ARCHITECTURE CIVIL ENGINEERING ENVIRONMENT
The Silesian University of Technology No. 4/2009

PRELIMINARY TESTS OF COD REMOVAL FROM LANDFILL LEACHATE USING COAGULATION-FLOCCULATION PROCESSES

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Received: 16.06.2009; Revised: 18.07.2009; Accepted:27.07.2009

Abstract

The preliminary tests of effective COD removal by coagulation-flocculation processes from landfill leachate were carried out. The municipal landfill, from which leachate was collected has been exploited since 2004. The leachate characterized with comparatively low contents of organic matters expressed as COD (2000-2600 mg O_2/L), and pH value within the range of 7.4-7.6. The coagulation process was conducted using 3 coagulants: PIX 110-10, $Al_2(SO_4)_3$ and $FeCl_3$. The applied coagulant doses were within the range of 100-2500 mg/L. In the first part of research the most profitable parameters of coagulation were chosen. It was noted that the ferric coagulants were determined to have bigger treatment efficiency than aluminium sulphate. The highest effectiveness of COD removal (56%) was obtained when $FeCl_3$ was used in dose of 2100 mg/L. The worse efficiency (only about 44%) was observed when $Al_2(SO_4)_3$ was used in coagulation process in dose of 1550 mg/L. In the second part of research the influence of polielectrolite Magnofloc 156 addition on effectiveness of COD removal was investigated. This research showed that the addition the polielectrolite to coagulation process didn't significantly improve the treatment effects when the best doses of PIX 110-10 and $Al_2(SO_4)_3$ were used. However, when $FeCl_3$ was used, the addition of polielectrolite improves the efficiency of COD reduction by about 10%.

Streszczenie

Przeprowadzono wstępne badania usuwania zanieczyszczeń organicznych wyrażonych jako ChZT z odcieków składowiskowych za pomocą procesu koagulacji. Miejskie składowisko odpadów, z którego pobierano odcieki, eksploatowane jest od 2004 roku. Odcieki charakteryzowały się stosunkowo niską zawartością związków organicznych (ChZT = 2000-2600 mg O_2/dm^3) oraz pH w zakresie 7.4-7.6. Proces koagulacji prowadzono przy zastosowaniu 3 koagulantów: PIX 110-10, $Al_2(SO_4)_3$ oraz $FeCl_3$. Dla każdego koagulantu zastosowano dawki z zakresu 100-2500 mg/dm^3. Na podstawie uzyskanych wyników w pierwszej części badań wybrano najkorzystniejsze parametry prowadzenia procesu koagulacji. Stwierdzono, że koagulanty żelazowe powodowały większą efektywność oczyszczania niż siarczan glinu. Największą skuteczność redukcji ChZT (56%) odnotowano przy zastosowaniu FeCl3 w ilości 2100 mg/dm^3, natomiast najmniejszą (jedynie około 44%) dla $Al_2(SO_4)_3$ w ilości 1550 mg/dm^3. W drugiej części badań sprawdzono wpływ dodatku polielektrolitu Magnofloc 156 do procesu koagulacji na efektywność oczyszczania. Wyniki badań wykazały, że polielektrolit nie zwiększał w istotnym stopniu efektów oczyszczania, przy zastosowaniu najkorzystniejszych dawek koagulantów PIX 110-10 oraz $Al_2(SO_4)_3$. Natomiast zastosowanie polielektrolitu wraz z koagulantem $FeCl_3$ zwiększało efektywność oczyszczania o około 10%.

Keywords: **Landfill leachate; COD; Coagulation; Flocculation.**

1. INTRODUCTION

Much of the municipal solid waste is disposed in sanitary landfills, where it undergoes physical, chemical and biological transformations. The solubilization of organic and inorganic components in water produces a leachate. Landfill leachate is generated as a result of precipitation, surface run-off, and infiltration or intrusion of groundwater percolating through a landfill. The discharge of landfill leachate can lead to serious environmental problems, since the leachate contains a large amount of organic matter (both non-biodegradable and biodegradable carbon), ammonia-nitrogen, chlorinated organic, heavy metals and inorganic salts. Untreated landfill leachates can permeate the ground and mix with surface waters, contributing to their pollution, and hence posing considerable hazards to the natural environment [1, 2].

There are many different methods of treating landfill leachate. Different aerobic and anaerobic treatment techniques are most widely used treatment methods [3]. Efficiency of these treatment processes is highly affected by leachate flow and composition. Biological processes are quite effective, when applied to relatively younger (i.e. recently produced) leachates, containing mainly volatile fatty acids, but they are less efficient for treatment of older (i.e. more stabilized) leachates. Biorefractory contaminants, contained mainly in older leachates, are not amenable to conventional biological processes, whereas the high ammonia content might also be inhibitory to activated sludge microorganisms. Furthermore, a supplementary addition of phosphorus is often necessary, as landfill leachates are generally phosphorus-deficient [4]. Nevertheless, biological treatment processes are insufficient in the removal of persistent organics [1]. That is why for the treatment of leachate, we need different treatment processes, the most widely used of which are the physicochemical processes. To treat these kinds of wastewater advanced oxidation processes [5], air stripping [6], ion exchange, and membrane processes [7] could also be used to remove nitrogen and organic matter. Some researchers tried to find appropriate coagulation/flocculation for the efficient treatment of leachates [8, 9].

In this paper the preliminary tests of effective COD removal by coagulation-flocculation processes from landfill leachate were investigated.

2. MATERIALS AND METHODS

The municipal landfill, from which leachate was collected has been exploited since 2004. The leachate characterized with comparatively low contents of organic matters expressed as COD (2000-2600 mg O_2/L), and pH value within the range of 7.4-7.6. COD_{Cr} in leachate was determined in accordance with Polish Standard [10], while pH was measured by pH-meter (pH-196, Poland).

Coagulation studies were performed in a conventional jar-test apparatus (Flocculator SW1) equipped with 6 beakers of 1 L volume. The coagulation process was conducted using 3 different coagulants: PIX 110-10, $Al_2(SO_4)_3$ and $FeCl_3$. At the beginning, leachate was subjected the pH correction to optimum value for each coagulant: pH = 6.0; 6.5 and 5.0 for $FeCl_3$, $Al_2(SO_4)_3$ and PIX 110-10 respectively. After addition of suitable quantity of coagulant solution into leachate, it was fast stirred for 1 minute with speed of 200 rpm and next low mixed for 60 minutes with speed of 35 rpm. The samples for analysis were collected after 20, 40 and 60 minutes of flocculation process. After that, they were filtered to separate post-coagulation sludge and COD was determined in clear filtrate (treated leachate). As a result, the most profitable parameters (i.e. coagulant dosage and low stirring time) of coagulation process were chosen.

In the second part of research, the influence of polielectrolite addition to coagulation process was investigated. The coagulation was performed using the most profitable doses of each coagulant. On the basis of earlier results, which were carried out by authors [11], Magnofloc 156 was chosen as a suitable polielectrolite. Doses of this polielectrolite were as follows: 0.1; 0.3; 0.5; 0.7 and 1% dose of each coagulant. Moreover, the procedure of coagulation-flocculation processes were as follows:

- pH correction to optimum value,
- adding coagulant PIX in dose of 1500 mg/L,
- fast stirring for 40 seconds with speed of 200 rpm,
- adding polielectrolite,
- fast stirring for 20 seconds with speed of 200 rpm,
- slow stirring for 20 minutes with speed of 35 rpm,
- filtrating of treated leachate,
- COD determination.

3. RESULTS

3.1. Coagulation process

Applied coagulant doses were within the range of 100-2500 mg/L. It was observed that the most profitable flocculation time was 20 minutes in all applied reagents. The extension of flocculation time resulted in deterioration of the effects of the organic matters removal. It could be due to the partial break-up of flocs of metals hydroxides and desorption of pollutions.

The best effects of treatment were obtained when the ferric chloride iron was used as coagulant. Efficiency within the range of 25-56% decrease of COD value is depending on applied dose. It was shown, that within the range of dose 100-2100 mg/L, bigger dose of the reagent caused decrease of COD value in treated leachate. Dose of 2100 mg $FeCl_3$/L enabled the highest reduction of organic matter, expressed by 56% of COD reduction. Application of larger quantities of coagulant did not cause any improvement of treatment efficiency. The COD removal was within the range of 54-56% (Fig. 1).

A little worse effects of organic matter removal were obtained when PIX 110-10 was used as coagulant – effectiveness was within the range of 20-50%. For this reagent it was observed, that the treatment efficiency showed the increase tendency from 16% to 49% of COD reduction within the range of doses 100-1500 of mg/L (Fig. 2). Doses within the range of 1700-2500 mg/L did not cause growth of treatment effects, and they even were decreased to about 44% of COD removal.

The smallest treatment efficiency was observed when aluminium sulphate was used as coagulant. For this reagent the maximum reduction of organic matter (44% of COD removal) was observed when it's dose was equal to 1550 mg/L (Fig. 3). In case of aluminium sulphate much worse treatment effects were achieved, when applied doses were lower or higher than 1550 mg/L. The considerable deterioration of efficiency for doses higher than 1550 mg/L was observed, because new stable colloidal arrangement appeared in the treated leachate [11].

As a result of mentioned above experiments the following parameters for coagulation process were chosen: $FeCl_3$ = 2100 mg/L, PIX = 1500 mg/L and $Al_2(SO_4)_3$ = 1550 mg/L with 1 minute of quick mixing and 20 minutes of flocculation time.

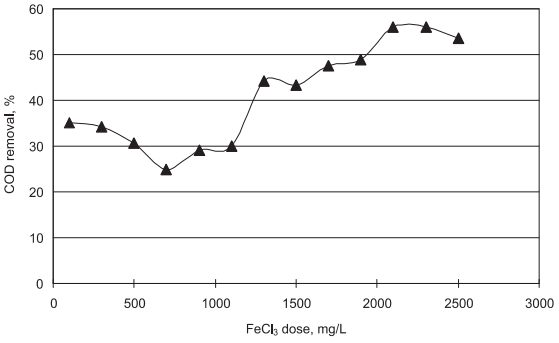

Figure 1.
COD removal from landfill leachate using $FeCl_3$

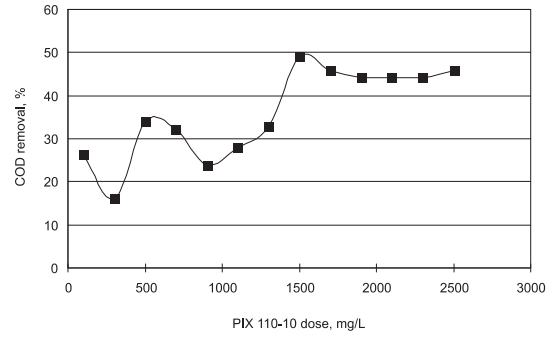

Figure 2.
COD removal from landfill leachate using PIX 110-10

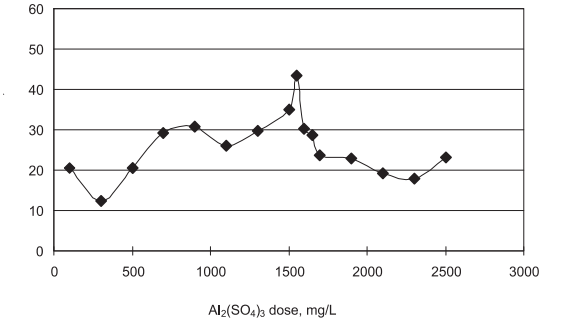

Figure 3.
COD removal from landfill leachate using $Al_2(SO_4)_3$

3.2. Coagulation in the presence of polielectrolite

In this part of research the best doses for each coagulant were used: $FeCl_3$ = 2100 mg/L, PIX 110-10 = 1500 mg/L and $Al_2(SO_4)_3$ = 1550 mg/L. It was shown that adding Magnofloc 156 as polielectrolite with two of three used coagulants didn't significantly improve efficiency of COD removal (Fig. 4). When PIX 110-10 (1500 mg/L) and aluminium sulphate (1550 mg/L) were used with polielectrolite, the best improvement of COD removal effectiveness was equal to 2% in comparison with coagulation effect when those coagulants were used without polielectrolite. It was obtain when doses of Magnofloc 156 were equal to 1.0% (for PIX 110-10) and 0.7% (for $Al_2(SO_4)_3$) of coagulant dose respectively. However, when ferric chloride was used as coagulant, addition of polielectrolite increased the treatment efficiency up to about 10%. It was obtained when dose of Magnofloc 156 was equal to 1.0% of ferric chloride dose ($FeCl_3$ = 2100 mg/L).

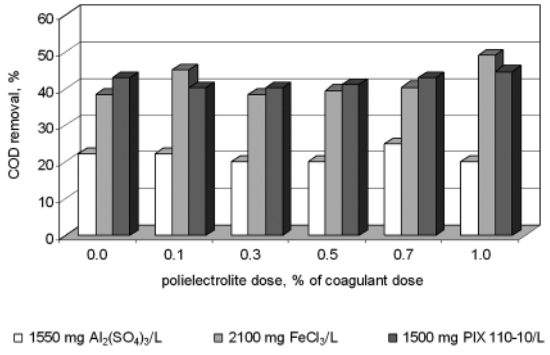

Figure 4.
COD removal from landfill leachate using coagulation in the presence of polielectrolite

4. SUMMARY

In the research the preliminary tests of effective COD removal by coagulation-flocculation processes from landfill leachate were investigated. Three different coagulants were used: PIX 110-10, $Al_2(SO_4)_3$ and $FeCl_3$. Moreover, in the second part of research the influence of polielectrolite (Magnofloc 156) addition to coagulation process was also investigated.

The first part of experiment showed that the best slow stirring time in coagulation process was 20 minutes, because the extension of flocculation time resulted in deterioration of the efficiency. Obtained results showed that coagulation can remove organic matter (expressed as COD) from landfill leachate with effectiveness within the range of 44-56%. It was also observed that the ferric coagulants were determined to have bigger treatment effectiveness than aluminium sulphate coagulant. When $FeCl_3$ was used in coagulation process in dose of 2100 mg/L, the highest removal of COD (56%) was obtained. A little smaller efficiency of COD removal (50%) was observed when PIX 110-10 was used as coagulant in dose of 1500 mg/L. In case of aluminium sulphate treatment effect equaled only about 44% at the dose of 1550 mg/L.

In the second part of research it was observed that the addition of polielectrolite didn't significantly improve treatment effect. When PIX 110-10 and $Al_2(SO_4)_3$ were used with polielectrolite the efficiency was only about 2% better than when those coagulants were used without polielectrolite. However, in case of ferric chloride the addition of Magnofloc 156 improves the efficiency of COD reduction up to about 10%.

Obtained results showed that it is possible to effectively reduce organic matter in landfill leachate using coagulation process. Landfill leachate is this kind of wastewater whose treatment is very difficult and it often requires applying a few different treatment methods. Coagulation process is a relatively inexpensive treatment method, therefore it can be applied as pretreatment of leachate before its further treating. Because the best results of COD removal from landfill leachate could probably be obtained in combined treatment system including a coagulation process, followed by a biological and/or chemical oxidation (e.g. Fenton reagent), the coagulation process used as a pretreatment stage may reduce the required doses of reagents applied in next stage of multi-stage treatment process. It can be stated, that more experiments need to be done towards optimization of such combined systems. Therefore, the authors have an

intention to conduct further research using the treatment system including a coagulation process followed by a Fenton oxidation.

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