

The percentage removal of SS was 75% and 88% with particle size micro zeolite 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 70% above. The results for percentage removal in SS showed in the Figure 4.72.

Besides that, the removal percentage of colour 65% and 79% with particle size of micro zeolite for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentages of colour were around 60% which is in between 60% to 69%. The results achieved 70% when using the particle size of micro zeolite for 181µm to 212µm. The results for removal percentage of colour showed in the Figure 4.73.

Furthermore, the removal percentages of COD were achieved 51% and 70% with particle size micro zeolite for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The results for removal percentage of COD showed in the Figure 4.74.

Otherwise, the particle size of micro zeolite for 75µm to 90µm and 181µm to 212µm in NH_3N were achieved 35% and 59% respectively with 10 mg/L dose of polymer. NH_3N was the lower removal percentage among 4 parameters which is suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N). The results for removal percentage of NH_3N showed in the Figure 4.75.

From the experiment, it was showed the alum was no significant in removal of leachate treatment, although the alum combination with cationic polymer and micro zeolite (alum + cationic polymer + micro zeolite).

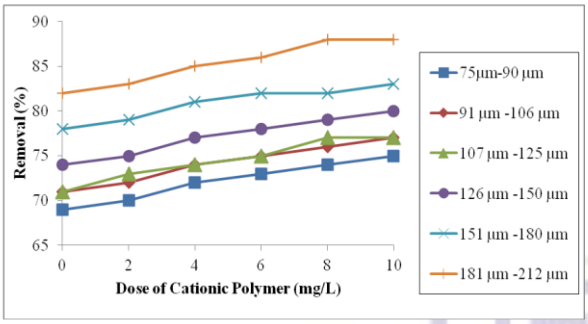

Figure 4.72: Removal percentage of SS for 4000 mg/L micro zeolite and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

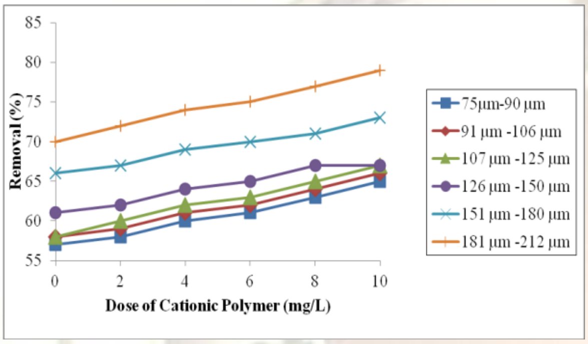

Figure 4.73: Removal percentage of colour for 4000 mg/L micro zeolite and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

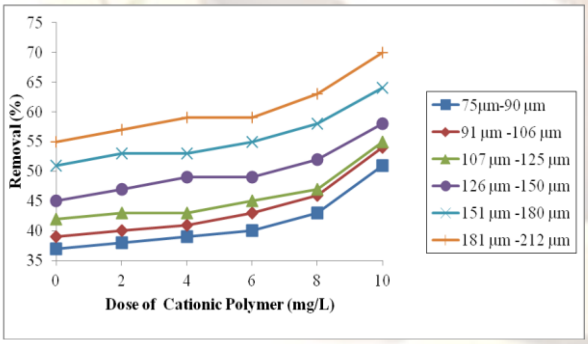

Figure 4.74: Removal percentage of COD for 4000 mg/L micro zeolite and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

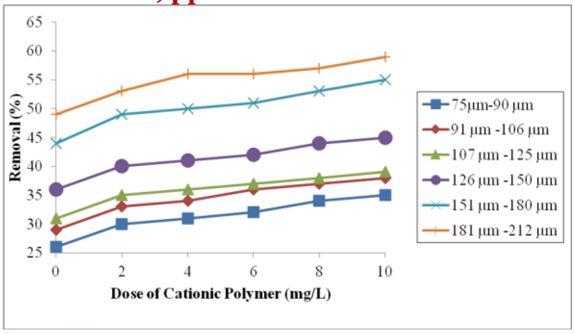

Figure 4.75: Removal percentage of NH_3-N for 4000 mg/L micro zeolite and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

D. Efficiency of micro zeolite combination alum with anionic polymer

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

The removal percentages of SS were achieved 73.8% and 86.8% with size particle micro zeolite for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentages of SS majority in between 70% to 79%. Anyway, the removal percentages were achieved more than 80% with different doses of polymer and particle size of micro zeolite. It was showed that 82% for 0 mg/L, 83% for 2 mg/L and 4 mg/L, 84% for 6 mg/L, 86% for 8 mg/L and 86.8% for 10 mg/L. The results for removal percentage of SS showed in the Figure 4.76.

Furthermore, the results for the removal of colour in this experiment were 64.2% for particle size of micro zeolite 75µm to 90µm with 10 mg/L dose of polymer and 78% for particle size of micro zeolite 181µm to 212µm with 10 mg/L dose of polymer. Anyway, the removal percentage of colour were no significant different when the cationic polymer replaced by anionic polymer. The results for removal percentage of colour showed in the Figure 4.77.

Otherwise, it was achieved 41% and 59% in removals of COD for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The COD increased slightly with increased the dose of polymer and particle size of micro zeolite. The results for removal percentage removal of COD showed in the Figure 4.78.

From the experiment, NH_3N were achieved 31% and 56% with particle size of micro zeolite 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentage of NH_3N achieved more than 40% when using particle size of micro zeolite for 151µm to 180µm and 181µm to 212µm. The results for removal percentage of NH_3N showed in the Figure 4.79.

Finally, it were showed that the removal percentage of alum combination with anionic polymer and micro zeolite (alum + anionic polymer + micro zeolite) lower slightly if compared with using alum combination with cationic polymer and micro zeolite (alum + cationic polymer + micro zeolite).

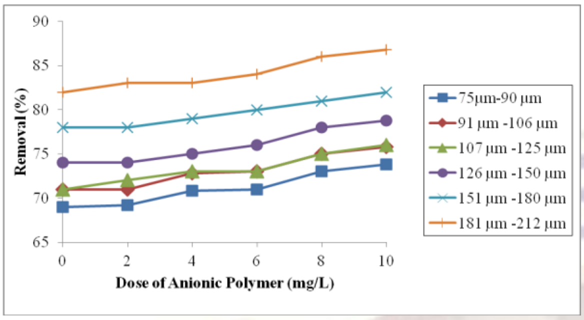

Figure 4.76: Removal percentage of SS for 4000 mg/L micro zeolite and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute

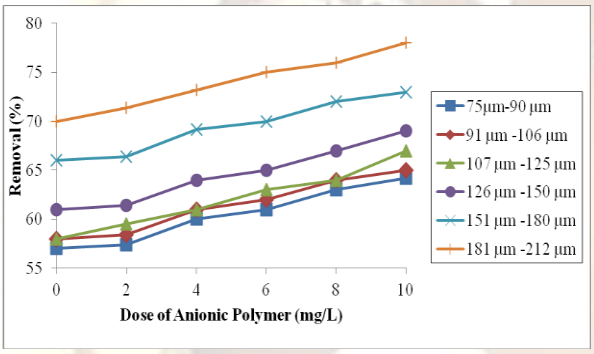

Figure 4.77: Removal percentage of colour for 4000 mg/L micro zeolite and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

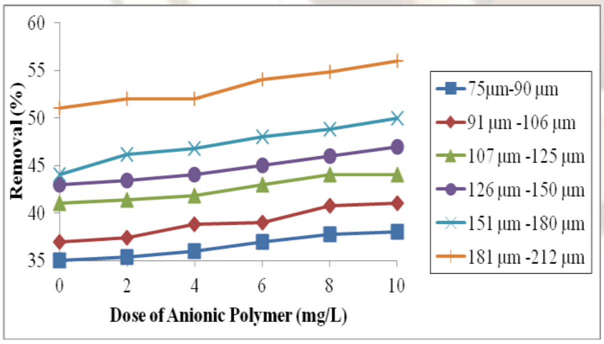

Figure 4.78: Removal percentage of COD for 4000 mg/L micro zeolite and pH 7, by using 2000 mg/L alum, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

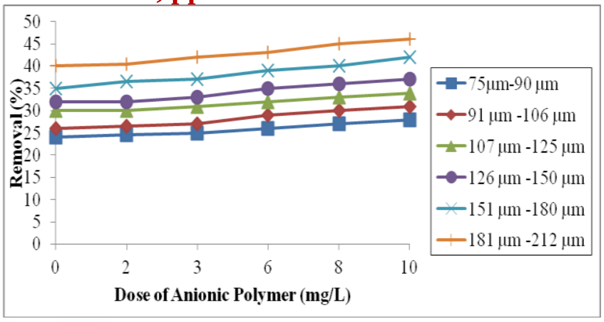

Figure 4.79: Removal percentage of NH_3-N for 4000 mg/L micro zeolite and pH 7, by using 2000 mg/L alum rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

E. Efficiency of ferric chloride combination with cationic polymer

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

The removal percentages of SS were achieved 97% and 99% with particle size of micro zeolite for 75µm to 90µm and 181µm to 212µm with 10 mg/L dose of polymer. The results showed more effective that the majority percentages were 97%, 98% and 99%. The results for removal percentage of SS showed in the Figure 4.80.

Furthermore, the removal percentages of colour were also achieved very good performance in this experiment. It was 90% and 96% with particle size of micro zeolite for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentages of colour were majority more than 90%. The results for removal percentage of colour showed in the Figure 4.81.

From the experiment, COD achieved 52% and 70% with particle size of micro zeolite for 75µm to 90µm and 181µm to 212µm with 10 mg/L dose of polymer. The percentages were increased with the increased of the particle size of micro zeolite. The experiment with the 10 mg/L dose of polymer and results showed 54%, 57%, 60% and 65% for particle size of micro zeolite for 91µm to 106µm, 107µm to 125µm, 126µm to 150µm and 151µm to 180µm respectively. The results for removal percentage of COD showed in the Figure 4.82.

Otherwise, the removal percentages of NH_3N were showed that 38% and 63% with particle size of micro zeolite for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentages of NH_3N were increased slightly with started around 20% to 30%. After that, the results were increased to 40% above for particle size of micro zeolite for 107µm to 125µm and 126µm to 150µm. The results achieved around 50% with particle size of micro zeolite for 151µm to 180µm and finally it was achieved 63% with particle size of micro zeolite 181µm to 212µm. The results for percentage removal in NH_3N showed in the Figure 4.83.

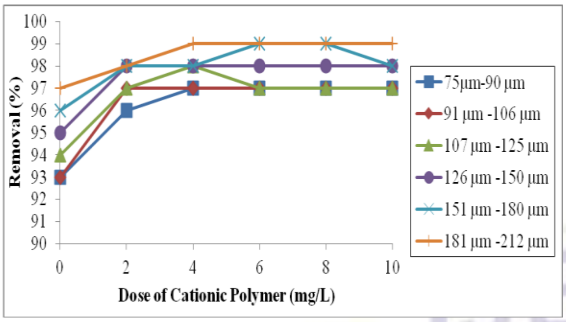

Figure 4.80: Removal percentage of SS for 2000 mg/L micro zeolite and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

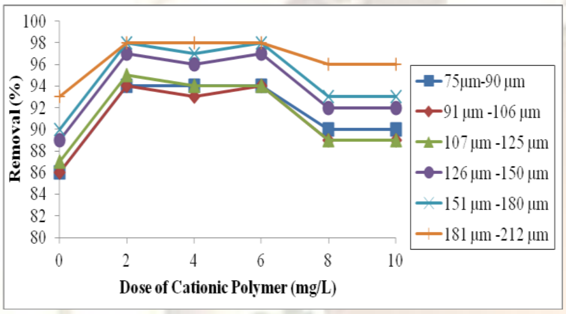

Figure 4.81: Removal percentage of colour for 2000 mg/L micro zeolite and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

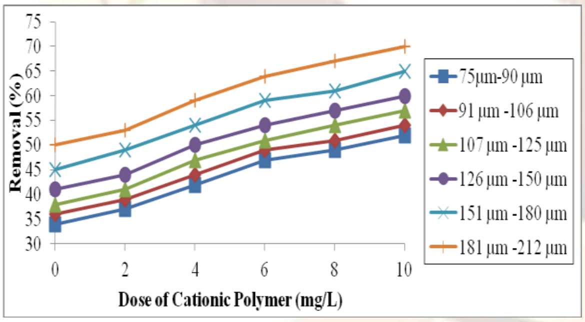

Figure 4.82: Removal percentage of COD for 2000 mg/L micro zeolite and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

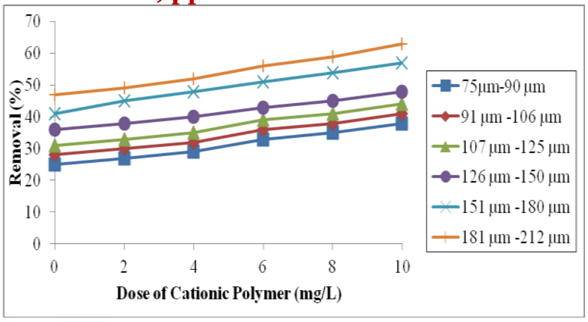

Figure 4.83: Removal percentage of NH_3-N for 2000 mg/L micro zeolite and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

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

Figure 4.84, Figure 4.85, Figure 4.86 and Figure 4.87 shows that the leachate treatment using the ferric chloride, anionic polymer and micro zeolite (ferric chloride + anionic polymer + micro zeolite). From the graph, it shows that the ferric chloride was significant in removal of suspended solid (SS), COD, colour, and ammoniacal nitrogen (NH_3N) compared with alum. The results were 80 % above for SS and colour.

The removal percentages of SS were achieved 95% and 96% with particle size of micro zeolite for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. The removal percentages were achieved very high which is 95% and 96%. The result was 95% with particle size of micro zeolite for 75µm to 90µm. The results showed 96% for other particle size of micro zeolite which is 91µm to 106µm, 107µm to 125µm, 126µm to 150µm, 151µm to 180µm and 181µm to 212µm. The removal percentages were decreased slightly at 8 mg/L and 10 mg/L dose of polymer. The results for removal percentage of SS showed in the Figure 4.84.

Furthermore, removal percentage of colour were achieved 84 % and 91% with particle size of micro zeolite for 75µm to 90µm 181µm to 212µm respectively with 10 mg/L dose of polymer from this experiment. The removal percentages were around 80% with particle size of micro zeolite for 75µm to 90µm, 91µm to 106µm, 107µm to 125µm and 126µm to 150µm. It was 90% or more than 90% with particle size of micro zeolite for 151µm to 180µm and 181µm to 212µm. The removals 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 4.85.

From this experiment, it showed that COD achieved 47% and 67% with particle size of micro zeolite 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 zeolite and dose of polymer. For example with particle size of micro zeolite for 91µm to 106µm, it showed that results was 36% for 0 mg/L, 40% for 2 mg/L, 41% for 4 mg/L, 46% for 6 mg/L, 48% for 8 mg/L and 52% for 10 mg/L. The results for removal percentage showed in the Figure 4.86.

The NH_3N was achieved 34% and 59% with particle size of micro zeolite for 75µm to 90µm and 181µm to 212µm respectively with 10 mg/L dose of polymer. For whole results, it was achieved from 25% to 59%. The removal percentages of NH_3N were increased slightly with started around 20% to 30%. After that, the results were increased to 40% and 50% above for particle size of micro zeolite for 151µm to 180µm and 181µm to 212µm. The results for removal percentage of NH_3N showed in the Figure 4.87.

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

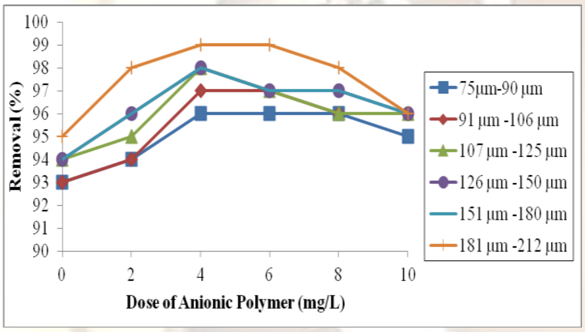

Figure 4.84: Removal percentage of SS for 2000 mg/L micro zeolite pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

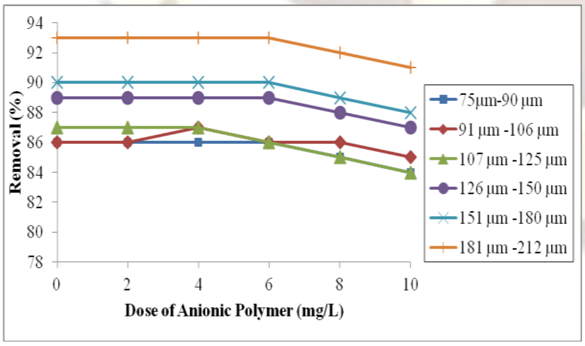

Figure 4.85: Removal percentage of colour for 2000 mg/L micro zeolite and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

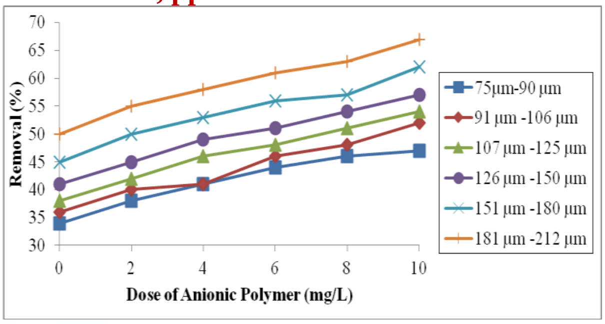

Figure 4.86: Removal percentage of COD for 1000 mg/L micro zeolite and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

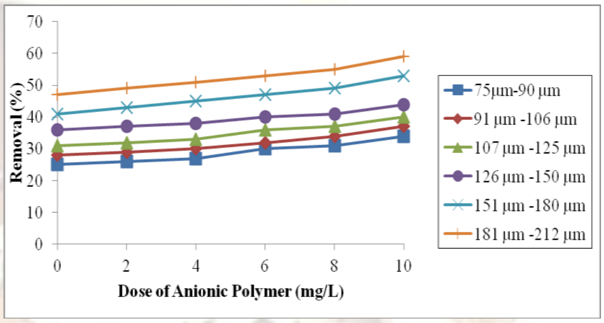

Figure 4.87: Removal percentage of NH_3-N for 2000 mg/L micro zeolite and pH 7, by using 2000 mg/L ferric chloride, rapid mixing speed 150 rpm for 3 minute, slow mixing speed 30 rpm for 20 minute and the settling time of 30 minute.

V. CONCLUSION

Results showed that the PAC was more effective in leachate treatment compared with alum and ferric chloride. 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 99.7%, 96%, 76% and 68% 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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REFERENCES

[1] A, I, Zoubolis, M, D, Petala, "Performance of VSEP vibratory membrane filtration system during the treatment of landfill leachates," *Desalination*, 222, 2008, pp. 165-175.

[2] P.H. Chen, "Assessment of leachates from sanitary landfills: impact of age, rainfall, and treatment," *Environment International*, vol. 22, 1996, pp. 225-237.

[3] S, D, Parkes, D, F, Jolley and S, R, Wilson, "Inorganic nitrogen transformation in the treatment of landfill leachate with a high ammonium load: A case study," *Environ Monit Assess*, 124, 2007, pp. 51-61.

[4] A, M, Cook & S, J, Fritz, "Environmental impact of acid leachate derived from coal-storage piles upon groundwater," *Water, Air and Soil Pollution*, 135, 2002, pp. 371-388.

[5] S, Mor, K, Ravindra, R, P, Dahiya and A, Chandra, "Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site," *Environmental Monitoring and Assessment*, 118, 2006, pp. 435-456.

[6] M, Sartaj, M, Ahmadifar and A,K, Jashni, "Assessment of in-situ aerobic treatment of municipal landfill leachate at laboratory scale," *Iranian Journal of Science & Technology, Transaction B, Engineering*, 34 (B1),2010, pp. 107-116.

[7] S, Veli, T, Ozturk and A, Dimoglo, "Treatment of municipal solid wastes leachate by means of chemical- and electro-coagulation," *Separation and Purification Technology*, 62, 2008, pp. 82-88.

[8] A, A, Abdulhussain, J,S, Guo, Z,P, Liu, Y, Y, Pan and W, S, Al-Rekabi,``Reniew on landfill leachate treatments," *American Journal of Applied Science*, 6(4), 2009, pp. 672-684.

[9] R, Shah, M, C, Payne and J, D, Gale, "Acid-base catalysis in zeolites from first principles. *International Journal of Quantum Chemistry*, *61*, 1997, pp. 393 – 398.

[10] S, Ghafari, H,A, Aziz, and M,J,K, Bashir,``The use of poly-aluminium chloride and alum for the treatment of partially stabilized leachate: A comparative study," *Desalination*, 257, 2010, pp. 110-116.

[11] E, Neczaj, E, Okoniewska, M, Kacprzak,"Treatment of landfill leachate by sequencing batch reactor," *Desalination*, 185, pp. 357-362.

[12] M, J, K, Bashir, H, A, Aziz and M, S, Yusoff, "New sequential treatment for mature landfill leachate by cationic/anionic and anionic/cationic processes: Optimization and comparative study," *Journal of Hazardous Materials*, 186, 2011, pp. 92-102.

[13] E. Durmusoglu,C, Yilmaz, "Evaluation and temporal variation of raw and pre-treated leachate quality from an active solid waste landfill," *Water, Air and Soil Pollution*, 171, 2006, pp. 359-382.

[14] A, Ozkan & M, Yekeler, "Coagulation and flocculation characteristics of celestite with different inorganic salts and polymers," *Chemical Engineering and Processing*, 43, 2004, pp. 873-879.

[15] K, Gnandi, G, Tchangbedji, K, Kili, G, Baba and O, Salim, "Processing of phosphate mine tailings by coagulation flocculation to reduce marine pollution in Togo: laboratory tests," *Mine Water and the Environment*, 24, 2005, pp. 215-221.

[16] K, J, Choi, S, G, Kim, C,W, kim and J, K, Park, " Removal efficiencies of endocrine disrupting chemicals by coagulation/flocculation, ozonation, powdered/granular activated carbon adsorption, and chlorination," *Korean J. Chem. Eng*, 23(3), 2006, pp. 399-408.

[17] X, J, Wang, S, Chen, X, Y, Gu and K, Y, Wang, ``Pilot study on the advanced treatment of landfill leachate using a combined coagulation, fenton oxidation and biological aerated filter process," *Waste Management*, 29, 2009, pp. 1354-1358.

[18] U, Ulusoy, & S, Simsek. " Lead removal by polyacrylamide-bentonite and zeolite composites: Effect of phytic acid immobilization , " *Journal of Hazardous Materials, B,127, 2005*, pp. 163 – 171.

[19] T, Sun, L,L, Liu, L,L, Wang and Y, P, Zhang. "Preparation of a novel inorganic polymer coagulant from oil shale ash". *Journal of Hazardous Materials, 185*, 2011, pp. 1264-1272.