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Development of a system for the continuous monitoring of odour annoyance from a waste centre

Mona Arnold
VTT Technical Research Centre Finland
P.O.Box 1000, FI-02044 VTT Finland

Juha Uuksulainen
YTV Helsinki Metropolitan Area Council
P.O.Box 521, FI-00521 Helsinki Finland

Tuula Kajolinna
VTT Technical Research Centre Finland

Kuusisto Sari
VTT Technical Research Centre Finland

This paper concerns a practical approach for on-line monitoring of the odour load from a large waste centre for municipal solid waste. The waste centre included a composting plant, a large municipal solid waste landfill as well as a site for recycling of construction waste.

Possessing comprehensive existing data on the odour, the waste centre still called for an on-line tool demonstrating the immediate effect of the activities on the landfill on the odour annoyance perceived by the inhabitants in the neighbourhood.

By combining several data sets; the number and timing of odour complaints from the inhabitants, total reduced sulphur (TRS) concentration in the ambient air at the waste centre, local weather conditions and data from population studies and field investigations, a correlation could be drawn between the ambient TRS-concentration measured at the site and the general annoyance perceived in the environment.

TRS-monitoring at the site functions as an on-line tool for the waste site itself to indicate the load of its activities to the environment diminishing the need for expensive and time requiring field investigations. An average TRS-value can thus be selected as a marker for a supportable number of complaints /month and as an indicator of the average odour load (percentage of total time) in the neighbourhood.

Furthermore, data analysis of TRS-monitoring results and concurrent meteorological data showed a relationship between the outdoor temperature as well as wind speed and the odour load caused by landfill gas fugitive emissions.

1. Introduction

Landfill sites pose significant management challenges. One of the key issues concerns odour emissions – they can be a major cause of public opposition to the existence of landfills. Odour emissions from waste centres originate generally from a number of diffused sources at the site, and therefore the only reliable means for measuring the odour load rely traditionally on quite laborious field investigation and population panel methodologies.

This paper concerns a practical approach for on-line monitoring of the odour load from a large waste centre for municipal solid waste. The approach was based on an investigation of the relationship between ambient concentration of total reduced sulphur (TRS) measured at the site, the number of odour complaints to the waste management organisation and the results of field investigations and a population survey performed in the surroundings of the site The aim was to be able to use TRS-concentration as an indicator for the odour load from the waste centre.

Reduced sulphur compounds are commonly regarded as the major odour components in emissions from anaerobic degradation of organic material. Nevertheless, waste handling and particularly biowaste processing emit a number of other odorants with low odour threshold as well, eg. aldehydes, alcohols, ketones, volatile fatty acids, terpenes and ammonia compounds, which in unfavourable conditions likewise pose a significant risk for odour annoyance (e.g. Rosenfelt *et al.* 2004).

2 Site description

The main landfill in Helsinki area – Ämmässuo - is the largest disposal site in Nordic Countries with a total area of 150 hectares. The heaping area in use covers some 50 hectares. The site was taken in use in 1987 and until the end of 2006 the volume of waste disposed was over 9 million tonnes. Yearly, it receives some 600 000 t of waste, half of which is municipal solid waste. In addition to the landfill, the waste centre also includes a composting plant for source separated household biowaste (ca 30 000 tn/a). The composting plants consisted of precomposting in closed tunnels and aftercomposting outdoors in windrows.

The main odour sources at the waste centre are diffuse landfill gas emissions, the open waste fill area and the biowaste composting plant. At this specific site the concentration of hydrogen sulphide in the landfill gas was quite high (~ 600 ppm). The odour threshold of hydrogen sulphide is very low and even minor gas leakage has a potential for having an extensive detrimental effect on the perceived air quality outside the waste centre. Despite extensive gas recovery and landfill cover, diffuse emissions occasionally occur, caused by physical and biochemical processes and changes naturally taking place inside the heap.

3. Odour determination methods

3.1 Monitoring of total reduced sulphur

For identification of the main odour sources at the site a monitoring station for ambient concentration of total reduced sulphur (TRS) had been installed The location of the monitoring station was selected based on the general wind direction and the location of the main odour sources. It was positioned downwind from the landfill (225 °) between the waste heap and the biowaste plant (figure 1). Consequently the contribution from the main odour sources could be distinguished.

TRS was monitored with a continuous sulphur dioxide analyser (Thermo 43i) based on UV fluorescense. Before analysing, the sample was led into a converter (Measurement technologies Model 1000), where the TRS compounds sample was oxidised to sulphur dioxide. The result was corrected by the ambient air sulphur dioxide concentration, which was monitored as well. The monitoring station also included a meteorological station measuring wind speed and direction, temperature, humidity and ambient air pressure.

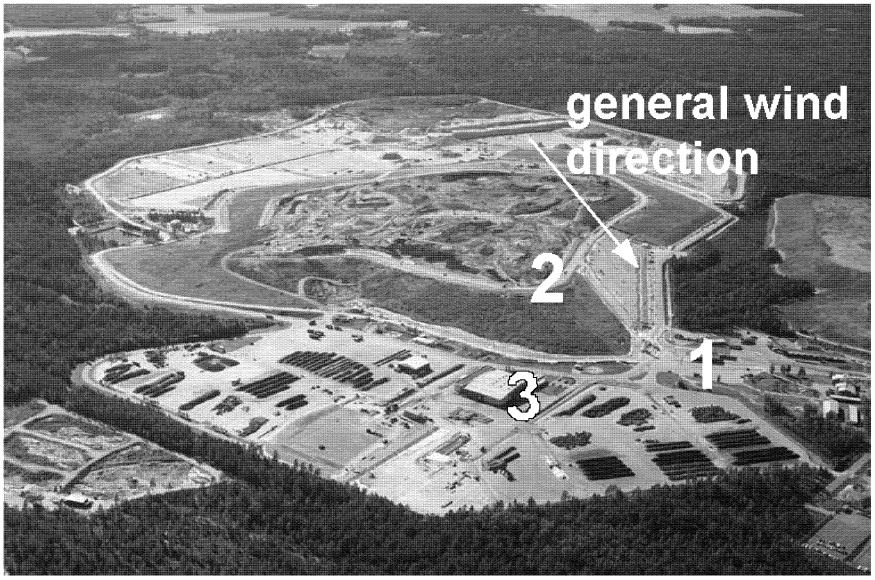

Figure 1. Ämmässuo waste centre. 1) TRS measurement station 2) Landfill 3) Biowaste composting plant.

3.2 Odour load in the surroundings of the waste centre - Field investigations and population studies

The odour load in the environment of the waste centre had been monitored by field investigations 2000, 2002, 2003, 2005-2006 and 2007. An independent team of trained observers did the measurements downwind from the waste centre in a systematic fashion, determining odour frequency, quality and strength according to a method described in the German guideline VDI 3940 (VDI 1993a). Based on the observations the odour frequency of odour emitted by the waste centre was determined on different distance zones around the waste centre. The investigation covered an area extending to 5 km from the waste centre.

Odour annoyance caused by the waste centre had been determined in 2004-2005. A panel of 40-50 inhabitants recorded the odour situation in their home surroundings during seven months. From the data odour annoyance as the proportion of inhabitants perceiving odour nuisance was determined according to the German guideline VDI 3883 (VDI 1993b). This survey covered also and area extending approximately to 5 km from the waste centre.

3.3 Odour complaint data

Feedback and complaints relating to odour emission had systematically been recorded and processed since 1999 as a part of the waste organisation's general environmental and quality system.

3.4. Data collection and processing

The TRS results was organised by wind direction for identification of odour sources at the site and the results were analysed for relationships between meteorological factors and perceived odour in the surroundings.

4. Results

4.1 Meteorological data and TRS emissions from the landfill

The ambient TRS-concentration measured in wind direction from the landfill (210 - 240 °) was averagely higher compared to the values measured in other directions. For investigation in meteorological factor eventually influencing landfill gas emissions, only data in the wind direction 210-240° was processed. Then a weak negative correlation between TRS and concurrent temperature as well as between TRS and wind speed was noticed. Further analysis showed that the ambient TRS concentration was averagely doubled at temperatures below zero. Also the TRS-concentration at low wind speed, < 1.5 m/s, was significantly higher than at less stable atmospheric conditions. Lastly, there was no clear difference was noticed between TRS measured at high and low atmospheric pressure (table 2).

Table 1. Correlation of ambient TRS-concentration and meteorological data. hourly average, N = 4278.

factors	correlation
TRS - temperature	- 0.24
TRS - wind speed	- 0.40
TRS - air pressure	0.02

Table 2. Average concentration of total reduced sulphur from the landfill in different meteorological circumstances.

	ug/m³	N
Average TRS, t >0	7,3	3828
Average TRS, t < 0	3,6	450
Average TRS, wind speed < 1.5 m/s	10,7	281
Average TRS, wind speed > 1.5 m/s	3,2	3997
Average TRS, atmospheric pressure < 1013 mbar	3,9	3391
Average TRS, atmospheric pressure > 1013 mbar	4,4	887

4.2 Correlation between TRS, odour frequency and number of complaints

Figure 2 shows the results from field investigations performed in the environment of the waste centre (< 5 km), number of odour complains registered and the average TRS-concentration measured in wind direction from the landfill. Figure 3 again compares the results from the population study and TRS –monitoring.

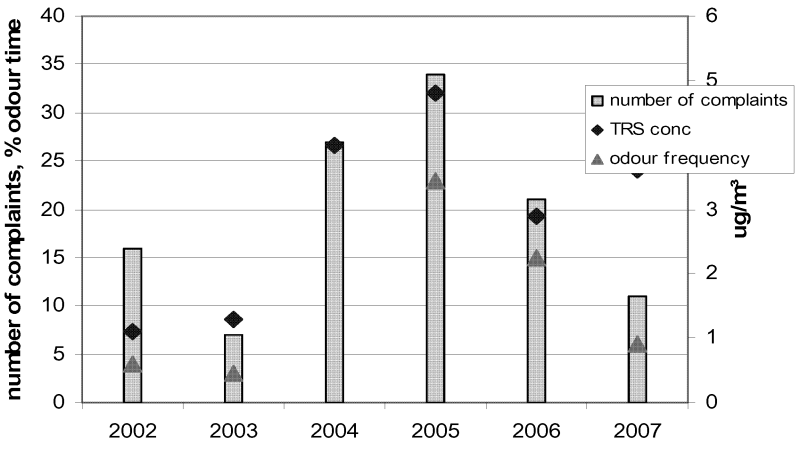

Figure 2. Number of odour complaints/year, odour frequency determined by field investigations and average TRS-concentration down wind from the landfill.

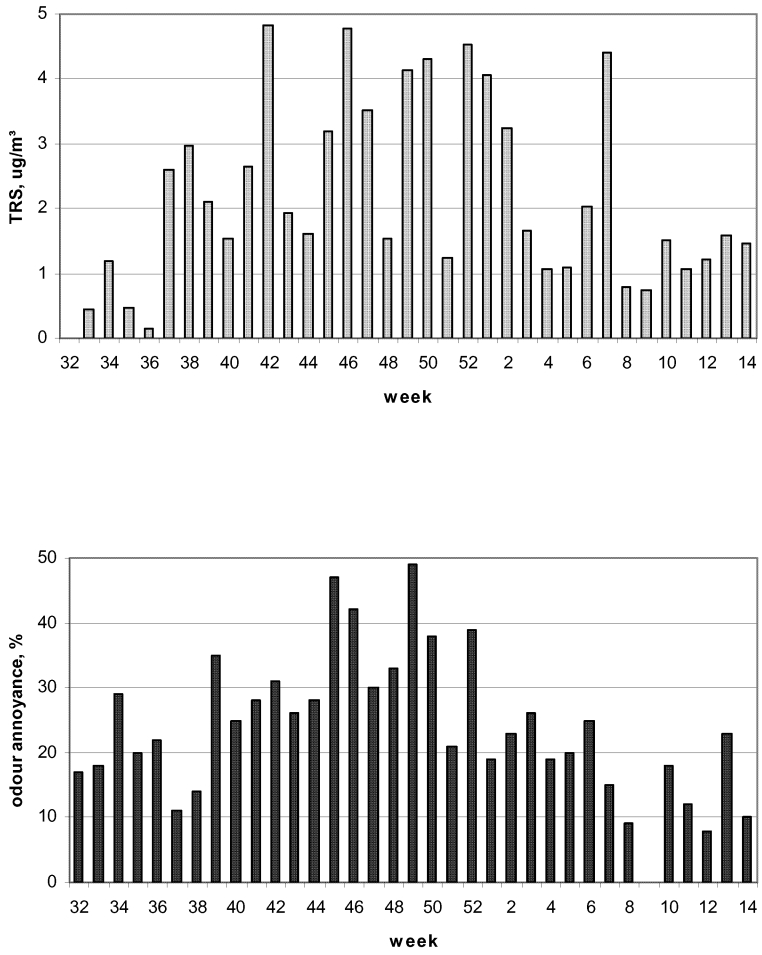

Figure 3. Ambient TRS-concentration at the site (above) and proportion of inhabitants experiencing odour annoyance (below). Measurement period 1.8.2004-31.3.2005.

The pictures show quite a good correlation between the results for odour frequency and number of odour complaints to the waste centre. The concentration of TRS in the ambient air at the waste centre seemed in this case also to correlate (0.56) with the perceived odour annoyance, and is a very good potential indicator of odour annoyance in the environment.

The use of TRS as an odour indicator for waste centres presumes naturally that reduced sulphur compounds containing landfill gas is the main odour source. Emissions from e.g. composting windrows or disposed organic waste can contain very odorous non-

sulphur compounds as well, weakening the relationship between TRS and odour. According to the results from field investigation landfill gas was the main odour contributor, but the proportion varied somewhat throughout the years. The landfill was identified as the odour source in 65 % (2007) to 94 % (2002) of all odour observations.

4. Conclusions and discussion

Landfill gas containing high concentration of hydrogen sulphide poses a significant odour risk in the environment. TRS monitoring proved to be a useful tool for on-line monitoring of odour nuisance from a landfill. Based on the correlation between measured odour load, number of odour complaints and ambient concentration of TRS an average TRS-value can be selected as a marker for a supportable number of complaints /month and as an indicator of the average odour load (percentage of total time) in the neighbourhood. This serves as an on-line tool for the waste centre site itself to indicate the load of its activities to the environment diminishing the need for expensive and time requiring field investigations.

Data analysis did not support a common theory that the ambient air pressure influences the risk for fugitive landfill gas emissions. Neither was there a relation between increased humidity and increased TRS-emissions. The wind speed and the temperature had though a clear effect on odour caused by landfill gas emissions. The concentration of total reduced sulphur measured on the site doubled on the average when temperature dropped below zero.

A reason for this phenomena can be that the landfill top layer – which to a large extent included compost - functions as a biofilter, oxidising odorous sulphides to less odorous sulphate. Biological activity, in this case degradation of TRS-compounds significantly slows down in with lower temperature, thus increasing the risk of odour annoyance caused by landfill gas fugitive emissions.

Wind speed correlated negatively with measured TRS. At high wind speed the odour emission is more efficiently dispersed and concentrations diluted. The influence on wind speed on odour dispersion has also been identified eg. by Schauberger *et al.* (2001), who showed that risk for occurrence of odour around an odour source is highest when the wind speed is 1–1.,5 m/s.

Acknowledgement
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