

## Integration of Automatic Remote Systems for Olfactory Annoyance Detection and Evaluation in the City of Taranto

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Odour annoyance represents one of the most emerging aspects related to odour emissions, produced by industrial plants. The possibility of making objective this type of annoyance constitutes a complex issue to face, due to the subjective features of the olfactory perception and to the difficulty to identify with certainty the source of emissions.

To the purpose, some international guidelines consider the employment of human assessors as a valuable method for the impact evaluation of an industrial plant on the territory (by means of administration of questionnaires addressed to the residents or field inspections, properly planned). These approaches provide only qualitative and quantitative indexes of annoyance and require some months of investigation before obtaining results.

This paper focuses on the development of a methodology for the detection and evaluation of olfactory annoyance, integrating automatic remote systems able to record the olfactory perception of human receptors and to collect odour samples in real time.

The experimental study has been applied in the city of Taranto, in the South of Italy, where the residents have been reporting so much discomfort for odour emissions, produced by plants located in the industrial area. The integrated system requires the direct involvement of population; by means of a phone switchboard, the residents communicate in real time the perception of odour events and their intensity (according to an intensity scale of three levels). The different warnings are displayed on a map together with the meteorological data in order to associate the emissions to the sources on the territory. According to a chosen routine (number of warning for index of intensity recorded in a defined time range), remote automatic sampling systems, located in particular sites on the territory, are activated in order to collect a representative sample, that could be analyzed through dynamic olfactometry. In this paper, the preliminary results obtained during the experimental campaign will be presented, underlining the advantages connected with a remote sampling.

### 1. Introduction

Odour impact constitutes an indicator of an unhealthy environment, strongly felt by population. Even though real risk for human health have not been demonstrated yet, the association between an annoying odour perception and psycho-physical symptoms such as states of anxiety, headache, depression, eye irritation, respiratory problems, nausea, etc., is verified (Shiffman, 1998; Sucker et al., 2008; Stenlund et al., 2009; Aatamila et al. 2011). So, odour emission is considered as one of the most important causes of population complaints and its evaluation represents a matter characterized by great complexity, due principally to the strict association of odour pollution to human perception (Brattoli et al., 2011). In fact, the need to establish a causal relation between odour events (often characterized by a brief duration) and odour sources is often problematic. On the other hand, population living in the surroundings of odour sources denounces the occurrence of odour events to the local authorities (municipalities, police, environmental agencies, etc.), that are often overwhelmed by continuous complaints, not easily

manageable. Moreover, another aspect to take into account is the evaluation of the reliability of population complaints and how it is possible to make objective these warnings, since, in most cases, these protests are considered the alarm bells to start a monitoring activity.

Some international legislation, above all German one, standardize methods involving directly the population in order to evaluate the olfactory annoyance and define its entity through specific indicators (VDI 3883:1993; VDI 3940:2006).

These methods will involve, for instance, the distribution of questionnaires to people living in the surroundings of the emission source (VDI 3883:1993) or methods of odour evaluation in field using selected sniffers who have to evaluate systematically the perception of odour in different fixed positions on the territory at different times every day (VDI 3940:2006). The described methodologies are screening qualitative investigations and request long time of study before providing useful information regarding the real entity of odour impact.

In most cases, it is necessary to give prompt answers to population and to this purpose, the opportunity to perform a measurement in real time when citizen perceive the odour is the only one method to provide objectivity to their complaints. Obviously it is a critical aspect, since a variable period of time passes from the signal to the operative intervention of environmental agencies and it can occur that the odour event is often no more verified.

The paper focuses on the development and the application of a methodology for the detection and the evaluation of olfactory annoyance, integrating automatic remote systems to record the olfactory perception of human receptors and to collect odour samples in real time.

The experimental study has been applied in the city of Taranto, in the South of Italy, and the preliminary results are explained.

## 2. Materials and methods

### 2.1 Site description

The experimental study has been conducting in the area of Taranto, a city of the South of Italy, seriously afflicted by a strong environmental pollution produced by the different plants in the industrial area. In fact, it constitutes an important pole of steel production (it is located the biggest metallurgic center in Europe) and of petroleum refining. Moreover, there are some other facilities among them a landfill, a cement plant and a military arsenal.

All of these industrial sources produce odour emissions and annoyance for the residents living in the area. The Figure 1 shows the position of the principal plants on the industrial area of Taranto.



Figure 1: Map of the city of Taranto

### 2.2 The system architecture

Since November 2013, Regional Environmental Agency of Puglia (ARPA) has been carrying out an experimental activity, based on the application of a methodology to evaluate the odour annoyance perceived by residents living in Taranto. It consists of a telephonic system that systematizes the population complaints and of an automatic sampling system, remotely activable, able to collect air sample in real time, at the moment of the significant odour events. This system is called Odortel® and it has been realized by Lenviros srl, a spin-off company of the University of Bari, in collaboration with University of Bari and

Labservice srl, specifically dealt with the sampling device development. Arpa is testing this integrated system at the aim of better understanding the odour phenomena detected by the citizens of Taranto.

Odortel® is based on the direct involvement of a sample of citizens, available to communicate their odour perception using a telephone switchboard. Each participant (called receptor) is georeferenced on the map and is coded inside the system database. Through a phone call, the receptor communicates the odour perception and also its intensity (via the telephone keypad), choosing among three level of intensity, visualized with different colors:

1. Faint odour (green color)
2. Persistent odour (yellow color)
3. Very strong odour (red color)

The phone calls are recorded and displayed on the map in real time on a website, accessible from stakeholders through an username and a password. The graphical interface allows to interact with database to obtain information regarding date, time and number of calls in a synoptic visualization or in a graphical one. Figure 2 displays an example of a synoptic daily visualization and the localization of the signals in the map (white points).

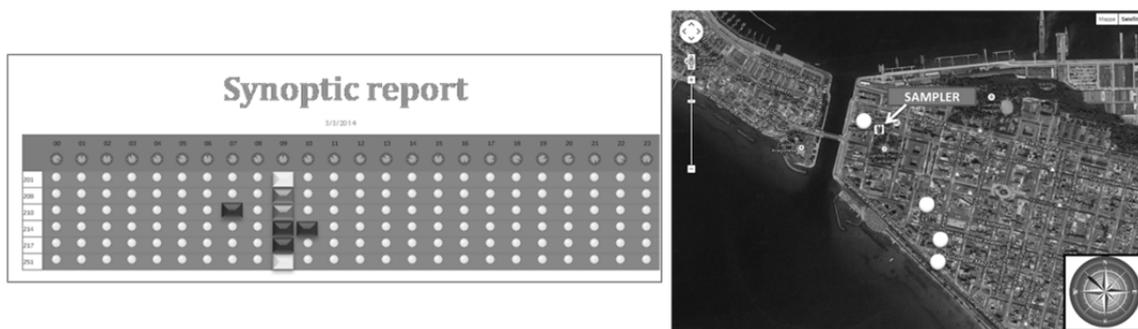


Figure 2: Example of a synoptic daily visualization and localization of the signals in the map

The setting of specific routine, based on the number of calls for index of intensity in a period of time, allows to activate remotely a sampling system, a depression pump, located in a representative site. It collects air samples in real time that will be measured by means of dynamic olfactometry, according to the technical law EN 13725/2003. The olfactometric measurements are carried out by a dynamic olfactometer (series TO8 by Ecoma), employing the yes/no method for the sample presentation.

The information about the pump activation is immediately sent to the technical operators through telephone messages in order to pick up the sample and prepare the olfactometric measurement within 30 hours. A schematic diagram related to the system architecture is presented in Figure 3.

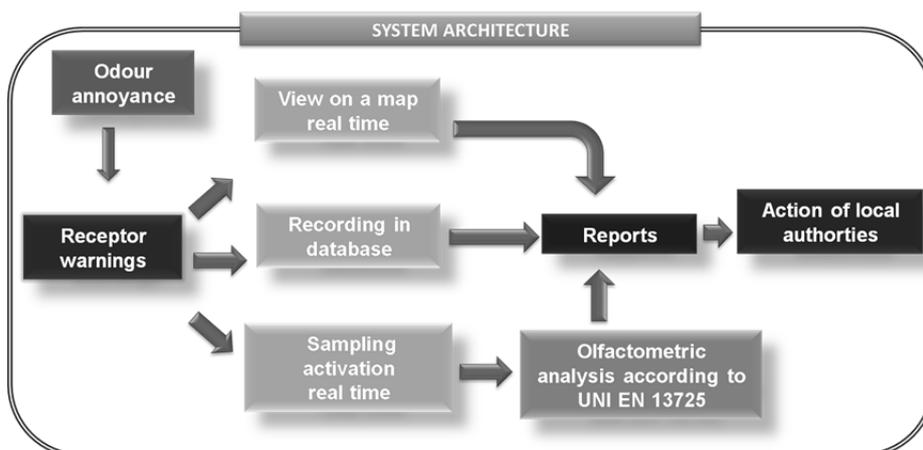


Figure 3: Schematic diagram related to the system architecture

At the moment, the experimental activity involves twenty-nine volunteers receptors (white triangle in Figure 4), most of them located in the center of Taranto, and employs only one sampling device, planted in Piazza Garibaldi, as shown in Figure 4.



Figure 4: Sampling device position in Taranto city

### 3. Preliminary results and discussion

In this section, the preliminary results regarding the period November 2013 – March 2014 are presented. The data collected during the first phase of the experimentation have pointed out that residents, living close to the coastal area, have communicated the most copious complaints, as shown in Figure 5.

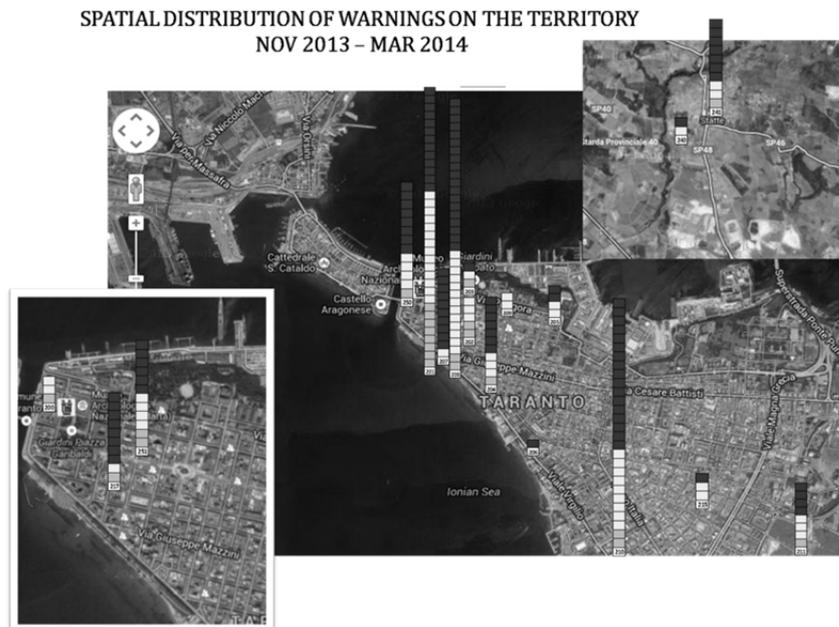


Figure 5: Spatial distribution of receptor warnings on the territory

During the above-mentioned period, twenty-seven samplings have been activated in correspondence of significant events. In addition to the odour sample, the sampling protocol includes also the collection of a blank, taken in order to verify the level of concentration in absence of odour annoyance.

Figure 6 shows the olfactometric results of odorous and blank samples. In correspondence of some events, no histogram bars are indicated due to the fact that no odour concentration has been objectively detected;  $11 \text{ uoE/m}^3$  represents the instrumental quantification limit for the olfactometric laboratory.

This occurrence has been verified above all for blank samples, pointing out a significant difference with the odour sample concentrations. Moreover, the analysis of wind directions and wind speed, recorded at the moment of the citizen's complaints, constitutes an indispensable requisite to individuate the possible source, carrying out a preliminary attribution of the odour events to it. Among the occurred events, it can be possible to underline that four events reveal significant odour concentrations for the ambient air (indicated with arrows in Figure 6). In these cases, the analysis of wind directions, blowing from the north-west quadrant, has permitted to attribute the odour annoyance perceived by residents to a particular source in the industrial area, constituted by the refinery.

It must be emphasized that, despite the sampler is not located near the coast (the area from which the most complaints have been recorded), appreciable odour concentrations have been detected.

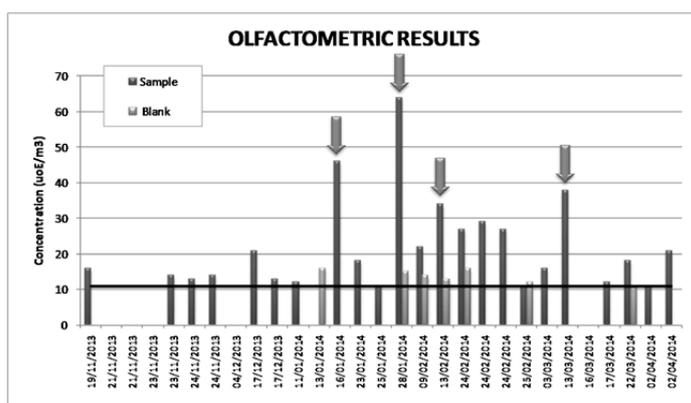


Figure 6: Olfactometric results

### 3.1 Integration of Odortel® with air quality data

To support the evidences shown by the application of Odortel®, possible correlations with air quality data (in particular,  $\text{H}_2\text{S}$  and sulfur compounds) recorded by monitoring stations, have been investigated. In particular, two monitoring stations, located at "Ospedale Testa", close to the refinery, and Piazza Garibaldi, in the same place of the olfactometric sampler, have been considered. In correspondence of the most significant events,  $\text{H}_2\text{S}$  concentration peaks are verified for the two monitoring stations, displaying higher concentrations at "Ospedale Testa" than at "Piazza Garibaldi". In Figure 7 odour event occurred on 28<sup>th</sup> January 2014 is illustrated; the correlation between odour perception signaled by population and  $\text{H}_2\text{S}$  concentration data, monitored by the two stations, reveals clearly the causal relationship existing between the supposed source and the resident perception.

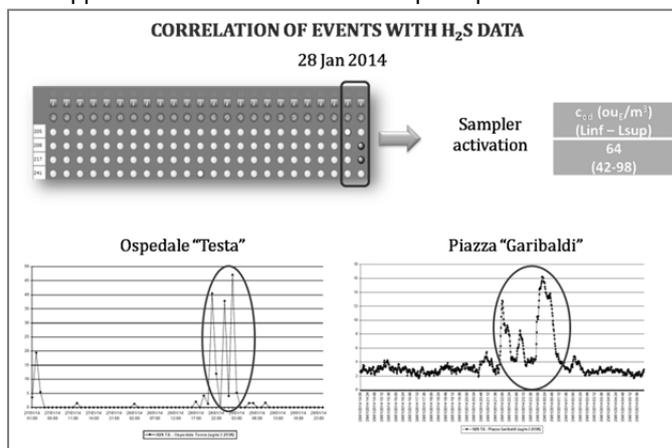


Figure 7: An example of correlation of annoyance events with  $\text{H}_2\text{S}$  data

#### 4. Conclusions

The preliminary results of the Odortel® application in the area of Taranto have permitted, for the first time, to manage the population complaints in a systematic way, in order to gain information related to the entity and distribution of odour phenomenon. The olfactometric results, measured in correspondence of the events perceived by receptors, have shown concentration levels significantly higher than those measured for blank samples. During the most significant odour events, signaled through Odortel® system, the study of the wind directions (North-West quadrant) indicates a potential source, represented by the refinery. Moreover, this causal relationship seems to be plausible since H<sub>2</sub>S and sulfur compound concentration peaks have been also recorded in two monitoring stations, one located near the supposed source and the other close to the receptors. The distribution of the most frequent warnings have revealed that the most annoyed receptors live near the coast, indicating to move the sampler to a more opportune site and to add other samplers in other sites in the immediate future in order to have more sampling sites and to gain more representative data.

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