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Assessment of the odour footprint of an underground WWTP in Barcelona (Spain)

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The decrease in drinking water consumption, climate change, the evolution of regulations and the increased social pressure on olfactory comfort are changes that nowadays are leading to more odour complaints. It is therefore necessary to know the cause of odour problems and how to avoid them. As an example, this paper presents a study carried out on a delicate case of an underground wastewater treatment plant (WWTP) in Barcelona (Spain), which aimed at assessing the odour footprint of the plant. The study considered several tools, based mainly on odour panels, odour measurement and odour dispersion modelling. It allowed the identification of the main critical points and the suggestion of corrective actions, mainly in the sludge line treatments of the plant.

1. Introduction

Nowadays odour nuisance is facing many changes leading to increased odour complaints. In terms of odours, residents are more and more demanding, and general odour regulations are more and more aimed at guaranteeing the olfactory comfort of the population. An example is the regulation concerning Catalonia (Spain), where is located the wastewater treatment plant under study: a draft bill about odour pollution has been published, which establishes limit values between 3 and 7 european odour unities, ou_E (GenCat, 2005) at the nearest residential zone. The WWTP studied, formerly conventional and built in an "adequate" zone, has undergone many changes due to the growth of population, and rehabilitation of the seafront of the city in this area. However, despite all the measures undertaken, odour nuisance is still perceived.

2. Methodology

The study consisted mainly in measurements of the emission sources (both odour and odorous compounds concentrations), odour dispersion modelling, odour panels (one in summer and another in winter) and several samplings and analyses of effluent and sludge of the plant in order to predict odour production.

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The measurements of emissions were carried out on the different emission sources of the plant, *e.g.* the outlets of the odour treatments of pre-treatment, primary settling, secondary treatments, sludge thickening and sludge dewatering. At each sampling point, the sampling was carried out over 2-3 hours, and a wide variety of compounds were analysed: ammonia, amines, sulphur compounds, aldehydes, ketones, alcohols, and VOCs. Additionally, odour concentrations were measured using the European Standard EN 13725 (CEN, 2003). These measurements were also used as input data for the dispersion modelling study, which was carried out using the model developed by the AERMIC workgroup (EPA, 2004).

Odour profile measurements were carried out by odour panels over three days, including one day for training in the plant (recognition of the typical odours of each step of the treatment) and two days in the surroundings: one in summer and another in winter. The weather data from the days of the study were collected and used to interpret the results. The method used was the "odour wheel" technique, developed by Suez Environnement, described in the literature (Burlingame et al., 2004; Suffet et al., 2004).

Regarding the odour production prediction, in the case of the wastewater treatment, it was assessed taking into account literature emission values (Stuetz and Frechen, 2001; Frechen, 2004; Zarra et al., 2008). In the case of drying, the evaluation of odour emission was carried out using an internal methodology described in the literature (Bouchy et al., 2009). These models are based on data both from the sludge (volatile solids and nitrogen content, etc.) and drying technology characteristics, so data from the former Seghers dryer and from the new STC dryer under construction were collected in order to evaluate the drying odour emissions.

3. Results and discussion

3.1 Measurements of the emission sources

Results for the measurements of different emission sources of the plant are shown on Figure 1.

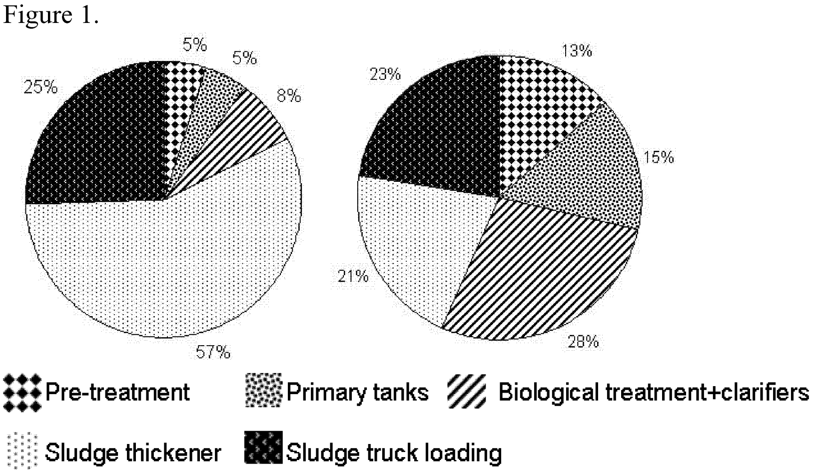

Figure 1. Odour emissions of the different areas. Left: odour concentration (ou_E/m^3). Right: odour flow (ou_E/h) of different treatment areas

As illustrated on Figure 1, the sludge management accounts for the greatest odour concentration. The analyses to identify odorous compounds have shown a high concentration in sulphur organic compounds and volatile organic compounds in this area. However, in terms of odour flow, *i.e.* taking into account the air flow rate values, the main sources of odour emission after treatment are biological treatment and clarifiers. This result is very surprising, however, it is possible that the odour treatment unit (activated carbon filters) was not operating efficiently, thus leading to these results.

3.2 Odour dispersion modelling

The modelling of odour is still a developing field when compared to that of other pollutants. Several parameters, as the percentile or the integration time, can strongly influence the results, as well as the meteorological data, that must be taken from the closest meteorological station (Rousseille et al., 2008). One of the most critical aspects is the input data for odours emissions, which must be carefully evaluated, as well as local and site parameters. Different models, as Gaussian, Eulerian or Lagrangian models have been used for odour modelling. In the framework of the study presented in this paper, a Gaussian model was used to carry out the odour dispersion modelling. This model is AERMOD, which uses data from meteorology, emission sources and terrain and an average wind rose. The results were shown as footprint for 3, 5 and 7 ou_E/m^3 (percentile 98), as they are values currently used in several European regulations. Figure 2 illustrates the map obtained with the AERMOD model.

Figure 2. Odour dispersion modelling.

It shows that the odour footprint goes beyond the fence of the plant, and therefore that the plant does indeed have an impact on the surroundings.

3.3 Odour panels

Odour panels were implemented in order to establish the perceived odour footprint of the plant. In order to assess which odours in the environment were due to the plant, panels were also used to identify the characteristic odours for each specific treatment area in the WWTP and to identify the odour intensity of each one. Results have shown that at points close to the chimney of the primary tanks the odour perceived with more intensity is rotten eggs, as it is expected. Rotten cabbage is an odour identified with high intensity in the area of sludge treatment. During the development of the odour panels, the wind rose was considered in order to know the wind direction for days when the odour map was being established. Strong odours were located in areas further north or further south, according to the specific wind rose for each day. Different kinds of odours were identified when odour panel was carried out. For a better comparison, the data were placed on a map of the area (Figure 3).

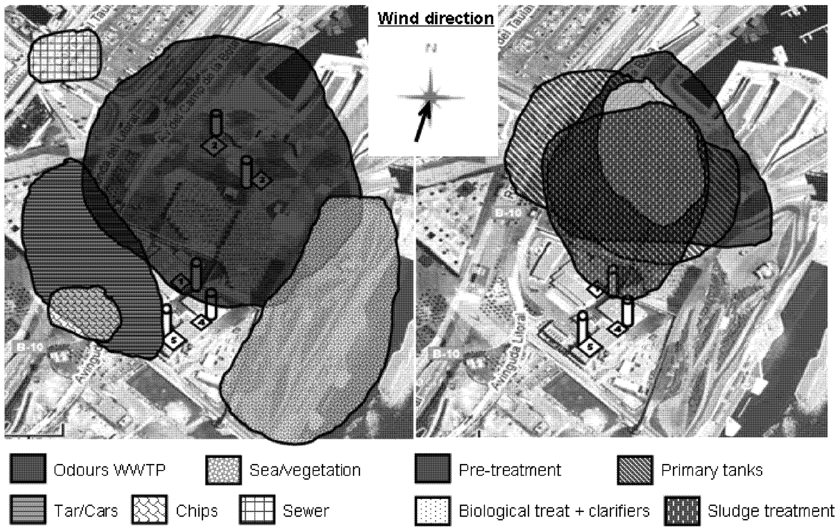

Figure 3. Odour footprint July 08. Left: general odours. Right: specific treatment areas. Chimneys 1,2,3,4 and 5 represent, respectively: pre-treatment, primary tanks, biological treatment, sludge thickening and sludge treatment.

The map on the left of Figure 3 shows the general odours in the surroundings of the WWTP. "Black" footprint shows the odours that presumably belong to the plant. However, there are other odours that do not belong to the plant and what could be mistaken for the odours from the plant, such as sewers odours from gutters present in the area (illustrated on Figure 3 and Figure 4 with a "checked" footprint).

The wind direction and the temperature are parameters with a high influence in the odour footprint of the plant. On the one hand, the wind direction (indicated by the wind rose in the maps) influences the position of the odour footprint. On the other hand, the temperature (lower in February, Figure 4, than in July, Figure 3) influences the odour intensity.

There is a difference in the area of the footprints from odour panels and dispersion modelling. A reason is the wind rose used for the dispersion modeling: an average was considered for the dispersion modeling, while the specific conditions of the day were considered for the panels. It is important to note too that odour panels are more detailed in terms of type of odour, while the footprint established via dispersion modeling concerns global odours.

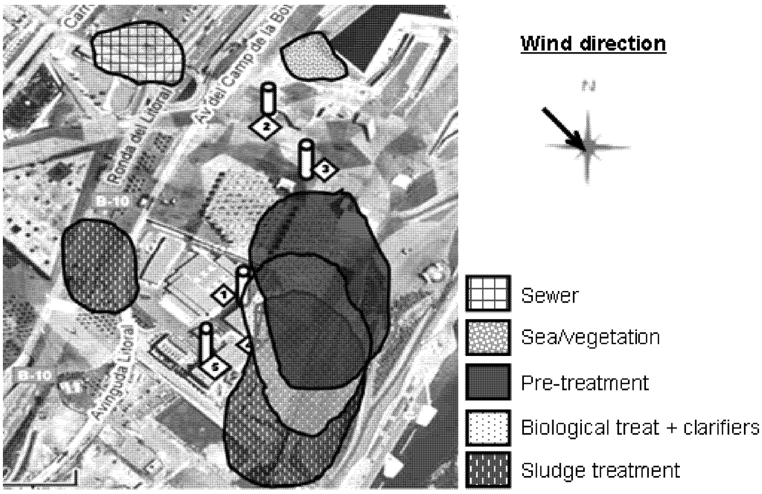

Figure 4. Odour footprint February 09. Chimneys 1,2,3,4 and 5 represent, respectively: pre-treatment, primary tanks, biological treatment, sludge thickening and sludge treatment.

Figure 3 and Figure 4 shows that one of the main odour sources which accounts for a high footprint in the environment is that from the sludge treatment line. In order to prevent as much as possible any risk of nuisance, a special procedure was implemented to load the trucks of dewatered sludge in confined tunnels (which ventilation air is sent to the treatment unit). However the trials have showed that the odour treatment unit – although well designed for "normal conditions" – cannot overcome such an emission peak during loading.

3.4 Odour production prediction: wastewater treatment and drying

In the case of wastewater treatment, the data collected was difficult to use, for example because some of the units referred to surface emissions, which is difficult to define specifically for some equipments such as screenings or centrifuge. Furthermore, values obtained were unexpected, showing higher emissions for the biological treatment (and not the sludge treatment), and not coherent with previous measurements carried out in another study (not shown on this paper).

In the case of drying, the odour compounds as well as odour emissions were calculated theoretically, to compare the emissions of the sludge during drying either through Seghers or through STC technologies. The operation of both dryers differs in terms of type, temperature and residence time:

Seghers: indirect dryer, oil at 250ºC, retention time 25 min

STC:direct dryer, air at 85ºC, retention time 90 min.

Results of odour compounds emission were very similar, as the emissions depend very much on the sludge itself, and in this case the goal was to compare 2 types of dryer. Methylmercaptan and Dimethylsulphide were assessed as the main sulphur compounds to be emitted in both dryers. Higher differences were found for amines, which depend a lot on the residence time, and are lower with Seghers dryer. However, the overall odour emissions are found to be higher with the Seghers dryer, because temperature favours odour production. The odour emission value obtained for the Seghers dryer was $4{,}8 \cdot 10^9$, being $2{,}7 \cdot 10^9$ in the case of STC dryer. Thus, these results show high expectations for new STC dryer to be built.

4. Conclusions

The combined use of different odour assessment techniques has allowed to better understand the main sources of odour which actually create the nuisance in the surroundings of the plant. The wind direction and the temperature are very important factors impacting the odour dispersion and thus the nuisance, and difficult to apprehend and assess in such a complicated context on the seafront. High temperature and low wind speed strongly favor odour emissions.

Moreover, the evaluation of the predicted odour treatment for the new dryer showed promising prospects for the construction of the new STC dryer, which will therefore hopefully not impact the overall footprint of the plant.

The main critical aspects identified in terms of future prospects and suggestions for implementation were the full assessment of the activated carbon treatment systems for the aeration tanks and clarifiers, and optimization of the ventilation of the sludge line treatments. In addition, a more detailed footprint analysis is planned using more complex models and a more thorough follow-up with the odour panel.

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