The methodological approach to impact assessment for promoting a sustainable and healthy community in Val d'Agri (Basilicata - Italy)

G. de Gennaro[1*], A. Demarinis Loiotile[1], A. Di Gilio[1], J. Palmisani[1], S. Petraccone[1], F. Stasi[1]

[1] Department of Biology, University of Bari Aldo Moro, Via Orabona, 4, 70126 Bari

*corresponding author:

e-mail: gianluigi.degennaro@uniba.it

Abstract This study aims to develop an innovative and methodological approach for environmental monitoring in critical industrial areas as the Val d'Agri (Basilicata - Italy). The interest for this area is due to the proximity of the largest Italian gas and oil pre-treatment plant, called the "Center Oils Val d'Agri" (COVA), to the urban settlement in Viggiano (PZ), a small village in South of Italy. Since the extraction of oil is carried out in populated areas, chemicals released by this type of industrial activity could have impact on population health. In particular, oil refineries and petrochemical plants are usually associated with the emission of Volatile Organic Compounds (VOCs), mainly deriving from production processes, storage tanks, gas pipelines and exhausted areas. Therefore, in this study, VOCs were monitored at the high spatial-temporal resolution, by means of a smart network consisting of highly sensitive Photo Ionization Detectors (PID) and by air samples collection during nuisance events and AirServer-TD-GC/MS-O analysis. In addition, sensors of meteorological parameters (i.e. temperature, humidity, pressure, wind speed and direction) were used for source identification. This monitoring network is proven to be a useful tool to collect real time information about the emission sources and their impacts on the urban settlements and to provide a mapping of the territory.

Keywords: VOCs, Photo Ionization Detectors (PID), gas and oil pre-treatment plant, petrochemical complex, sensor network.

1. Introduction

The increasing interest of scientists and stakeholders air quality assessment in Val d’Agri (Basilicata – Italy) is due to the presence of the largest Italian gas and oil pre-treatment plant, called the "Centro Oli Val d'Agri" (COVA). It is located in the industrial area of Viggiano (PZ), a small village in the South of Italy, nearby the urban settlement. The COVA performs the extraction of the crude oil from the various wells placed in the surrounding territory and successive desulphurization. Air pollutants from large-scale petrochemical plants have been recognized as an important risk factor for public health in many countries [1]. Among these pollutants, volatile organic compounds (VOCs) are one of the most significant contaminants which are emitted during production processes from storage tanks, gas pipelines and exhausted areas [2]. When oil extraction is carried out in populated areas, human beings and animals that live in these areas become organic supplements of chemicals released by this type of industrial activity. In fact, several studies have shown a positive correlation between VOC inhalation exposure and adverse effects on human health such as sore throat, irritation of airway mucous membranes, feeling of sickness or dizziness, asthma and serious pathologies such as leukemia or brain tumor [3-4]. In addition, another factor to take into account is the odor nuisance associated to petrochemical plants that could affect the citizen welfare. Odour emission is considered as one of the most important causes of population complaints and its evaluation represents a environmental issue of great complexity, because of the causal relationship between odour events (often characterized by a brief duration) and odour sources. Therefore, the aim of this study is the development of an innovative methodological approach that integrate technologies able to provide real time information about the emissive sources and odor annoyance in order to promptly evaluate their impacts on population.

2. Materials and methods

In order to monitor the pollutants at high spatial-temporal resolution, an experimental design was developed and an innovative methodological approach was applied in the industrial area of Viggiano (PZ), covering an area of 171 700 m^2 (Figure 1). The monitoring campaign started from 1st February 2017 and is still ongoing (the expected end of activities is 30th June 2017). The experimental design was developed *ad-hoc* taking into account the typology of the industrial activity and the proximity to the surrounding populated settlements. The monitoring strategy implied the use of a smart network consisting of eight Photo Ionization Detectors (PID, LabService Analytica srl) placed at different distance around the plant, as shown in Figure 2. More specifically, seven PID (1-4 and 6-8) were installed in the populated area around the "Centro Oli Val d'Agri" (COVA) at different distance from it, while PID number 5 was installed in the center of Viggiano village to be representative of background concentrations. In

Figure 1. The ‘Centro Olio Val D’Agri’and its position in South of Italy.

correspondence of PID number 4, an electronic nose and metereological sensors were also installed (Figure 3). This approach allowed to obtain VOCs time profiles and a mapping of the territory.The odour impact assessment is also carried out by involving citizens. A telephonic system, called OdorLab (LabService srl), that systematizes the population complaints, automatically actives the air sampling in real time when significant odour events occurred. Each citizen (called receptor) is georeferenced on the map and using a telephone switchboard, communicate the odour perception and also its intensity choosing among three level of intensity, visualized with different colors. The phone calls is recorded and displayed on the map in real time on a website, accessible from stakeholders (Figure 4). The setting of specific routine, based on the number of calls for index of intensity in a period of time and on threshold values of VOCs concentration registered by PID 4 (nearest the COVA), allows to activate remotely sampling systems (OdorPrep, LabService Analityca srl), located near the PID 4. In particular, the air sample collection starts on the basis of the following combinations of VOCs concentration and number of citizens’ alert: a) VOCs concentration higher than 1 ppm, b) VOCs concentrations higher than 0.5 ppm and one alert and c) VOCs concentrations higher than 0.2 ppm and two alerts. The information about the sampling system activation is immediately sent to the technical operators through telephone messages in order to pick up the sample and prepare the olfactometric measurement according to the technical law EN 13725/2003 [5].

Air samples are collected in Nalophan bags by means of OdorPrep and transported in the shortest period of time to the laboratory for the analysis. VOCs are analyzed using a thermal desorber UNITY 2™ (Markes International Ltd) connected to a gas chromatograph (GC Agilent 7890) equipped with an olfactometric port (ODP 3 Gerstel) and connected to a mass spectrometer (MS Agilent 5975) (Figure 4). The collection of VOCs onto the sorbent-pack focusing trap at -10 °C of the desorption system UNITY2™ was performed; afterwards the cold trap was flash heated to 300 °C and the compounds were transferred via the heated transfer line (200 °C) to the GC column. After the GC separation the column flow was splitted with the ratio 1:1, one part was led to the MS system and the other one to ODP. The effluent from the capillary column reached the olfactometric port through an uncoated transfer line (deactivated silica capillaries) and was sniffed by the assessor in a PTFE conical port, fitted to the shape of a nose. The transfer line was heated to prevent the condensation of compounds on the walls of the capillary. Auxiliary gas (make-up gas) was added to the GC effluent to prevent the drying of the assessors’ nose mucous membranes, which could cause discomfort especially in longer analyses. Two trained panelists were asked to indicate when odor was perceived and the duration of the odor activity and to describe with clear words the quality and the intensity of the perceived odor. The panelists were selected according to a standardized procedure used for the panel selection in Dynamic Olfactometry, the official methodology for odor emissions assessment standardized by a European technical law (EN 13725/2003) [5].

The identification of odor active VOCs was performed by comparing the mass spectra of the unknown compounds with those listed in the NIST library (Agilent Technologies). The identification was considered valid if the confidence rating of mass spectra comparison was superior or equal to 95%. The attribution was further confirmed using the retention times of authentic compounds, when applicable.

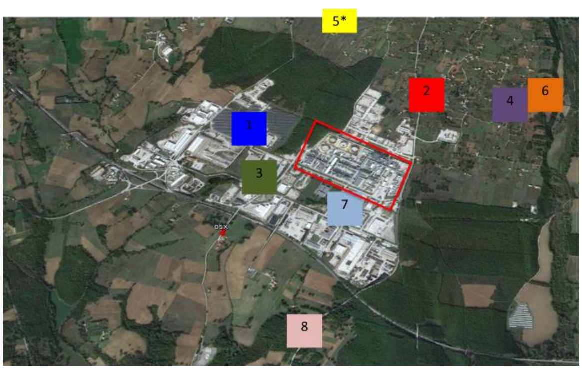

Figure 2. PID Network (8 coulored square) and COVA (Red rectangle).

Figure 3: PID, electronic nose, OdorPrep and an example of OdorLab network

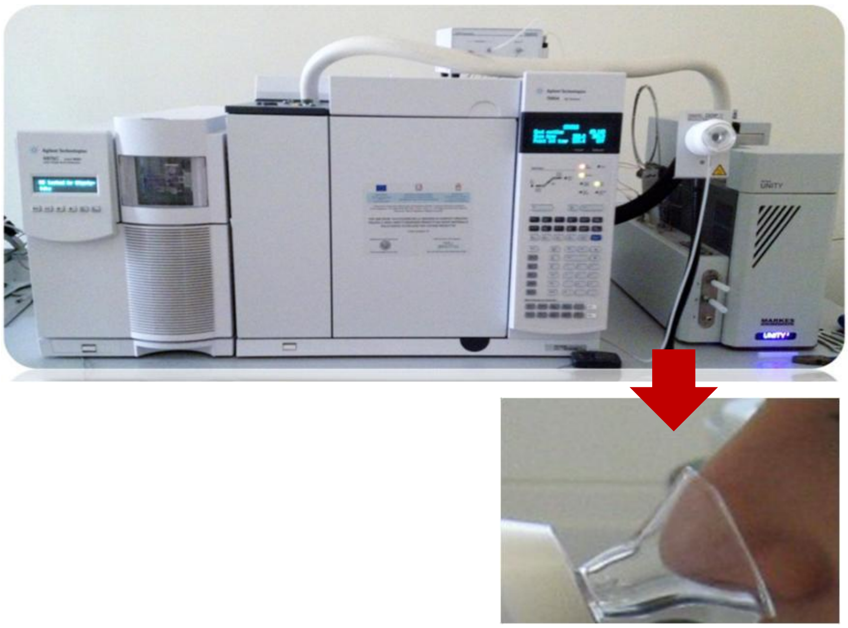

Figure 4: Thermal desorber UNITY 2™ (Markes International Ltd) connected to a gas chromatograph (GC Agilent 7890) equipped with an olfactometric port (ODP 3 Gerstel) and connected to a mass spectrometer (MS Agilent 5975).

3. Results and Discussion

In the present study, an innovative methodological approach was developed in order to study the critical industrial area around the COVA and to provide potential solutions to environmental issues. Taking into account that citizens often alerted about the perceived odour annoyance and the adverse effects on human health were frequently reported, stakeholders supported by the scientific community started to question about the possible sources of pollutants in the industrial area and about advanced systems to develop and use on the field in order to analyze this critical issue. More specifically, the starting point of this study was the awareness that conventional methods for air pollution monitoring could fail in source identification, mainly in critical industrial areas where different and unpredictable fugitive emissions impacted on surrounding villages generally characterized by no relevant emission sources and clean air. Moreover, limitations of conventional monitoring techniques in this area are due to the difficult to detect air pollution events because, although frequent, they are generally short-term. The perception of these events by citizens is also depending on meteorological conditions, especially wind speed and direction. The conventional methodological approach generally allow an accurate speciation and characterization of VOCs carrying out weekly air sampling on adsorbent substrates (e.g. Carbograph) and successive analysis by GC/MS. If applied in the investigated area, this methodological approach could be not successful because it could fail in the identification of short-term critical sources considering that the VOCs emission events are mediate on more days characterized by very low concentrations (0.1 ppm on average). Therefore, in order to overcome all these limitations an innovative approach based on high time and space resolution was developed. The aim of this study was to obtain the mapping of the territory and to take a real time representation of air pollution critical events depending on the citizens' alerts. The implementation of a smart network consisting of several Photo Ionization Detector placed at different distance around the plant allowed to map the territory and obtain high resolution time profiles of VOCs. In addition, the telephonic system, called OdorLab, systematizing the population complaints and taking into account the threshold values of VOCs concentration previously established, allowed to activate remotely air sampling systems (OdorPrep), only in correspondence of critical events. The application of the aforementioned methodology during the nuisance events allowed also to overcome the limitations related to the lack of instrumental sensitivity in the identification of the chemical compounds contributing to the annoyance. The preliminary analysis of collected data showed a strong correlation among VOCs concentration, citizen alerts and wind direction. In particular, when citizens called OdorLab in order to communicate their odor perception, high VOCs concentrations (upper than 2 ppm) were registered by the PIDs located downwind the petrochemical plant. Further activities involved elaboration of the data obtained by the chemical characterization of air samples, collected during critical events and analyzed by Air Server TD-GC-O/MS.

4. Conclusions

The innovative and automatic monitoring approach, proposed in this study, is proven to be a useful tool to collect real time information about the emission sources and their impacts on the urban settlement. Moreover, it provides a mapping the territory and allows to discriminate between local and industrial sources also very close to each other.

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