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PHYSICAL MODELLING ON THE ENHANCEMENT OF AEROBIC STABILIZATION OF MUNICIPAL WASTE LANDFILL

Ljudmilla Bokányi–Terézia Varga
University of Miskolc
Institute of Raw Material Preparation and Environmental Processing

ABSTRACT

The stabilization period of old closed landfills is generally 13− 35 years, while the soil polluting leachate and green-house effecting methane has been producing for decades after the closure. According to the studies, 40− 60 million tons of methane generate from these old landfills, which is about 11− 12% of the global anthropogenic methane emission (Heyer et al., 2005). To reduce the harmful emissions of the closed landfills the in situ enhanced aerobic stabilization can be applied. The Department of Bioprocessing and Reaction Techniques has been dealing with the aerobic degradation and other biotechniques for two decades, it was Professor Imre Szabó who advised our team to look at the possibility to apply forced aeration to enhance the aerobic degradation in the landfills providing opportunity to shorten the stabilization period after the closure.

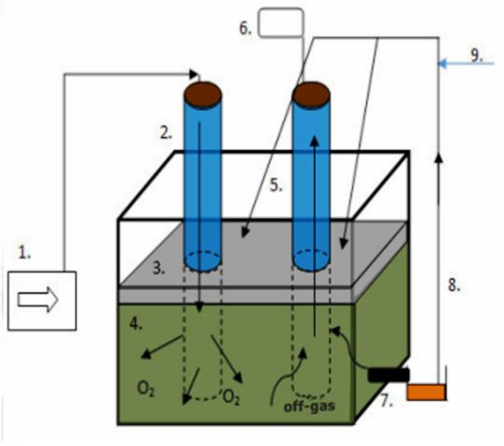
INTRODUCTION

The least desirable solution in the waste management is the deposition, however in Hungary there was no comprehensive legislation for landfilling until 2000 (Szabó I. et al., 2011). Before the 2000s, the most commonly applied process for the disposal of solid wastes was the uncontrolled dumping on the surface or in the hollows of the ground. The stabilization period of these old landfills is generally 13− 35 years, so the polluting leachate and methane has been producing for decades after closure (Vermes, 2005). According to the studies, 40− 60 million tons of methane generate from these old landfills, which is about 11− 12% of the global anthropogenic methane emission (Heyer et al., 2005). To reduce the harmful emissions of the closed landfills the in situ aerobic stabilization can be applied, which has been successfully implemented in many countries. The aerobic stabilization is recommended to apply, when there is no recoverable amount of methane in the landfill, but it still carries a significant risk to the environment (Szabó I. et al., Ritzkowski et al., 2012). Due to the aerobic stabilization the degradable organic materials decompose aerobically faster, the degree of methane production reduces significantly, the sedimentation process of landfills takes place in a shorter time, and the polluting impact of the leachate also decreases, as well as the carbon-dioxide production increases (Ritzkowski et al., 2006, 2012). The aim of the experiment, which was performed at the Bioprocessing Laboratory of Institute of Raw Material Preparation and Environmental Processing, University of Miskolc, was the investigation of the possibility to enhance the landfill stabilization process by forced aeration using physical modeling of aerated and non-aerated municipal solid landfill.

MATERIALS AND METHODS

For the experiments two 115 cm long, 75 cm wide and 66.5 cm high plastic tanks, as the reactors were installed. The aeration was carried out through PVC tubes using a compressor and the sampling of leachate was performed at the bottom of the tanks *(Figure 1)*. The fresh

MSW were supplied by AVE Company, it was sampled and analyzed. After loading of the homogenized municipal solid waste portion into the reactors, they were covered by plastic bags, on which small halls were cut to simulate the failures on the external insulation of the old landfills. Finally, the bags were covered with 3cm layer of gravel. One of the reactors was aerated by a compressor for 4 hours a day. Another one was without forced aeration.



1. Compressor
2. Perforated tube for air inlet
3. Covering with plastic bags and gravel
4. Municipal solid waste
5. Tube for gas collecting
6. Gas analyzer
7. Drain tube for leachate
8. Leachate recirculation
9. Water addition

Figure 1. The schematic illustration of the aerated reactor, physical model of landfill (Bokányi et al., 2012)

In the first part of the experiments one of the reactors was aerated using a Pneumair 85/15-A.P. type compressor and 470.4 m^3 of air was introduced into the waste mass during 196 h. Another reactor was operated without aeration. At this part of the experiments the temperature, the composition of the generated gas (methane and carbon-dioxide), as well as the leachate production were measured.

The temperature was measured below the surface in 15cm depth. It can be seen in *Figure 2* that it was higher by 5− 6°C within each reactor, than the ambient one. Difference in the measured values between the two reactors was not observed. Nevertheless, the aerobic degradation can be obviously recognized based on the tendency of temperature profile.

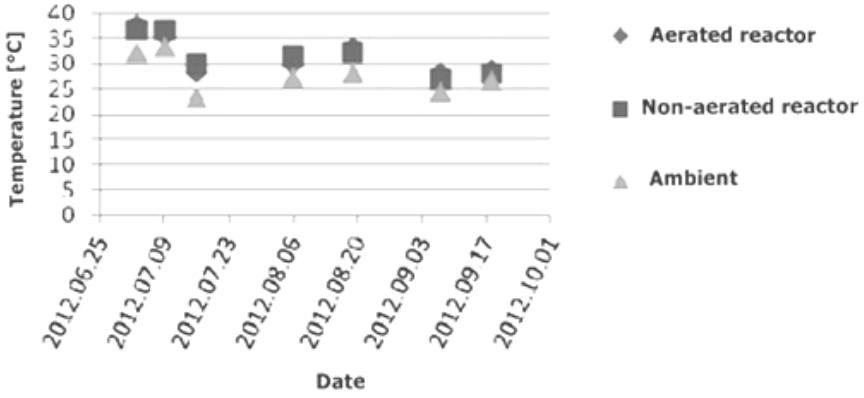


Figure 2. Variation of the temperature in the first part of the experiments

The composition of the generated gas was determined using a Dräger X-am 7000 type gas-analyzer device. According to the results, it can be noticed that no methane and only small amount of carbon-dioxide was produced *(Figure 3)*. Significant difference between the results obtained from the two reactors was not observed. The reason might be the low bio fraction rate of the feed-waste (appr. 10%), or in case of the aerated reactor the produced gas was blown through the perforations of the tube by the compressor.

Separable amount of leachate was not produced in the aerated reactor, only in the non-aerated one (20 cm^3) during 3 months.

After the first four months there were no significant changes in the process, therefore the reactors were inoculated with food residues in order to increase the biodegradable amount in the waste. Furthermore, the waste was sprinkled with water to promote the leachate-production, as well as to ensure the optimal environment for the microorganisms. The aeration was carried out using Pneumair 85/15-A.P. and an Elektra Beckum type compressor, and 391.44 m^3 air was introduced into the waste mass during 185 h. Hereinafter, there was still no any changes in the temperature.

In the second part of the experiments methane was obviously not generated. Only a small amount of carbon-dioxide was detected in the gas generated in the aerated reactor. This amount was a little bit higher, than in case of the gas obtained from the reactor operated without aeration. It can be concluded that the inoculation with kitchen residue resulted in an additional degradation peak in respect to the gas composition.

According to the evidence of *Figure 3*, it can be noticed that in the first part of the experiments the amount of the carbon-dioxide produced in the aerated reactor reaches a maximum value at 27.04.2012, while in case of the another, non-aerated reactor a shift in the time can be seen. The maximal value appears one month later. In the second period the maximum value is higher, which can be resulted by the addition of kitchen residue and the delay can also be observed: the aerobic degradation is more intensive. Summarizing the results, especially based on the time delay, it can be postulated that the aeration can intensify the degradation, thus the stabilization will occur faster.

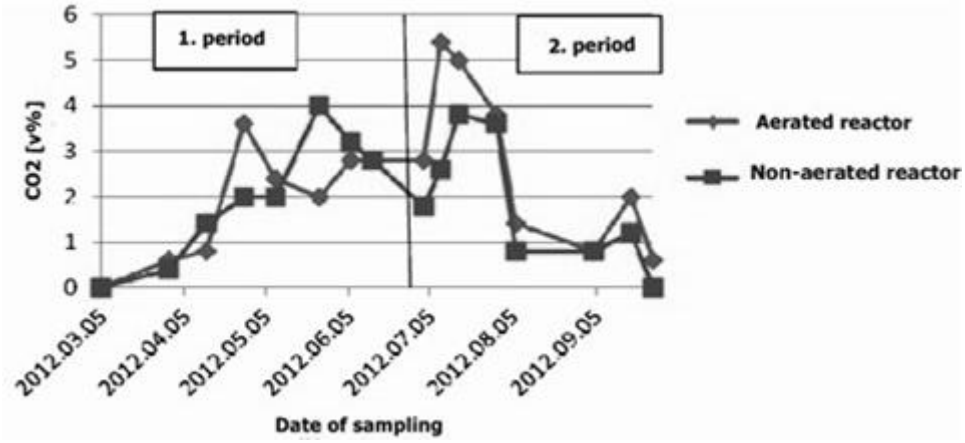


Figure 3. Produced CO_2 amount as function of time

In the second part of the experiments the waste was sprinkled initially with 10 L water, later with 8.5 L water and 2.5 L of leachate. The obtained leachate was analyzed, and the

Figure 4 and 5 represent the COD (chemical oxygen demand) and BOD (biological oxygen demand) values respectively.

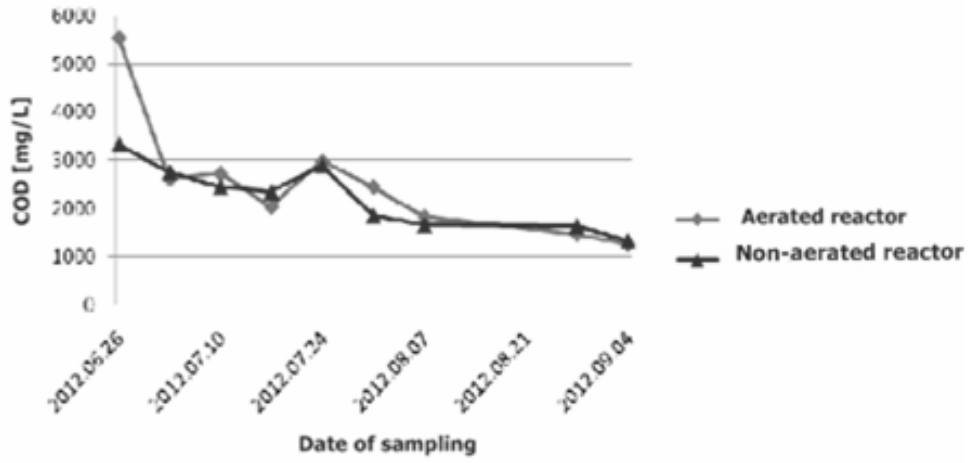


Figure 4 Chemical oxygen demand values of leachate sampled from the reactors

As it can be seen in *Figure 4* the reduction of the COD values in the aerated process is more prominent, thus the aeration has a positive effect to the bio waste degradation. In terms of the BOD_5 values, the degree of the reduction is quite similar in both reactors.

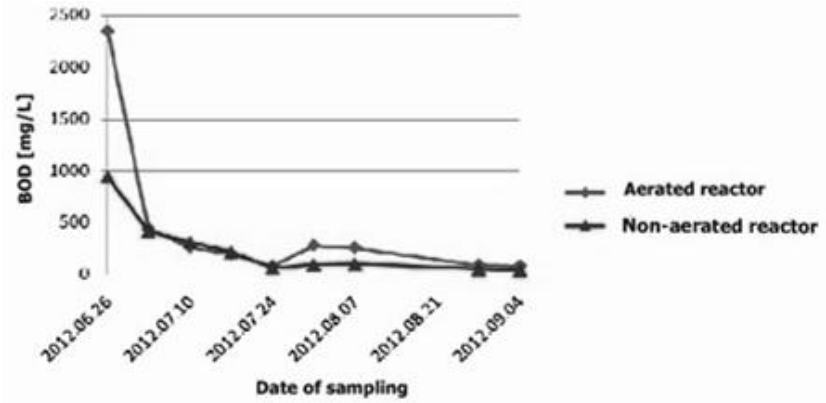


Figure 5. BOD_5 (biological oxygen demand) values of leachate separated from the reactors

CONCLUSIONS

A very first experimental attempt on the physical modeling of the degradation processes in MSW landfill with and without forced aeration was done in the Bioprocessing Laboratory of our Institute. Based on the gained experience the following consequences can be drawn. The size of the reactor was not chosen properly: it should be larger than used in our physical model. The volumetric air distribution in the forced aeration should be more homogeneous. The composition of the applied MSW feed next time should be chosen more

carefully as well. Moisture content of the MSW feed is also of a great importance. Nevertheless the experiments should be continued, the obtained in this phase results in general are promising. Analyzing the composition of the generated gas it was found that the amount of carbon-dioxide was higher in case of the forced aerated degradation process, methane was not detected. The time delay in the CO_2 production of the two reactors indicates that the forced aeration does intensify the aerobic degradation, thus the stabilization process will occur sooner. The COD values of leachate samples show a decreasing tendency, which reduction was more prominent (appr. 77%) due to the forced aeration, so this aerobic degradation process was faster. In respect of BOD_5 values the degree of the reduction was around 96% at both reactor types. Finally, the surface subsidence was found to take place relatively quickly, only after 6 months. In this respect there was no difference between the forced aerated and the non-aerated reactors.

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