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Assessment of the odour impact of the industrial area of Terni (Italy)

Laura Capelli[1]*, Selena Sironi[1], Renato Del Rosso[1], Paolo Centola[1], Sauro Pierucci[1], Caterina Austeri[2], Adriano Rossi[2]
[1] Politecnico di Milano, Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Piazza Leonardo da Vinci 32, 20133 Milano
[2] ARPA Umbria, Department of Terni, Via Federico Cesi 24, 05100 Terni
*corresponding author: laura.capelli@polimi.it

This paper describes the methodology adopted for assessing the odour impact on the city of Terni, caused by the co-presence of three important industrial poles: the steel industry pole, the chemical pole and a third industrial pole, comprising different activities for the treatment of wastewaters and solid waste. The combination of olfactometric analyses and dispersion modelling allowed both to quantify the emissions and to evaluate their impact on the territory. The overall odour emissions were estimated to be equal to 218000 ou_E s^{-1}: 51% from the steel industry pole, 29% from the chemical pole and 20% from the other plants, respectively. The simulation of the emission dispersion shows that the odour impact relevant to all three studied industrial poles is considerable, actually investing almost the whole city of Terni. The comparison between odour perception reports by the citizens and dispersion modelling results showed a correspondence in 6 out of 7 cases, therefore adding to the validation of the applied simulation procedure.

1. Introduction

Odour nuisance problems are particularly worrying when more industrial activities exist near residential areas. In Italy this is often the case, given to the expansion of cities that took place in the last decades of last century, which has brought industrial poles to be englobed within urban boundaries. One example of this situation is represented by Terni, a city of 112000 inhabitants, with a high density of industrial activities, which makes it the most industrialized city of central Italy. More in detail, within the boundaries of the city of Terni, there are three important industrial poles. In the north-eastern part of the city there is the steel industry pole. South west with respect to the town centre there is the chemical pole, consisting of different industries for the production of polypropylene and polypropylene products. Finally, there is a third industrial pole at the north-western part of the city, comprising different activities mainly for the treatment of wastewaters and solid waste. Since several years odour nuisance is a serious environmental concern in the city of Terni, whose citizens are repeatedly lamenting the presence of malodours, especially by night. Given the entity

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and frequency of the complaints and the particular character of the pollutant (i.e. odour), the local authorities have decided to undertake a specific study of odour impact assessment in order to evaluate the entity of the problem, and to investigate its origins. For this purpose, the study involved the identification of the principal odour sources of the three industrial poles of the city, the quantification of emissions by specific techniques for odour sampling and measurement (dynamic olfactometry) and the simulation of the dispersion of odour emissions on the territory by application of a suitable mathematical model.

2. Materials and methods

2.1 Odour sources identification and sampling

The first important step for odour impact evaluation is the identification of the major odour sources to be monitored for the study. This was achieved with the help of the local agency for environmental protection (ARPA), based on a first survey of the three industrial poles, i.e. the steel industry (SI), the chemical pole (CP) and the other plants located north-west from the town centre (OP). Over 60 different odour emission sources were identified. For dispersion modelling purposes, the single odour sources must be considered separately. For an easier and more general interpretation of the results, it was decided to assemble similar odour sources into a reduced number of groups, according to their typology (Table 1).

Samples were collected on all the identified potential odour sources, adopting specific strategies based on the source typology (Sironi et al., 2010). The sampling operations required 4 days, from Monday, 8th June 2009, to Thursday, 11th June 2009.

Table 1. Odour sources considered for the study

Industrial pole	Source	Description
Steel industry Thyssen Krupp (TK)	Blue Daneco	Primary emissions from furnaces
	LAF 4	Emissions from the furnaces for the annealing of the cold rolled product
	Oily mists abatement	Emissions from the filters for the abatement of oily mists
	Post-combustors	Post-combustors of waste gases from the preheating of the re-built ladles
	Slag storage	Basins for slag storage
	IDAPIX	Wastewater treatment plant for the treatment of the effluents from cold rolling section
	SIDA	Wastewater treatment plant for the treatment of the effluents from casting and hot rolling section
Chemical pole (CP)	Treofan	Production of polypropylene film
	Novamont	Production of Mater-Bi
	Meraklon	Production of polypropylene yarn and flock
	WWTP	Wastewater treatment plant for the treatment of the effluents from the three firms
Other plants (OP)	En.A.	Pulper incinerator
	Printer	Biomass incinerator
	ASM - waste selection	Municipal solid waste (MSW) selection plant
	ASM - WWTP	Municipal wastewater treatment plant

2.2 Determination of odour concentration and odour emission rate by dynamic olfactometry

Dynamic olfactometry allows to determine the odour concentration (c_{od}) of an odorous air sample, which is expressed in European odour units per cubic metre (ou_E m^{-3}), and represents the number of dilutions with neutral air that are necessary to bring the odorous sample to its odour detection threshold concentration (CEN, 2003).

In general, in order to characterize an odour emission, it is not sufficient to measure odour concentration in isolation. The quantity to be considered for odour impact evaluation purposes is the so called "Odour Emission Rate" (OER) associated with each odour source, which is measured in ou_E s^{-1}. The methods for the calculation of the OER depends on the source typology (Sironi et al., 2006).

2.3 Dispersion modelling

The model used is the CALPUFF model, a non-stationary puff atmospheric dispersion model, which is proved to be effective for the simulation of the dispersion of odours (Wang et al., 2006).

The model needs three different kinds of input data: orographical, meteorological and emission data.

As far as orography is concerned, the dimensions of the receptor grid on the simulation domain are 8000 m x 8000 m, with a receptor point every 200 m. The domain dimension was chosen in order to include the whole city of Terni and the three industrial poles at issue.

The meteorological data used for the simulation are the data registered over a complete year (2008) by a meteorological station located in the town centre (42°33'56'' North and 12°38'50'' East), at a height of 13 m.

The emission data for the simulation are based on the results of the olfactometric analyses. As already mentioned, in order to characterize an odour source, the OER, expressed in ou_E s^{-1}, must be evaluated. It is worth to highlight that, given that the OER from area sources is a function of the wind speed over the emitting surface, the OERs relevant to area sources are calculated for each hour of the simulation domain based on the current wind speed (Sohn et al., 2003). Moreover, the model requires other information about the emission sources, i.e. the geographical coordinates, height, geometry (e.g., horizontal or vertical) and operating times.

As far as the dispersion modelling output is concerned, for each receptor of the simulation grid and for each hour of the simulation period, the model calculates the hourly mean odour concentration. I order to take account of the instantaneous fluctuations of odour concentration due to turbulence, the hourly mean odour concentration values were multiplied by a peak-to-mean ratio of 2.3, according to the technical document about the modelling and assessment of air pollutants published by the Department of Environment and Conservation of New South Wales (DEC 361, 2005).

Another important degree of freedom concerns the graphical representation of the modelling results. The choice should be based on current regulations about odour impact evaluation. According to the guideline about the characterization and authorization of gaseous emissions from odour emitting activities of the Region of Lombardi, which is on the point of being issued and whose criteria are already adopted as a reference in other Italian regions, we decided to extract the 98th percentiles from the matrix of the ground peak odour concentration values. The results of the odour dispersion simulation are therefore represented in maps reporting the isopleths relevant to the 98th percentile of the hourly peak concentrations.

3. Results and discussion

3.1 Olfactometric measurements

Figure 1 shows the OER values, expressed in $ou_E\ s^{-1}$, relevant to the grouped odour sources listed in Table 1.

By considering the odour sources of the three industrial poles separately it is possible to evaluate the relative contribution of each industrial pole to the overall odour impact, as the ratio between the sum of the OER values relevant to the sources of each industrial pole and the total OER (Figure 2).

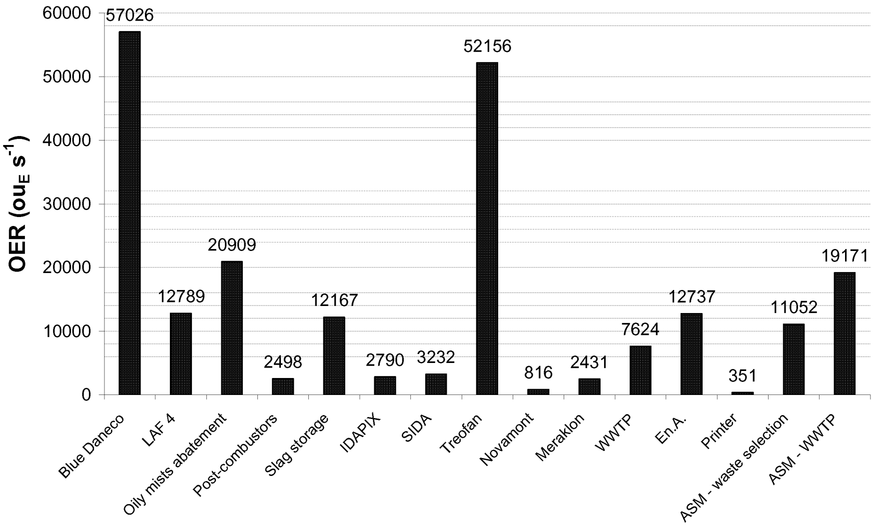

Figure 1. OERs relevant to the considered grouped odour sources

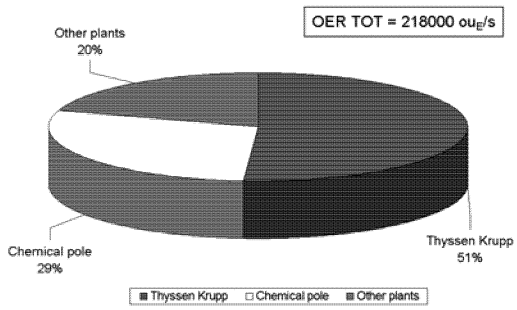

Figure 2. Distribution of the total OER among the three industrial poles

3.2 Simulation of odour emission dispersion

The results of the simulation of the odour emission dispersion are illustrated in Figure 3 and Figure 4. It is possible to observe that the odour impact relevant to all three studied industrial poles is considerable, actually investing almost the whole city of Terni. One important consideration derives from the comparison of the dispersion modelling results with the results of the olfactometric analyses, i.e. the determination of the OERs of the industrial poles. More in detail, based on the olfactometric measurements results, the OER relevant to the steel industry turned out to be significantly higher than the OERs relevant to the chemical pole and the other plants. Despite of these differences, the odour impact relevant to the three industrial poles simulated by the model seems to be comparable. This can be explained making some considerations about the different source typologies. The odour sources of the steel industry are mainly point sources, consisting of high stacks (over 20 m high) that enhance the dispersion of odours into the atmosphere. On the contrary, the chemical pole and the other plants are both characterized by the presence of odour sources with a poorer dispersion capacity, such as lower stacks (less than 20 m high) and especially area sources.

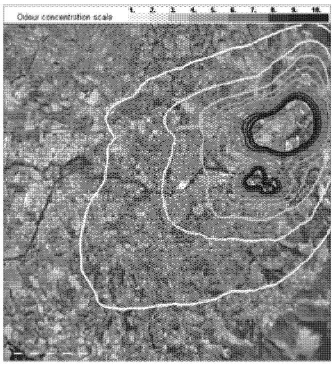

Figure 3. Map of the 98° percentile of the peak odour concentration values relevant to the emissions from the steel industry pole, in a scale from 1 ou_E m^{-3} to 10 ou_E m^{-3}.

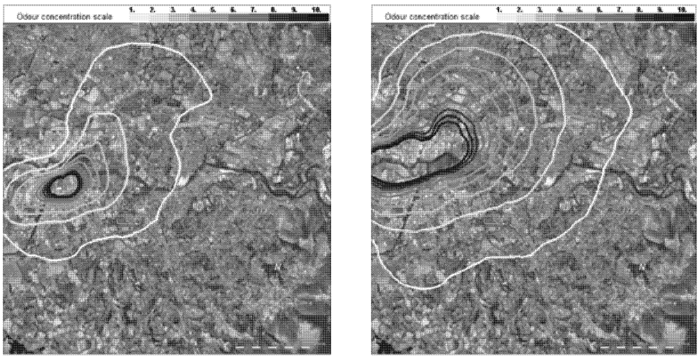

Figure 4. Map of the 98° percentile of the peak odour concentration values relevant to the emissions from the chemical pole (on the left) and from the other plants (on the right), in a scale from 1 ou_E m^{-3} to 10 ou_E m^{-3}.

The comparison between odour perception reports by the citizens and dispersion modelling results showed the existence of a correspondence in 6 out of 7 cases (86%), therefore adding to the validation of the applied simulation procedure

4. Conclusions

This paper describes the methodology adopted in order to evaluate the entity of the odour impact on the city of Terni, and to investigate its origins.

The olfactometric measurements allowed to determine the odour concentration values (ou_E m^{-3}) and the odour emission rate values (ou_E s^{-1}) relevant to each sampled odour source.

The overall odour emissions released into the atmosphere were estimated to be equal to 218000 ou_E s^{-1}: 51% from the steel industry pole, 29% from the chemical pole and 20% from the other plants, respectively.

The results of the simulation of the odour emission dispersion, illustrated as maps reporting the 98th percentile, on an yearly basis, of the peak odour concentration values relevant to the three studied industrial poles, show that the odour impact relevant to all three studied industrial poles is considerable, actually investing almost the whole city of Terni. Despite of the differences in the odour emission rate values resulting from the olfactometric analyses, the odour impact relevant to the three industrial poles simulated by the model is comparable.

Finally, the comparison between odour perception reports by the citizens and dispersion modelling results showed the existence of a correspondence in 6 out of 7 cases (86%), therefore adding to the validation of the applied simulation procedure.

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