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Efficiency of different coagulants in pretreatment of composting plant leachate

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Abstract

Leachate is an important pollution factor resulting from composting plant. The method applied to treat leachate is highly dependent on the characteristics of the leachate. One of the most common and simplest methods is using coagulation process. This study was aimed to compare the efficiencies of different coagulants which include ferrous sulfate, ferric chloride, poly ferric sulfate, alum and poly aluminum chloride along with two anionic and cationic commercial co-coagulants (K350CF and LT25) in removing chemical oxygen demand (COD) and total suspended solid (TSS) from the leachate generated in a composting plant. Leachate samples were collected from the Isfahan composting leachate´s collection ponds. In this study, jar-test experiments were carried out to determine the optimum conditions for the removal of COD and TSS, effective dosage, optimum pH and the most convenient coagulant. According to the results, poly ferric sulfate resulted in the highest COD and TSS removal at pH= 11, with 2 g /L of coagulant. At this experimental condition, COD and TSS removal efficiencies were obtained 49% and 51% respectively. Results also showed that using K350CF and LT25 along with coagulants can improve COD and TSS removal and PFS along with K350CF had the highest removal efficiency. Based on obtained results, it may be stated that Coagulation-flocculation can be used as a simple and efficient pretreatment in which composting leachate is processed for better and more convenient treatments during the following stages.

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Introduction

leachate is one of the most polluting and toxic liquids with high adverse environmental impacts (Ozturk *et al.*, 2003). Control, collection, disposal, and treatment of leachate must be conducted attentively. If not, water resources (surface and ground water) and soil would be polluted by leachate pollutants (Kurniawan *et al.*, 2006a). Due to variable composition of leachate in different regions, it's treatment methods have not been unified so far (Kulikowska and Klimiuk, 2008; Abdul *et al.*, 2009). Persistent organic materials are not removed merely by biological processes.Thus, pretreatment or high post treatment is needed for their removal (Ozturk *et al.*, 2003).Low pH and high chemical oxygen demand (COD) of leachate represent that biological processes are not suitable for direct biological treatment of these type of leachates (Renous *et al.*, 2008; Yang and Zhou, 2008). In some studies, it has been proven that membrane processes including reverse osmosis can be used along with biological treatment methods. Not only these treatment methods are expensive, but also they have some inherent obstacles such as Pore-clogging of membranes (Ngoc and Schnitzer, 2009; Kurniawan *et al.*, 2006b). Nevertheless, different methods of advanced oxidation such as ultrasound and nanoparticles have been studied for treatment of leachate. Their application is sophisticated and expensive (Wang *et al.*, 2008; Wang *et al.*, 2009; Hermosilla *et al.*, 2009). Adsorbtion method has been investigated for leachate treatment. Although adsorbents can be effective in leachate treatment, frequent regeneration and their high cost limited their application (Abdul *et al.*, 2009; Ince *et al.*, 2010). Some physicochemical processes such as coagulation-flocculation can be effective as primary treatment methods (Kurniawan *et al.*, 2006b). Nowadays, using coagulants in water and wastewater treatment is a very conventional and developed method. Because coagulants have a high efficiency to remove suspended matters and turbidity from aqueous solutions. Coagulation can be used as a primary treatment method of leachate (Monje-Ramirez and Velásquez, 2004).

Several studies have been reported on the examination of coagulation–flocculation for the treatment of landfill leachates, aiming at performance optimization, i.e. selection of the most appropriate coagulant, determination of experimental conditions, assessment of pH effect and investigation of flocculant addition (Sletten *et al.*,1995). Aluminum sulfate (Alum), ferrous sulfate(FS), ferric chloride (FC) were used as coagulants by Uygur and Kargi (2004). Samadi *et al.*, (2010) studied the effects of Poly Aluminum Chloride (PAC), FS and Alum in removing Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS) from leachate. Zainol *et al.*, (2013) used PAC as coagulant to treat leachate of Kulim Landfill Site (KLS) in Malaysia. Since most studies have compared the efficiency of a very few number of coagulants, increasing the number of coagulants being compared may lead to better results. Additionally, most studies focused on the treatment of leachate generated in landfills and there seemed to be a lack of studies concerning treatment of composting plant leachate. Hence it seems necessary to conduct an integrated study to compare the efficiency of more coagulants and co-coagulants in the treatment of composting plant leachate.

Isfahan is one of the most crowded cities in Iran. Everyday, municipality has to manage approximately 1200 tons of solid waste generated from residential and commercial sources and a composting plant receives whole of them. Field data indicate that the produced leachate has a flow rate about 0.4 L S-1 which enters the surface evaporation lagoons. The aim of this research was to determine the efficiency of two category of coagulants (a. Aluminum compounds and b. Ferrous compound) which include alum, FS,FC, poly ferric sulfate (PFS), and PAC in removal of TSS and COD from compost leachate. In the following, efficiency of two co-coagulant (K350CF and LT25) was studied in excess removal of COD and TSS. More specifically, the aim was the determination of most appropriate coagulant type and dose, studying of pH effect on removal effeciency, the investigation of combined action of coagulants–

flocculants and the identification of optimum experimental conditions for the efficient application of this process. This experimental study was conducted to investigate the efficiency of coagulation–flocculation process on Isfahan composting leachate treatment. Also the effects of various dosages of coagulant and different pH values on the coagulation processes were compared.In the following, efficiency of two co-coagulant (K350CF and LT25) was studied in excess removal of COD and TSS.

Material and methods

Sample preparation and characterization

Leachate samples were collected once every week for 10 months between December and September from the composting plant of Isfahan (Iran), which has been in operation since 1989. The leachate samples were obtained directly from leachate ponds of Isfahan compost system. The leachate samples were collected in 20 L plastic bottles. Then, they were transported to the Isfahan composting laboratory and stored in a refrigerator at 4 °C temperature. Some of the raw leachate characteristics of Isfahan composting are presented in table 1.

Experimental apparatus and procedure

Coagulation-flocculation and sedimentation analysis tests were performed in a conventional jar-test apparatus, which was equipped with six containers (1 liter volume). Befor starting experiments, leachate samples had been kept at ambient temperature. Samples were thoroughly stirred in order to suspend the settled solids. Samples were transferred to similar jar-test beakers.To obtain the coagulants optimum pH, 1.5 g/L of ferrous compounds and 1.2 g/L of aluminum compounds were used (Zazooli *et al.*, 2000). pH values for coagulants were set for 4, 5, 6, 7, 8, 9, 11, and 12. The samples' pH were adjusted by adding sufficient NaOH and HCL. To obtain the optimum coagulant dosage, different coagulant dosages as 0.5, 1, 1.5, 2, 2.5, and 3 g/L were tested. The experimental process consisted of three subsequent stages. The initial rapid mixing stage took place for 5 min at 100 rpm, followed by a slow mixing stage for 15 min at 30 rpm, and finally 30 min for settling stage. After accomplishment of jar-tests, supernatant samples were withdrawn from 2 cm below liquid level for chemical analysis. Before and after experiments, electric conductivity (EC) and pH had been measured. The laboratory tests were done according to standard methods (APHA,1998). Along with conventional coagulation, some commercialized polyelectrolytes, including a cationic (K530CF) and an anionic (LT25) polyelectrolyte, were added by 1:10 ratio. The aim of this stage was to examine excess removal of COD and TSS. Finally, after every run of the experiments BOD_5: COD ratio was examined for each coagulant at optimum pH and dosage.

Coagulants efficiency for COD and TSS removal were calculated by following equation (Eq.1).

$$RE = [(C_o - C_t)/C_o] \times 100 \qquad (1)$$

Where RE denotes the coagulant efficiency removal, C_o expresses the TSS and COD concentration before treatment, C_t refers to TSS and COD concentration after treatment.

Result and discussion

pH optimum

In this study, different pH measures and coagulant dosages were examined. According to the results, efficiency of ferrous compounds in alkaline pH was higher than acidic and neutral pH. however, aluminum compounds were more efficient in neutral pH.

Figure 1 shows the coagulants efficiency in removal of COD at the same dosage of coagulants and different PH values. The highest COD removal efficiencies, obtained for PAC and alum at pH=7, were equal to 37% and 35% respectively. FS and FC had the highest COD removal efficiencies at pH equal to 10 which were 41% and 35%, respectively. At pH=11, PFS had the highest COD removal efficiency which was equal to 48%.

Figure 2 shows the coagulant efficiency for TSS removal at different pH values. For PAC and alum, the highest TSS removal efficiencies were obtained at pH=7 which were equal to 35% and 39% respectively. These results are in agreement with those obtained by Zainol *et al.*, (2013). They used PAC as coagulant to treat leachate. According to the results, the optimum pH was 7. FS and PFS had the highest TSS removal efficiencies at pH=10 which were equal to 38% and 49% respectively. The highest TSS removal by FC was obtained at pH= 11 which was equal to 44%. In general, chemical coagulation-flocculation is a process, which is highly pH dependant. The pH influences the nature of produced polymeric metal species that will be formed as soon as the metal coagulants are dissolved in water. The influence of pH on chemical coagulation-flocculation may be considered as a balance of two competitive forces: (1) between H^+ and metal hydrolysis products for interaction with organic ligands and (2) between hydroxide ions and organic anions for interaction with metal hydrolysis products (Stephenson *et al.*, 1996).

Table 1. Characteristics of raw leachate.

Parameter	Volume	Unit
pH	6.1	--
Total Dissolved Solids (TDS)	65700	mg/l
Chemical Oxidation Demand(COD)	124500	mg/l
Biological Oxygen Demand (BOD)	34600	mg/l
Total Suspended Solids (TSS)	15200	mg/l
Temperature	21	^{o}c
Electric conductivity (EC)	35.4	dS/m

Optimum coagulants dose

At optimum pH, COD removal was studied by using different dosages of coagulants (Fig. 3). It was found that PAC, PFS, and FS had the highest removal efficiencies with dosage of 2 g/L of coagulant, equal to 44%, 49% and 43% respectively. Alum and FC had the highest COD removal at the dosage of 1.5 g/L of coagulant which were equal to 39% and 36% respectively. According to Fig. 3, as the coagulant dosage increased, removal efficiency decreased. The best yields of COD removal using alum and ferric chloride were obtained by Maleki *et al.*, (2009) in dosage of 1.4 and 2 g/L, respectively. This result is mainly due to the fact that the optimum coagulant dosage produced flocs have a good structure and consistency. But in the lower dose than optimum dose, the produced flocs are small and influence on settling velocity of the sludge. In the higher dose than optimum dose, in addition to small size of floc, restability of floc can be happened. The results shown the addition of alum and ferric chloride to leachate resulted in 18 and 28% reduction of COD values, respectively (Maleki *et al.*, 2009).

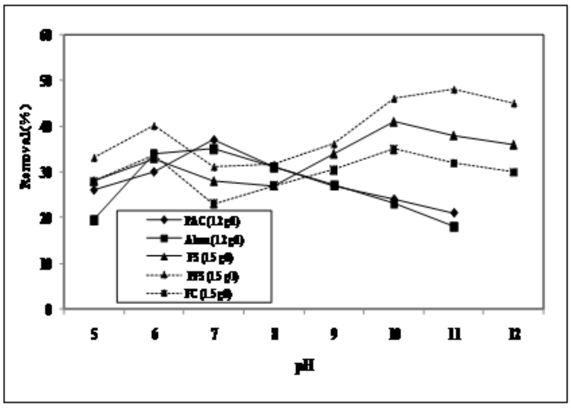

Fig. 1. COD removal efficiency by different coagulants at different pH values.

At optimum pH, TSS removal related to different dosages of coagulants was examined (figure 4). The highest TSS removal efficiencies of PAC, FS, and FC obtained at 2 g/L of coagulant injection which were equal to 38%, 38%, and 47% respectively. As Fig. 4 shows, the optimum concentration of alum was 1.5 g/L with 40% removal of TSS, while PFS had the highest removal efficiency at dosage 2.5 g/L which was equal to 51%. According to the results of the study conducted by Samadi *et al.*, (2010), the highest efficiency for TSS removal by PAC that was obtained at 2.5 g/L concentration of PAC, by alum at 1.5 g/L concentration of alum and by FS at 2.5 g/L concentration of FS, were 39.14%, 58.37% and 35.58%, respectively. Zainol *et al.*, (2013) indicated that PAC at optimum dosage of 1 g/L successfully removed 94% SS, 96% turbidity, 95% colour, and 70% COD from landfill leachate. These results displayed high removal efficiency of contaminants by PAC, this is conforming that stabilized leachates are rich with organic matter such as humic substance (measured as COD intensity) and fulvic like fraction which weak against hydrolysing coagulants such as PAC, hence these substances were successfully removed (Zainol *et al.*, 2011). The removal of substance can be explained by the charge neutralization mechanism in coagulation-flocculation process whereas negative charges of particles in leachates are neutralized by addition of cationic coagulant (PAC) and form larger particles during flocculation(Al-Hamadani *et al.*, 2011).

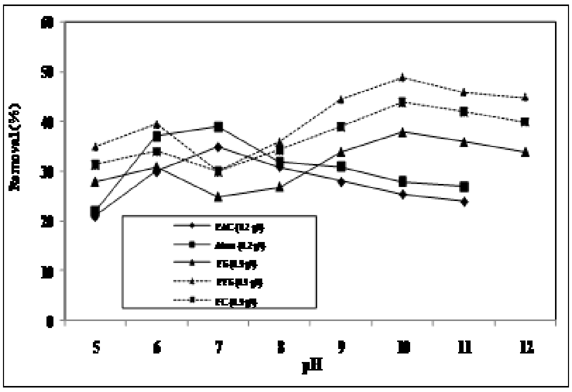

Fig. 2. TSS removal efficiency by different coagulants at different pH values.

BOD_5/COD ratio

To determine the influence of coagulants on BOD_5/COD ratio, the pre studied coagulants were employed at optimum pH and dosages which were examined before. Figure 5 shows the influence of different coagulants on BOD_5/COD ratio at optimum pH and dosage. The initial ratio of BOD_5/COD was 0.29, while after coagulation process the PFS had the highest BOD_5/COD ratio amongst other coagulants which was equal to 0.45. This ratio for alum, PAC, FC, and FS was 0.43, 0.41, 0.39, and 0.38 respectively.

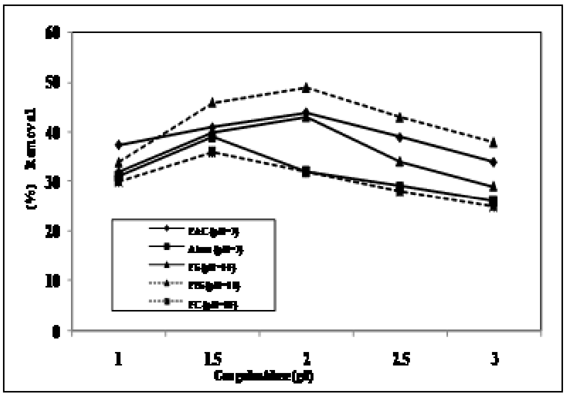

Fig. 3. COD removal efficiency by different coagulants at different dosages.

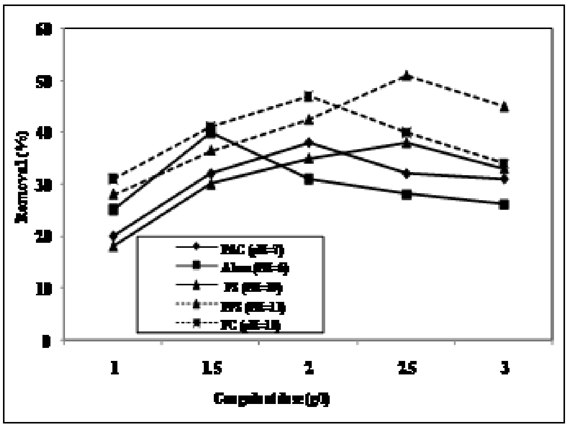

Fig. 4. TSS removal efficiency by different coagulants at different dosages.

COD and TSS removals using coagulants along with co-coagulants

Figure 6 shows the coagulants COD removal along with co-coagulants at optimum pH and dosage. In this study, K350CF and LT25 were used as co-coagulant. According to the results, PFS along with K350CF had the highest removal efficiency which was 53%. When LT25 was used as co-coagulant along with common coagulants, PAC had the highest removal efficiency equal to 49%. PFS along with LT25 and

K350CF had the highest removal efficiencies of TSS which were equal to 54% and 52% respectively (Fig. 7). Among studied coagulants, PFS had the highest effectiveness in reducing TSS and COD. Its optimum concentration for COD and TSS removal was 2 and 2.5 g/L (Fig. 3, 4) respectively, and also optimum pH was 11 (Fig. 1). Comparison of coagulants showed that due to unsuitable and fragile flock generation in neutral pH, PFS was less effective in neutral and acidic conditions than alkaline conditions. Alum and PAC were more effective in acidic and neutral conditions. Amongst studied coagulants, PFS, by increasing concentration up to 2 g/L, had the highest removal efficiency due to generation of suitable and firm flocks. By increasing PFS concentration more than 2 g/L, flocks were fragile and breakable. PFS was the most effective coagulant in TSS removals.

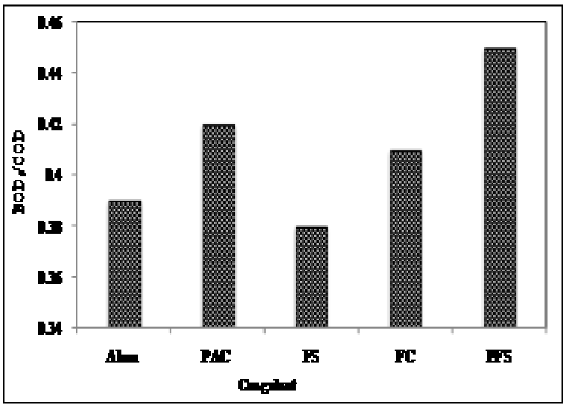

Fig. 1. The influence of coagulants on BOD5/COD ratio at optimum pH and dosage.

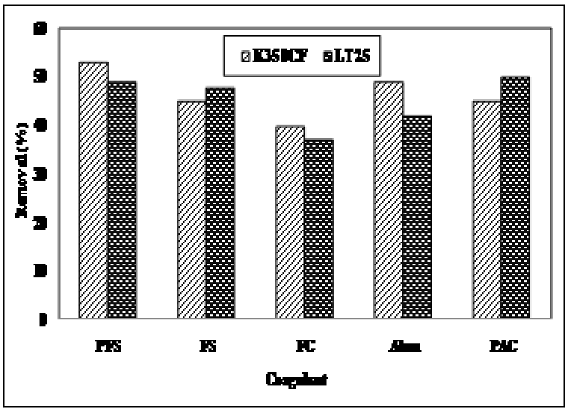

Fig. 6. COD removal comparison by different coagulants at optimum pH and dosage along with co-coagulants.

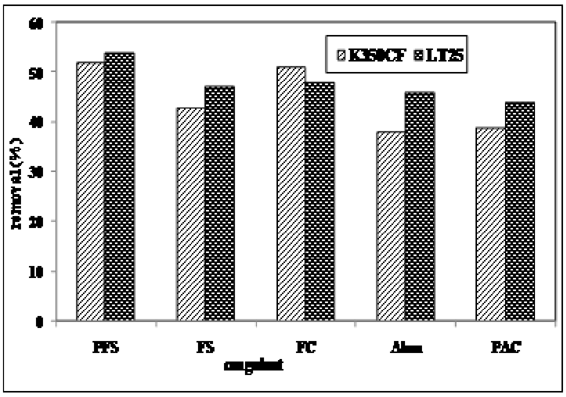

Fig. 7. TSS removal comparison by different coagulants at optimum pH and dosage along with co-coagulants.

FS and FC had lower COD removal efficiencies at higher dosages due to generation of fine flocs as well as permanent breakdown produced flocks. In this study, the maximum COD removal was equal to 35% obtained by FC at pH=10 while, Tatsi *et al.* (2003) obtained 40% COD removal in fresh landfill leachate with initial COD equal to 70900 mg/L at pH=6.2 although measure of applied coagulant was 5.5 g/L. According to the results, maximum COD removal by alum and FC obtained at natural and alkaline pH respectively. At neutral conditions (pH=7), alum flocs were bigger and their sedimentation was better while the foregoing situation was observed for FC at alkaline conditions. So COD removal is expected to be better, because suspended COD has a significant share in total leachate COD. Big, tight and heavy flocs have a grate share in removal of suspended COD. However, at pH values beyond 10, produced flocs by FC would be small and fragile and their settlement would be hard, thus COD removal efficiency would decrease (Zazooli *et al.*, 2000). As the results show, Using co-coagulants (K350CF and LT25) have better outcome in removal of COD and TSS. Application of K350CF along with alum could increase COD removal 23%. LT25 had better outcome in removal of TSS and COD compared to K350CF.

Conclusion

Coagulation and flocculation studies conducted on the leachate from the Isfahan Composting Plant in

Iran indicated that the most effective coagulant for COD and TSS removal was poly ferric sulfate which contributed to better results with an alkaline pH. Results also showed that using K350CF and LT25 along with coagulants can improve COD and TSS removal and PFS along with K350CF had the highest removal efficiency. Based on obtained results, it may be stated that Coagulation-flocculation can be used as a simple and efficient pretreatment in which composting leachate is processed for better and more convenient treatments during the following stages.

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References

Abdul JM, Vigneswaran S, Shon HK, Nathaporn A, Kandasamy J. 2009. Comparison of granular activated carbon bio-sorption and advanced oxidation processes in the treatment of leachate effluent. Korean Journal of Chemical Engineering **26(3),** 7224-7230.

Al-Hamadani YAJ, Yusoff MS, Umar M, Bashir MJK, Adlan MN. 2011. Application of psyllium husk as coagulant and coagulant aid in semi-aerobic landfill leachate treatment. Journal of Hazardous Materials **190 (1),** 582-587.

APHA A. 1998. Standard Methods for the Examination of Water and Wastewater 20th Edition. APHA publishing,2540D.

Hermosilla D, Cortijo M, Huang CP. 2009. Optimizing the treatment of landfill leachate by conventional Fenton and photo-Fenton processes. Science of the Total Environment **407(11),** 3473-3481.

Ince M, Senturk E, Onkal Engin G, Keskinler B. 2010. Further treatment of landfill leachate by nanofiltration and microfiltration–PAC hybrid process. Desalination **255 (1),** 52-60.

Kulikowska D, Klimiuk E. 2008. The effect of landfill age on municipal leachate composition. Bioresource Technology **99(13),** 5981-5985.

Kurniawan TA, Lo WH, Chan G. 2006. Degradation of recalcitrant compounds from stabilized landfill leachate using a combination of ozone-GAC adsorption treatment. Journal of Hazardous Materials **137(1),** 443-455.

Kurniawan TA, Lo WH, Chan G. 2006. Physico-chemical treatments for removal of recalcitrant contaminants from landfill leachate. Journal of Hazardous Materials **129(1),** 80-100.

Maleki A, Zazouli MA, Izanloo H, Rezaee R. 2009. Composting Plant Leachate Treatment by Coagulation-Flocculation Process. American-Eurasian Journal of Agricultural & Environmental Sciences **5 (5),** 638-643.

Monje-Ramirez I, Velásquez M. 2004. Removal and transformation of recalcitrant organic matter from stabilized saline landfill leachates by coagulation–ozonation coupling processes. Water Research **38(9),** 2359-2367.

Ngoc UN, Schnitzer H. 2009. Sustainable solutions for solid waste management in Southeast Asian countries. Waste Management **29(6),** 1982-1995.

Ozturk I, Altinbas M, Koyuncu I, Arikan O, Gomec-Yangin C. 2003. Advanced physico-chemical treatment experiences on young municipal landfill leachates. Waste Management **23(5),** 441-446.

Renou S, Givaudan J, Poulain S, Dirassouyan F, Moulin P. 2008. Landfill leachate treatment: Review and opportunity. Journal of Hazardous

Materials **150(3),** 468-493.

Samadi MT, Saghi MH, Rahmani A, Hasanvand J, Rahimi S, Shirzad M. 2010. Hamadan Landfill Leachate Treatment by Coagulation-Flocculation Process. Iranian Journal of Environmental Health Science & Engineering **7(3),** 253-258.

Sletten RS, Benjamin MM, Horng JJ, Ferguson JF. 1995. Physical–chemical treatment of landfill leachate for metals removal. Water Research **29(10),** 2376-2386.

Stephenson RJ, Duff SJB. 1996. Coagulation and precipitation of a mechanical pulping effluent: removal of carbon, colour and turbidity. Water Research **30(4),** 781-792.

Tatsi A, Zouboulis A, Matis K, Samaras P. 2003. Coagulation–flocculation pretreatment of sanitary landfill leachates. Chemosphere **53(7),** 737-744.

Uygur A, Kargi F. (2004). Biological nutrient removal from pre- treated landfill leachate in a sequencing batch reactor. Journal of Environmental Management **71,** 9-14.

Wang S, Wu X, Wang Y, Li Q, Tao M. 2008. Removal of organic matter and ammonia nitrogen from landfill leachate by ultrasound. Ultrasonics Sonochemistry **15(6),** 933-937.

Wang X, Chen S, Gu X, Wang K. 2009. Pilot study on the advanced treatment of landfill leachate using a combined coagulation, fenton oxidation and biological aerated filter process. Waste Management **29(4),** 1354-1358.

Yang Z, Zhou S. 2008. The biological treatment of landfill leachate using a simultaneous aerobic and anaerobic (SAA) bio-reactor system. Chemosphere **72(11),** 1751-1756.

Zainol NA, Aziz HA, Ibrahim N. 2013. Treatment of Kulim and Kuala Sepetang Landfills Leachates in Malaysia using Poly Aluminium Chloride (PAC). Research Journal of Chemical Sciences **3(3),** 52-57.

Zainol NA, Aziz HA, Yusoff MS, Umar M. 2011. The use of polyaluminum chloride for the treatment of landfill leachate via coagulation and flocculation processes. Research Journal of Chemical Sciences **1(3),** 35-39

Zazoli M, Parvaresh A, Movahedian H. 2000. Survey of heavy metals in Isfahan landfill leacheat and methods of decrease its, Proceeding of the 3th National Congress of Environmental Health, Tehran,Iran.