Development of a protocol for odor measurement and characterization in wastewater treatment plants.

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Abstract
The odor sources, dispersion and human response depends on many factors and as consequence to determine the pollution degree and nuisance is very complex. In order to deep into the study of the problem of odor emission in Wastewater Treatment Plants (WWTPs) and its environmental impact, a comparative study of odor measurement and detection techniques has been done. The best method for odor generation diagnosis and monitoring is that involves sensory methods and physico-chemical characterization. In this paper we propose a protocol for the evaluation and effective control of odor in WWTP facilities. All this work is based on a multidisciplinary study conducted at the Industrial Wastewater Treatment Plant (IWWTP) of the Ice Cream Factory "Helados Alacant" located in San Vicente del Raspeig, Alicante, Spain.

Keywords
WWTPs, odors, sensory methods, physicochemical methods, norms, protocol.

INTRODUCTION

Wastewater treatment can involve odor generation and nuisances for the neighborhood. In recent years the methodology of odor measurement studies has been improved significantly (McGinley & McGinley, 2000, Aitken et al, 1992) and there are two main types of methodologies: olfactometry techniques -sensory methods-, and instrumental compound analysis -physico-chemical methods- (Nicolai & Pohl, 2005). For this work the combined analysis of two kind of methods have been selected. The study was conducted between March and August 2011 at the IWWTP in an Ice Cream Factory (Helados Alacant) and its surroundings. Several odor events in the factory have caused complaints from neighbors. The production of treated water is around 430 m^3/day during the manufacturing season (peak season). The whole IWWTP is inside two deodorized adjacent buildings: the pretreatment one and the main one, with the next processes: dissolved air flotation (DAF), underground membrane bioreactor (MBR), sludge drying and storage. In the IWWTP there is a deodorization unit by activated carbon and a grid of pipes to collect the air to treat.

EXPERIMENTAL METHODOLOGY

Several points in the IWWTP were selected for sampling or for in situ measurements. Odor measurements were carried out in the chosen points and in the enivornment. For the sensory study Nasal Ranger ® (field dynamic olfactometry) was used and laboratory dynamic olfactometry on collected samples in the chosen points in the IWWTP. Several chemical-physical methodologies such as gas chromatography, portable analyzers and electronic nose were used.

Sensory methods

Olfactometry study was carried out following the methodology of the standard norm UNE-EN 13725 (AENOR, 2004) and VDI 3940 (VDI, 2003). For results evaluation, since in Spain there is no common national legislation, different criteria were used such as the Dutch law (Ner, 2004), the last draft of odor regulation in Catalonia (Generalitat de Catalunya, 2010) and the FIDO protocol from Socioenginyeria (Cid -Montañés et al, 2008). The Nasal Ranger® field olfactometer is a portable instrument that assesses the intensity of ambient odor using the technique of "Dilution to Threshold" (Nasal Ranger®, 2011). For the laboratory emission measurements, following the UNE-EN 13725, the main odor sources were identified and samples were taken by means probes and wind tunnel (Labaqua, SA, 2011). The olfactometry technique uses the human nose as detection system to quantify the sources and by means of a mathematical dispersion model (AERMOD) the odor dispersion (plume) in the atmosphere (EPA, 2004) is simulated. On the other side, a study in the IWWTP surrounding was done along a year where many measurements were made by panelists calibrated according to VDI 3940. Subsequently it produced a map of odor occurrence percentage by using the software SURFER.

Physico-chemical methods

Gas chromatography allows identification of main compounds causing odor, using the discontinuous punctual and passive or diffusive sampling techniques (diffusion of analytes through a diffusive surface onto an adsorbent) (Kleeberg et al, 2005; AENOR, 1991). On the other side, total reduced sulfur, TRS, nitrogen oxides (NOx) and ammonia (NH_3) were continuously monitored with two high precision portable analyzers (ECOTECH 57 Serinus (TRS) and ECOTECH 44 Serinus (NOx and NH3). These analyzers worked continuously and allowed to follow the evolution with time of the specific compounds and the response to different events.

The electronic nose is a device that works via electrochemical sensors. The E-Nose BMS2 Mk4, consists of six sensors for different groups of compounds and a temperature and humidity sensors. It has been calibrated to the particular conditions of the IWWTP. It allows to achieve measurements in odor units in real time and to compare their results with those from the dynamic olfactometry method.

RESULTS AND DISCUSSION

With the Nasal Ranger ®, 330 control events were carried out with 1974 data taken from 6 points inside the plant (1. Pretreatment, 2. Sludge tank , 3. Spin (on duty and off duty), 4. Biological tank, 5. DAF, 6. MBR). Additionally 20 control events were carried out with 120 data at 4 points in the vicinity. Figures 1 and 2 reflect the characteristic odor maps, indicating the values of dilution to threshold (D / T) and the corresponding European Odor Unit (UOE/m^3)

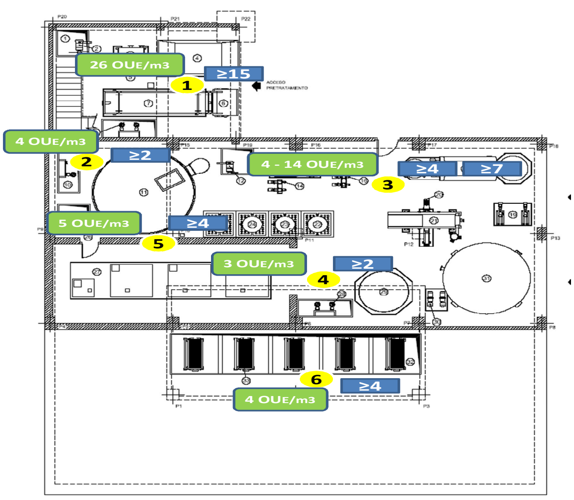

Figure 1. Odors Immission map. Continuous emission regime. Inside the IWWTP.

Figure 2. Odors Immission map. Discontinuous emission regime. Residential surrounding the IWWTP

The laboratory olfactometry campaign involved odor measurements of emission from potential sources of odor. The sample analysis and modeling led to the results shown in Figure 3

Figure. 3 Results of odor simulation for IWWTP UNE-EN 13725


Figure. 4 Odor occurence Porcentage map for IWWTP VDI-3940

For the field campaign a study area of 1.4 km x 1 km was defined, with a grid of 80 points and a duration of 26 weeks. Figure 4 shows the different levels of odor occurrence percentage in the surrounding area of this IWWTP. The results with different sensory methods show that despite there were some strong odor levels inside the plant –point 1- pretreatment and 3 centrifugation (see Figure 1) and some specific events in the sludge storage hopper discharge area or in the MBR. The emission levels in the surroundings can be considered "not unpleasant" and comply with all considered regulations (see Figures 2, 3 and 4).
Simultaneously from 2 to 5 samples per month were analyzed by gas chromatography. The results showed the occurrence of higher concentrations of two odorous compounds (limonene in pretreatment area and indole mainly in the MBR (6) at times when the biological process was not operating correctly. The evolution of the concentration of TRS, NOx and NH3 could be measured with the portable continuous monitoring system. The occurrence of high concentrations of these compounds was directly related to the sludge storage discharge moments. The electronic nose measurements showed a similar trend to that registered with the Nasal Ranger ® and the advantage of continuous work served as a warning alarm on time.

CONCLUSIONS

Using combined methods for odor measurement a complete characterization of odor generation (both physico-chemical and sensorial) in the studied IWWTP has been achieved. The processes causing odor events have been identified as well as their impact on the neighborhood. With the obtained experience we propose the following guide or protocol for evaluating performance and efficient control of odors in WWTP:

1. Preliminary selection of sampling points both for emision and inmision (inside facility and surrounding) by simple perception, taking into account the nuisance degree.
2. Simultaneous sensory measurements (field olfactometer) and physico-chemical (portable continuous monitoring device) monitoring.
3. Results review, comparation of data, and as a consequence definition of criteria (based on recommendations, current regulations, etc) for classification of critic activities or events causing annoying odor emision.
4. Take corrective actions and improvements for operation of WWTP and deodorization system.
5. Development of a monitoring plan with the support of Nasal Ranger ® and Electronic Nose.

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