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Proactive Approach for Odour Emissions Characterization in Wastewater Treatment Plant by H2Odour System

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The characterization and quantification of the odour emissions in wastewater treatment plant (WWTP) represents a fundamental step in order to identify potential odour problems and establish the best and most appropriate odour management tools. Nowadays odour emissions in WWTP are characterized by the use of sampling techniques which take samples directly from the gaseous phase: i.e. when the emission and consequently the potential problem are already present.
The definition of proactive tools for the assessment of potential odour emissions from the emitting sources can prevent the occurrence of potential significant odours events and as consequence complaints.
The research presents and describes a novel system, called H2Odour, useful to measure the potential Odour Emission Capacity (OEC) directly from liquids. The system has been designed and developed to standardize the stripping phase of gaseous samples, ensuring the maximization of the odour compounds transfer from the liquid to the gaseous phase. The application on a real full scale WWTP is highlighted. H2Odour represents a novel, proactive device to prevent potential critical situations, allowing a preliminary characterization of the maximum potential odour emissions directly from the liquid phase and through this control activity, leading to a greater environmental and social acceptability of the WWTP.

1. Introduction

Achieving the best quality of life in urban areas is increasingly being discussed among academics, urban planners and politicians. The study of complex interactions between human activities and biophysical processes has been challenging in recent years (Belgiorno et al., 2012; Badach, et al., 2018). The dispersion of unpleasant odours into the atmosphere has become a growing social problem in industrialized countries. due to the proximity between urban areas and industrial and environmental protection plants(Giuliani et al., 2012; Zarra et al., 2019). Consequently, to avoid complaints, the identification of smart and effective tools able to prevent the occurrence of odour impact events with a proactive approach is a priority (Capelli et al., 2009; Fasolino et al., 2016).
An internationally recognized method of data processing is the "Odor Emission Capacity" (OEC) method. The method was first introduced in the technical-scientific literature by Frechen and Köster in 1998 and recently standardized by the VDI3885 Blatt 1:2017-06 ("Olfactometry – Measurement of odorant emission capacity of liquids). The OEC provides an equation for calculating the maximum odour-producing potential of liquid samples (OEC), as the measure of the total mass of odorants, expressed in $OU_E\ m^{-3}$, which can be removed from 1 cubic meter of liquid under certain standardized conditions (Frechen, 2004; Zarra et al., 2012; Giuliani et al., 2013). However, this method does not allow defining in a pattern and complete way the criteria in terms of instrumental and structural equipment, for determining the gaseous samples to analyze.

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To overcome these limitations, the research presents and describes a novel device, called H2Odour, with the aim of generating the gaseous sample in a standardized and repeatable way, thus eliminating the uncertainties of the method related to sampling phase. The application of the novel device for the OEC determination in a real full scale wastewater treatment plant (WWTP) is discussed.

2. Material and method

2.1 H2Odour device

In Figure 1 is reported the layout of the H2Odour device, with the identification of the main components. The device consists of a main body with an internal chamber, configured to host the liquid to be analysed in terms of odour emissions capacity. The device comprises elements for heating the liquid contained in the internal chamber and for the insufflation of odourless air.

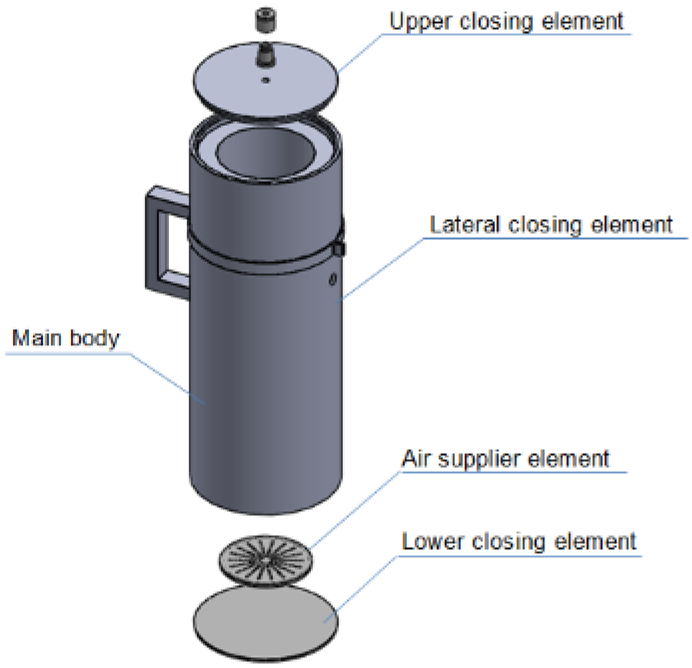

Figure 1: H2Odour device and main parts

Moreover, the device includes a control unit for the activation of heating and air supplying components to ensure predetermined operating parameters. The presence of volatile compounds within a liquid is intrinsically connected to its odour-producing potential, as these compounds, by volatilizing, can generate odour nuisance. In order to characterize the odorous potential of a liquid matrix, it is therefore essential to promote stripping of the above compounds in the gas phase, subsequently subjected to suitable characterization..

2.2 Experimental plan and program

The experimental activity, conducted at the Sanitary Environmental Engineering Division Laboratory of the University of Salerno (SEED), entailed fifteen sampling campaigns at a large Wastewater Treatment Plant (WWTP), designed for 700,000 equivalent inhabitants. The campaigns were carried out twice a week, taking 15 liters liquid samples, according to the APAT CNR IRSA 1030 method, at four units of the wastewater treatment line of the WWTP.
The identified sampling points are listed below:

- P1, coarse screening output;
- P2, primary sedimentation output;
- P3, oxidation tank;
- P4, secondary sedimentation output.

In Figure 2 is reported the localization of the investigated sampling points.

All collected liquid samples are characterized in terms of principal chemical-physical analysis and, using the novel H2Odour device, in terms of OEC measurements.

Figure 2: Sampling points at investigated WWTP

2.3 Chemical-physical analysis

Onsite and laboratory analysis are carried out for all collected liquid samples in order to characterize their chemical-physical composition. A multiparameter probe (Hanna Instruments model HI 9829) was used directly on site to measure temperature, pH, dissolved oxygen and conductivity. After their transport to the laboratory in a thermostat refrigerator at 4° C, LCK cuvette test and Oxitop method were applied to determine COD and BOD_5 respectively.

2.4 OEC characterization

The liquid samples were agitated for 1 minute in the original tank to promote the suspension of the sediment materials. Five litres of liquid samples were then taken from the tank and placed in the H2Oodur device. In Table highlights the main operating parameters of the H2Odour device set for the analysis.

Table 1: Operating parameters

Operating parameters	
T[°C]	50
Air flow rate [lpm]	10
Volume of liquid sample [l]	5

The generated odorous air, obtained thanks to the bubbling of the odourless air inside the chamber where the liquid was placed, were directly collected in 7 liters Nalophan® bags, inserted at the upper closing element connection of the H2Odour device, at 2, 4, 7 and 12 min from the start of the test.
All collected gas samples were analysed with dynamic olfactometric analyses, conducted at the Sanitary Environmental Engineering Division (SEED) Laboratory of the University of Salerno, according to the EN 13725:2003. A TO8 olfactometer (ECOMA, D), based on the ‘‘yes/no’’ method, was used, relying on a panel composed of four trained persons. All the measurements were analysed within 14 h after sampling, according to Zarra et al. (2012). OEC of all collected samples was calculated according to the following equation (VDI3885:2015):

$$OEC = \int \frac{C_{OD} - C_{100}}{V_L} dV$$

where: C_{OD} is the concentration of odour emission from air samples collected at the beginning of the experiment (V_{to}) to the volume at time t (V_t); 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.

3. Results

3.1 Chemical-physical characterization

Figure 3 shows the results of the in-situ parameters characterization, in terms of mean values and related standard deviations for the temperature ("T"), Dissolved Oxygen ("DO"), pH ("pH") and conductibility ("Cond.") measured at all the sampling points during the sampling campaigns. Figure 4 and 5 report instead the box-plot representation, respectively, of the COD and BOD_5 measurements, determined for the liquid samples investigated in the monitored period.

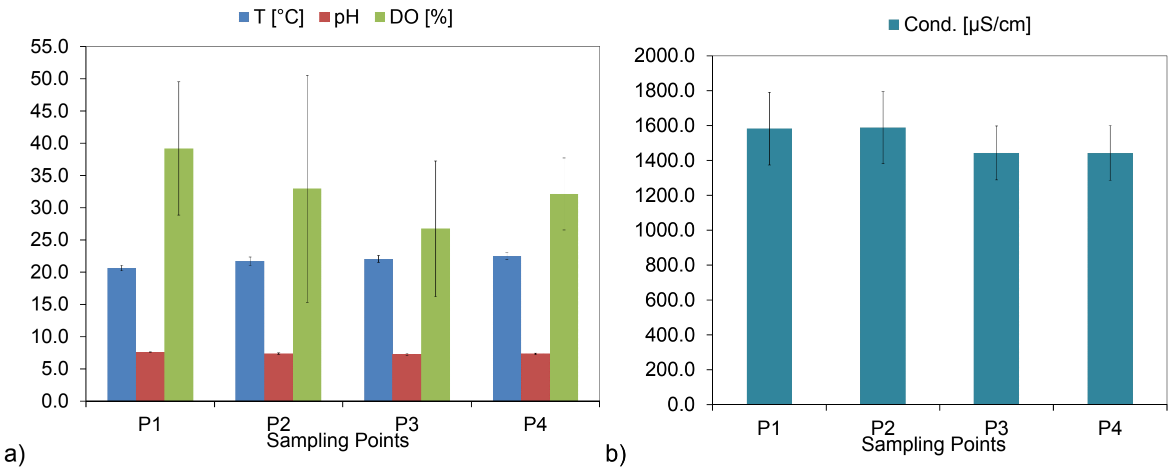

Figure 3: In-situ chemical-physical characterization (3a: T, pH, DO; 3b: cond.)

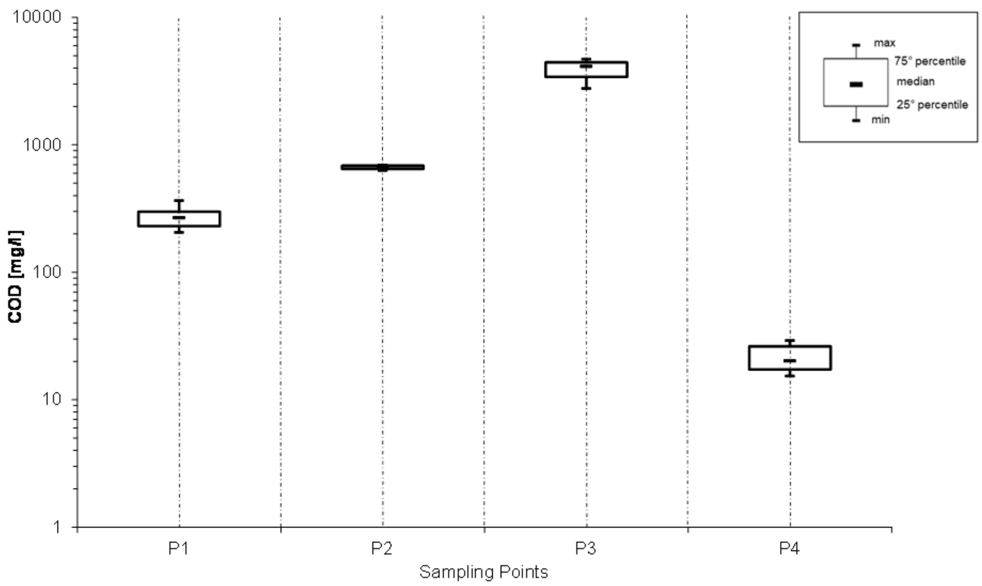

Figure 4: COD Box-plot of the four liquid odour sources during the different campaigns

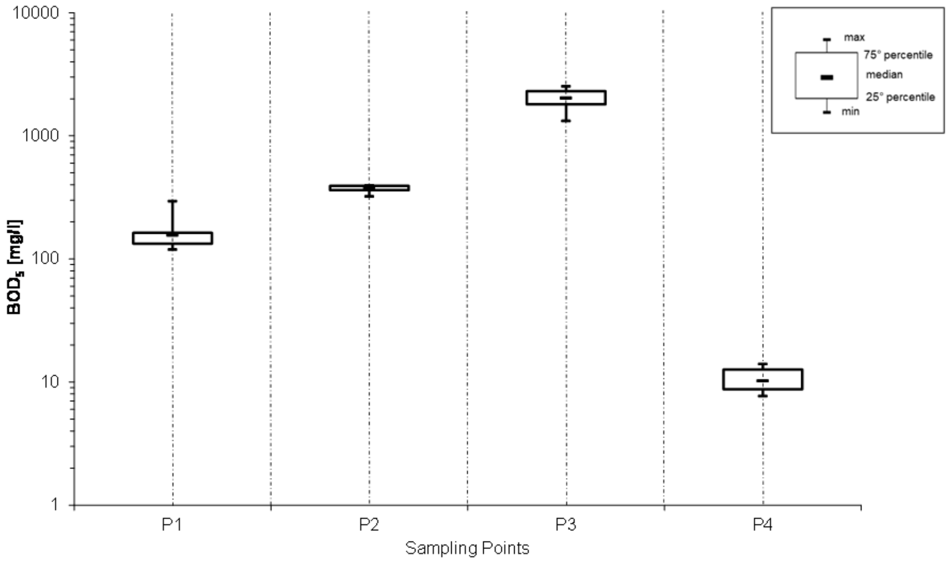

Figure 5: BOD5 Box-plot of the four liquid odour sources during the different campaigns

The chemical physical characterization results showed that the tendency of the monitored parameters, is quite constant along the wastewater treatment line and even during the different sampling campaigns. In particular, the pH value was quite stable at 7. Conversely, the results in terms of COD and BOD_5 highlighted more substantial differences in terms of organic contents along the treatment line. The trend of the ratio between BOD and COD measured in the investigated points was indicatively constant: as the measured BOD increases, the relative COD also increases and *vice versa*.

3.2 OEC characterization

Figure 6 shows the box-plot representation of the OEC values calculated with the H2Odour device for all the four odour sources during the different sampling campaigns.
The highest values in terms of OEC were measured in P2, corresponding to the primary sedimentation tank. The lowest values were detected at the secondary sedimentation tank.
The analysis of the chemical-physical characterization and the OEC determination of the investigated liquids showed some matching trends, in particular with reference to the organic contents.

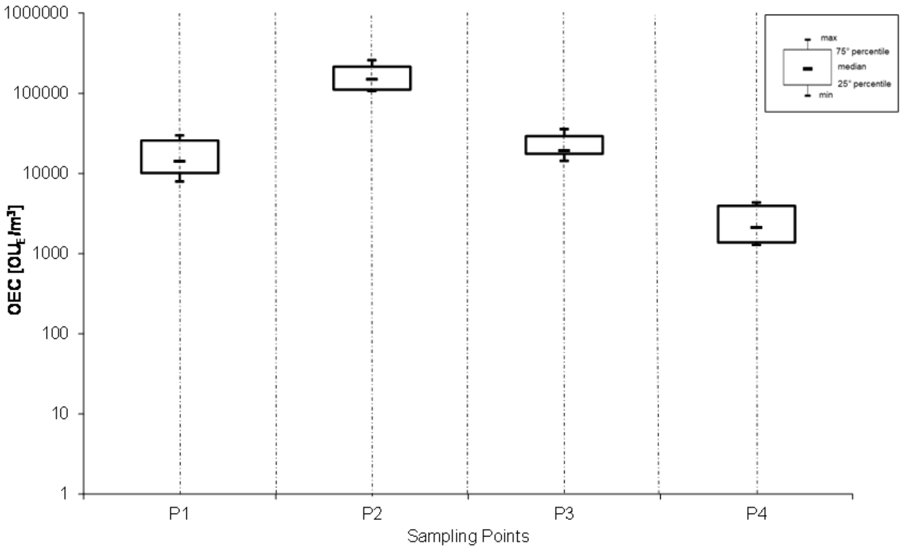

Figure 6: OEC Box-plot of the four liquid odour sources during the six different campaigns

4. Conclusions

OEC method is an important tool to pursuit proactive odour emissions prevention and control strategies especially in wastewater treatment plants where the main odour sources are generated by liquid matrix. This proactive approach matched the needs to increase the acceptability and sustainability of industrial plant and environmental protection facilities in a context aiming to the switch at green and smart factories. The H2Odour device can be included among the tools for environmental protection since it allows the identification of potential odorous emissions responsible for negative impacts. The application to a large wastewater treatment plant highlighted the ease and effectiveness of the device in order to generate odorous gaseous samples from the liquid sources. The standardization of the sampling phase is of fundamental importance to ensure reliable and consistent data, since the OEC determination can be used to control the treatment process, detect possible undesired conditions and act before the occurrence of odour events. In this context H2Odour represents an opportunity to spread and simplify the application of OEC method. The outcomes resulted in reliable measurements, which can be easily replicated in standardized conditions, representing reference values useful to preliminary detect possible causes of odour annoyance.

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