Different approaches to measure environmental odours emitted by landfill areas

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Abstract

This paper presents different methods to assess the odour emission and the odour annoyance in the surroundings. It is shown, on the example of landfill areas and composting facilities, that chemical analyses are helpful to identify key compounds of the odour release, and to set up the specification of a monitoring instrument. Sensitive methods, like dynamic olfactometry or sniffing team investigation, are mainly applicable to provide a global odour plume or an average annoyance zone. And the electronic nose can supply a warning signal to the plant manager or a real time estimation of the annoyance zone.

Introduction

Electronic noses were initially introduced as instruments able to mimic the human olfactory system. The vocabulary analogies and the similarities of the objectives and of the approaches contributed to ambiguity and to make believe that the artificial nose could compete with the human nose. But, it can be applied to any source which releases volatiles, whether they smell or not, provided that this occurs within the sensitive range of the sensors, which is rather narrow compared to human nose one.

This paper presents different approaches to measure the odour on the specific case of landfill areas. It shows original ways of adapting some usual methods and tries to deduce the particular niches for each of them in the frame of the current trends of regulation or guidelines in various countries. In Europe, there is indeed a trend towards quantitative air quality criteria for odours, using dose-effect studies to determine a level where 'no justified cause for annoyance' exists. That is to say that limits are generally prescribed at the immission level and not near the source. The exposure criteria to be respected near the receptor is translated into numerical value as an odour concentration (in ou/m^3) with one hour averaging and a given percentile compliance (e.g.: $C_{98,1\ hour} < 2$ ou/m^3).
A precondition for this approach is the availability of odour measurement techniques with a known uncertainty that is sufficiently small for use in a legal framework [1].

Now, few measurement techniques are adapted to assess odour in the field, far away from the source, where odour and chemical concentrations are very low. Particularly, electronic noses should be improved in order to preconcentrate the analytes prior the investigation.

In practice, exposure values are only obtained by atmospheric dispersion modelling, with suitable meteorological data. However, the odour emission rate needed by the model can be assessed by chemical analyses, sensitive methods or by electronic noses.

Experimental

Different odour investigation methods were applied to 9 landfill areas in Wallonia (South of Belgium), which is a region characterised by quite homogeneous climatic conditions, with prevailing wind directions NE and SW. Two of the investigated landifll sites include also organic waste composting facilities, with a specific odour which is mixed with the fresh waste one.

A first method to estimate the chemical composition of the emission and the concentrations of main compounds is gas chromatography-mass spectrometry (GCMS). Air above waste surface is sampled on Tenax and Spherocarb cartridges and analysed with TD-GC-MS.

A second investigation method is dynamic olfactometry, which uses a panel of 6 persons sniffing different dilutions of the odour, according to european standard EN13725 [3]. The emitted odour must be sampled through a dynamic flux chamber. We used a circular chamber with a cross section of 0.2 m^2 and a sampling flow rate of 6 l/min. The subsequent analysis is made in our lab with Odile olfactometer (Odotech, Canada).

In the field, a third and original method is also used. It is an adaptation of the method of sniffing team campaigns [4] to the particular case of fresh waste odours. The method is based on the field determination of odour perception points, followed by a data processing with a bi-Gaussian-type model, adapted to handle the odours (Tropos, Odotech, Canada). In a first step, field observers delineate the region in which odour impact is experienced. The typical duration of a sniffing field inspection is from 20 to 60 minutes. In a second step, the emission rate is manipulated in a dispersion model until the predicted size of the impact zone matches that observed in the field.

Portable electronic noses are also placed in the surrounding of the tipping area. Different self-made instruments are used: they all consist in battery powered sensor arrays and PC boards.

Results and Discussion

Chemical analyses

Several chemical analyses were performed on landfill areas and composting facilities. Hundreds of different compounds are identified in the samples. Among them, limonene is the most typical chemical involved in the gas emission from solid wastes and could be a "key compound" to monitor that kind of odour, even if the global waste odour tonality is the result of a complex mixture of many chemicals. Nevertheless, limonene is released in large amounts to the atmosphere from many biogenic and anthropogenic sources and its detection is not an evidence of an odour of fresh waste.

In any case, chemical analyses can help to the selection of correct monitoring instruments; for example, it is particularly useful for the selection of sensors in an electronic nose. Another application of "analytical" methods on landfill areas is the field screening with portable flame ionization detector (FID) instrument. It is particularly useful to localize emission spots or leaks in landfill gas collection network.

The chemical composition of exhaust air from compost windrows is indicative of the decomposition process. A study of the evolution of the chemical composition of the released air from a compost pile in Belgium has led to the identification of some compounds typical of stress events due to the absence of compost aeration and other ones that were predominant at the end of the maturation phase [5]. Such study shows that the "odour" can be considered as a process variable for the plant manager.

These previous methods are not relevant for a continuous monitoring. On line field techniques have to take over from analytical methods.

Sensitive methods

Contrary to chemical analyses, sensitive methods provide directly the global olfactive perception. However, particularly for waste management facilities, the sample surface collection, needed to calculate the odour emission rate, is not a good representation of the whole heterogeneous landfill area. Moreover, it is impossible to estimate the emitted odour flux when handling or transporting the solid waste. Hence, the result provided by that method is only a part of the total odour emission flux. By this technique, the odour emission rate is rather low (1500 ou_E/s).

The method of sniffing field inspection carried on during the transport and the handling of the garbage by scrappers and bulldozers supplies twenty to hundred times larger odour emission rate values (typically 30 000 … 150 000 ou/s).

Figure 1 shows a representative 1 ou/m^3 isopleth estimated by the TROPOS model and including "at best" the "odour" points as identified in the field around a landfill site [2]. The maximum downwind distance of odour perception is about 450 m from the centre of the tipping area. We adjusted an odour emission rate of 44 352 ou/s to surrounds nearly all the "odour" points and avoid the "no-odour" points.

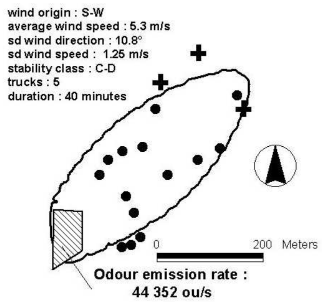

Figure 1 : 1 ou/m3 isopleth as estimated by the TROPOS model for a landfill site and including at best the odour points identified in the field (black circle) and not the points where the odour isn't perceived (cross).

Sensitive techniques provide useful results regarding exposition and annoyance in the surrounding of the landfill site. However, like chemical analyses, they are not suited for continuous operation.

Electronic nose

Complementary to previous methods, electronic nose is able to continuously monitor a global "odour" response and to predict the emergence of an annoyance in the surroundings. Nevertheless, the limit of detection of the sensors is too high to allow the measurement of the very low concentrations of chemicals in the field. Moreover, the method is not normalized and cannot be used so far to verify the compliance with some emission or exposition criteria. However, for a given odour type and for given sensor array and operating conditions, it is possible to estimate the odour concentration from the sensor responses. We experienced a portable electronic nose in the ambience of a landfill site including a composting area. The air was sucked just above a compost windrow. Firstly, by suitable calibration with typical chemicals of the "stress" or the "maturation" phases, we shown that an e-nose is able to monitor the odour considered as a process variable of the compost formation [5]. Additionally, when recording the sensor signals, parallel sampling and olfactometric measurements were carried out from time to time. By comparing sensor responses to the odour concentrations, a calibration curve was built, which allowed assessing the real time "odour level" from the electronic nose signal. By multiplying it by the volumetric air flow emitted by the compost windrow, the odour emission rate (in ou/s) can be estimated [6]. And finally, by introducing that value in a dispersion model, it is possible to predict in real time the "odour annoyance".

Conclusions

Different methods of odour investigation are available and presented in this paper. Each one presents both advantages and drawbacks and none of them is sufficient. However, by using them complementary and by exploiting the strong points of each of them, it is possible to tackle the whole investigation of a site, like a landfill area and to assess the odour annoyance in the living environment. Moreover, before working for this application, the e-nose needs to receive the information of the chemical and sensitive methods.

References

1. Van Harreveld, A. P. "Odour regulation and the history of odour measurement in Europe" Odour measurement review (2003), pp.54-61
2. Nicolas, J., Craffe, F., Romain, A.C. "Estimation of odor emission rate from landfill areas using the sniffing team method." Waste Management, Vol. 26, (2006), pp. 1259-1269
3. EN13725:2003 " Air Quality Determination of Odor Concentration by Dynamic Olfactometry" , CEN, Brussels, April 2003. www.cenorm.be.
4. Van Langenhove, H., Van Broeck, G., "Applicability of sniffing team observations: experience of field measurements." Water Science and Technology, vol. 44, (2001), pp.65-70.
5. Romain, A.C., Godefroid, D., Nicolas, J. "Monitoring the exhaust air of a compost pile with an e-nose and comparison with GC-MS data", Sensors and Actuators B, vol. 106, (2005), pp. 317-324
6. Nicolas, J., Romain, A.C., Ledent, C. "The electronic nose as a warning device of the odour emergence in a compost hall", Sensors and Actuators B, vol. 116, (2006), pp. 95-99