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Odour Impact Assessment in Industrial Areas

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Odours emitted by multi-source facilities, like industrial complexes, have become a major concern for local authorities because the resulting annoyance in the neighbourhood is generally high compex compared to a single source one. In the case of such multi-source odour emissions especially, common chemical analyses or odour concentration measurement methods are not often applicable.
This paper describes the methodology adopted for assessing the odour impact on the industrial area of the city of Salerno (Italy), caused by the co-presence of two strategic plants: wastewater treatment plant and composting plant of organic fraction of solid waste. The combination of olfactometric analyses and dispersion modelling allowed both the quantification of the odour emissions and the evaluation of their potential impact on the surrounding areas. Odour impact criteria, input parameters and emissive rate were evaluated. Results discuss and compare different emissive scenarios to assessment odour impacts in the industrial area.

1. Introduction

Odour pollution is of growing concern in industrial and agricultural areas and it is related to the quality of the life in the cities. Minimising odour nuisance is now a priority for some industrial categories of plants. Numerous steps can be taken to ensure that neighbouring odour sensitive receptors do not have cause to complain. These include the implementation of abatement techniques for existing units or the determination of accurate setback distances and appropriate siting of new units (Nicell, 2009).
It has become standard practice to use atmospheric dispersion models to predict the occurrence of odour nuisances around intensive odour plants (Hayes et al., 2006). Another method is to use trained “sniffers” to field assess the odour impact of the production unit (Zarra et al., 2010). This method has become popular in some parts of the Europe and US but is thought to be time consuming, expensive and largely dependent on local meteorological conditions.
It is well known that the absence or presence of background odours may also have a significant effect (Nicell, 2009) and this aspect is emphasized in industrial areas where different kind of plants operate concurrently emitting different odorous compounds (Zarra et al., 2008). The co presence of different multi-source industrial plants are likely to add to those influences the fact that both the background itself and the emerging odours are complex mixtures of different odour types, which fluctuate with time (Zarra, 2009a, 2009b).
A possible way of assessing the odour annoyance in such cases could be the use of an atmospheric dispersion model. Atmospheric dispersion modelling can be used in three ways for poultry units (Hayes et al., 2006): (i) to determine the odour impacts that existing or proposed units will have on the surrounding area; (ii) to calculate approximate setback distances for new units and to site the units appropriately; (iii) to estimate the maximum odour emission permitted and which abatement techniques will prevent odour complaints occurring.

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This paper describes the methodology adopted for assessing the odour impact on the industrial area of the city of Salerno (Italy) caused by the co-presence of two industrial plants. Dispersion modelling approach to determine the odour impact of single plant and of their overall effect is also discussed.

2. Materials and methods

2.1 Site description

The study was conducted in the industrial area of Salerno city (southern Italy) that includes two major odour sources: a wastewater treatment plant (WWTP) and a Composting Plant (CP) of organic fraction of municipal solid waste (MSW) (Figure 1).

WWTP is biological plant based on conventional activated sludge for 700,000 pe. CP treats a organic fraction of MSW of all Salerno City with an Anaerobic/Aerobic process where odour emission are treated by Scrubbers and then by Biofilters.

Figure 1: Industrial area of Salerno city (Italy) with the localization of the studied plants: wastewater treatment plant (WWTP) and Composting Plant (CP)

2.2 Odour Sampling

Odour emissions were taken at six different treatment units (Grit, Primary sedimentation, Oxidation, Sludge thickening, Sludge dewatering, Sludge storage) of the plant of WWTP and on all biofilters of CP. The plant have three biofilter, one for each stage of the aerobic/anaerobig process.

Air samples are taken using the ‘lung’ technique, whereby the sampling bag is placed inside a rigid container (length 685 mm, diameter 152 mm), and the container evacuated using a vacuum pump in accordance with EN 13725:2003. This method avoids contamination, which may arise from the direct use of pumps in the sampling line. Nalophan® sampling bags with 7 L volume are used for the sampling.

Sampling on passive area sources (i.e. liquid surfaces without an outward flow, e.g., wastewater treatment tanks) was performed using a wind tunnel system. Samples were collected from the wind tunnel over a period of 30–60 min, at flow rates between 50 and 150 mL min^{-1}. On other way sampling on solid active sources (i.e. biofilters) was performed by static hood with a surface of one square meter.

Measurement of velocity of emission (m/s) for determination of emission rate was carried out using a wind meter (Nielsen-Kellerman, PA, USA).
In both monitored plants there are also different small fugitive sources, which are difficult to determine and may be significantly different among the plants. These emissions weren't considered in this study because, there is an evidence that the contribution of the fugitive emissions to the overall odour impact is not relevant with respect to the other emission sources (Sironi et al.. 2010).

2.3 Odour Measurement

Odour measurement is performed by dynamic olfactometry according to EN 13725:2003 at the SEED (Sanitary Environmental Engineering Division) research centre of University of Salerno using an olfactometer model TO8 by ECOMA, based on the ‘‘yes/no’’ method. All the measurements were conducted within 30 h after sampling, relying on a panel composed of 4 panellists.

2.4 Dispersion model

Calpuff model system was used for the simulation of the odours emission dispersion in the surrounding area. In the model a spatial domain of 4,000 m x 4,000 m was considered, with a square grid of receptors every 50 m. The characterization of the "terrain following" was carried out by 7 vertical layers. Coefficients of used land were selected according to Scire et al. (2000) proposition. Hourly average data of meteorological parameters (Wind Direction, Wind Speed, pressure, temperature, precipitation) were collected for a period of 12 months at the meteorological station of Pontecagnano (SA, Italy) only a few kilometres from the plant. In a simplified way, the level of clouds and cloud cover were considered constant and equal respectively to 1500 m and 5/10 (Scire et al., 2000).
Three long term simulations were carried out referring to one year of data and with a calculation step of 1 hour: only WWTP scenario, only CP scenario and both the plants scenario. In all simulations the odour emission rate (OER) values were calculated considering the highest values of emission rates found out over all analysis period for each monitored sources: 6 for WWTP and 3 for CP. Evaluation of Odour impacts were conducted according the 98th percentile method proposed by Lombardia Region guidelines (Sironi et al., 2010) in commercial and industrial areas.
Odour impact was evaluated using the methodology of peak to mean ratio (P/M) and checking that the maximum frequency of odours, this being understood to mean the relative frequency of times when odours are clearly perceptible, not exceed a determinate odour hours, in the area (Table 1).

Table 1: Threshold value of 98th percentile for odour impact assessment suggested by guideline of Regione Lombardia

Type of area	Distance form the plant (m)	Odour Concentration (ouE/m^3)
Residential	>500	1
	200-500	2
	<200	3
Commercial	>500	2
	200-500	3
	<200	4
Industrial	>500	3
	200-500	4
	<200	5

3. Results and discussion

3.1 Odour emission rate

Odour emission rate (OER) of all monitored sources were summarized in the Table 2 for the WWTP and in Table 3 for the CP. Results show that in WWTP odour emitted by units of the sludges treatment line are highest of the odour emission from wastewater line. The highest odour concentration was detected at the sludge thickening (5600 ouE/m^3) while the lowest in the oxidation unit (43 ouE/m^3). On other way, in CP odour emission by biofilter are related to the organic fraction treatment stage in the CP, the first maturation of organic fraction of MSW is related to Biofilter #2 that report the high OER.

Table 2: Characterization of main odour sources of WWTP

Source	Area (m^2)	Max SOER (ouE/ m^2 s)	OER *(ouE/s)*
Grit	205	5.32	1,090.60
Primary sedimentation	8328	0.18	1,499.04
Oxidation	3320	0.22	730.40
Sludge thickening	230	8.41	1,934.30
Sludge dewatering	298	6.15	1,832.70
Sludge storage	110	4.83	531.30

Table 3: Characterization of main odour sources of CP

Source	Area (m^2)	Max SOER *(ouE/m^2 s)*	OER *(ouE/s)*
Biofilter #1	550	47.09	25,900
Biofilter #2	440	76.9	33,836
Biofilter #3	440	29.32	12,900

3.2 Dispersion model

For each receptor of the simulation grid and for each h r of the simulation period, the model calculates the hourly mean odour concentration. These values must be multiplied by a peak-to-mean ratio, in order to obtain the peak odour concentration for each receptor and for each hour of the time domain. In general, the peak-to-mean ratio can be evaluated as a function of wind velocity, stability and distance from the source (Schauberger et al., 2000). In this case, we adopted a peak-to-mean ratio of 2.3, according to the literature (Sironi et al. 2010). From the matrix of the ground peak odour concentration values the 98th percentiles were extracted. The results of the odour dispersion simulation can therefore be represented in maps reporting the isopleths relevant to the 98th percentile of the hourly peak concentrations (Figure 2 and Figure 3 relevant to the all studied emitted scenario).

Comparing the model results for the emitted scenario with a singular plant (Figure 2) clearly shows how the odour concentration at receptors from the only WWTP largely prevails with respect to the odour concentration caused form the only CP. According to guideline for odour impact assessment of Regione Lombardia, model results were evaluated respect the odour limits reported in Tables 2, suggested for commercial areas. In these comparison each studied plant have some impact in different zone of the industrial area. On other way considering the limits suggested from the same guideline for the industrial area both the plants have significant less impact on the neighbouring.

In Figure 3 is showed the maps of the 98th percentile of the hourly peak odour concentration values obtained in the scenario with both the plants: WWTP and CP. This scenario is the more realistic in

terms of possible odour concentrations in the area, because all main odours sources in the area were taken in account.
Comparing the model results of the third scenario (Figure 3), inclusive of the emission form both the plants, with the previous limits of Italian guideline, is easy to see that the real impacted area is more extensive and subjected at high concentration.

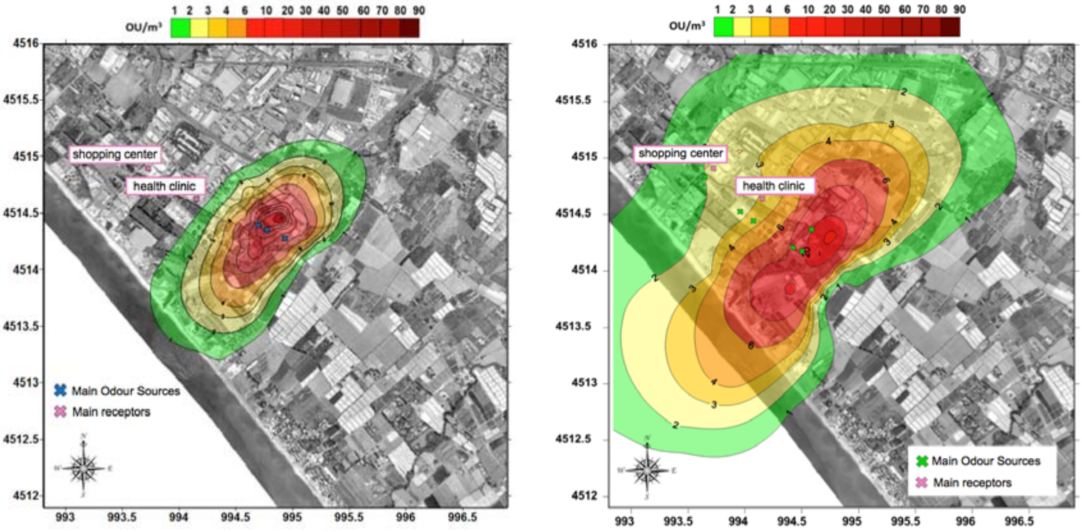

Figure 2: Maps of the 98th percentile of the hourly peak odour concentration values obtained in only CP scenario (left) and only WWTP scenario (right)

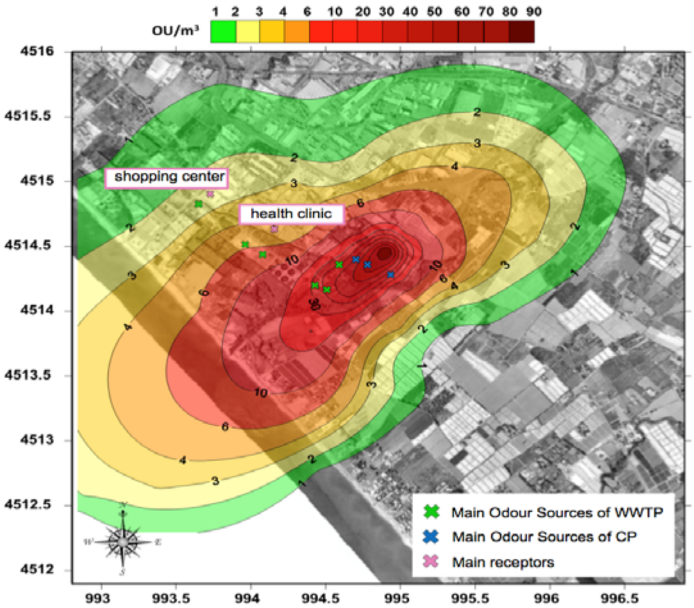

Figure 3: Maps of the 98th percentile of the hourly peak odour concentration values obtained in the scenario with both the plants WWTP and CP.

4. Conclusions

Based on the results of the study it is possible to draw some important conclusions about the odour impact of the industrial plants, and about the possibility of using odour dispersion modelling as tools for the control and management.

Use of odour dispersion modelling as a predictive technique to establish odour impact and possible health effects from industrial plants that include biological processes like WWTPs and CPs is currently limited by high variability of substances (solid and liquid) treated and by the absence of robust characterization of their odour emission and their effects.

Modelling results were evaluated according the Regione Lombardia guideline for odour impact assessment that foresee the assessment of single plant. Following this approach both the plant have a limited impact on the industrial area, but the overall effect due to the presence of both the plants is strongly high. This aspect is a limit of this approach for post analyses, but it is a good and strong way for the design criteria of new plants.

More-focused research is needed to address these uncertainties to enable informed risk management decisions to be made. There is a need to establish reliable source-term emission data, to carry out annoyances, with sufficient statistical power to develop meaningful dose related effects from odours exposure and undertake focused research to develop effective and reliable monitoring and modelling methods.

In the absence of safe levels of exposure and reliable monitoring and modelling protocols, the implementation of precautionary measures in light of this uncertainty may prove to be unnecessarily prohibitive. The management of this uncertainty will be of key importance in establishing public confidence in biological technologies. A robust and extensive evidence base is required to inform the odour assessment process, and this study provides do give additional data in this direction.

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