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The Application of PFZSSB in Advanced Wastewater Treatment from Landfill Leachate

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Abstract

The refractory landfill leach ate has characteristics about complicated composition and high content pollutants of micro-nanometer particles. At present it was treated by biochemical process, but it was difficult to meet the effluent water discharge standards and recycling because of difficult degradable organic matter. A new inorganic polymer flocculant---poly-silicate zinc ferric sulfate with boric acid radical, named PFZSSB, was developed. And it was especially suitable for removal of micro-nanometer particles of organic pollutants. The study focused on removing these pollutants in landfill leachate advanced treatment. The results illustrated that the treatment effect of PFZSSB was suitable, and the removal rate of NH_3-N, COD and turbidity were up to 13.68%, 51.09% and 59.09% respectively. This disposing process was highly efficient, simple and the cost was reduced greatly.

Keywords: Wastewater; Flocculation; PFZSSB ; Advanced treatment; GC-MS

1. Introduction

Landfill is widely used in the disposal of municipal solid wastes (MSW) [1]. Although other alternative methods are now used, including incineration, composting and pyrolysis, but not all the MSW can be treated like that based on different conditions. Incineration leaves about 10~20% residue that must be landfilled[2].-

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Landfills leachate is a major environmental problem as its emission may cause serious pollutions to surface water and groundwater [3]. There are a great deal of organic and inorganic matter in leachate, such as ammonia nitrogen, humus, chlorinated organics, heavy metals, as well as inorganic salts [4-5]. It has been confirmed that there are some potential dangers in leachate. So it is generally necessary to deal with it in order to meet the standards for discharging into natural waters.

It is very important to determine the most proper method and the optimal operating conditions to dispose leachate, thus achieving compatibility between the maximum removal of pollutants from landfill leachate and the treatment processes. In order to remove pollutions from leachate, various methods have been used in this process, namely coagulation-flocculation [6-8], biological processes, SBR and its modification[9-12], air stripping, up flow anaerobic sludge blanket (UASB) [13], adsorption [14-15], ion exchange, and so on. Coagulation-flocculation is a relatively simple physicochemical technique, which is mainly applied for the removal of heavy metals and non-biodegradable organic compounds from landfill leachate.

As the high concentration of refractory organic wastewater, in the actual production, the water quality condition of landfill leachate which was treated by common biological method was difficult to achieve the standard of discharging. According to the characteristics of leachate after biochemical treatment, a new high efficient inorganic compound flocculants---Poly-Silicate Aluminum Zinc Sulfate Borate (PFZSSB), was developed.

2. Materials and Methods

Reagents: 1% NaOH and HCl solution, Sodium silicate(AR), Ferric sulfate(AR), Aluminum sulfate(AR), and other reagents, the solution prepared with distilled water. The flocculants used were self-prepared. Experimental instruments: Flocculating and stirring device(JBY-Ⅱ), Constant temperature magnetic stirrer(HJ-3),UV multi-parameter intelligent tacheometer(5B-3B(V)) , Portable pH meter. The sample of raw wastewater was from Anding landfill in water regulating tank. The COD, NH_3-N, pH and turbidity in raw wastewater were 1500mg/L, 284mg/L, 8.1 and 6.3NTU. Flocculation experiment was performed using a program controlled jar test apparatus -Flocculating and stirring device(JBY-Ⅱ) at room temperature. The substances before and after treated were analyzed by scanning electron microscope(SEM).Organic compounds in percolate and supernatant after flocculation dispose were obtained by gas chromatography-mass spectroscopy(GC-MS).

3. Results and Discussion

3.1. The experimental results

For wastewater from leachate after bio-treatment, when the dosage was 4mL/L, and pH was about 6, the removal rate of COD, NH_3-N and turbidity were 51.09%, 13.68% and 59.09%% respectively. Compared with other flocculants, the advanced treatment effect of PFZSSB was best.

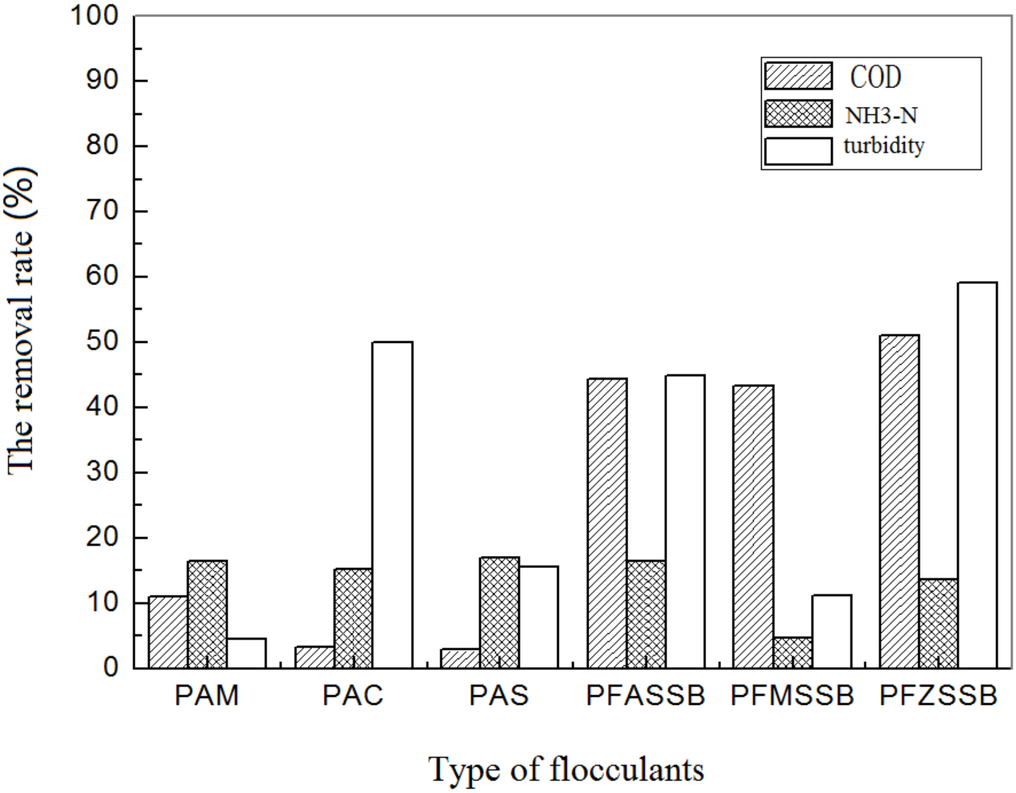

Fig.1 Comparative analysis of effect on different flocculants

3.2. Effect of PFZSSB dosage

Different wastewater needed different dosage of flocculants, because the dosage was related to pollutant in the water. In order to obtain better efficiency, it was important to choose proper dosage. Fig.2 showed that COD and turbidity removal rate were strengthened with the increase of the flocculants' dosage, and it attained its maximum at 4ml/L (100mg/L). When flocculants' dosage was overmuch, it would produce colloid protecting function. After the adsorption surface of the complete colloidal particle was wrapped by polymer, the mutually exclusive phenomenon by polymer occurred if two particles were too closed. Considering the cost and actual effect, 100mg/L PFZSSB was the optimum dosage, while COD, ammonia nitrogen and turbidity removal rates were separately 51.09%, 13.68% and 59.09%%. In the coagulation process, when the dosage of PFASSB was 100mg/L, large flocs appeared quickly and had the fastest settlement speed. Based on the coagulation mechanism, flocculants could compress twin electrical layer on the face of colloidal particles and made its thickness decreased. Then ζ potential was reduced and electrostatic repulsion between particles was decreased also. When the concentration of flocculants got to a certain value, particles began to condense with 0 of ζ potential, exclusive potential of colloid disappearing and mutual attraction between particles predominate.

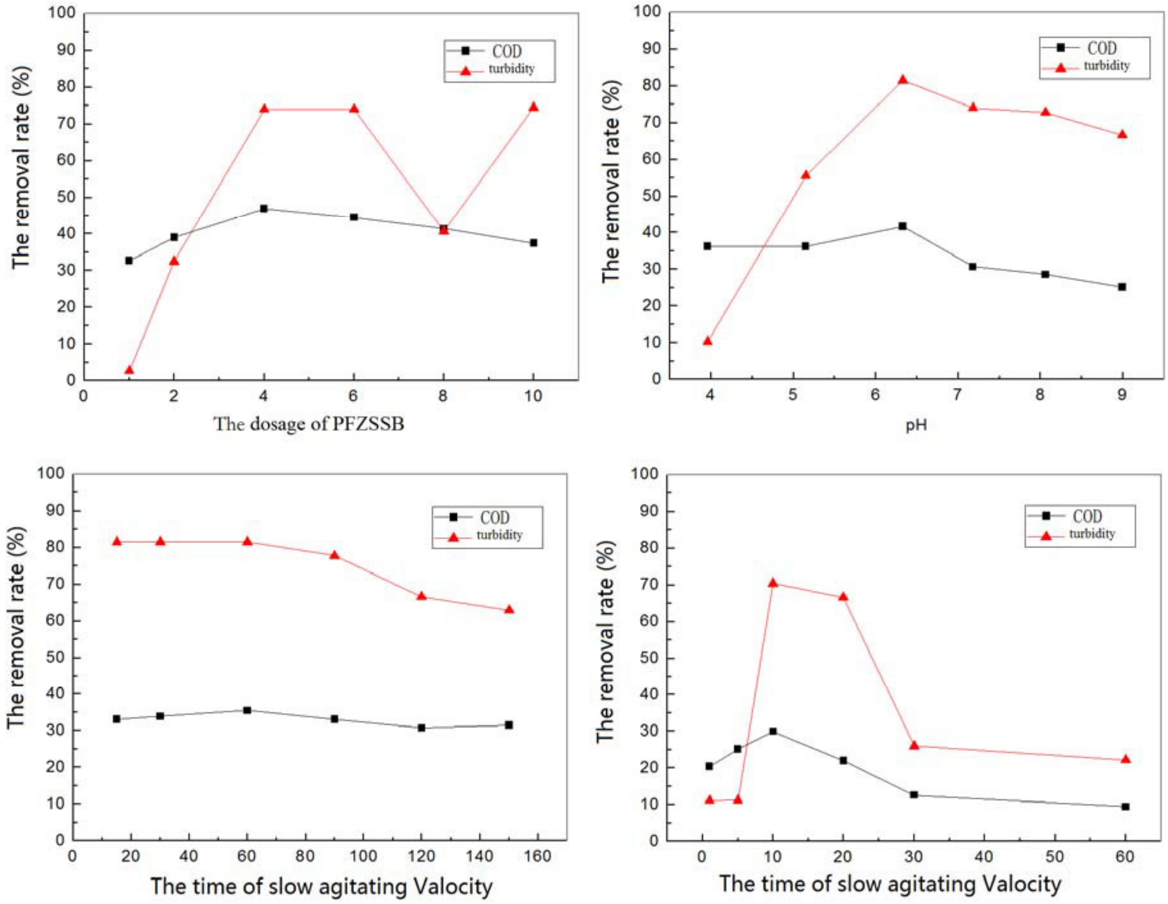

Fig.2 The flocculation effect at different experimental condition

3.3. Effect of initial pH

The pH had a big difference on Z potential of colloidal particles surface charge, the nature of flocculants and so on, which could further influence the flocculation effect. With different pH values, morphology of hydrolysate was various and flocculants effects were different.

When pH was low, alum blossom was difficult to form. Fig.2 showed that the removal rate of COD, NH_3-N and turbidity got the maximum, at 51.09%, 13.68% and 59.09%% at initial pH. Surface charge on particles in water was changed with increasing of pH. Then, charge neutralization played an important role in coagulation process. Meanwhile Fe^{3+} and Al^{2+} in the solution could hydrolyze quickly and plenty of hydrolysate was generated, so flocculation performance was given full play. Under acidic condition, hydrolysis of Fe^{3+} was $xFe^{3+}+yH_2O=Fe_x(OH)_y^{3x-y}+yH^+$, and hydrolysates included $Fe(OH)^{2+}$ 、$Fe_2(OH)_2^{4+}$ and $Fe_3(OH)_4^{5+}$. The positive charge on the surface of hydrolysate could neutralize negative charge of colloidal pollutant; flocculants could play well in coagulation process. But under the alkaline condition, hydrolysates were mainly $Fe(OH)_3$、$Fe(OH)_4^-$. Then the effect was bad because neutralization disappeared. As pH increasing, inorganic polymer with high polymerization degree and spot of charge was formed and developed into hydroxide precipitation. At this time, the property of flocculants was shown in adsorption bridging and netting mechanism.

3.4. Effect of kinetic factors

Fig.2 showed that slow stirring time had small effect on the removal rate of turbidity decreased as slow time prolonged. COD removal rate was 31.06% for 10min, and 23.95% for 20 mins. Comprehensive consideration suggested that when slow stirring time was 10min, the removal rate of COD and turbidity were the best respectively. Likewise, fast stirring time had almost no effect. However, the removal rate of COD reached the maximum 35.45% in 1 minute.

Kinetic factors in coagulation process had influence on the generation of flocs. The whole coagulation process had two periods: mixing and reaction. In order to make flocculants diffuse into water uniformly, the mixing needed to be finished fast and in a short time. In the period of reaction, to avoid scattering the flocs, agitation intensity should decrease. Finally, the kinetic factors were chosen that the best stirring conditions were fast stirring at 200r/min for 1min and slow stirring at 50r/min for 10min.

3.5. Component analysis of organism

By GC-MS detection, the species of organic in wastewater after bio-process were 29 (Fig.3). After advanced flocculation, some hazardous contaminants were removed with flocs. Meanwhile alkanes were mostly advanced saturated categories, which were refractory organics.

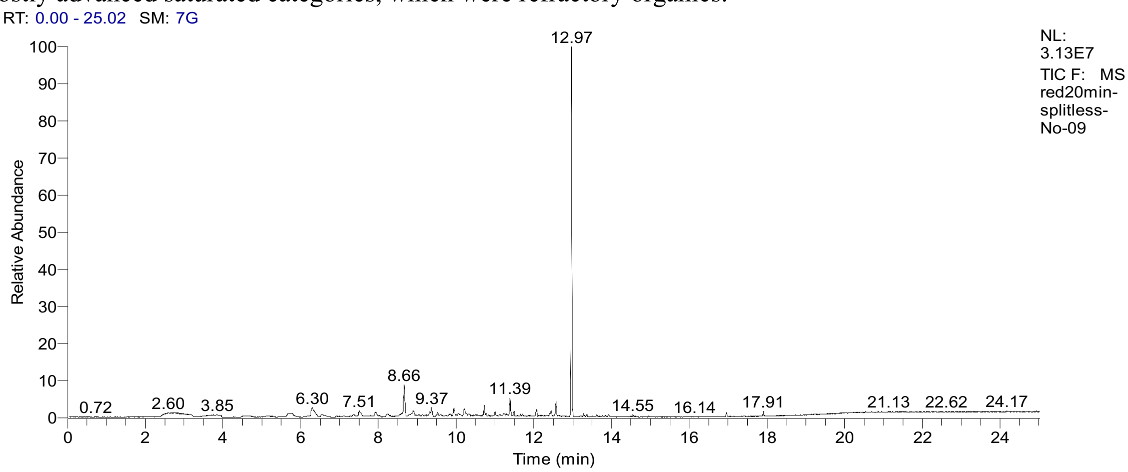

Fig.3 The species of organic pollutants by GC-MS after flocculation

Table 1. The species of organic in leachate before and after flocculation

The species	olefins	esters	aldehydes	ketones	phthalics
Before flocculation	1	1	1	2	2
After flocculation	0	1	0	1	1

From Table 1, the detection organics were mostly alkanes, olefins, esters, aldehydes, ketones, ethers and phthalics, whose molecular weights were basically less than 500. After flocculation, the species of olefins, aldehydes, ketones and phthalics were decreased. The conjecture was that mactomolecular organic compounds were settled with flocs and some compounds complexed with metal ions decomposed into small molecular organic. After flocculation treatment, some refractory compounds were removed effectively. Some Hazardous contaminants were removed to reduce toxicity.

3.6. SEM analysis

Fig.4 showed that before treatment, pollutants in leachate were dispersed in granular or colloidal shape. However after PFZSSB added, the structure of flocs was compacting. Because of flocculation, particulate matters and colloidal substances were packed in large and dense flocs. It could be seen from the flocs shape angle that the PFZSSB had strong adsorption bridging and precipitation enmeshment effect, which were also beneficical to the aggregation and deposition of unstable particles. Lots of small particles tightly attached to the floc structure, which was formed by the suspended solids, colloidal particles and the coagulant hydrolysis products. And it could not be easily destroyed for its strong stability between the tight wrapped particles.

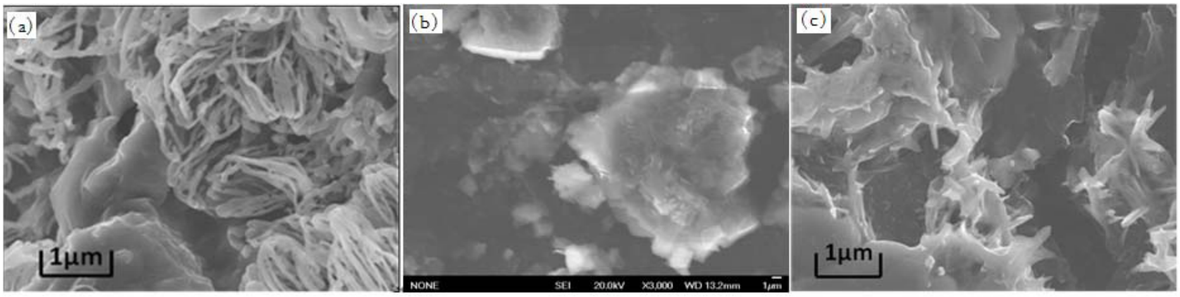

Fig.4 The SEM of PFZSSB(a), pollutants berore(b) treatment and flocs after(c) treatment

4. Conclusions

Experiments were conducted on the dosage of PFZSSB, kinetic conditions and pH. Under the optimal dosage was of 4ml/L , rapid stirring time was of 1min (200r/min), and the slow stirring time was of 10min (50r/min), and without pH adjusting, the removal rate of COD, NH3-N and turbidity were separately 51.09%, 13.68% and 59.09%%.

With SEM, the PFZSSB was formed by polymerization with sulfate, silicate, boron, zinc, iron and other groups. Because these groups were gathered with each other, flocculants had better power to break the stability of colloids and the flocs were large enough to absorb and bridge between pollutants particles easily. Metal ions hydrolyzed in the water neutralize the charge of suspended substance and colloidal particles.

In a word, the new flocculants has a great application prospect, whcih could be applied without changing the primary conventional treatment process, along with the advantages of high COD removing rate, low investment and running cost, easy and simple manipulation.

Acknowledgements

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