MEASUREMENT OF ODOR EMISSION CAPACITY IN WASTEWATER TREATMENT PLANTS BY MULTISENSOR ARRAY SYSTEM

Extended abstract

Stefano Giuliani, Tiziano Zarra*, Vincenzo Naddeo, Vincenzo Belgiorno

University of Salerno, Department of Civil Engineering, via Giovanni Paolo II - 84084 Fisciano (SA), Italy

Background

Odours emitted by wastewater are one of the major concerns for local authorities in relation to the nuisance generate in the neighborhoods of the wastewater treatment plants (WWTPs). Odour impacts from WWTPs are generated by primary and secondary odour emissions (Zarra et al., 2008); emissions of primary odours are mainly related to the wastewater type; emissions of secondary odours are related to the treatment units that are present in the plant (Zarra et al., 2012). Control of odour emissions is very important issue to avoid impacts and therefore complaints. A characterization of the potential odours emissions of wastewater from the different treatment units could be the best approach to identify the most appropriate abatement systems and to design an efficient management plant. At present, the more recognized way in the scientific literature used to measure the potential odour emissions of liquids is the determination of Odour Emission Capacity (OEC) according to the method presented by Frechen and Köster (1998). This method defines the Odour Emission Capacity of a liquid as the total amount of odorants, expressed in OU/m^3Liquid, which can be stripped from 1 m^3 of the liquid under given standardized conditions. The measure of the odour concentration, according to Frechen and Köster (1998) procedure, is performed using dynamic olfactometry technique.

Dynamic olfactometry (DO), standardised in Europe by EN 13725:2003, is a sensorial technique that uses human noses as a sensors and is able to measure odour by referring directly to their effects on a panel of qualified examiners. The most significant weaknesses of DO are related to high costs of qualified panels and their time-consuming feature, as well as the limit in the detection of low odour concentrations (Capelli et al., 2008). Odour concentrations can be also monitored by multisensor array systems often called as electronic noses (e.Noses) that can replace the use of human noses and can also work continuously (Belgiorno et al. 2013). The OEC method according Frechen and Köster (1998) procedure presents different problems due to the high costs and time related to the elevate number of DO determination (Belgiorno et al., 2013).

This paper presents a new way to detect OEC to control odour emissions in a WWTP using a innovative multisensor array system, based on combination of different specific and non specific sensors, instead of the dynamic olfactometry. The overall aim is to reduce costs and time for the determination of OEC, increasing the sensitivity of the measurements and automating the control of odour with an electronic device able to detect OEC in the WWTPs.

Methods

Sampling program

Wastewater samples were collected at the Salerno WWTP located in the industrial area of the Salerno City (Italy). The investigated WWTP is a conventional activated sludge treatment plant designed for 700.000 PE. Wastewater samples were collected at the following three different treatment units: screening channel before the grit (O1), primary sedimentation (O2) oxidation (O3).

* Author to whom all correspondence should be addressed: e-mail: tzarra@unisa.it
Sampling was carried out one time a month from January to June 2013 at each sampling treatment unit. The first 15 samples (from January to May) were used to create the odour quantitative model (training phase) for the multisensor array system (seedOA) and to characterize the OEC of all investigated treatment units according to Frechen and Köster (1998) procedure. The last 3 samples, collected in June 2013, were used to validate the use of the seedOA for the determination of the OEC, alternatively to the dynamic olfactometry. A total of 18 samples were collected over the research period, 6 from each sampling unit and a total of 90 DO analyses were carried out. All measurements were made at the SEED (Sanitary Environmental Engineering Division) Laboratory of the University of Salerno.

Odour emission capacity (OEC)

OEC was measured according to Frechen and Köster (1998) method by Eq. (1).

$$OEC = \int \left( \frac{C_{od} - C_{100}}{V_L} \right) dV$$

where:
- $C_{od}$ is the concentration of odour emission from air samples collected at suitable volume of fluxed air after beginning ($V_{od}=0$) to $V_t$ (volume at time t), detected by dynamic olfactometry in accordance with EN 13725:2003;
- $C_{100}$ is the concentration of odour emission established as the limit which defines the end of the test, fixed at 100 OU/m$^3$ (Frechen et al., 1998);
- $V_L$ is the volume of liquid sample used for the analyses.

Air stripping tests were used to collect odour emissions from wastewater samples using the experimental setup schematized in Fig. 1. Air samples are collected in 7 liters Nalophan® bags respectively at 2, 10, 20, 30 and 40 min of air fluxing with a constant flux of 1.5 L/min of odourless air and a degree of turbulence of 0.5 L/min. All the collected samples have been analyzed using both the dynamic olfactometry and the seedOA.

Dynamic olfactometry

Olfactometric analyses were conducted according to EN 13725: 2003 in the Olfactometric Laboratory (SEED) of the University of Salerno, using an olfactometer model TO8 (ECOMA, D) based on the “yes/no” method. All the measurements were analyzed within 14 h after sampling (Belgiorno et al., 2013).

Multisensor array system (seedOA)

The novel multisensor array system (seedOA) designed by the SEED of the University of Salerno (Italy) was used in this research activity. The system consists of a set of 2 specific gas sensors (NH$_3$ and H$_2$S), 12 metal oxides non-specific gas sensors and 2 internal conditions control sensors (humidity and temperature), placed in the innovative fluid dynamics chamber (CODE®) patented by the SEED of the University of Salerno (Italy) (Viccione et al., 2012). The sensors used for the experimental research were selected on the basis of the potentially odorous substances emitted from the investigated type of plant according to previous studies (Zarra et al., 2009). A working flow rate of 300 ml/min for the sampling air analysis was used during all the analyses period. Air samples are analyzed by seedOA thought cycles of “odourless air-odour-odourless air”.

Acquired data are recorded in an external computer and processed by statistical and mathematical tools. The Partial Least Squares (PLS) pattern recognition technique was used to create quantitative model for each investigated treatment unit (Gardner, 1991).
Results and discussion

OEC characterization with odour concentration determined by dynamic olfactometry

Fig. 2 shows the odour concentrations detected by dynamic olfactometry for all collected wastewater samples at the investigated treatment units (O1, O2, O3) at different sampling time (2, 10, 20, 30, 40 min) over the OEC stripping tests. Results show that all analyzed samples of the investigated units fell below the lower limit of 100 OU/m³ after 30 minute. The highest concentrations to the respective measurement times were detected for the oxidation unit (O3), while the lowest were determined for the wastewater influent (O1).

![Fig. 2. Results of the odour concentration detected by dynamic olfactometry analysis of the samples collected at the investigated units (O1 (left), O2 (centre) and O3 (right)) out over the OEC stripping test](image)

Values of odour emission capacity (OEC) measured according to Frechen and Köster (1998) method are summarized in Table 1. Results show that the higher average value of the OEC in the monitored period was detected for the unit O3 (18.324 OU/m³ liquid), while the lowest value was determine for the unit O2 (3.737 OU/m³ liquid).

During the time, in May were detected the highest values of OEC for all the investigated units. The highest change in percentage, between the OEC values was recorded for the sedimentation (O2 unit), with a variation of 248% from the minimum to the maximum value.

Table 1. OEC characterization of the investigated treatment units according Frechen et al. 1998 procedure

<table>
<thead>
<tr>
<th>Investigated treatment units</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEC (OU/m³ liquid)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O1</td>
<td>5.759</td>
<td>7.573</td>
<td>8.884</td>
<td>6.376</td>
<td>9.034</td>
</tr>
<tr>
<td>O2</td>
<td>1.517</td>
<td>2.840</td>
<td>4.299</td>
<td>4.753</td>
<td>5.275</td>
</tr>
<tr>
<td>O3</td>
<td>14.534</td>
<td>16.781</td>
<td>20.133</td>
<td>17.221</td>
<td>22.953</td>
</tr>
</tbody>
</table>

Odour quantitative model creation

Fig. 3 shows the scatter plot of the odour concentrations measured during the OEC stripping tests by dynamic olfactometry according to EN13725:2003, and predicted with the seedOA applying the PLS models obtained for the each treatment unit investigated.

![Fig. 3. Scatter plot of odour concentration for O1 (left), O2 (centre) and O3 (right)](image)

Results show for all three calculated PLS models a good linear regression with very high level of confidence, respectively equal to 0.99, 0.98 and 0.97 for O1, O2, and O3. These results confirm the high performance of seedOA to measure the odour concentrations at the WWTP.

Validation of OEC measurements by multisensor array system

Fig. 4 shows the OEC calculation for the last samples taken in June. In detail, the comparison between the odour concentrations measured at different striping time by dynamic olfactometry analyses versus the odour
concentration predicted by seedOA applying the PLS models were shown. The results show that there is a good fit between the predicted and measured values.

**Fig. 4.** Comparison of predicted and measured odor concentrations during the OEC stripping test.

Table 2 shows the OEC values calculated using the odour concentration measured by both dynamic olfactometry (DO) and seedOA.

The results suggest that the new method can be considered highly reliable since there is almost no difference in terms of OEC values (i.e. < 5%) between the responses of the two presented tools.

**Table 2.** Comparison between OEC measured by dynamic olfactometry and predicted by multisensor array system (seedOA).

<table>
<thead>
<tr>
<th>Investigated treatment units</th>
<th>Sample</th>
<th>Spread (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DO</td>
<td>seedOA</td>
</tr>
<tr>
<td></td>
<td>OEC (OU/m³ liquid)</td>
<td></td>
</tr>
<tr>
<td>O1</td>
<td>7.008</td>
<td>6.764</td>
</tr>
<tr>
<td>O2</td>
<td>4.588</td>
<td>4.823</td>
</tr>
<tr>
<td>O3</td>
<td>19.311</td>
<td>19.804</td>
</tr>
</tbody>
</table>

**Concluding remarks**

The comparison of OEC values measured by dynamic olfactometry and predicted by multisensor array system (seedOA) have shown a minimum margin of difference, ever lower than 5%.

The use of multisensor array system in the determination of OEC reduces drastically the costs and the time of analyses, making real and sustainable it use in the management of odour emission in wastewater treatment plants.

Further studies will improve the use of the seedOA for direct and continuous analysis on site making possible a constant monitoring of potential odour emissions.

**Keywords:** dynamic olfactometry, e.noses, multisensor array system, odour emission capacity (OEC), wastewater.

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**References**


