Electronic nose: a promising tool for landfill odour monitoring

NICOLAS, Jacques – ROMAIN, Anne-Claude – DELVA, Julien
University of Liège
Department Environmental Sciences and Management
Research group "Environmental Monitoring"
Avenue de Longwy, 185
B6700 ARLON
BELGIUM
phone : +32-63-230857
e-mail : j.nicolas@ulg.ac.be

Unpleasant smells often cause serious nuisance in the vicinity of landfill sites. Odours of different kinds are released by the fresh deposits of municipal solid waste, by the landfill gas (LFG), by the leachate treatment plants, by flares and by some waste treatment works, like composting facilities. In particular, emissions from fresh waste are highly variable and often unpredictable, because they result from intermittent activities: active tipping and transportation by disposal trucks, intermediate storage, handling process after the garbage deposit... Seasonal, diurnal and short term variations of odour emissions are observed.

Hence, the monitoring of the odour annoyance generated by a landfill area is difficult. Sources are very larges and heterogeneous; chemical analyses are not appropriate for field investigation and, anyhow, do not provide the global olfactive perception; and olfactometric measurements require point sampling which are not always representative of the typical odour emission from the whole site. As for methods of field sniffing squads, although they are particularly suited to assess the global odour of the landfill[1], they are not adapted to a continuous monitoring.

Recently, some attempts were made to use the electronic nose (e-nose) for the field monitoring of the landfill odour[2-4]. Such technique leads to very promising results at the research stage, while its routine use to monitor on-site odour remains exceptional[5].

An electronic nose may be briefly defined as an array of non specific gas sensors. When all the sensor responses are put together, they form a pattern which is typical of the odour presented to the array, like a signature.
The method is characterised by a learning phase, during which a great number of gaseous mixtures are presented to the sensor array. Thanks to a pattern recognition engine, using for example chemometrics techniques, a model is created which allows the classification of the different odour sources or "events". Moreover, when the specific odour is recognized, a regression model can be used on-line to predict an operational variable, such as the strength of that odour, from the sensor signals.

Continuous identification and measurement of odour emissions in the field by an electronic nose affords many promising possibilities. It could be one of the components of the process control. For example, the detection of the emergence of an odour in the background could trigger an odour abatement device. It could also awake the plant manager to a problem or could be used to predict the annoyance zone in the surroundings. On a more fundamental level, continuous odour measurement makes possible to study the dynamics of the waste fermentation process. It can also help the operator to detect the best moment to collect the air sample for more sophisticated analysis.
Moreover, electronic noses are not limited to the monitoring or the prediction of odour emissions. As the gas sensors are sensitive to a wide range of molecules present in the air, they give also a response to odourless compounds. For example, they can be targeted to

deleterious volatiles or to methane, which is a component of landfill gas, in order to prevent intoxication or explosion hazard.

However, although electronic noses were initially introduced as instruments able to mimic the human olfactory system, they are more considered at the present time as detectors complementing other sensitive or chemical measurement techniques. Similar components with human nose (the array of chemical sensors, the data processing unit and the pattern recognition engine respectively for the olfactory receptor cells, the olfactory bulb and the brain), the vocabulary analogies (neural networks, genetic algorithms, …) and the similarities of the objectives and of the approaches (odour recognition, overlapping sensitivity of the sensors, …) should not make us forget that the electronic nose is not only sensitive to odorous compounds, but to a great number of volatiles. Consequently, there remain some obstacles to the monitoring of field odour with e-nose.

- Selecting the sensors which are more sensitive to odorous chemical compounds and chiefly, to the key compounds of the studied process: for landfills, for example, terpenes are often identified as typical volatiles.
- Finding a reliable relationship between the odour qualitative tone or the odour magnitude and the response of the sensor array: in a landfill site, one must distinguish the odour of fresh refuse from the one of landfill gas or the one of leachates and the calibration with sensitive methods must concern exactly the same period and the same location in the site area.
- Coping with the influence of ambient parameters (temperature, humidity level, pressure, wind speed…) which deteriorate the quality of the classification and so, the relevance of the decision taken from the response of the sensor array: open sites like landfill areas suffer particularly from those influences.
- Correcting the drift of the sensors by choosing an appropriate calibration procedure for field applications and by using some selected targeted compounds: for example, it is not sure that calibrating the sensors with ethanol vapour is sufficient to compensate the drift when measuring the complex landfill odour.
- Lowering the limit of detection of the sensors and the limit of recognition of the array, in order to be able to detect the very low concentration of chemicals in the field: insuring good signal-to-noise ratio is particularly difficult for field operation.
- Improving the sample uptake in order to be able to compensate the poor limit of detection of the sensors and/or to make the electronic nose more specific to key compounds. A good way to progress towards a solution to that problem should be to pre-concentrate the sample prior the measurement. Without such pre-concentration, it is quite impossible to detect any odour when the electronic nose is displaced out of the immediate vicinity of the landfill.

To sum up, the monitoring of landfill odours with an electronic nose remains a challenge. With respect to laboratory analysis, all the drawbacks are cumulated when working in the field: fluctuation of the quality of the studied atmosphere, influence of ambient parameters, interference of many volatiles, risks, uncertainties, lack of electrical autonomy…

Nevertheless, findings of different scientific studies using array of sensors on landfill sites are promising. Moreover, for environmental use, there is no need for as accurate response as with laboratory applications: a rough response is often sufficient for the landfill manager to make a decision.

References

[1] Nicolas, J., Craffe, F., Romain, A.C. (2006) Estimation of odor emission rate from landfill areas *using the sniffing team method.* Waste Management, **26**, 1259-1269

[2] Nicolas, J., Romain, A.-C., Monticelli, D., Maternova, J., Andre, P., 2000. *Choice of a suitable E-nose output variable for the continuous monitoring of an odour in the environment.* Proceedings of ISOEN2000 - Brighton - 20-24 July 2000 – ed. By J.W. Gardner and K.C. Persaud 141-146

[3] Littarru, P. (2007) *Environmental odours assessment from waste treatment plants: Dynamic olfactometry in combination with sensorial analysers "electronic noses"* Waste Management, **27**, 302-309

[4] Micone, P.G., Guy, C. (2006) *Odour quantification by a sensor array: an application to landfill gas odours from different municipal waste treatment works.* in press in Sensors and Actuators.

[5] Guy, C., Giasson, F., Purenne, P. (2004) *Automated electronic nose network for measuring industrial odours.* International Conference Environmental Odour Mangement, Cologne, 17-19 Nov. 2004 – VDI-Berichte 1850 – 431-439