ELECTRONIC NOSE FOR CONTINUOUS EMISSION MONITORING AND ODOUR CONCENTRATION MEASUREMENT: CASE STUDY AT A WASTE WATER TREATMENT PLANT

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ABSTRACT

One extremely interesting and useful application of electronic noses is the continuous monitoring and control of environmental odour emissions. The possibility of continuously characterizing an odour emission over time by means of an electronic nose allows to account for the fluctuations that are typical of some emission typologies, thus providing a better description of the effective odour impact.

This study discusses the possibility of installing an electronic nose directly at an emission, with the purpose of continuously measuring the odour concentration and thus to obtain data that could be possibly used as real-time inputs for dispersion models. As target emission we chose a stack that conveys the exhaust gases from the wastewater pretreatment and the sludge treatment unit at a waste water treatment plant.

An EOS 507 electronic nose appositely developed with SACMI Imola S.C. was first trained in laboratory both with pure compounds in order to verify the instrument capability to correctly estimate odour concentrations. The results obtained suggest that the odour concentration values measured by the electronic nose are consistent and reliable.

Index terms– electronic nose, odour emissions, odour concentration, continuous monitoring

1. INTRODUCTION

The presence of odour in ambient air is nowadays recognized as an environmental stressor that negatively affects the quality of life. In order to evaluate odour exposure at receptors, several methods can be applied [1]. Different regulations provide to use dispersion modelling to simulate how odour disperses into the atmosphere, and consequently to calculate hourly ground odour concentration values in the simulation space-time domain [2-4]. Given that a detailed characterization of emissions over time would require frequently repeated olfactometric analyses, thus resulting in a very expensive (in terms of money and time) approach, emission data employed as model inputs are usually single or averaged values derived from one or few olfactometric analyses. This approach may provide a good description of the average odour impact, but doesn't take account of fluctuations that are typical of some emission typologies [5].

This study discusses the possibility of installing an electronic nose directly at an emission, in order to measure odour concentration continuously and therefore to obtain real-time data to be used as inputs for dispersion models.

The studied emission is the exhaust line from the wastewater pretreatment and the sludge treatment unit at a civil wastewater treatment plant.

In this work the first results of this project are presented. First, chemical analyses were conducted with the aim of identifying the chemical substances contained in the exhaust gas in order to optimize the sensor array.

Then, laboratory tests were conducted to evaluate the electronic nose capability of quantifying odour concentration. The tests were conducted using "artificial" samples prepared with compounds (pure and mixed) that were identified in the target emission.

2. MATERIALS AND METHODS

2.1 The EOS 507 electronic nose

The electronic nose used for this work is an EOS 507 produced by SACMI Imola S.C.. The instrument has two inlets: one is connected with the system for the neutral air realization; while the other is connected with an electronic valve that regulates the sample flow to the sensor chamber, which contains 6 MOS sensors, specifically selected for this application. The electronic nose is equipped also with a temperature and humidity sensor.

2.2 Instrument training

The emission considered for this study is a stack conveying the exhaust gases from the wastewater pretreatment and the sludge treatment unit at a waste water treatment plant. The exhausts are treated by a scrubber before emission.

Specific chemical analyses were conducted in order to determine the composition of the emission.

The main odorous compounds identified in the target emission were used in order to prepare "artificial" samples, i.e. pure compounds and mixtures of those compounds at different concentrations for the electronic nose training.

2.3 Tests with target odours

The compounds to be used for the laboratory tests were chosen among those identified in the target emission by means of chemical analyses. More in detail, the Odour Activity Value (OAV) [2] relevant to each compound was evaluated as the ratio between the measured chemical concentration and the odour threshold concentration (Table 1). The compound having the highest OAV turned out to be H_2S, which was thus selected as target compound for laboratory tests. Also other compounds associated with urine odour were identified, such as ammines, sulphur compounds and ketones. For this reason, besides H_2S, we decided to use urine odour obtained from an artificial l urine fluid, appositely developed by our research group within another research project in order the same odour concentration and hedonic tone with respect to real urine [6].

Gaseous samples of each target odour were analysed by means of the electronic nose at different concentrations in order to create a suitable training dataset for the estimation of odour concentration (Table 2). After the training, other gaseous samples were analysed as test set, whereby the instrument estimated their odour concentration. The odour concentration of analysed samples was in the range between 16 and 6500 ou_E/m^3.

For the odour quantification, two different approaches were considered:

• "Single" training dataset: for each target odour, only the corresponding training dataset was considered (e.g. H_2S testing using H_2S training dataset only);

• "Complete" training dataset: both training datasets were considered together as a unique training dataset (e.g. H_2S testing used training datasets relevant both to H_2S and urine).

3. RESULTS

3.1 Tests with target odours

Some results of the tests for the estimation of the odour concentration by electronic nose with the target odours are shown in Table 3, which reports both the "real" (by "real" the odour concentration determined by dynamic olfactometry is meant) and the estimated odour concentration values; as well as the per cent error relevant to the estimations.

The per cent error relevant to the odour concentrations estimated by the electronic nose is comprised between 1.4 and 85 %, depending on the type of training dataset used and the odours analysed. More in detail, the highest errors (72% and 85%) are observed for the H_2S sample at the lowest concentration (1600 ou_E/m^3). This may be connected to the extremely low odour threshold concentration of H_2S (Table 1), which makes that an odour concentration of 1600 ou_E/m^3 corresponds to an analytical concentration of about 0.5 ppm. As a matter of fact, accurate recognition at such low concentration levels appears problematic. This is also evident from the per cent errors relevant to the artificial urine sample, which are much lower (<6%).

Another interesting observation is that some improvement of the estimation accuracy is obtained using the "single" training instead of the "complete" training set. This observation requires further experimental observations in order to be confirmed.

4. CONCLUSIONS

The results of the preliminary laboratory tests discussed in this abstract show that the EOS 507 is able to quantify the odour concentration of samples of pure compounds with an accuracy that is comparable with the uncertainty of dynamic olfactometry.

The per cent error observed towards the tested target odours is comprised between 1.4 and 85%. The capability of the system to estimate the odour concentration is dependent from the training dataset used.

5. FUTURE WORK

The first implementation of this work consists in the training of the electronic nose with real samples collected at the plant and then in the installation in the field, i.e. at the stack at the wastewater treatment plant, in order to measure the odour concentration continuously. Further laboratory tests will also be required in order to investigate the dependence of the estimation accuracy from the training procedures as well as from the type of odour.

6. REFERENCES

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Table 1. Concentration of compounds identified by chemical analysis, their odour threshold concentrations (OT) and the estimated OAV

Compound	Concentration [ppm]	Odour Threshold [ppm/ou_E]	OAV [ou_E/m^3]
H_2S	0.43	3.21E-04	1340
Ammonia	1.00	4.65	0.22

Table 2. Odour concentrations of the target odour samples used for instrument training and testing

Sample	Odour Concentration	
	Training set [ou_E/m^3]	*Test set* [ou_E/m^3]
H_2S	65-6500	1600, 3250, 6500
	30-3200	
	16-1600	
Artificial Urine	12-1250	1250
	6-630	

Table 3. Real and estimated odour concentrations relevant to the tests with the target odours conducted using "single" and "complete" training dataset

Sample	Odour Concentration			Type of training dataset
	Real [ou_E/m^3]	*Estimated* [ou_E/m^3]	*Error%*	
H_2S	1600	447	72%	Single training dataset
H_2S	3250	3294	1.4%	
H_2S	6500	4997	23%	
Artificial Urine	1250	1320	6%	
H_2S	1600	2958	85%	Complete training dataset
H_2S	3250	4265	31%	
H_2S	6500	2891	56%	
Artificial Urine	1250	1220	2%	