ODOUR REDUCTION BY AERATION PRIOR TO EXCAVATION

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SUMMARY: In order to gain a new permit to remediate, excavate and re-open the former Zeeasterweg landfill, adequate measures were demanded by the authorities to prevent odour nuisance to housing areas and areas with industrial activities located nearby the landfill. Afvalzorg initiated a test excavation. A part of the landfill was aerated prior to excavation of waste with a landfill aeration system. Both an aerated and non aerated part of the landfill were excavated. Smelling squad measurements were conducted in order to determine the odour concentration released at both approaches.

Due to the application of the aeration system Afvalzorg has met the demands of the authorities and confined the nuisance to the nearest housing area and thereby gained her permit. Waste treated by the aeration system had an odour emission of $60 \cdot 10^3$ su$\cdot h^{-1} m^{-2}$. This was a reduction by $301 \cdot 10^3$ su$\cdot h^{-1} m^{-2}$ compared to non-aerated waste. The efficiency obtained by the system was therefore 83 percent. Furthermore the system had a positive effect on the odour itself. The odour released by excavation aerated waste measured by smelling squad members was marked as slightly annoying.

1. INTRODUCTION

In April 2002 Afvalzorg obtained a permit to remediate and re-open the former Zeeasterweg landfill site near Lelystad. Between 1982 and 1995 1.5 million m³ of waste (Table 1) were landfilled without bottom liner or impermeable capping. Afvalzorg acquired the site in 1997 with the obligation to remediate the site. The permit contains the obligation to excavate the old waste and deposit it in modern landfill cells. The new permit allows landfilling of 4.3 million m³ of waste including relocation of the old waste. Any material that can be recycled allows for accepting more new material to be landfilled.

Lelystad is a city, which is expanding rapidly. In a few years from now the distance from the nearest houses to the landfill will only be 500 m. During the procedures of the environmental impact assessment and permit application, the odour emission was the most important issue. The Netherlands for several years have landfill bans and high landfill tax rates for combustible waste.

This means that hardly any degradable organic waste is landfilled. It will not be the new waste that will dominate the odour emission but the excavation of old waste.

Calculations based on available data indicated that under certain conditions nuisance could occur in the nearest housing area. During the procedures the authorities demanded that adequate measures should be taken to prevent such nuisance. At first measures like stopping excavation in unfavourable wind directions and covering the waste were examined. The authorities were not convinced this would be sufficient. Therefore application of landfill aeration prior to excavation was proposed as a measure. Because it was difficult to find data to model the effect of aeration, a test excavation was carried out between October 2001 and February 2002. In total 120.000 m3 of waste were excavated in December 2001 and January 2002. Half the amount was aerated prior to excavation (Figure 1 and Figure 5). For aeration a ambient air aeration system was rented from an Austrian manufacturer. For a description of the system see Scharff et al. (2001).

Table 1. Age and amounts of waste landfilled at the Zeeasterweg landfill.

Year	Soil & gravel	Construction & demolition waste	Commercial waste	Sewage sludge	Street cleansing waste	Household waste	Agricultural waste	Total
1980	54810	10500	2400			13700		81410
1981	44810	9290	4470			28810		87380
1982	34830	8880	5230			27430		76370
1983	22790	9500	9030			22980		64300
1984	21340	9850	18495			29805		79490
1985	17788	7719	16217	3923		31148		76795
1986	6852	11724	21974	3472		31860	2670	78552
1987	7261	13057	25231	4046		33798	2688	86081
1988	14151	21949	31200	1927	820	43612	3773	117432
1989	9429	15662	31433	2028	745	32084	177	91558
1990	10151	22740	27009	3774	1216	36518	8182	109590
1991	25885	18788	19366	3001	3696	41461	10060	122257
1992	40169	9404	23716	2642	1199	42080	8333	127543
1993	63339	5808	19987	2514	4221	40987	9925	146781
1994	80498	6731	21808	3006	126	34427	4251	150847
1995	7475	907	3485	233	7	5597	428	18132
Total	461578	182509	281051	30566	12030	496297	50487	1514518

2. METHODS

2.1. Smelling Squad

It is not practical to take odour samples for delayed olfactometry from landfills due to size and unknown airflow. Therefore the smelling squad method is chosen to determine the odour emission of the landfill before and after aeration. The walking method using smelling squads is explained in detail in Anon. (1994) and is briefly described below.

Figure 1. Excavation of non aerated waste at Zeeasterweg landfill

Figure 2. Installation of the aeration system

A smelling squad consists of one co-ordinator and six certified smellers according to NVN2820. A certified smeller has an “average nose” with respect to the reference gas butanol. On each measuring day—before the actual measurement—the odour of the source is smelled close by the source so the whole squad is able to distinguish the landfill odour from other odours present. Each measurement consists of walking along six to eight lines at various distances leeward of the landfill and perpendicular to the wind direction (Figure 3).

Figure 3. Smelling squad in action

The smellers take note of the current odour strength on paper on each line every 20 seconds according to the measuring scale in Table 2.

Table 2. Measuring scale of odour strength used in smelling squad measurements.

Intensity	Description	Counts as
0	No Odour observed.	–
1	Odour is weakly observed.	+ –
2	Odour is observed without doubt.	+
3	Odour is strongly observed.	++

The lines are chosen by the co-ordinator so, that (close by the source) the whole squad has observed intensity 2 and (at greater distances) most of the panel has observed intensity 0 or 1.

The smelling distance is by definition the distance at which half of the squad smells the odour. This is defined as the same number of scores + and – at an interpolated distance. The concentration at the smelling distance is per definition 1 smelling unit per m^3 ($su \cdot m^{-3}$). The odour emission is calculated from the smelling distance by a short-term Gaussian dispersion model with an averaging time of 600 s.

To perform a smelling squad measurement meteorological parameters must be within specified limits. The wind speed measured at a height of 10 m must be in the range of 3 to 10 $m \cdot s^{-1}$, the wind direction must be stable during the measurements and no measurements are allowed during or within 15 minutes after precipitation.

During modelling of odour dispersion a worst case scenario was set out. This scenario beholds the excavation of waste at hill 3 and landfilling of compartment B simultaneously. Hill 3

and compartment B are situated nearest to the housing area (housing area indicated as area 1 in Figure 6).

2.2. Hedonic scale

To determine the pleasantness of an odour a hedonic survey is carried out. The smelling squad notes the pleasantness of the odour for the highest concentration observed on each line on the scale ranging from extremely pleasant (+4) through neutral (0) to extremely unpleasant (–4). From these measurements the squad average pleasantness of the odour is calculated for each line. The short-term dispersion model calculates the odour concentration on each line. Next, the relation between concentration and hedonic scale is determined. From this relation the odour concentrations for H=–1 and H=–2 are calculated. Table 3 illustrates that when H=–2 is reached at higher concentrations this indicates a less annoying odour.

Table 3. Concentration at H=–2 and annoyance potential.

Concentration at H=–2 [su·m^{-3}]	Annoyance potential
<1.5	Very annoying
1.5–5	Annoying
5–15	Mildly annoying
15–50	Slightly annoying
>50	Not annoying.

Based on the concentration at H=–2 and the corresponding annoyance potential in Table 3 authorities might specify limits on concentration levels.

In this case the authorities have set the criteria for the nearest housing area the Villapark at H=-1 and 99.5% confidence interval divided by two. The authorities have set the criteria for the area with industrial activities (indicated as 2 in Figure 6) located between the Villapark and the Zeeasterweg landfill at H=-1 and 95% confidence interval.

3. RESULTS

Smelling squad campaigns were carried out by Buro Blauw on December 12, 2001 and January 22, 2002.

3.1. Non aerated waste

The average calculated odour emission caused by the excavation of non-aerated waste is $108 \cdot 10^6$ su.h^{-1}. The confidence interval and variance of the different measurements for non aerated waste is not given. The measurement by the smelling squad was carried out only once. Comparison of odour emissions at hill 3 and other non-aerated waste at Zeeasterweg showed that the confidence interval and variance can be considered equal. The concentration belonging to the hedonic value H = -1 is 0.7 su·m^{-3}. The concentration corresponding to the hedonic value H = -2 is 1.7 su·m^{-3}.

3.2. Aerated waste

The average calculated odour emission caused by the excavation of the aerated waste with the Smell Well System (Figure 5) is $15 \cdot 10^6$ su.h^{-1}.

Figure 5. The aeration of waste

The 95 percent confidence interval is within the range of $11.4 \cdot 10^6$ su.h^{-1} and $21.0 \cdot 10^6$ su.h^{-1}. The concentration of odour with value H = -1 is 1.9 su·m^{-3} with a variance ranging from 1.5 and 2.2 su·m^{-3}. The concentration of odour with value H = -2 is 11.0 su·m^{-3} with a variance ranging between 5.4 and 14.3 su·m^{-3}.

An overview of the odour emission measurements of both the non-aerated as the aerated waste at landfill hill 3 is given in Table 4.

Table 4. Overview of odour emission measurements for aerated and non-aerated waste

		Aerated	Non aerated
Date	-	12/12/01	22/01/02
Run	-	1	2
Distance	m	264	595
Odour emission	10^6 su·h^{-1}	15	108
Excavation surface	m^2	250	300
Odour emission	10^3 su·m^{-2}h^{-1}	60	361
Concentration H =-1	su·m^3	1.9	0.7
Concentration H=-2	su·m^3	11.0	1.7

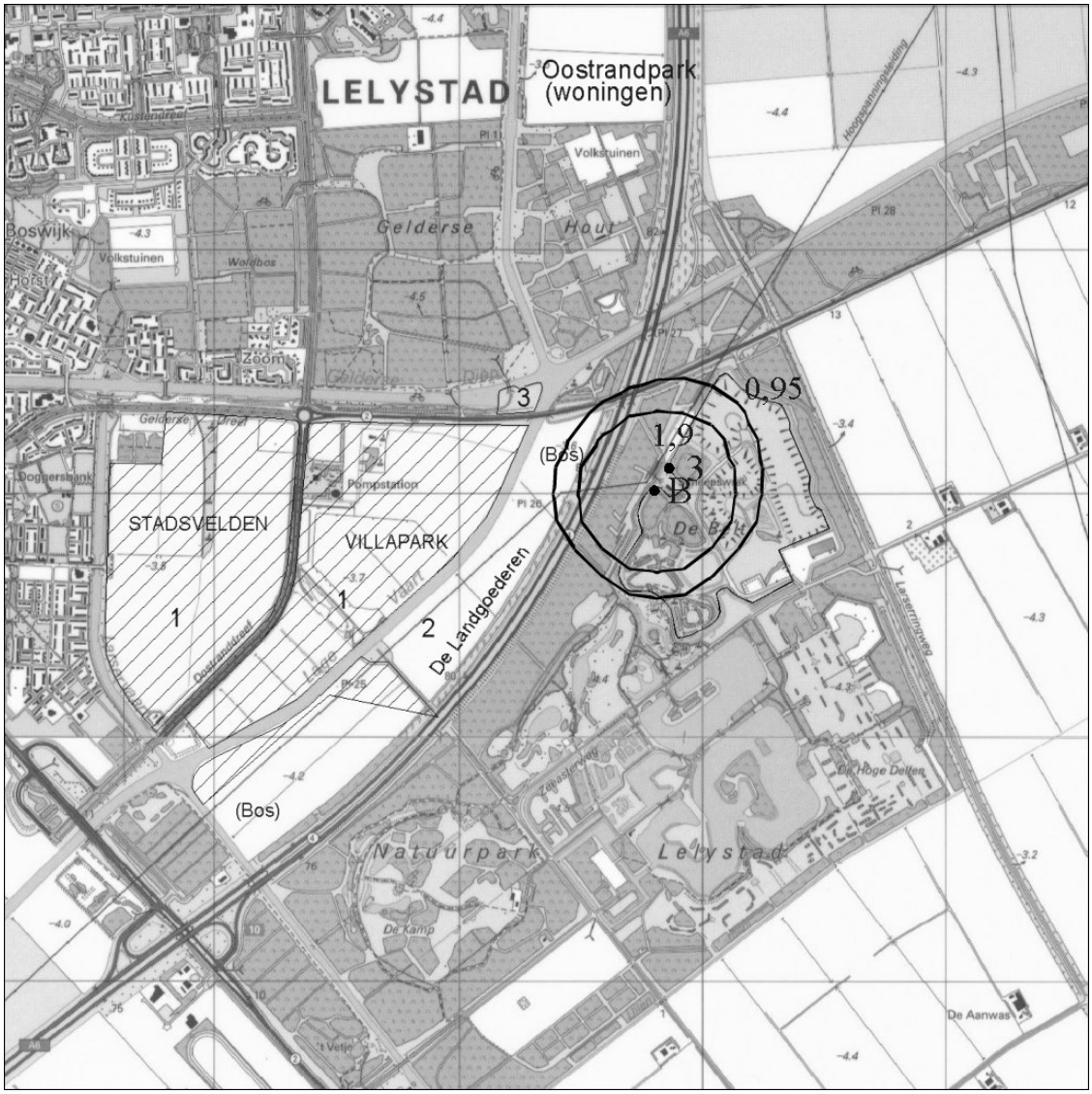

Figure 6. Odour concentration plot of H=-1 and 99.5% confidence interval (1.9) and H=-1 and 99.5% confidence interval divided by two (0.95)

In order to visualise whether the emission limits specified by the authorities are achieved during the pilot, data were modelled with the KEMA model (Anon., 1994). This model generated an odour concentration contour plot for H=-1 and 99.5% confidence interval and H=-1 and 99.5% confidence interval divided by two (Figure 6). The plot shows that the odour concentration does not extend to the Villapark north the area with industrial activities.

4. CONCLUSION

As shown in Figure 6, Afvalzorg has met both criteria specified by the authorities and thereby gained a permit for re-opening the former Zeeasterweg landfill in Lelystad. Afvalzorg confined the nuisance to housing areas and areas with commercial activities by aeration of waste. The reduction of the odour emission with the aeration system has proven to be successful. The odour emission was $60 \cdot 10^3$ su$\cdot h^{-1} m^{-2}$, which was a reduction by $301 \cdot 10^3$ su$\cdot h^{-1} m^{-2}$. Therefore the

efficiency of odour reduction by the aeration system was 83% under the assumption that the odour emission was proportional to the excavation area.

Furthermore landfill aeration had a positive effect on the odour itself as well. The concentration whereas the odour was marked as only slightly annoying rised from 0.7 $su \cdot m^{-3}$ to 2.2 $su \cdot m^{-3}$. This increase in concentration means that fewer people of the smelling squad mark the detected odour as slightly annoying.

REFERENCES

Anon.(1994), Document Measuring and Calculating odour (in Dutch), Ministerie van VROM, *Publikatiereeks lucht & energie*, nr. 115.

NVN2820 (1995 and 1996), Air quality. Sensory odour measurement using an olfactometer, *UDC* 543.271.2:628.52 and *ICS* 67.240, Nederlands Normalisatie-instituut, Delft, The Netherlands.

De Gier, C.W. (2001), Smelling squad measurements Zeeasterweg landfill, Buro Blauw. Wageningen, The Netherlands.

Rettenberger, G. (1998), Rückenbauen und Abgraben von Deponien und Altablagerungen, *Verlag Abfall aktuell*, Stuttgart, Deutschland, pp 99 –130.

Scharff, H., Oonk, J.,Vroon, R., Van der Sloot, H.A., Van Zomeren, A., Hensen, A. (2001), Improved methane oxidation by means of forced aeration under a landfill cover, *Sardinia Proceedings 2001*, Eight international waste management and landfill symposium, pp 555 – 564.