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Impact of Technological Solutions and Operating Procedures on Odour Nuisance of Municipal Solid Waste Landfills in Poland

Andrzej Kulig, Krystyna Lelicińska-Serafin, Grzegorz Sinicyn
Warsaw University of Technology, Faculty of Environmental Engineering
ul. Nowowiejska 20, Warsaw, Poland

This paper analyses 537 municipal solid waste (MSW) landfills operated in Poland in terms of methods employed to handle the collected landfill gas, how leachate is collected and handled, application of insulating intermediate layers, and the influence of those factors on the olfactory impact. Quantitative and qualitative examinations were executed with the regard of the technological solutions and applying operation procedures. The odour nuisance of most examined facilities was assessed by respondents (employees of the facilities) as low, or the facilities were considered to be without any odour impact at all: respectively 50% (269 out of 537) and 47% (254 out of 537) of the examined landfills. Remaining facilities were characterized as noxious (8 out of 537) or very noxious (6 out of 537) in olfactory terms, but they accounted merely about 3% of the landfills covered by the questionnaire survey.
Out of the examined group of 537 landfills operated in Poland, receiving municipal solid waste, only 12 facilities (accounting for 2% of the examined facilities) were distinguished, demonstrating simultaneously the following characteristics: low or non-existent olfactory noxiousness, landfill degassing combined with burning of the collected landfill gas or using it for power generation purposes, landfill bottom sealing, and daily covers. In the case of most aforementioned facilities (11 out of 12) local population did not complain about the olfactory noxiousness.

1. Introduction

Activities aimed at reduction of odorant emissions and the noxiousness of the olfactory impact, as well as attempts to regulate this subject area in Poland by legal means require, among other things, more information about the odorant sources in municipal management facilities. Waste treatment plants, including landfills, are potential sources of odorants emissions, wherethrough these objects can be nuisance for both the employees and neighbouring inhabitants, as well as important cause of public complaints to the authorities (Petts and Eduljee, 1996). Assessment and control of odour nuisance generated by municipal landfills due to the character of fugitive sources of pollution is a complex research task (Casey et al., 2008; Nicolas et al., 2006).
Uncontrolled landfill gas migration can be a major problem at a MSW landfill. Gas emission control becomes more common for environmental and regulatory reasons. The

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gas must be controlled to avoid explosions and vegetation damage in the vicinity of the landfill. Venting is also usually done to minimize the potential of odor problems.
Leachate treatment options include on-site treatment, discharge to a municipal sewage treatment plant or a combination of these approaches. Some studies have indicated that leachate recirculation has certain benefits, which include increasing the rate of waste stabilization, improving leachate quality and increasing the quantity and quality of methane gas production (EPA, 1995). Solid waste should be covered at the end of each operating day to prevent exposing the waste to birds, insects and rodents. Cover material also reduces the exposure of combustible materials to ignition sources, reduces odors and controls blowing litter. The goal of conducted research was to answer, how above mentioned processes can influence on olfactory noxiousness of Polish landfills.

2. Materials and Research Methodology

An identification and inventorying of MSW dumping sites in Poland were made using various source date. The data about the landfills operated in Poland which are or could potentially be olfactory substances (odorants) emitters came from a large number of sources offering varying levels of quality and detail. The only common feature of all those sources was the unavailability of direct information about the location of a given facility. Since there were no data about coordinates of a given facility available, it was necessary to use its address information (street and property number, location, Gmina, Poviat). In order to find the coordinates navigation maps were used which could give geographical and/or cartographic coordinates in response to an address data input. As a result of that work over 1,400 landfills were catalogued.
In order to collect technical and technological data and data on the odour nuisance of the facilities listed in the database, an attempt was made to conduct a questionnaire survey for each facility. The questionnaire (script) developed for the landfills contained 11 formal and general questions, 8 about the characteristics (parameters) and 10 about the odour nuisance of a given facility. The methodology employed to catalogue the solid waste management facilities operated in individual Voivodships is described in detail in the paper by Kulig et al. (2008). A preliminary database, created after the record de-doubling and updating procedure, was used as a contact and address database for the purposes of the survey based on the Computer Assisted Telephone Interviewing (CATI) method. Characteristic and odorous assessment of landfills were conducted with survey throughout Poland in the period of November to December 2007 and January to February 2009. Locations of 537 individual catalogued landfills covered by the questionnaire survey can be found in Figure 1.

3. Research Results

3.1 Type of degassing plant and method of handling the landfill gas

In the course of the questionnaire survey covering 537 landfills in Poland, a degassing process carried out during operation of a landfill was recorded in the case of 265 facilities (49%). In a majority of cases vertical degassing wells were used.

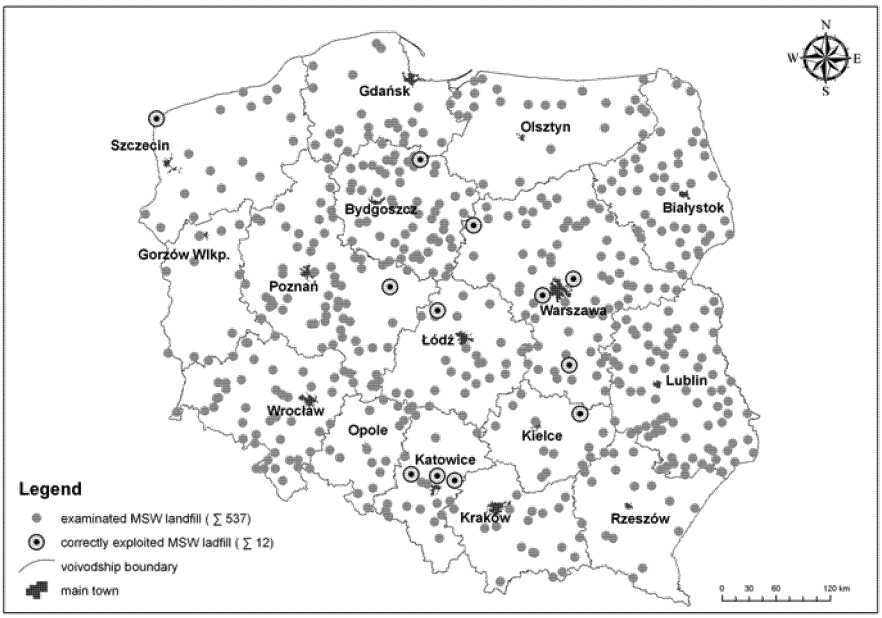

Figure 1. Locations of individual MSW landfills in Poland covered by the questionnaire survey. The landfills which are correctly operated in terms of degassing, leachate handling and insulation layers are highlighted.

Further landfill gas handling included its discharging into the atmosphere (applied in violation of legal regulations), burning in torches or using for energy generation purposes. Most landfill sites evaluated as very noxious in olfactory terms are not subject to degassing in the process of their operation (5 out of 6). Half the facilities considered to be noxious in olfactory terms are subject to degassing (4 out of 8) and the collected landfill gas is burned in a torch (1 out of 4), or used in a power generator unit (1 out of 4) or discharged into the atmosphere (2 out of 4). Also half the examined landfill sites, evaluated as hardly noxious or without any odour impact at all (51% and 48% respectively), is subject to degassing. Landfills where the landfill gas is discharged into the atmosphere predominate (44% and 39% respectively); in the remaining facilities the landfill gas is burned in torches or used as energy source. It is important to point out that on landfill sites evaluated as facilities without any olfactory impact at all a slightly smaller number of the cases of incorrect landfill gas handling was recorded (discharging into the atmosphere) – see Table 1. Therefore a landfill site degassing is an effective method of reducing the odour nuisance of the landfill only if degassing is done in a correct manner, i.e. if the collected landfill gas is subsequently burned or utilised. The collection of the landfill gas and its further discharging into the atmosphere contributes to reduction of the fire or explosion hazards, however it does not decrease the odour impact of the facility.

Table 1. Degassing of MSW landfills in Poland set against their olfactory noxiousness

	Declared odour nuisance of examined landfill sites				Total examined landfills
	High	Medium	Low	No odour	
Share of landfills equipped with a degassing system	1/6	4/8	137/269 (51%)	123/254 (48%)	265/537 (49%)
Method of handling the collected landfill gas:					
burning in torches	0	1	11/269 (4%)	7/254 (3%)	19/537 (3%)
using for power generation	0	1	7/269 (3%)	10/254 (4%)	18/537 (3%)
discharging into the atmosphere	1	2	119/269 (44%)	101/254 (39%)	223/537 (42%)
no data	0	0	0/269 (0%)	5/254 (2%)	5/537 (1%)

3.2 Method employed to collect and handle leachates from the MSW landfills

In Poland landfill sites with sealed bottom predominate. They account for 79% of all the examined landfills. But information about organised leachate management was obtained only for about 62% of the examined facilities. In most cases the leachates collected in tanks are (in 38% of the facilities) removed to external wastewater treatment plants. In the remaining cases further processing takes place on the premises of the landfill, usually in a local wastewater treatment plant or by means of recirculation (spray irrigation) in 14% and 9% of the facilities covered by the questionnaire survey respectively. On the basis of the results produced by the survey one can concluded that collection of leachates in open tanks and their treatment on the premises of a landfill increases the odour nuisance of the facility, see Table 2.

3.3 Application of insulating intermediate layers in operation of the MSW landfills

In the course of the questionnaire survey covering 537 landfill sites in Poland, information was obtained about application of insulating intermediate layers (technological intermediate layer) in the process of landfill site operation in 498 facilities (93%). However the recorded frequency of this exercise varied substantially: from making such layers on a daily basis (which is a correct solution) to doing it once within 5 years.

Solid waste is covered on the end of each operating day only in 42 facilities (8%), and it is covered at least once a week in 82 landfill sites (15%). In the remaining cases the insulating intermediate layers are applied less frequently than every week (Table 3). In the answers provided by the respondents the frequency of putting the technological layers is not always identified in a comparable way. The frequency is characterised is relation to a timescale or the thickness of the solid waste to be covered and this characterisation makes it more difficult to interpret the results. Further questionnaire surveys should aim at obtaining more precise answers.

Moreover it is important to point out that the awareness of the effectiveness of the insulating intermediate layers applied as a method of preventing the odour nuisance is low. In spite of the fact that the technological intermediate layers are applied in 93% of the examined landfills, only in 36% of the landfills this action was defined as a component of the odour emission reduction system.

Table 2. Leachate management system set against the odour nuisance of landfill sites receiving other solid waste than hazardous or neutral one in Poland

	Declared odour nuisance of examined landfill sites				Total examined landfills
	High	Medium	Low	No odour	
Share of landfills equipped with sealed bottom					
	4/6	6/8	212/269 (79%)	200/254 (79%)	79% (422/537)
Share of landfills for which information about leachate management was obtained					
	3/6	6/8	176/269 (65%)	147/254(58%)	332/537 (62%)
Leachate collection method:					
in an open tank	0/6	3/8	92/269 (34%)	63/254 (25%)	158/537 (30%)
in a closed tank	2/6	3/8	78/269 (29%)	84/254 (33%)	167/537 (31%)
no data	1/6	0/8	6/269 (2%)	0/254 (0%)	7/537 (1%)
Further handling of leachate:					
removal to an external wastewater treatment plant	2/6	3/8	106/269 (39%)	94/254 (37%)	205/537 (38%)
treatment on the facilities premises	1/6	1/8	47/269 (17%)	27/254 (11%)	76/537 (14%)
recirculation	0/6	1/8	23/269 (9%)	24/254 (9%)	48/537 (9%)
no data	0/6	1/8	0/269 (0%)	2/254 (1%)	3/537 (1%)

Table 3. Application of insulating intermediate layers set against the odour nuisance of landfill sites receiving other solid waste than hazardous or neutral one in Poland

	Declared odour nuisance of examined landfill sites				Total examined landfills
	High	Medium	Low	No odour	
Share of landfills with wastes covered by insulating intermediate layers					
	6/6	8/8	253/269 (94%)	231/254 (91%)	498/537 (93%)
Frequency of insulating intermediate layer application:					
at least once a week	1/6	3/8	44/269 (16%)	34/254 (13%)	82/537 (15%)
as daily cover	1/6	2/8	24/269 (9%)	15/254 (6%)	42/537 (8%)

4. Discussion

Degassing during operation of a landfill is done in 49% of the examined landfill sites in Poland. To this aim, mainly vertical wells are used, and further landfill gas handling involves, first and foremost, its discharging into the atmosphere (in over 40% of the degassed facilities). In the remaining cases the landfill gas is burned in torches or used for power generation purposes. This solution is an effective measure reducing the odour nuisance of the landfill sites. Discharging of the landfill gas into the atmosphere contributes only to reduction of the fire or explosion hazards, but it does not decrease the odour impact of the facility.

Most examined landfill sites (79%) is equipped with a sealed bottom system, but information about organised leachate management was obtained only for 62% of the examined facilities. Collection of the leachates in closed tanks limits the olfactory

noxiousness. In the case of solutions based on open tanks and leachate treatment on the premises of a landfill, a greater odour impact on the neighbourhood was recorded.
A substantially varying frequency of the insulating intermediate layer application during operation of the examined landfills was recorded. The daily covers are made only in 8% of the facilities, or with a frequency of at least once a week in 15% of the landfills. In the remaining cases the technological intermediate layers are made less frequently than once a week. Only in the case of 36% of the facilities the application of intermediate layers was defined as a component of the odour emission minimisation system.

5. Conclusions

The questionnaire survey conducted in Poland for 537 landfills of solid waste other than hazardous or neutral one made it possible to formulate the following conclusions:

1. Collection of landfill gas, combined with its simultaneous burning or using for power generation, and collection of leachates in closed tanks and periodical removal of the leachates to an external wastewater treatment plant should be numbered among the most effective measures reducing the odour nuisance of landfill sites.
2. Low awareness of the effectiveness of the insulating intermediate layers applied during landfill operation as a method of preventing the odour nuisance was found.
3. Only 2% of the examined landfills receiving municipal solid waste show the following combination of characteristics: sealed bottom, daily application of insulating covers, degassing combined with subsequent burning of the collected landfill gas or using it for power generation, and low or non-existent odour nuisance.

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