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Predictive Numerical Evaluation of Odour Dispersion, Case Study: Non-Hazardous Waste Landfill

Nicola Pettarin*, Silvia Rivilli, Riccardo Snidar

LOD S.r.l. (Laboratory for Dynamic Olfactometry), via Linussio 51, 33100 Udine, Italy
nicola.pettarin@lodsrl.com

Among the existing types of industrial installations that can cause odour nuisance, landfills represent one of the most common sources of odour emissions and complaints. Odours from landfill sites originate principally from the atmospheric release of compounds that are formed during the biological and chemical processes of waste decomposition.
Because of this it is essential to find methods to predict the correct location of these types of plants and study its environmental impact before they are installed.
This study describes the numerical approach adopted to evaluate the odour dispersion of a non-hazardous waste landfill located in a small town near Udine (Italy)
The study consisted in different phases:

- Study of the winds, orography and landuse;
- Identification of odour input data (throw dynamic olfactometry);
- Development and evaluation of results.

1. Scene characterization and numerical method

1.1 Scene characterization

The evaluation of odour dispersion and pollutants has been done using CALPUFF dispersion model, recommended by U.S. EPA for planning, monitoring and control of air quality. CALPUFF is particularly useful for the simulation of the dispersion of odours on a local scale.
The dispersion models use complex algorithms to simulate the transport and kinetic pollutants in the lower atmosphere where the air is more affected by pollution. To achieve this, the models require input data divided into the following categories:

- Meteorological data: wind (direction and intensity), temperature and humidity, atmospheric stability;
- Mapping data: topography, cartography, land use;
- Emission data: geometry and location of emission sources, type of polluting and mass flow.

The choice of model is often made based on the characteristics of the plant, defined as the set of elements that characterize a specific application. Based on the guidelines of the UNI 10796 (2000) (Evaluation of the dispersion in atmosphere of gaseous effluents - Guidance on the selection criteria for mathematical models) a scene can be described based on five elements:

- Spatial scale: computational domain for the dispersion. Can be distinguish between microscale applications (up to 1 km), local scale (up to 10-20 km), mesoscale (up to 100-200 km) and large-scale (up to 1,000-2,000 km);
- Time index: short-term application (from minutes to days), medium term (from one hour to one week) long-term (seasonal and annual);

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- Geographical area: simple site (flat, uniform spatial features) or complex site (complex terrain, not constant spatial characteristics);
- Types of sources: point, linear or aeral;
- Simulated species: odour.

1.2 Description of odour dispersion model

CALPUFF is a puff Lagrangian dispersion model, in which the conservation equations of mass are written and solved by reference to emission releases called puff, that approximates the continuous emission.The equations for each puff is determined from the wind field. This wind field is calculated using a meteorological pre-processor (CALMET), which uses as input data, the data coming from the meteorological and mapping refer to the concerned site and for the simulation period. The output file of CALMET is processed by CALPUFF, together with the emissions data to get the desired concentration field.

For the development and evaluation of results have been taken as reference the documents: the "Guideline for the characterization, analysis and permission of gas emissions into the atmosphere of the activities to impact odour " (Lombardy Region, December 2009) and the Environmental Guidelines of the United Kingdom (UK-EA) IPPC-H4. Integrated Pollution Prevention and Control - Draft. Horizontal Guidance for Odour. Part 1 - Regulation and Permitting (Environmental Agency, Bristol, 2002).

2. Input data for the model

2.1 Meteorological data

For the selected area were acquired meteorological data taken on the ground level and data soundings.

- Meteorological ground data , were taken from Friuli Venezia Giulia OSMER center and refer to the meteorological station of Udine Sant'Osvaldo (Udine) located about 7 km far from the landfill site. Were considered the data at the ground for the year 2007, collected every hour and referred to the following parameters: wind speed (m / s), wind direction (deg.), air temperature (° C), barometric pressure at the ground (hPa), relative humidity (%), hourly global radiation (KJ/m2).
- Soundings data were taken from the meteorological station of Udine Campoformido (46 ° 02'N 13 ° 11'E) which is about 10 km far from the site. The meteorological model considers the representativeness of these data by assigning a weight inversely proportional to the distance from the site. These data were obtained from the website http://raob.fsl.noaa.gov/ and values used in the model were: wind speed (m / s), wind direction (deg.), temperature (° C); pressure (hPa).

Anemometrical and meteorological data are useful to properly describe the climatic situation in the area, so we can deduce the expected dispersion already from this analysis conducted in a preliminary stage. This is required by the Guideline of the Lombardy Region (Requirements for impact studies by odour dispersion simulation) to explain the appearance of isoconcentration curves impact on the map.

2.2 Preliminary analysis

The data analysis conducted in the first step has allowed us to acquire information about the expected behavior for adour dispersion. As can be seen from the analysis of the wind rose shown in Figure 1, in 2007, there has been a strong head wind from the East-Nord-East and, secondly, from the North-East; in other directions have recorded winds with frequencies below 9 %. This result allows us to say that the disperse pollutants emitted by the landfill will mainly spread in the South direction.

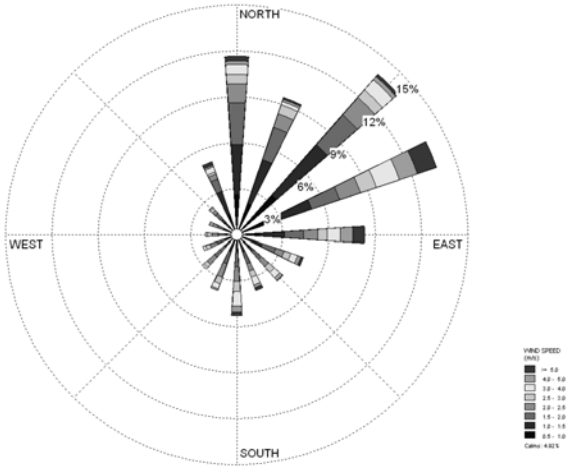

Figure 1: Wind rose for the year 2007, referring to the meteorological station considered: the radial coordinate (length of the circular sector) is the frequency, the color of the wedge indicates the intensity of the wind

2.3 Landuse and orographic data analysis

The dispersion model CALPUFF allows you to take into consideration the effects of orography characteristic of the territory. This kind of information were given through a matrix composed by array of elevations and land uses data into the spatial domain. In this case study we decided to study the dispersion of pollutants on a local scale and work with a computing grid of 3 x 3 km and a grid spacing of 100 m. The center of the grid was set on the existing part of the landfill site. Within the computational grid were also identified particular receptors corresponding to specific houses or settlements located near the studied site in which have been quantified pollutants and odours caused by the landfill.

2.4 Emission data

he landfill has a surface of about 40,000 m^2 and it has been divided into four sub-areas according to the state filling and coverage like in Table 1:

Table 1: Emission data

Emission	Area (m^2)	Est (UTM)	Nord (UTM)	Heigh (m)	Altitude (m)
Sub-area A	10,550	367.619	5105.809	8.5	111
Sub-area B	10,550	367.712	5105.855	8.5	111
Sub-area C	10,550	367.767	5105.747	8.5	111
Sub-area D	10,550	367.691	5105.712	8.5	111

The landfill is a passive areal source, this means that is a source where "the only flow is that due to this transfer of matter from the surface to air above it. An example of this type are landfills and tanks of water purification plants waste "(as defined by the Guideline of the Lombardy Region).
The odour input data considered in this model were:

- Odour flow generated by covered waste;
- Odour flow generated by uncovered waste;
- Odour flow generated by biogas.

3. Specific receptors

In order to evaluate the release of odour on the territory have been considered different buildings placed next to the landfill area, in a range of 3 km radius
In this study have been identified 9 specific receptors (Figure 2):

- Receptor A: located 700 m in the West direction;
- Receptor B: located 1 km in the South direction;
- Receptor C: located 300 m in the East direction;
- Receptor D: located 300 m in the North direction;
- Receptor E: located in the first houses of Grions del Torre, about 1600 m far from the landfill;
- Receptor F: located 1800 m in North-West direction, in the center of Godia;
- Receptor G: located 1100 m in West direction, in the center of di Beivars;
- Receptor H: located 1500 m in South-West direction in the center of San Gottardo;
- Receptor I: located 1700 m in South-East direction, in the first houses of Remanzacco.

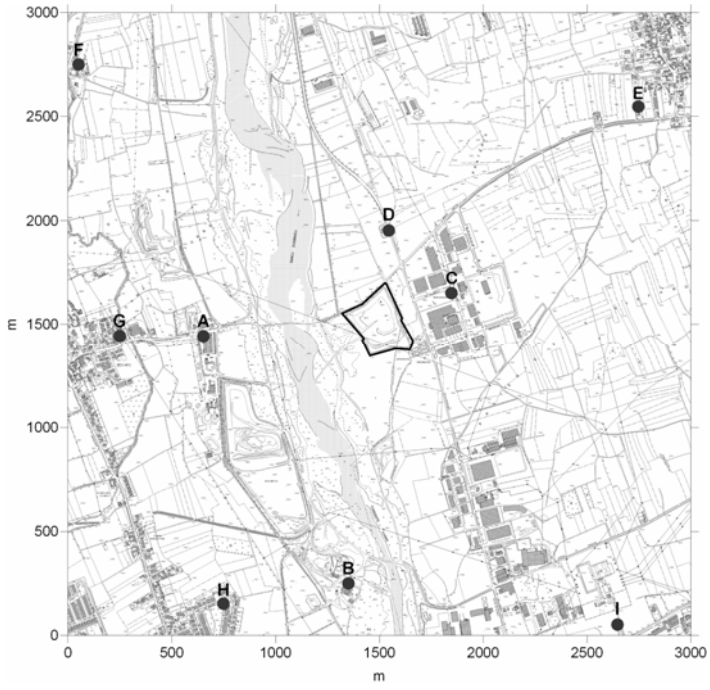

Figure 2: specific repectors where the odour concentration has been evaluated

These receptors allow to assess accurately the fallout of the odour in the area, quantifying the value referred to 98 % percentile of the simulated concentrations of odour.

4. Results and conclusions

In Figure 3 you can see the map of the odour dispersion originated by the landfill, in which is highlighted the limit value of 4 ou_E/m^3 defined by Guidelines of Lombardy Region as the limit for new business located in an industrial area.

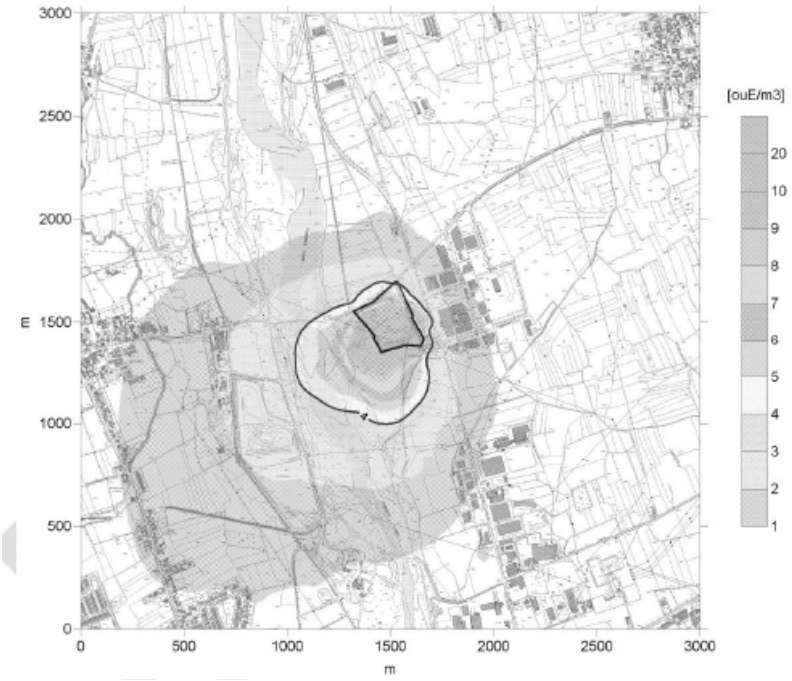

Figure 3: Odour dispersion map

In this map we see that the curve representing the value of concentration of 1 ou_E/m^3 extends to the center of Beivars and San Gottardo. The curve indicates that the limit value of 4 ou_E/m^3 not interested in any house because it is confined to South-West by the river "Torre" bed. In Table 2 are reported the values of the 98 percentile calculated at the specific receptors.

Table 2: odour concentration assessment

Receptor	Position	East (UTM)	North (UTM)	98% percentile
A	West	366,850	5105,735	1,536
B	South	367,550	5104,535	0,772
C	East	368,050	5105,935	1,234
D	North	367,750	5106,235	1,143
E	Grions del Torre	368,950	5106,835	0,108
F	Godia	366,250	5107,035	0,145
G	Beivars	366,450	5105,735	0,994
H	San Gottardo	366,950	5104,435	0,946
I	Remanzacco	368,850	5104,335	0,120

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