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Short communication

A monitoring strategy to assess the fugitive emission from a steel plant

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HIGHLIGHTS

- A careful experimental design was developed for fugitive emission impact assessment.
- Specific monitoring campaign was performed around Europe's the biggest steelmaker.
- PM, PAHs and metals were measured.
- High Fe, Mn, Zn and PAH levels occurred when receptor sites were downwind respect to steel plant.
- PCA provided four sources: coke ovens, mineral parks, harbour area and crustal source.

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ABSTRACT

An assessment of the fugitive emission impact on ambient air PM, PAHs and metal concentrations was performed in a residential area near the biggest European steel plant. A careful experimental design was developed to characterize fugitive emissions produced by the integrated steel plant. A PM10 and PM2.5 monitoring campaign was conducted at three sampling sites around the steel plant, in order to perform a triangulation in the area surrounding the investigated site and evaluate its impact based on wind direction. Data analysis showed that the transport of air mass, from the steelworks to one of the receptor sites, resulted in ambient air concentrations of Fe, Mn, Zn and PAHs higher than those observed in the other two sites. Principal component analysis allowed the identification of four emission sources: coke ovens stack, mineral park, a crustal source and vanadium source. The first two sources were characterized by high concentrations of PAHs and metals and related to the steelworks, while the vanadium source was probably associated with maritime traffic in the port area. This preliminary monitoring approach proved effective in identifying the fugitive emission contribution of the steel plant to the surrounding air quality.

1. Introduction

Several studies have shown that, as a consequence of industrial activities, significant quantities of trace elements are transferred to the surrounding areas (Cachier et al., 2005; Bosco et al., 2005). Three main sources of pollutant emissions can be found in industrial plants: accidental, canalised (chimney and stack) and fugitive sources. The national effort to control industrial sources of air pollution is focused on ducted emissions from stacks, ducts or flues, which are carried to the point of discharge in confined flow streams. Control strategies are based on the assumption that the primary air quality impact of industrial operations results from the discharge of air pollutants from conventional ducted sources. However, in addition to ducted emission control, a detailed monitoring of fugitive emission sources is important in order to achieve air quality improvements. Fugitive (no ducted) emissions, in fact, contribute to the air quality impact of industrial operations and, in some industries, could be added to the effects of stack emissions (Santacatalina et al., 2010). Fugitive emissions are generally due to equipment leaks (ESA, 2005), emissions from the bulk handling or processing of raw materials, windblown dust and a number of other specific industrial processes. Vehicular traffic around storage piles, comprising the movement of front-end loaders, bulldozers and trucks, can generate fugitive dust emissions from a dust-laden surface, usually the storage pile material (Hassim et al., 2010). Additionally, fugitive emissions escape from reactor vessels during

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charging, process heating and tapping. These emissions constitute a big problem for air quality control because they contain large quantities of fine particulate with smaller amounts of vaporous metals and organics in hot and corrosive gas streams. Fugitive smaller amounts of vaporous metals and organics in hot and corrosive e emissions from single sources can be very small, but industrial plants with many thousands of similar sources can produce an extremely significant aggregated impact of fugitive emissions (Lakhapate, 2006).

Steel is mainly produced through integrated works using a series of closely linked processes involving: coke ovens, sintering, blast furnaces, basic oxygen steelmaking and finishing processes. Among these processes, the coke ovens and sinter plants are potential sources of organic and inorganic pollutants such as metals and polycyclic aromatic hydrocarbons (PAHs). Relatively few studies have been carried out to characterize fugitive emissions produced by coke making or sintering plants (Aries et al., 2006; Tsai et al., 2007) and there is still a lack of information on the impact of fugitive emissions from coke making on local urban air quality.

In our previous studies, it was found that in the urban area near the industrial zone of Taranto pollutant concentrations, obtained by using either the regional inventory emissions database or dispersion models applied at measured ducted emissions, were at an order of magnitude lower than concentrations monitored on the ground (Bruno et al., 2006; Andriani et al., 2011). Mensink et al. (2011) also showed that, in most cases, levels obtained by applying dispersion models at registered emission sources yield neither justification nor explanation of PM registered regulatory exceedances. These findings suggest that the discrepancies may be due to the contribution of fugitive emissions which should not be neglected. Moreover it's also important to note that the building downwash could play an important role in the measured occurrence of high pollutant concentrations near some plants (Olesen et al., 2009; Lefebvre et al., 2012, 2013).

In this work, a monitoring campaign was carried out around the biggest European steel plant which is located in Taranto, Italy. The monitoring was conducted in order to identify the fugitive emissions of the plant's activities on the surrounding air quality. Taranto has been identified as an area of high environmental risk in Italy and has been included in the list of polluted sites of national interest because of the large industrial area in close proximity to the urban settlement (Amodio et al., 2011). Hence, to assess the impact of fugitive emissions from the steel plant and identify those emissions in terms of PM, PAHs and metals, a careful experimental design based on prevailing wind directions was developed. This consisted of a monitoring campaign of PM10 and PM2.5 which was conducted from 15th April to 6th May 2010 at three sites located around the steel pole of Taranto. Even if this experimental design didn't allow to quantify the fugitive emissions, it provided a triangulation in the surrounding area of the examined site on the basis of wind direction in order to prove the origin of the pollutants that has not been shown in this area, until now. Considering that limited information can be obtained from PM concentrations, a chemical analysis of the PM2.5 samples was carried out in order to identify specific source markers. In particular, PAHs and element concentrations were identified. Meteorological parameters and low Planetary Boundary Layer (PBL) mixing ratios allowed the evaluation of pollutant concentrations according to wind direction and pollutant dispersion. Finally, principal component analysis (PCA) was applied to the dataset in order to discriminate between the different sources of the fugitive emissions.

2. Material and methods

2.1. Sampling sites

A PM10 and PM2.5 monitoring campaign was performed from 15th April to 6th May 2010 in three different sites around the iron and steel pole of Taranto (Fig. 1). Taranto (40°28′N 17°14′E) is the third most populated city in southern Italy and it hosts one of the biggest steel plants in Europe. In addition, an important industrial centre with petrochemical and cement plants, a military and trade harbour and a naval shipbuilding industry are all located in close

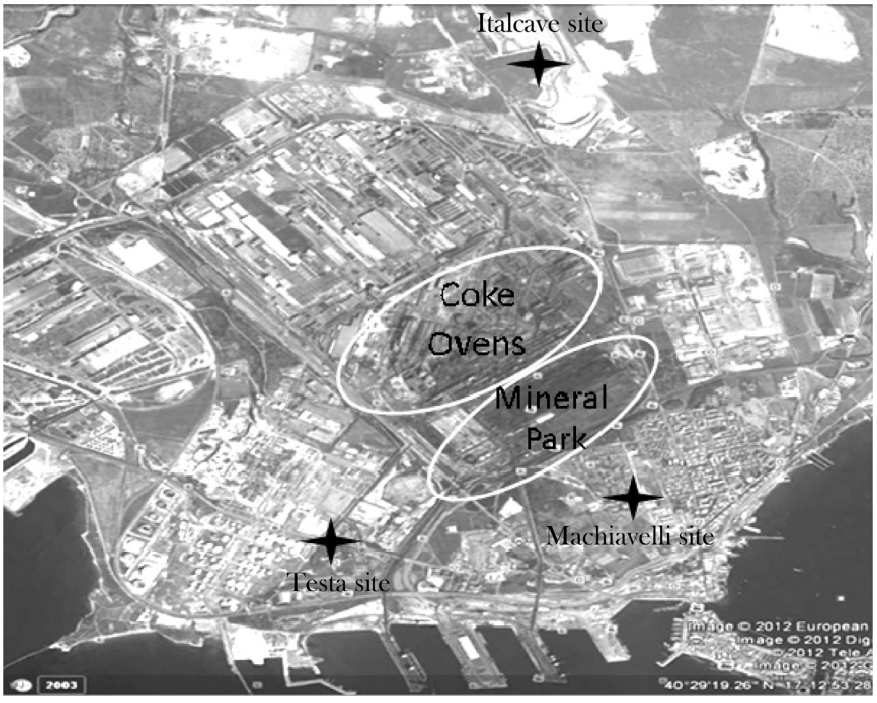

Fig. 1. Map of sampling sites.