

# PROGRESS OF SUSTAINABLE LANDFILL STABILIZATION AFTER 3 YEARS OF LEACHATE RECIRCULATION AT THE VLAGHEIDE LANDFILL (NL)

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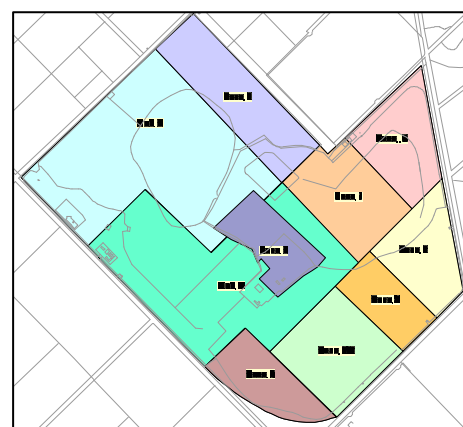
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**SUMMARY:** The Urban District of 's-Hertogenbosch is the owner of the Vlagheide landfill in Schijndel (NL). The Vlagheide landfill measures 40 hectares and 6 million m<sup>3</sup> of municipal solid waste (MSW), stored over the last 35 years. The landfill has been closed in 2003. Half of the landfill comprises a newer part ( $\approx 20$  ha) with a bottom liner, but still without a top liner. Within the framework of the current sustainable landfill management programme (SLMP) at the Vlagheide landfill (started in 2005), at this newer part a leachate recirculation test at 1 ha is carried out since June 2008 in order to investigate and monitor the expected acceleration of the stabilization process (i.e. the degradation of degradable organic matter) in the landfill body. After almost three years of infiltration the results with respect to landfill stabilization are considered to be that promising and encouraging, that it was decided to expand the leachate infiltration system to the total surface of the newer part of the Vlagheide landfill. This will be implemented by the end of 2011 and will last for at least 5 years. This research aims to deliver the undisputed proof that sustainable landfill management (SLM) is capable to achieve the admissible emission limit values in such a way that it enables the competent authorities to make the decision for minimalization of aftercare or even for discharge from aftercare.

## 1. INTRODUCTION

The Urban District of 's-Hertogenbosch is the owner of the Vlagheide landfill in Schijndel (NL), which complies with the EU-standards with respect to aftercare measures. The Vlagheide landfill measures 40 hectares and 6 million m<sup>3</sup> of municipal solid waste (MSW), stored over the last 35 years. The landfill has been closed in 2003. Half of the landfill comprises a newer part ( $\approx 20$  ha) with a bottom liner, but still without a top liner. Within the framework of the ongoing sustainable landfill management programme (SLMP) at the Vlagheide landfill (started in 2005), at this newer part a leachate recirculation test is carried out since June 2008 in order to investigate and monitor the expected acceleration of the stabilization process (i.e. the degradation of degradable organic matter) in the landfill body.



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## 2. HYPOTHESIS AND OBJECTIVES

The hypothesis behind the leachate recirculation test is that the infiltration of leachate will increase the moisture content in the landfill body. As a consequence a bigger part of the present degradable organic matter will be degraded (the so called dry pockets become moisturized) and the gas production will increase. This will enhance the landfill stabilization process. The final goal is to achieve a sustainable emission reduction of landfill gas and leachate, which complies with the admissible limit values of emission to groundwater and air compartment.

## 3. INFILTRATION SYSTEM

The pilot started in June 2008 by the installation of the infiltration fields over a surface of 1 ha. The infiltration field consists of 10 drains with a length of 100 meter each and a distance in between of circa 10 meter (see figure 1 and 2). The drains consist of trenches, filled with gravel. Leachate from the leachate collection pits of other compartments is pumped to the buffer tank on top of the landfill next to the infiltration field. From the buffer tank the leachate is pumped into two infiltration pits, which have been connected to the 10 infiltration drains.

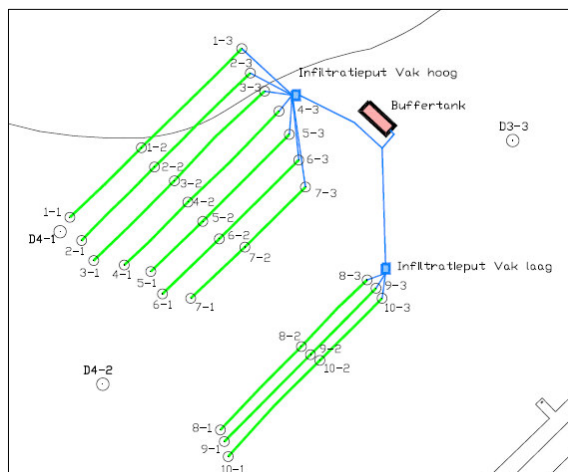


Figure 1 Plan position of infiltration drains

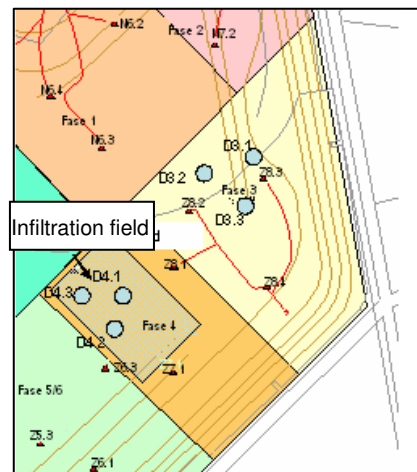


Figure 2 Infiltration field and measurement points D3/D4

## 4. RESULTS

### 4.1 Infiltration rate

The objective is to infiltrate the highest possible amount of leachate, but without saturating the waste body and flooding the landfill surface. In fact it is the intention to increase the moisture content in the waste body without exceeding the field capacity of the waste body. The higher the moisture content, the higher the biogas production and as a consequence the faster the stabilization of the landfill will be achieved due to the degradation of anaerobic degradable organic matter.

At the other hand transport of water is needed to remove inhibitors, which might be counter-productive to a succesfull and effective degradation process. Water transport is also needed to

remove dissolved organic matter (DOC), to which heavy metals are bounded.

Figure 3 shows the infiltration rate in mm/year during the period of almost 3 years from June 2008 up to April 2011.

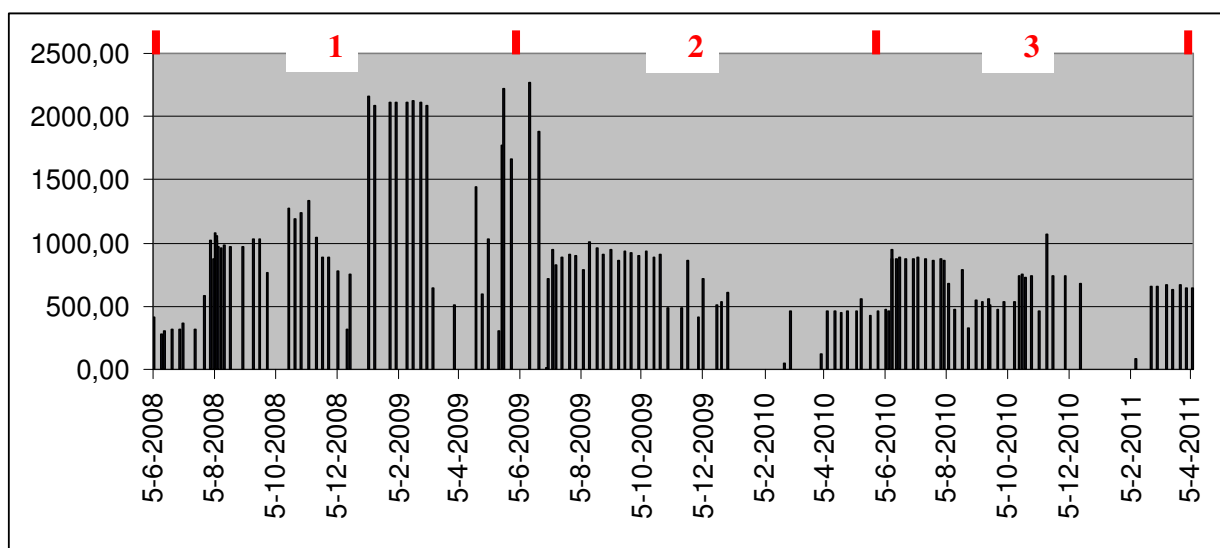


Figure 3 Infiltration rate in mm/year

Due to regularly short periods of flooding at the slope of the landfill, it has been decided to close down the three infiltration drains in the vicinity of the landfill slope. Therefore the total infiltration period is divided into two periods:

1. Infiltration by 10 infiltration drains at a surface of 1 ha from 6 June 2008 up to 7 June 2010.
2. Infiltration by 7 infiltration drains at a surface of 0.7 ha from 7 June 2010 up to 7 April 2011.

Since the start, the infiltration of leachate had to be stopped during short periods because of maintenance, replacing pumps, and periods of frost. Table 1 shows the total amounts of infiltrated leachate during the time in which the infiltration was operative.

Table 1 Amounts of infiltrated leachate

	<b>Period 6/6/2008 – 7/6/2010 10 drains at 1 ha</b>	<b>Period 7/6/2010 – 7/4/2011 7 drains at 0.7 ha</b>
Calendar time	731 days	308 days
Total inoperative periods	102 days	74 days
Effective infiltration period	629 days	234 days
Total amount of infiltrated leachate	16,930 m <sup>3</sup>	3,233 m <sup>3</sup>
Average effective infiltration flow rate	26.9 m <sup>3</sup> /hr	13.8 m <sup>3</sup> /hr
Average effective amount of infiltration	982 mm/year	720 mm/year

As shown in figure 3, the total infiltration period can be subdivided into three equal periods of time with respect to the infiltration rate.

1. The first year after the start of infiltration is considered to be a period of trial and error in order to achieve the maximum infiltration rate without flooding and saturation of the waste body. In this time period high amounts of leachate has been infiltrated (up to 2000 mm/year).

2. The second year of infiltration with 10 drains (from June 2009 up to June 2010), the average infiltration rate was 630 mm/year. In spite of the reduced infiltration rate, still incidentally short periods of flooding at the slope of the landfill have been recorded, especially in combination with periods of (heavy) rainfall. Therefore it was decided to close down the 3 drains situated along the landfill slope.
3. The last period of infiltration, only 7 drains were operational. The average infiltration rate of leachate was 720 mm/year. During this period no flooding was noticed anymore. This means that the maximum average infiltration rate could be established at an average of 720 mm/year at that location of the landfill. This means a total infiltration rate of 1000 mm/year, including the natural effective infiltration of precipitation of approximately 280 mm/year. Compared to the natural infiltration of precipitation, this is a three- to four-fold of the amount of effective infiltration by rain water.

#### 4.2 Moisture content in waste body

The additional infiltration of leachate in the waste body of compartment 4 resulted in a noticeable higher moisture content in the waste body. This is demonstrated by the results of resistivity measurements in the waste body below the infiltration field. The resistivity measurements have been executed by Deltares in four rows within the infiltration area, before and after the start of infiltration (June 2008). The results are presented in figure 4.

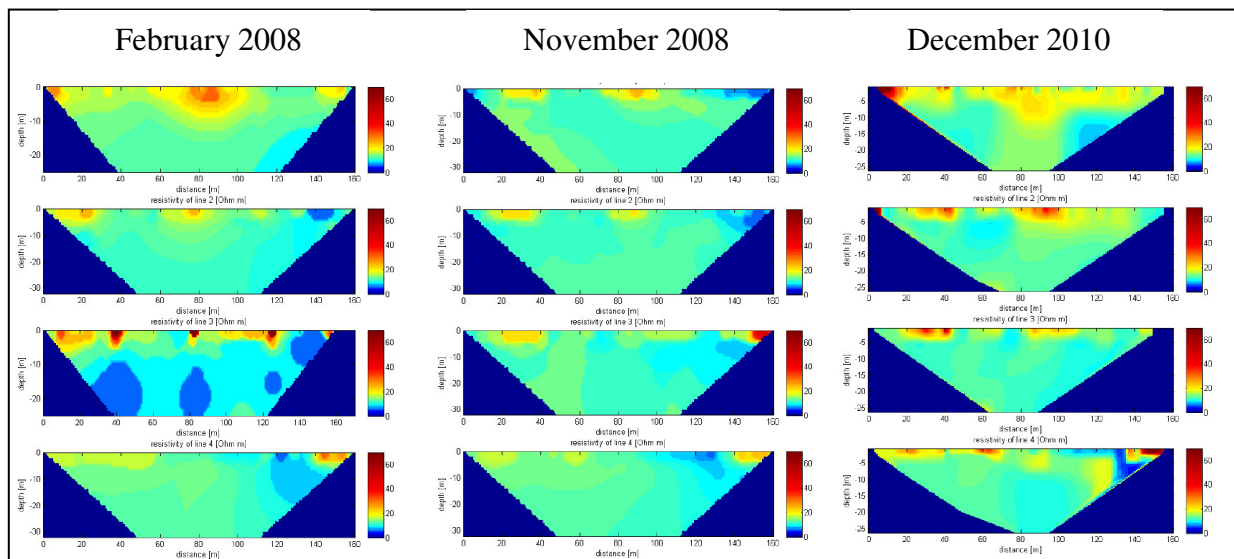


Figure 4 Geo-electrical resistivity measurements at infiltration area (source: Deltares 2011)

With respect to the hydrology in the waste body it is generally accepted, that moisture content and transport of water to the drainage system take place according to the triple porosity model by distinguishing the following three zones:

1. Stagnant zones: negligible moisture content (only initial moisture content of the waste before disposal) and negligible transport of water.
2. Mobile zones: slow transport of water.
3. Preferential channels: fast transport of water.

The patterns of resistivity can be related to hydrological zones in the waste body. In literature<sup>1</sup> three resistivity zones are distinguished related to the hydrology in the waste body, as presented in table 2.

Table 2 Resistivity zones related to hydrological zones in the waste body

Hydrological zones	Resistivity	Resistivity value	Colour in geo-electrical profiles (see figure 4)
Stagnant zones ('dry pockets')	High	> 20 – 50 Ωm	Red
Mobile zones, slow water transport	Medium	10 – 20 Ωm	Yellow or green
Preferential channels: fast water transport	Low	< 5 – 11 Ωm	Blue

The most favourable conditions for the progress of landfill stabilization are the mobile zones with slow water transport and high moisture contents. Figure 4 shows a noticeable increase of the yellow and green colours (low resistivity → more water) in the measurements after 9 months (november 2008) and after 34 months (december 2010) of infiltration in comparison to the measurements before infiltration (february 2008). So it can be concluded that the infiltration process meets its goal, which is the overall increase of the moisture content.

#### 4.4 Landfill stabilization process

The progress of the landfill stabilization process is monitored by measuring the composition of landfill gas (LFG) at monitoring points in the landfill body as well as the biochemical and chemical oxygen demand (BOD and COD) in the leachate, being the most important key performance indicators.

##### 4.4.1 Gas composition

The LFG-composition was measured at several points in the infiltrated part of the landfill body before as well as after the start of infiltration. This was done in shallow and deep piezometers, which have been installed at the top and at the bottom of the waste body. Figure 5 shows the development of the gas components (CH<sub>4</sub>, CO<sub>2</sub> and O<sub>2</sub>) of piezometer D4-1-deep at the bottom of the waste body below the infiltration field. It shows that modest methane volume percentages were measured after the start of leachate infiltration in June 2008. This indicates that the 'dry pockets' before the start of leachate infiltration became moisturized and that the present degradable organic matter started to produce LFG. This image also goes for the other measured piezometers.

<sup>1</sup> Resistivity zones from the Risk Assessment Toolbox (Hoekstra et al. 2010)

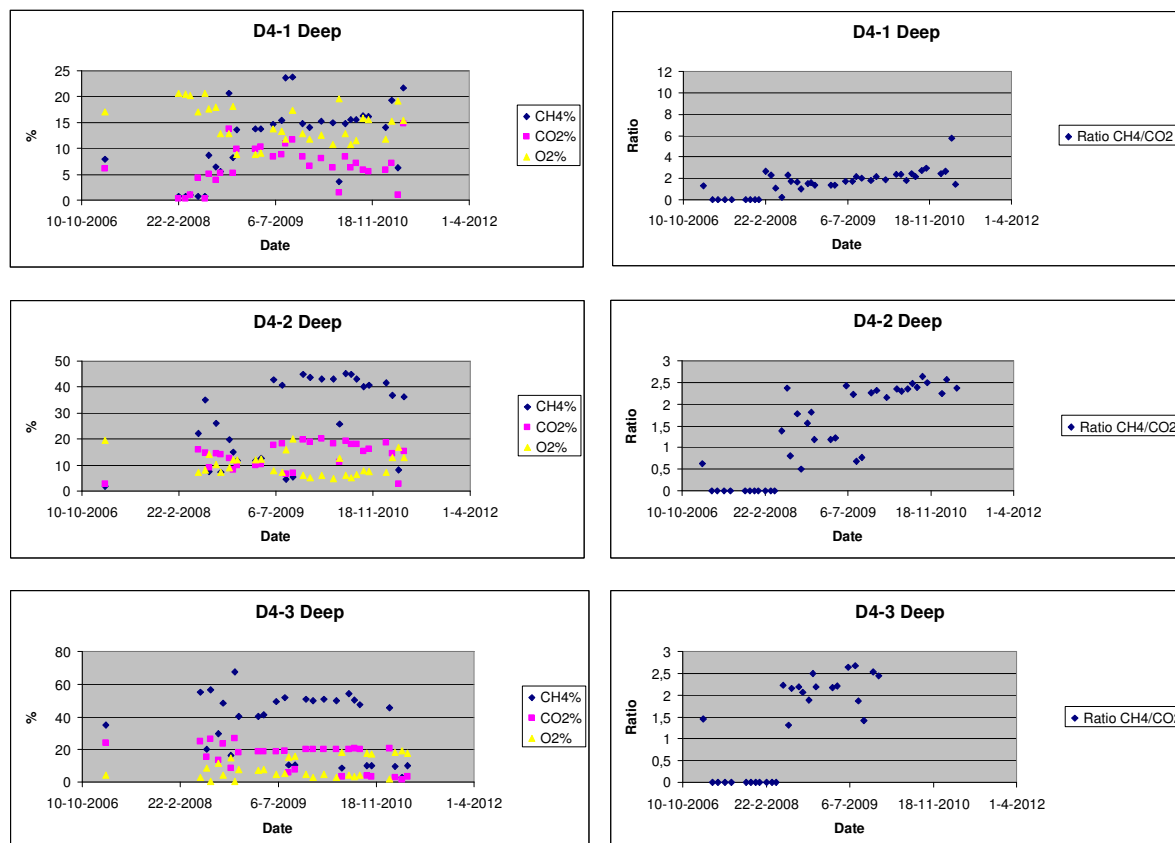


Figure 5 Gas composition in deep piezometers at the bottom of waste in compartment 4

#### 4.4.2 Leachate composition

Figure 6 shows the measurements of BOD and COD in the leachate of the waste compartments 3, 4 and 5/6. Due to frost periods and maintenance of the infiltration system, the leachate infiltration had to be stopped during the following periods:

1. 18 days from 26 september 2008 to 14 october 2008
2. 19 days from 11 march 2009 to 30 march 2009
3. 7 days from 24 june 2009 to 1 juy 2009
4. 56 days from 29 december 2009 to 23 february 2010
5. 78 days from 30 november 2010 to 16 february 2011-07-07

From the start of infiltration up to the first relatively long inoperational period 4, an increase of the BOD concentrations took place. After the inoperational infiltration period 4, the BOD concentrations demonstrates a decreasing trend, which reverse in a increase of BOD concentrations after a relative long period. We see the same image at the second inoperational infiltration period 5. This indicates the sensitivity of leachate supply to the moisture content and biological activity with regard to degradation of degradable organic matter.

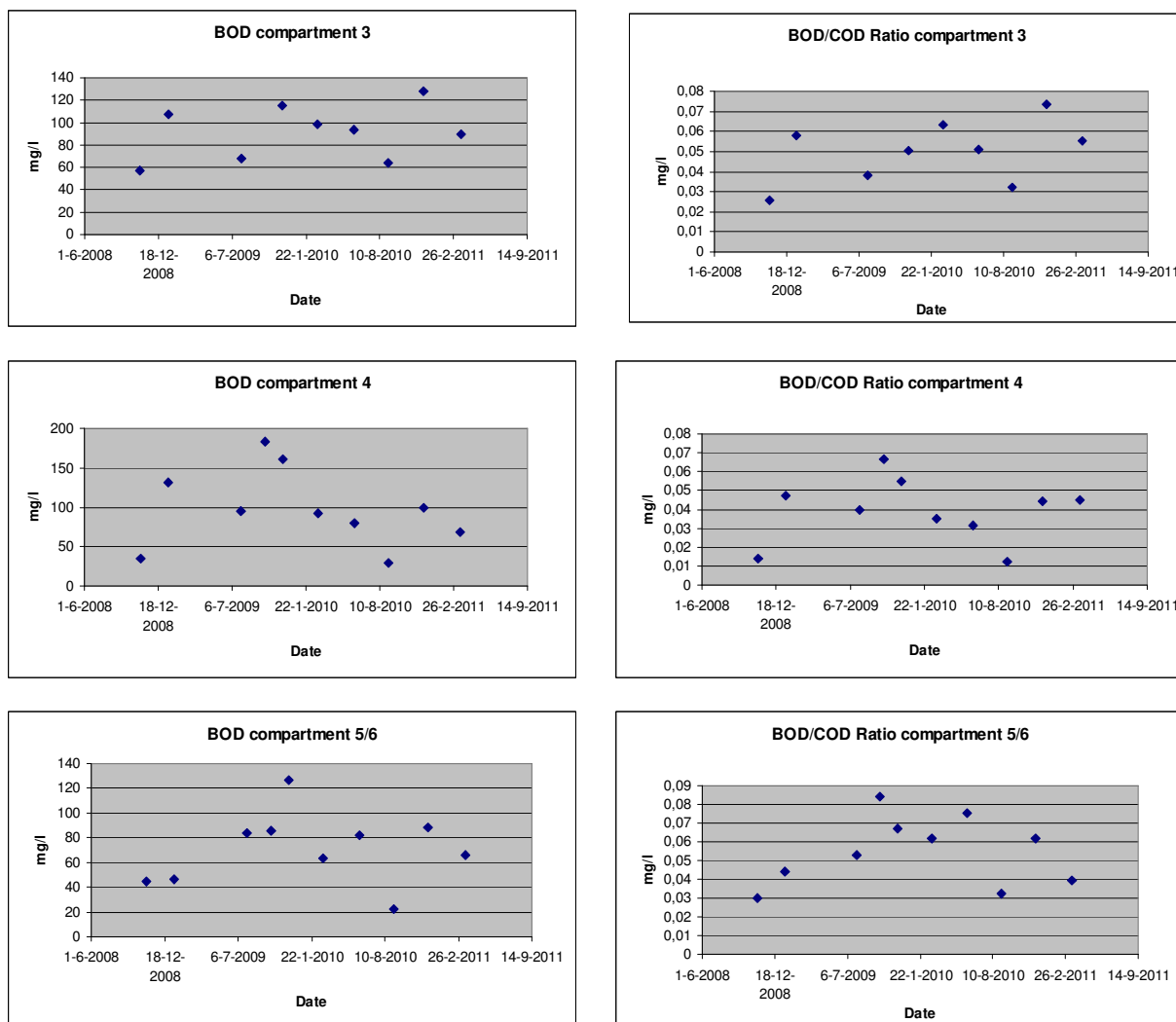


Figure 6 BOD and COD in the leachate of the waste compartments 3, 4 and 5/6

#### 4.5 Summary

With respect to the effects of leachate infiltration , the results can be summarized as follows:

- The optimal additional leachate infiltration rate could be fixed at the order of magnitude of 720 mm/year. This is, added to the effective infiltration of precipitation, a three- to four-fold of the natural effective infiltration of rain water (280 mm/year).
- The infiltration resulted in an increase of the moisture content in the waste body, by which an important boundary condition has been fulfilled for the success of landfill stabilization.
- The infiltration resulted in a start of gas production in the so-called ‘dry-pockets’, which became moisturized due to enhanced infiltration.
- There appears to be a certain reaction time between the infiltration rate and BOD rate.

#### 5. CONCLUSIONS

The leachate infiltration process meets the main conditions, which are the increase of moisture content and water transport. These favourable circumstances could be translated into a noticeable

increase of gas production and as a consequence in a progress of the landfill stabilization process. The period of 3 years of leachate infiltration is still relatively short to draw final conclusions whether or not the sustainable emission reduction will meet, at the end, the admissible emission limit values. Nevertheless the results are considered to be that promising and encouraging, that it was decided to expand the leachate infiltration system to the total surface of the newer part of the Vlagheide landfill (20 ha).

## **6. FOLLOW UP**

The Vlagheide will be integrated in the national program 'Introduction Sustainable Landfill Management', started by the Dutch Ministry of Environment in 2010. Together with 3 other demonstration projects, this programme aims to deliver the undisputed proof that sustainable landfill management (SLM) is capable to achieve the admissible emission limit values and in such a way that it enables the competent authority to make the decision for minimalization of aftercare or even for discharge from aftercare.

By the end of 2011 a start will be made to extent the leachate infiltration system to the total surface of the newer part of the Vlagheide landfill. Further measurements during at least the next 5 years will contribute to achieve the above mentioned proof that SLM will lead to minimalized or ending aftercare.

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- Mr. J. Bloemen, Financial Director of the Urban District of 's-Hertogenbosch.
- Mr. H. Scharff, as a representatieve of the Association of Waste Management Companies.
- Mr. H. van Zoelen, as a representative of the Dutch Ministry of Environment.

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