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Integrated environmental quality monitoring around an underground methane storage station

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HIGHLIGHTS

- The environmental quality of an area with a methane station was evaluated.
- Two monitorings were applied: measures of air components and lichens biomonitoring.
- The two monitorings results were in agreement.
- The environment quality of the area surrounding the station did not show signs of declining.
- Results suggest the validity of biomonitoring to integrate the environmental network for pollution assessing.

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ABSTRACT

The study reports an integrated environmental quality monitoring of a 100 km^2 area in central Italy mostly occupied by an underground station of methane storage, working since 1982. The nitrogen oxides, ozone and isoprene concentration detached with a network monitoring of passive filters were compared with the results of lichens biomonitoring.

Data from the two monitorings were in accordance: there was an inversely correlation between lichen biodiversity index (IBL) and NOx (−0.96) and ozone (−0.80), and a positive correlation between IBL and isoprene (0.67). IBL indicated that the area ranged between medium naturalness and medium alteration status, values fully compatible with the medium–high level of eutrophication, caused by intensive agriculture. Only two areas were in high alteration status, due to their proximity to glass factories and to a quarries area. Despite almost thirty years of activity, the environment quality of the area around the station did not show signs of declining.

1. Introduction

Natural gas is an essential resource as it represents a source of clean energy for homes, public buildings and businesses. Italy is in close dependence on other countries: more than 40% of Italian natural gas consumption is imported, with growth forecast to 70% in 2020.

The storage of natural gas can be considered a strategic process. In fact, while the gas supply is basically constant throughout the year, the demand has a marked seasonal variation and this is more evident in case of adverse weather that result in the absence of cover the natural gas needs.

Since during the compression activity there are emissions of chemical species, these stations may be sources of pollution and therefore require a monitoring to assess their environmental impact. This environmental monitoring can be due through direct and continuous monitoring of the main pollutants, generally operated with stationary or mobile automatic stations. Among these, passive filter has been increasingly used, because of low operating cost, simplicity of sampling, independence from the

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electricity and good correlation results with compared direct monitoring methods (Lozano et al., 2009).

The measurements of potential harmful chemical species are necessary to evaluate the effect of polluting sources, but they do not provide information on the impact of these pollutants on the environmental matrices. For this kind of evaluations the biomonitoring is very suitable, because assesses the effects of the atmospheric constituents through the observations of biological materials.

The most appropriate biological species used for biomonitoring are lichens, for their demonstrated high sensitivity to air pollution (Loppi et al., 2002; Gombert et al., 2004; Munzi et al., 2007; Frati et al., 2007; Pinho et al., 2008). This feature is due to their slow growth and efficiency in absorbing nutrients from air and water (Nash, 1996). Among the biomonitoring methods, the official procedure ANPA (2001) consists in the determination of the lichen biodiversity index (ILB). This method is most widely applied in Italy and the ILB is computed by the sum of the presence of lichen species occurred in a defined grid. Its evaluation allows to define the areas with an alteration state, based on the scale of naturalness/alteration proposed by Frati et al. (2003).

The thallus physiological properties and structure make lichens mainly dependant on atmospheric deposition for their nutrition, especially for the nitrogen supply (Gombert et al., 2003). Several researches demonstrate an influence of nitrogen deposition on the lichen communities (Loppi and de Dominicis, 1996; Van Dobben and De Bakker, 1996), as a high concentration of nitrogen in environmental matrices leads to regional acidification and eutrophication (Erisman et al., 2003) and therefore the selection of lichen species suitable to these environmental conditions. Indeed, the level of substrate acidity can be also influenced by dust deposition. Calcareous dust, typically present in Mediterranean areas (Pieri et al., 2009) or deriving from human activity (e.g. rushing machinery in quarries), raises the bark pH, favoring the selection of lichen species adapted to basic substrates (Gilbert, 1976; Loppi and De Dominicis, 1996; Loppi et al., 1997).

While the relationship nitrogen-lichens and dust-lichens is quite known, previous studies do not identify a clear and univocal correlation between ozone and lichens communities: Nali et al. (2007) reports no correlation between ozone patterns and lichen distribution (*Parmelia* and *Lecanora* genus), while Scheidegger and Schroeter (1995) highlights that high ozone concentration determines biophysical and physiological modifications on several species.

The tropospheric ozone (O_3) reflects the climatic conditions and the presence of precursor substances sources (VOCs, NOx, CH_4, CO, isoprene). The stations for methane storage are VOCs sources, emitting nitrate oxides, sulphur oxides, carbon dioxide, and methane, during the combustion processes, but their contribution in the ozone production is low (Derwent et al., 2007).

The two monitorings (direct and biomonitoring) provide information substantially different: the direct monitoring of pollutants provides an assessment of the current state of air quality, while the biomonitoring photographs an ecological condition, stabilized in a wider timeframe. The correlation between IBL and the main pollutants distribution could suggest the validity of biomonitoring to integrate the environmental network for assessing the atmospheric pollution.

The aim of this paper is three folds: (i) evaluating the environmental impact of a station of methane storage, (ii) comparing and finding correlation between two approaches of environmental quality monitoring, the pollutants direct monitoring and the lichens biomonitoring; (iii) providing a general picture of pollution pattern of the investigated area and determining the main causes of changes in lichens communities.

2. Materials and methods

2.1. Location

The monitored area is located in an hilly sub-mediterranean area of about 100 km^2 in Central Italy. During the monitoring period, weather stations within the area recorded mean temperature ranging between 16.1 °C and 36.4 °C, with mean of 26 °C. Compared with the climate historical data, this period can be considered typical for the area. The wind direction was predominantly W–NW, with some episodes from E–ESE.

Within the area there are four Site of Community Importance (SCI), in which natural habitats and animal and vegetables species have to be safeguarded: SCI1 "Gessi di Lentella" (IT7140126), SCI2 "Macchia Nera – Colle Serracina"(IT228226), SCI3 "Fiume Trigno"(IT7140127), and SCI4 "Colle Gessaro" (IT 222212) (Fig. 1).

The main potential sources of NOx and VOCs within the area are the following: (i) an underground station of storage and distribution of methane, (ii) a landfill, (iii) a mining zone, and (iv) an industrial area. The rest of the surface is occupied by heavy cultivated arable lands (Fig. 1).

In particular the methane station, located at Cupello (80 km South-East from Chieti), covers about the 80% of the total monitored area. In the past the station was used for primary production of methane, while since 1982 the activity has been limited to the compression and the storage of methane coming from the national network, and the delivery when requested by customers. The mean annual volume of the stored gas is about 8.3×10^9 S m^3, and the delivery is about 7.6×10^9 S m^3. The storage occurs within a gas compression station, which during spring and summer stocks methane in underground reservoirs through wells distributed throughout the station, while in fall and winter the gas is distributed to customers.

The landfill and the mining zones are located within the area of the methane storage station, the first one in North-West and the second in South-East direction (Fig. 1). The landfill has a volume of 300 000 m^3 and contains a plant of biogas and cogeneration. In the quarries area, sand, clay, gravel, and rock are excavated from the ground. Moreover, next to the excavation area, there is a station for the treatment of quarried material (brick industry with kilns for the production of expanded clay). Finally, outside the storage station, there is an industrial area, with two glass factories.

Technical reports on environmental impact provided by the glass factories show NOx emissions of 320 t ha^{-1}, while in an official document, the methane station declares NOx emissions of 80 t ha^{-1}. There are no official emission data of the other potential sources of pollution. However, as visually observed, the area occupied by quarries is characterized by dust arising from the excavations. Moreover, a survey of the area revealed that, the riverbed Trigno, which passes through this zone, is in a severe degradation state, while the riparian vegetation (shrubs, hornbeam and poplars) leaves are very damaged.

2.2. Monitoring of air components

The direct air quality monitoring network was based on a total of 12 sampling points. The monitoring was done through passive filters, which provided the daily average concentration for each week of the period June 18–September 10, 2012. The monitored potentially harmful substances were ozone and its common precursors, nitrogen oxides (NO and NO_2) of anthropogenic origin, and isoprene of prevalent biogenic origin. The detected concentrations were compared with the EU Limit Values (Directive 2008/50/EC on air quality).