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Environmental Odour Monitoring at Receptors by means of an IOMS: Assessment of the Odour Impact of a Paper Mill

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Summary:

Instrumental Odour Monitoring Systems (IOMS) are more and more frequently applied for monitoring odours directly where their presence is complained. They analyse in real-time the ambient air to detect odour presence and determine their provenance. This paper describes the monitoring of paper mill odour emissions by two IOMS located at two receptors, where residents frequently report the occurrence of odour events. It describes the protocol involved for plant odour sources characterization, IOMS training and validation. The monitoring, lasting 4 months, allowed assessing the odour impact at receptors, expressed as the detection frequency of plant odours, and identifying critical emissions deserving maintenance interventions or upgrading.

Keywords: electronic nose, odour nuisance, real-time monitoring, industrial emissions

Background, Motivation and Objective

Odour pollution represents a limiting factor to the operation of industrial activities, especially when they are located very close to residential areas. Indeed, odours are currently subjected to regulations, which foresee the execution of periodical monitoring campaigns at plant emissions and receptors located in their proximity. Among odour measurement techniques [1], Instrumental Monitoring Systems (IOMS) offer the opportunity to analyse the ambient air directly where the odour presence is complained with the purpose to assess the odour impact at sensitive receptors. During the monitoring, the IOMS is intended to real-time detect the presence of odours and estimate their provenance [1]. The unique capability to discriminate different odours makes the use of IOMS particularly interesting when there is the necessity to recognize the source from which the odours are originated: this can be the case when different industrial odour emitting activities co-exist on the same territory or, for one single plant, if different odour types are emitted [2-3]. This is typically the case of a paper mill, in which two very different types of odours are emitted: the odour emissions (typically conveyed in stacks) related to the paper production, which is often described as "cooked paper", and the odour emissions associated with the wastewater (WW) treatment, which are usually rich in H_2S.

This paper proposes the use of two IOMS for the direct assessment of the odour impact associated to a paper mill located in northern Italy, accused by citizens are responsible for the odour nuisance in the area. The plant, producing recycled paper with a capacity of about 1200 ton/d, is characterized by considerable variability of odour emissions mostly due to discontinuous operating conditions. Besides providing an objective evaluation of the odour nuisance nearby the plant, the IOMS were expected to contribute on identifying critical sources causing the odours perceived by the citizens, thereby helping in the definition of most adequate strategies for intervention.

Description of the New Method or System

Two commercial electronic noses (EOS03 and EOS42 produced by Sacmi, Italy) were used as IOMS for this study. They are equipped with a 6 MOX sensors array and systems for generating odourless reference air and regulating moisture.

3 independent campaigns were carried out at the plant to collect odour samples. For IOMS training, the samples were diluted at suitable concentration ranges (20-350 ou_E/m^3) after determination of their odour concentration by dynamic olfactometry (EN 137125:2022). IOMS were trained to discriminate 4 odour classes: 'Air', 'Wastewater (WW)', 'Paper Production (PP)' and 'Unknown (UN)' (Fig. 1). The 'UN' class was introduced to account for other sources, different from the paper mill, which could cause the perception of odours at receptors. Overall, the training involved the analysis

of 184 diluted samples obtained from 64 samples collected directly at the odour sources of the paper mill and at the external ones. During the monitoring, the IOMS performance was tested using 23 independent samples collected at sources and then diluted, for a total of 60 IOMS analyses.

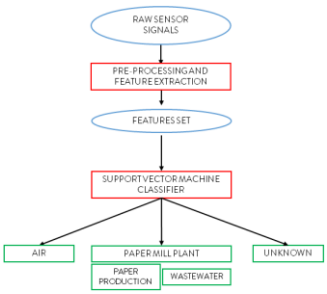

Fig. 1. Data analysis scheme.

Results

IOMS were installed for 3 months at the monitoring sites, located about 500 m NO (EOS 42) and SO (EOS 03) of the plant, respectively. They proved effective in detecting and recognizing odours from the plant (Tab. 1).

Tab. 1. IOMS classification performances: Accuracy - AC, Recall – RC, value (confidence interval 95%).

	EOS 03	EOS 42
AC	97% (88%-99%)	94% (81-99%)
RC_{Air}	100% (88-100%)	100% (75-100%)
RC_{WW}	100% (85-100%)	100% (83-100%)
$RC_{PP.}$	82% (75-90%)	80% (67-92%)
RC_{UN}	100% (66-100%)	100% (63-100%)

Monitoring data were processed as in Fig. 1 and odour impact was assessed as frequency of detection of different odour classes over the monitoring period (Fig. 3). For EOS03, it resulted higher than the 10% threshold suggested as reference for residential areas by guidelines [4]. This was further confirmed by citizens' reports collected during the monitoring. Given the high variability of emissions from some sections of the plant devoted to the processing of excess process WW, IOMS data were also correlated with information about production start and stop and filling levels of WW tanks. WW odours were frequently detected at receptors, even during plant shutdowns, and were mainly associated to the handling of wastewaters stored in emergency tanks, where undesired anaerobic reaction may occur, originating reduced sulphur compounds, which have very low odour threshold and unpleasant odour character. As an example, Fig. 4 illustrates the correlation between the WW tank filling levels, citizens' reports and H_2S concentration at the tank vent, which was proven for about 67% of odour events occurred during the monitoring. Based on such evidence, the project is still ongoing and currently focusing on the realization of an IOMS network at WW emissions sources aimed at investigating their variability and identifying critical operating conditions related to the odour events.

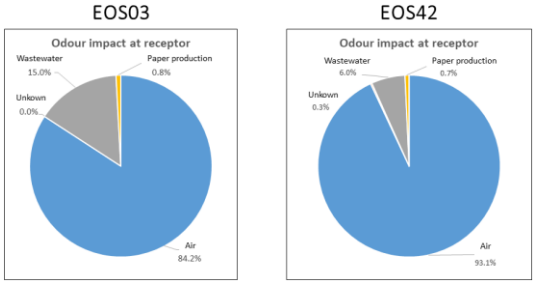

Fig. 3. Odour impact by IOMS at receptors.

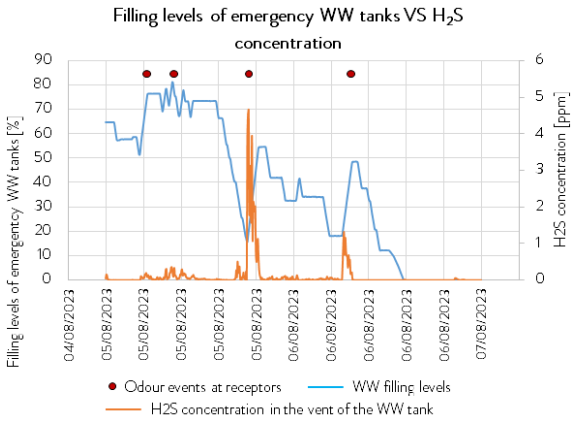

Fig. 4. Example of correlation between WW tank filling levels, citizens' reports and H_2S concentration at the vent.

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