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# ODOUR IMPACT ASSESSMENT IN THE FIELD: THE PLUME METHOD

## *Extended abstract*

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### *Background*

Odours coming from human activities may cause adverse effects on citizens (Sucker et al., 2009), and therefore have recently become a growing social problem in industrialized countries (Ranzato et al., 2012). For this reason, odours are nowadays subject to control and regulation in many countries (Nicell, 2009). The need to regulate odour impacts entails the need of specific methods for odour of odour on citizens.

Different approaches can be used in order to evaluate measurement. Dynamic olfactometry (CEN, 2003) is now a widespread and common technique for the quantification of odour emissions. However, besides source characterization, it is important to evaluate the effective impact the odour impact on receptors, and therefore to regulate it. The two common approaches used are dispersion modelling and field inspection (Ranzato et al., 2012; Dentoni et al., in press). Odour dispersion modelling is commonly applied to simulate how odour disperses into the atmosphere, and therefore to calculate ground odour concentration values in the simulation space-time domain (Capelli et al., 2011). This approach may be useful for the definition of specific odour regulation. The wide diffusion of this approach is probably due to the fact that odour dispersion model is relatively cheap and results are easily understandable. Another important approach for direct assessment of odour impact in the field involves field olfactometric surveys, conducted relying on a panel of trained human assessors (field inspection) (Nicolas et al., 2006). This way of assessing odours entails the advantage of allowing the determination of ambient air concentration close to the odour detection threshold. The growing importance of this odour impact assessment method is proved by the current draft of an European Standard (Guillot et al., 2012).

The new European standard includes two methods of field inspection: the grid method and plume method. The differences between these methods are shortly described as follows: the grid method is a long period (one year) statistical survey method to obtain a representative map of a recognizable odour exposure over a selected area; the plume method is a short period method to determine the extent of recognizable odour from a specific source (Dentoni et al., in press). Both methods (grid and plume) are based on odour detection and recognition by human panellists (Guillot et al., 2012).

The aim of this work is to describe the application of a modified, site-adapted, plume method field inspection in order to evaluate the odour impact by determining the absence or presence of odour downwind relative to the considered source (plume extent), for the case of two different industrial plants: a food industry sludge composting plant and a biomass anaerobic digestion plant, both located in Northern Italy. As already mentioned, the plume method described in the draft European Standard had to be adapted according to the specific area on which the plants are located, and this paper has the aim of using these two case studies to discuss the feasibility of applying field inspections as odour impact assessment methods.

### *Methods*

The plume method is used to determine the extent of the area where the plume originating from a specific odour source or an odour emitting installation can be perceived and recognised, under specific meteorological

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conditions. The odour plume extent is described by points where a transition from absence to presence of the recognizable odour under investigation, occurs. Panel members are used to determine the presence or absence of the specific odour under study at different points downwind of a source under well-defined meteorological conditions. The meteorological conditions during the field observations are measured and recorded. Usually, the measurement is repeated to reduce uncertainty to an acceptable level. In this way variability due to random variations in meteorological conditions, panel member performance and odour emission is averaged out. There are two versions of observation methods for plume measurement in this standard (Fig. 2): •Stationary plume method •Dynamic plume method

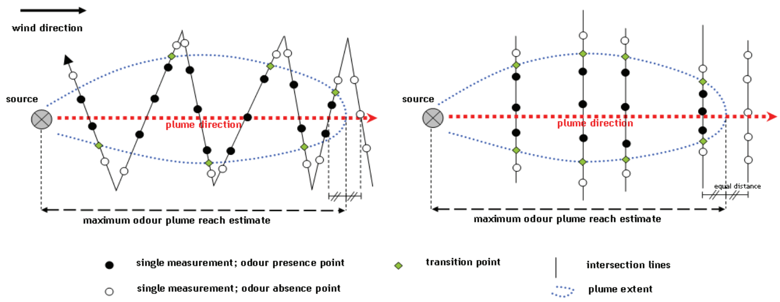


**Fig. 1.** Dynamic (left) and stationary (right) plume measurement

Using the stationary method, the panel members are located at specific intervals along intersection lines perpendicular to the plume direction. Each panel member determines the percentage odour time in the course of one single measurement. If the result of a single measurement reaches a percentage odour time <10%, the odour is considered as being absent; at higher values the odour is present. All observations at one intersection line are conducted simultaneously.. At least one intersection line has to be at sufficient distance to ensure that no recognizable odour is present at any measurement point to be able to determine the maximum odour plume reach.

Using the dynamic method, the panel members are traversing the plume, while conducting single measurements at frequent intervals. By successively entering and exiting the plume and in this way determining the transition between absence and presence of recognizable odour, the extent of the plume is defined. This approach helps to avoid adaptation. For both the stationary and the dynamic method the plume extent is defined by the transition points. A transition point is the point halfway between the last odour absence point and the first odour presence point for the odour type under study. In order to prevent possible adaptation effects causing incorrect observations, transition points are in the dynamic plume method only determined while entering the plume, and not while exiting.

*1. Site description*

The first site studied performs the composting of agro-alimentary sludge produced by a food industry for the production of cheese located in Northern Italy. The studied emission sources were the composting sludge heaps and the final product storage. The composting sludge heaps has an emitting surface of about 1600 $m^2$, whereas the final product storage surface is about 320 $m^2$. The second plant studied performs the anaerobic digestion of agricultural biomasses, and is located in Northern Italy, as well. The sources of odours of this plant are: the emissions from the biogas combustion, the shed for the biomass grinding and preparation, and the pond for the digestate storage, which, having a surface about 7100 $m^2$, represents the main source of odours.

*2. Site-specific adaptation of the plume method*

For this study it was decided to perform field inspections by applying the plume method with a dynamic approach. In both cases (plant 1 and plant 2) the dynamic plume measurement had to be adapted to the specific area where the plants are located. A preliminary study was performed in order to set up the plume measurement. This study involved the simulation of the odour dispersion at different times using the historical meteorological data relevant to the same month in which the field inspection should be run. This allowed planning the field inspection by evaluating the expected extension and direction of the odour plume in function of the time of the day. In addition, the area to be studied was mapped in a detailed way, in order to identify the paths around the source that could be used by the panellists for the field inspection. The field inspection planning also involved the training of the panel to recognize the characteristic odour of the considered source. For each measurement, 5 panellists divided in two groups were involved. More in detail, each group (A and B) was asked to go along the different paths identified during the preliminary study towards the odour emission source and to indicate the point at which they started to perceive the characteristic odour from the plant on each path. As soon as the panels perceived the odour, they had to stop in the position where they started perceiving the odour for 10 minutes, breathe normally, and fill in a specific form. After having indicated the time (hour and minute) at which they started perceiving the odour, every 10 seconds they have to fill in the grid indicating whether they continue to perceive the odour or not. Meanwhile, the group leader, by means of a GPS, registers the geographic coordinates of the point where the odour was first perceived.

***Results and discussion***

*Plant 1* - The paths identified to be covered by the two groups of panellists (A and B) during the two field measurements are shown in Fig. 3. The results of the two field inspection campaigns (I and II) are shown on the left side of Fig. 3. More in detail, the maps reports, for both campaigns, and for each panel group (A and B, in different colours on the maps) the points on the different paths where the odour started to be perceived. In the right side of Fig. 4, there are shown the odour exposure simulated by running the odour dispersion model at the same time when the I and the II field inspection campaigns took place, i.e. with the meteorological conditions that were present at the time of the field measurement, in order to make it possible to compare the two assessment methods. In order to compare the dispersion modelling results with the outcomes of the field inspection, the lines connecting the points where the odour started to be perceived during the field measurements should be compared with the modelled iso-concentration lines. More in detail, the lines resulting from the field inspection should not be compared with the iso-concentration line of 1 $ou_E\ m^{-3}$, which corresponds by definition to the odour detection threshold concentration, but rather with the iso-concentration line corresponding to the odour recognition threshold concentration, which is assumed to be about 3 $ou_E\ m^{-3}$. Thus, the odour impact assessed with the two different approaches seems to be quite comparable. Nonetheless, a slight overestimation of the odour impact may result from dispersion modelling, due to the experimental evidences of overestimation of odour impacts obtained when Calpuff is applied to area sources. Moreover, based on the experience of our laboratory, in some cases, especially when dealing with odour emissions having an organic matrix located in an agricultural context, high odour concentrations are measured at the source, but odour becomes less perceivable when moving away from the source, probably because it tends to be confused with the background odour. In addition, the different shapes of the odour impacts may be due to an essential difference between the two compared approaches: while the odour dispersion modelling uses the hourly prevalent wind direction, the field measurements is affected by instantaneous wind direction changes.

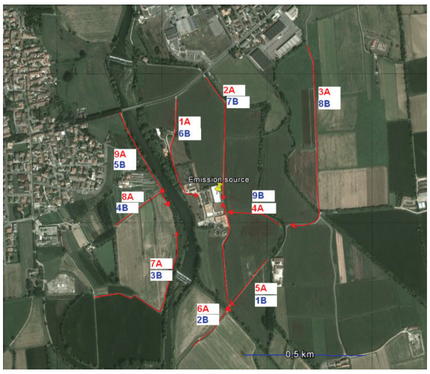


**Fig. 2.** Paths identified for field inspection

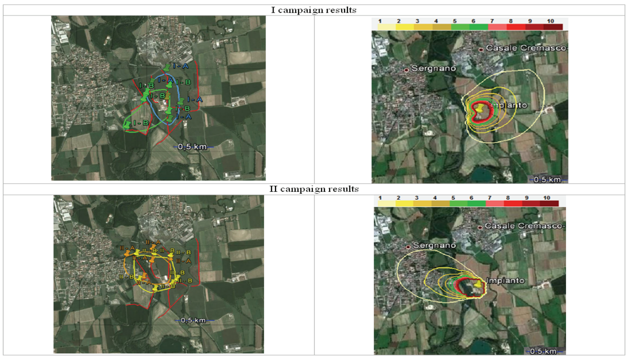


**Fig. 3.** Odour impact relevant to the I and II campaigns: assessed by field inspection (left) vs. simulated by odour dispersion modelling (right)

***Plant 2***

The paths identified to be covered by the two groups of panellists (A and B) during the field measurements are shown in Fig. 4. The results of the field inspection are shown in Fig. 5 (a).

**Fig. 4.** Paths identified for field inspection

The different lines (red and green) represent the results of the field inspection divided in two different time ranges: 16-17 (red line) and 17-18.30 (green line). Fig. 5b, 5c, 5d show the odour impact simulated by running the odour dispersion model at the same time when the field inspection campaigns took place, i.e., with the meteorological conditions that were present at the time of the field measurement, considering three different time ranges, i.e. 16-17 (b), 17-18 (c), and 18-19 (d). Comparing the plume obtained with field inspection with those obtained by dispersion modelling (comparison with iso-concentration line corresponding to an odour concentration of 3 $ou_E$ $m^{-3}$), a slight overestimation of the odour impact assessed by dispersion modelling is observed: the odour impact evaluated by field inspection is about 1/3 in comparison with the results obtained by dispersion modelling, in term of maximum distance of odour perception/recognition.

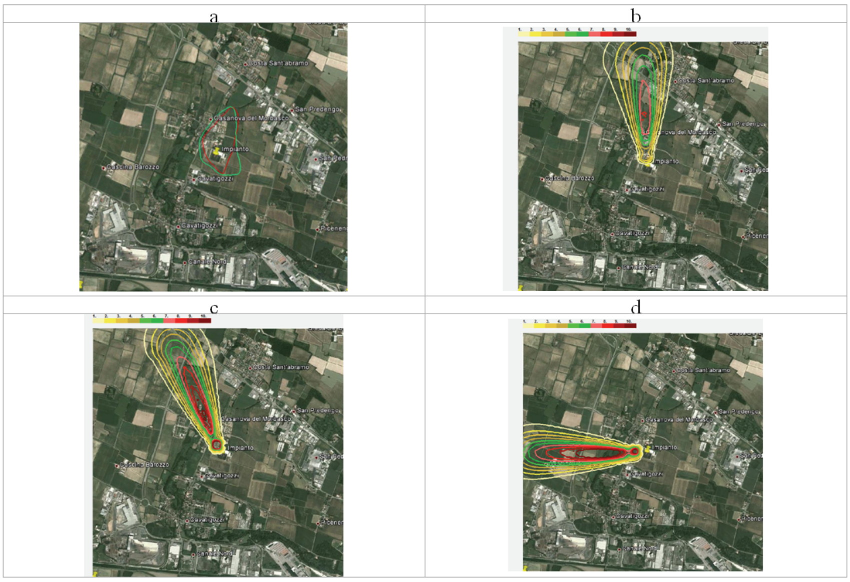


**Fig. 5.** Odour impact assessed by field inspection (a) vs. simulated by odour dispersion modelling considering different time ranges: 16-17 h (b), 17-18 h (c), 18-19 h (d)

### *Concluding remarks*

The main purpose of this work was to describe the application of a modified, site-adapted, plume method field inspection in order to evaluate the odour impact by determining the absence or presence of odour downwind relative to the considered source (plume extent), for the case of two different industrial plants: a food industry sludge composting plant and a biomass anaerobic digestion plant, both located in Northern Italy. In both cases, the odour impacts resulting from the application of the field inspection turned out to be quite comparable with those obtained by simulating the dispersion of emissions by means of a suitable dispersion model (CALPUFF), thus indicating that both approaches may be effective and complementary for odour impact assessment purposes. More in detail, the dispersion modelling shows a slight overestimation of the odour impact. From the experience of our laboratory, this result could be explained by the fact that in some cases, especially when dealing with odour emissions having an organic matrix located in an agricultural context, high odour concentrations are measured at the source, but odour becomes less perceivable when moving away from the source, probably because it tends to be confused with the background odour. Further studies will be necessary in order to consolidate the experience with field inspections and to verify these preliminary results.

***Keywords:*** dispersion modeling, field inspection, human panellists, olfactometry

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