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Outdoor in situ monitoring of volatile emissions from wastewater treatment plants with two portable technologies of electronic noses

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Abstract

This paper reports the test of portable electronic noses for outdoor air monitoring of sewage odours directly in the field. Two commercial devices with two different gas sensor technologies were tested: conducting polymer (CP) and metal oxide semiconductor (MOS) in order to select the most appropriate one for this application. As a means to improve the classification ability, the influence of environmental parameters in different data pre-processing algorithms was studied. The algorithm that permitted the least humidity, temperature and day correlation as judged with partial least squares (PLS) was selected. The effectiveness of the systems to discriminate between samples was observed using principal component analysis (PCA). The results indicated that CP sensors appear to be unacceptable for this application while MOS sensors tested were better for discriminating between the different odours. Correlation between the sensor responses and CH_3SH concentration in water shows that location of samples for MOS sensors depends on the water quality.

Keywords: Sensor; Sewage; Environment; Pollutants; Odours

1. Introduction

Atmospheric dispersion of malodours produced from wastewater treatment processes can cause a nuisance to the adjacent populations. The nature and concentration of volatile organic compounds (VOCs) in wastewater varies from one situation to another depending on several factors such as water quality or weather conditions. In order to monitor pollutants rapidly, a real-time monitoring system needs to be used. Previous studies have shown that an electronic nose could be capable of detecting and recognising different environmental odours [1–5], but very few studies are carried out directly in the field [6,7]. The aim of our research is to determine the ability of portable electronic noses for in situ monitoring of odours from a wastewater treatment plant under uncontrolled meteorological conditions. Two commercial devices with two different technologies (CP, MOS) of gas sensor array were tested. The dependence on humidity, temperature and day of analysis was studied for each electronic nose.

2. Materials and methods

2.1. Electronic noses

Two different portable commercial instruments were used: a Pen-2 (WMA Airsense Analysentechnik, 10 MOS) and a Cyranose 320 (Cyrano Sciences, 32 CP). For performing the experiments in the same meteorological conditions the analyses were carried out at the same time with the two electronic noses. The electronic noses operated by a series of cycles alternating 50 s of reference air and 50 s for the Pen-2 and 60 s for the Cyranose 320 of ambient air directly pumped to the sensors chambers. Due to the high flow of the pumps (400 ml/min for the Pen-2) and in order to simplify experimental conditions for field monitoring, reference air was filtered air (using a charcoal filter) which was sampled in a Tedlar bag from the ambient air of an office located in the wastewater treatment plant. A portable PC saved raw data and a 12 V battery powered all instruments.

2.2. Landfill site

Experiments were performed from five different outdoor locations of the wastewater treatment plant, four of them

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Table 1
Locations of the measured points in the wastewater treatment plant

Point	Locations
a	Outdoor sludge/bark mixer
b	Outdoor dedorization tower
c	A little apart from the treatment works
d	Outdoor sludge dewatering
e	Clarifier

near wastewater treatment works and the last one a little apart from the treatment works (Table 1).

These experiments were conducted during 8 days with different meteorological conditions either sunny, cloudy or rainy days. The experiments were carried out at the same time with the Cyranose 320 and the Pen-2 (120 observations for the Cyranose 320 and 123 observations for the Pen-2). Various meteorological parameters were measured: temperature, humidity, wind speed and wind direction. Also, odour intensity and odour character, as perceived by the operator, were noted.

3. Results and discussion

Five different algorithms were studied in order to select the most appropriate one for our study. Only significant sen-

Table 2
Correlation (underlined) and validation coefficients results for the Cyranose 320 and the Pen-2 for the significant sensors ($P < 0.05$) with the humidity, temperature and day of analysis using various pre-processing algorithms

Algorithm	Cyranose 320 (32 CP)				Pen-2 (10 MOS)			
	Number of significant sensors	H	*T*	Day	Number of significant sensors	H	*T*	Day
$1/R$	25	<u>0.94</u>	<u>0.91</u>	<u>0.99</u>	5	<u>0.67</u>	<u>0.81</u>	<u>0.61</u>
		0.89	0.88	0.99		0.64	0.79	0.59
$1\text{-}R_{norm}$	17	<u>0.87</u>	<u>0.88</u>	<u>0.99</u>	10	<u>0.83</u>	<u>0.82</u>	<u>0.75</u>
		0.84	0.86	0.99		0.77	0.76	0.68
$\Delta R/R_0$	0				9	<u>0.83</u>	<u>0.83</u>	<u>0.78</u>
						0.81	0.80	0.72
Log R	25	<u>0.95</u>	<u>0.90</u>	<u>0.99</u>	5	<u>0.68</u>	<u>0.82</u>	<u>0.61</u>
		0.88	0.88	0.99		0.64	0.81	0.58
Log R/log R_{norm}	17	<u>0.88</u>	<u>0.90</u>	<u>0.99</u>	10	<u>0.89</u>	<u>0.86</u>	<u>0.84</u>
		0.83	0.87	0.99		0.87	0.82	0.79

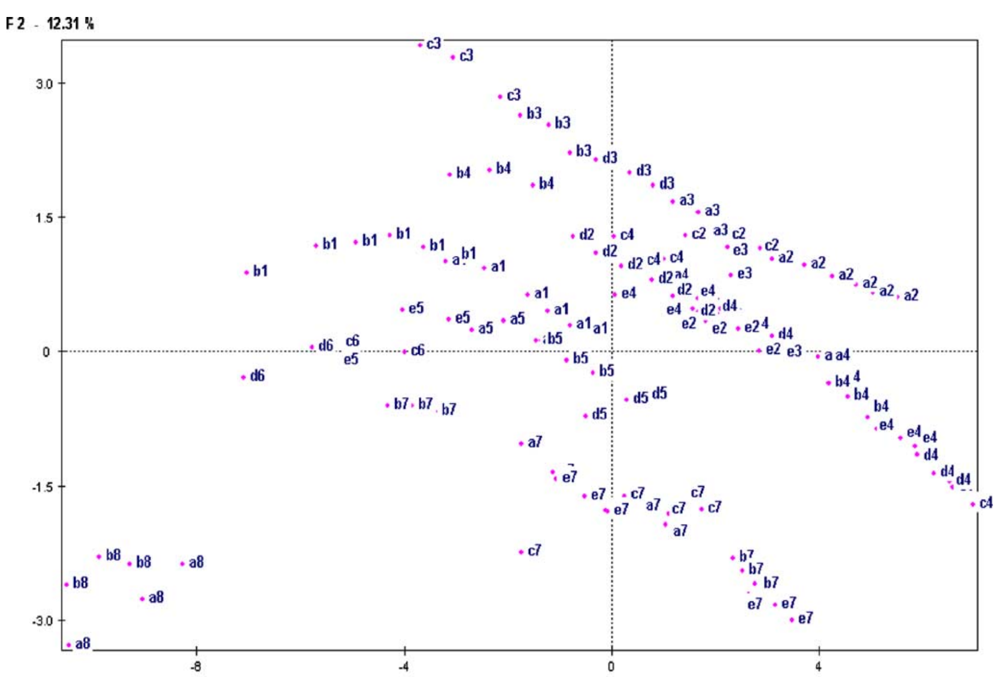

Fig. 1. PCA between samples based on 17 sensors responses ($1\text{-}R_{norm}$) with the Cyranose 320.