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Application of dispersion models as useful tool for the evaluation of odour impact of industrial plant

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In the perspective of the improvement of life quality and citizens wellness, odour pollution is becoming a more and more relevant topic. In this work a study about odour dispersion phenomena in the province of Bari is presented. The attention was mainly focused on the evaluation of odour relapse in the surroundings of some industrial plants, as they reasonably have the greatest impact on the investigated area. A careful analysis of the available references allowed the identification of the plants at higher olfactory impact; for a more detailed plant localization, thematic maps were elaborated. Both olfactometric monitoring campaigns and Gaussian model based simulations of the different odor dispersion scenarios were carried out. The odor concentration data provided by the modeling elaboration were finally compared with the experimental ones: the reliability of modeling simulations as powerful tools for the legislative setting of limits, not only at the odor emission, but also at the sensitive receptors, was demonstrated. This study, by providing a detailed description of the most critical odor impact zones, intend to be an useful tool for a sustainable planning of industrial areas in the Bari territory.

1. Introduction

Among the variables that could influence the citizens sense of a healthy environment, odour emissions play an important role, as they deeply affect the human life quality and psycho-physical wellness. For this reason in the last decade the scientific community has been developing an increasing attention for odour pollution, generally caused by industrial activities. Different types of productive plants such as tanneries, refineries, slaughterhouses, distilleries, and especially civil and industrial wastewater treatment plants, landfills and composting plants are often source of olfactory nuisances. Although the olfactory impact of these plants is almost never involved in a real toxicological risk, bad smells are often related to "unhealthy" air conditions, thus contributing to the population unease and anxiety.

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Dispersion models are an useful tool for evaluating the impact of odour sources on their surrounding areas, as they can estimate the odour transport depending on the site weather conditions: through algorithms describing the effluent motion (transport and distribution) and the relative atmospheric phenomena, dispersion models provide codes for calculating the pollutant concentration in the areas around emissive sources.
The present paper focuses on the study of odour dispersion phenomena produced by high olfactory impact industrial plants, located in the Bari Province. After a first screening of the industrial activities in the territory, the most relevant as potential odour sources were monitored by means of olfactometric campaigns; starting from the collected experimental data, a Gaussian dispersion model, WinDimula3, was then used to predict odour transport and distribution in the plants surrounding areas.

2. Methodology

2.1. Determination of the most impactful plants in the Bari Province

The first step of this study was the choice of the more interesting industrial plants from the point of view of the odour impact. At this purpose a cadastre of the possible osmogenic sources in the investigated territory was established: to collect all necessary information, a questionnaire was administered for each plant. The following parameters were considered as relevant to the assessment of the potential osmogenic effect:

- size and production capacity (indication of the plant size);
- presence of odour abatement systems or purification systems;
- type of plant location area;
- distance from the town (indication of the possible fallout of odorous substances in the surrounding areas).

Some information were found in the Province databases, that, unfortunately, were often obsolete or inadequate. To overcome this drawback, other references, such as technical reports for the Integrated Environmental Authorization and documents of Apulia Region or individual municipalities property were considered.
Moreover, to evaluate the potential odor impact of urban and inert waste landfills, composting plants, and hazardous and no-hazardous waste storage plants, other information were also requested such as: the daily rate of the treated waste, the waste type and the plant size. Inert waste landfills were not considered due to their low osmogenic content.
For the wastewater treatment plants, Acquedotto Pugliese S.p.A. (AQP), the managing authority of the most of plants in the province, provided the following information:

- register of the facilities in the Bari Province: name, location, municipalities served, etc...;
- final dumping position and its distance from the surrounding towns;
- short description of purification process stages;
- odor abatement systems type;
- plant size (expressed as inhabitants equivalent or wastewater daily flow)

Thematic maps representing the most impactful odor plants in the Bari Province were realized by mean of the Geomedia® software. Figure 1 is an example: the most relevant osmogenic sources in the investigated territory, classified in typologies, are shown.

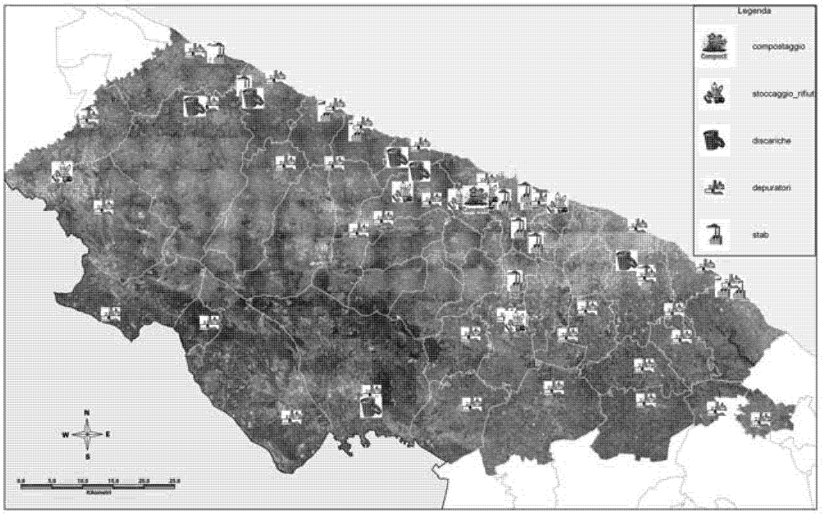

Figure 1 – Map of the most important osmogenic plant in Bari Province.

2.2. Olfactometric campaigns

The redaction of the osmogenic plants cadastre was useful to the choice of the more interesting and suitable sites for conducting olfactometric monitoring campaigns. By agreement with the provincial administration, three wastewater treatment plants, three urban waste landfills (one with a platform for the mechanical treatment and biostabilisation) and a composting plant were selected. In order to collect representative samples, the odor emission sources of each plant were individuated; the analysis was carried out in the olfactometric laboratory of University of Bari. Both samplings and analysis procedures were adopted in accordance with European Standard EN 13725, which provides standard procedures for olfactometric measurements and quality criteria for the evaluation of experimental results (accuracy and precision). The olfactometric measure uncertainty was calculated according to the indication reported in the German law VDI 3881.
In order to assess the impact of the above-mentioned plants on sensitive receptors, modeling simulations were performed. The results obtained in the framework of the olfactometric campaigns and the meteorological data were used as input for the Gaussian dispersion model "WinDimula3".

2.3 Application of dispersion model

2.3.1 Windimula model

WinDimula is a Gaussian multisources model allowing to perform simulations in both short and long term way. Gaussian models base on an analytical solution of transport and diffusion equations in atmosphere. This solution is obtained under particular simplifying assumptions and is influenced by parameters that vary according to the atmospheric stability described by the Pasquill-Turner classes (Pasquill, 1983).

2.3.2 Tuning of the model

In order to verify the model uncertainty, the odour concentration values predicted by the model were compared to the ambient air experimental values measured at different sampling points within the investigated plant. At this purpose only the sampling hours, in the sampling day, were taken into account for the model simulation. The predominant wind direction was identified, but, in order to evaluate the model variability interval, a 20° range of directions, centred at the identified wind direction, was considered. The minimum and maximum measured wind speed were also considered.

Combining wind direction and wind speed, four scenarios, representing possible extreme conditions, were obtained. The model variability interval was evaluated as the difference between the maximum and minimum values obtained at each point of sampling for each scenario. The concentration interval calculated by the model was compared to the analogous interval measured through dynamic olfactometry, taking into account both the obtained uncertainties.

Table 1 reports the comparison between the measured and calculated odour concentration interval for a wastewater treatment plant: the dispersion model WinDimula3 seems to give reliable results, in good agreement with the variability interval of experimental data.

Table 1- Comparison between model data and experimental data

Odor sources	**Model**			**Sampling**		
	Lower limit	c_{od} (ou_E/m^3)	*Upper limit*	*Lower limit*	c_{od} (ou_E/m^3)	*Upper limit*
Screening and grit removal	1520	2580	4280	1611	2600	4054
Primary treatment	7.4	25.6	1320		<11	
Sludge thickening	46.8	222	592	182	300	493
Oxidation treatment	5.83	67.4	448	13	38	96

3. Results

The aim of the simulations was the identification of the plants sensitive receptors, that is the plant surrounding area mainly affected by odour dispersion. For each monitored plant different simulations, both in short and long term way, were elaborated. Four scenarios, one for each season, were produced in short term way: the spatial distribution of odor concentrations in a short period with particularly defined meteorological conditions was thus considered.

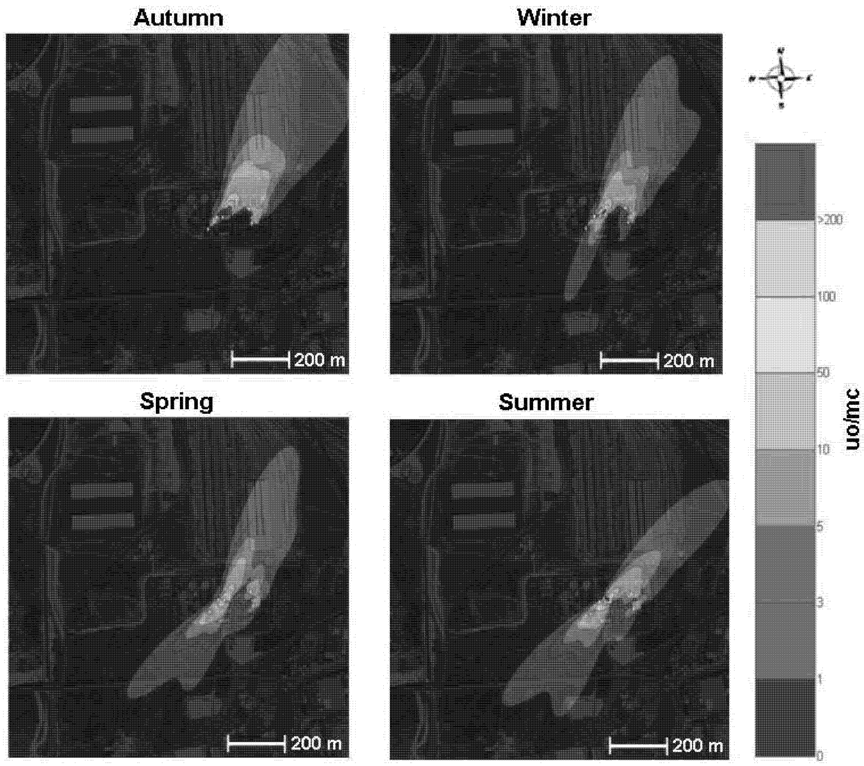

Figure 2 – Odor dispersion simulations of a wastewater treatment plant

Figure 2 shows the four seasonal scenarios obtained for a monitored civil wastewater treatment plant. The isolines for the odour concentration ranges 1-200 ou_E/m^3 are presented; higher concentrations were not reported as they were found within the plant area. The first isoline delimits the areas where odor concentrations lower than 1 ouE/m3 were predicted; higher detailed dispersion is given for odor concentrations in the 1-10 ou_E/m^3 range, as, according to the English standard IPPC-H4 (Appendix 1), 5 ou_E/m^3 corresponds to a weak odor, while 10 ou_E/m^3 corresponds to a distinct odor. It seems that in winter, spring and summer odor disperses mainly along two directions (NE-NNE e SO-SSO), while in autumn only the NE-NNE directions result affected. Anyway in all seasons, except in autumn, the 10 ou_E/m^3 odor concentration is never exceeded outside the plant area.

Moreover, in order to study the worst odor dispersion situation, the meteorological conditions characterized by high value of wind speed and low solar radiation were taken into account. In such scenario odor emissions mainly accumulate at low altitude and they disperse along horizontal direction: sensitive receptors, eventually located at long distance, could be affected.

Fig. 3 shows the worst scenario elaborated for the previously mentioned wastewater treatment plant: also if odor emission inside the plant is lower than that produced in other situations, it strongly disperses in the NE-NNE directions, affecting nearby industrial zone.

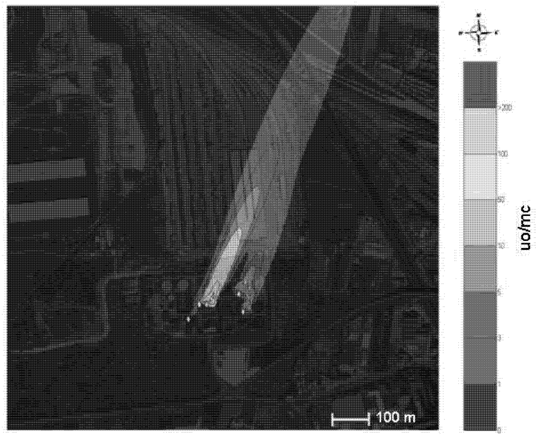

Figure 2 – Worst scenario elaborated for a wastewater treatment plant

4. Conclusions

The application of dispersion models represents an useful tool for evaluating the odor impact produced by plants, whose emissions are measured by means of olfactometric analysis. This paper has shown an analytical investigation aimed at an assessment of the osmogen risk in the Bari Province territory. Within the uncertainty interval, a good agreement between the dispersion model results and the collected experimental data was found. In the perspective of a sustainable planning of industrial areas in the Bari territory, this tool could be really useful for the public administration, in order to establish the critical sites with the higher olfactory impact on the surrounding areas.

Acknowledgements

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References

EN 13725: European dynamic olfactometry standard.

Verein Deutscher Ingenieure (VDI) – *Olfactometry – odour threshold determination – Fundamentals* – VDI 3881.

F. Pasquill, F.R. Smith "Atmospheric Diffusion" (3° edition), John Wiley & Sons Inc., New York, 1983.

Integrated Pollution Prevention and Control (IPPC), IPPC Guidance H4: Horizontal Guidance for Odour, Part 1—Regulation and Permitting, Environment Agency UK, Bristol, UK (2002) pp. 50–57.