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Civil aviation impacts on local air quality: A survey inside two international airports in central Italy

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HIGHLIGHTS

- Comparison of airports with different layout/aircraft traffic load.
- Higher NO_2 and PB-PAHs, lower SO_2 found in the smaller airport.
- Maximum SO_2 measured at airports despite decrease of aircraft traffic recorded.
- BbF/BjF diagnostic of aircraft emissions didn't prove to be conclusive.

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ABSTRACT

The results of air quality monitoring carried out over several years (2008–2012) in two international airports near Rome (labelled as A and B) are reported and discussed. Airport A serves regular flights, airport B operates low-cost flights and, during the period investigated, had about 17% of airport A aircraft traffic load.

Diffusive sampling of gaseous species (NO_2, SO_2, BTX and O_3) was performed at several sites inside the airports. During 2012 the investigation was improved by including PM_{10} and polycyclic aromatic hydrocarbons (PAHs). Higher concentrations of NO_2 (+18%) and lower of SO_2 (−20%) were found at airport B, compared to A, over the whole period investigated. The maximum concentrations of SO_2 were measured in 2011 at both airports (13.4 μg/m^3 and 10.8 μg/m^3 respectively for A and B), despite the decrease of aircraft traffic load recorded. Statistical analysis of PM_{10} data showed that there was no significant difference between the average concentrations measured at the two airports (25.7 μg/m^3 and 27.4 μg/m^3 for A and B respectively) and among the sites investigated. The concentration of PAHs at airport B (4.3 ng/m^3) was almost twice that of airport A (2.2 ng/m^3), though the respective percentages of compounds were similar.

Airport B seemed to be negatively influenced by its surroundings, in particular by vehicular traffic flows of two major roads, whereas airport A was positively influenced by the proximity to the seaside. PCA data analysis showed that airport A sites are differently impacted by the LTO flight phases according to their position, whereas at airport B it was impossible to find similar relationships.

1. Introduction

Civil Aviation, as a source of air pollution, has attracted a growing interest over the years since the global air traffic, according to former estimations, was expected to increase greatly in the present and the upcoming decades (Wood et al., 2008). Despite the decreasing trend due to the economic crisis recently recorded in some European countries, from 2015 onwards the forecasts for air traffic anticipate an annual growth at around 2.5% per year (EUROCONTROL – Seven Year Forecast, 2013). By consequence, the environmental impact of airport operations is still an important issue to deal with, in air quality management.

At present, the impact of low-altitude aircraft emissions on local and regional air quality is still not well-known. The chemical composition of aircraft exhausts changes according to the different thrust levels employed during landing and take-off cycle (LTO)

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operations performed at the airports. Carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC) are predominantly emitted at the low power settings or idle phases mainly occurring during the LTO cycle, so that this latter accounts for about 60% of total emissions (Tarrasón et al., 2004). By contrast, approximately 95% of the total emissions of nitrogen oxides (NO_x) are released during non-LTO flight phases (i.e. above 915 m and at cruise level) (Tarrasón et al., 2004).

Though total emissions of CO and NMVOC from aviation are smaller when compared to NO_x, however they can play an important role in the formation of ozone surface levels, especially where the process is VOC-controlled due to low NO_x levels.

Non-LTO emissions of NO_x affect significantly the regional air quality, however the influence of NO_x emissions from LTO cycle on background concentration values near airports is not negligible. The impact of NO_x emissions and subsequent photochemistry (including the formation of ozone and secondary aerosol) on public health and environment is well documented (Herndon et al., 2004; Pison and Menut, 2004; Carslaw et al., 2006; Wood et al., 2008).

Several studies report data on direct hydrocarbons emission from aircrafts as well as average concentrations in the proximity of airports (Tesseraux, 2004; Herndon et al., 2006; Schürmann et al., 2007; Jung et al., 2011). The speciation of the hydrocarbons emitted by aircraft turbine-engine shows a profile where the principal compounds are ethylene, formaldehyde, acetaldehyde, olefins and C_{10}-paraffins (Wilkerson et al., 2010 and references therein), Despite that, no typical component or tracer of jet engine exhaust has been definitely identified. Both composition and concentration of hydrocarbon blends in aircraft exhausts look similar to those of common diesel engine exhausts (Tesseraux, 2004). A peculiarity in the composition of the exhausts may be the presence of a handful of alkanes (e.g. nonane), which are scarce in gasoline engine exhaust and have been adopted as jet engine emission marker for workers exposed to both emission types (Zeiger and Smith, 1998).

Recent studies conducted inside or near airports have addressed the topic of PM emission from aircrafts (Westerdahl et al., 2008; Mazaheri et al., 2009; Lobo et al., 2012), sometimes including organic compounds such as polycyclic aromatic hydrocarbons (PAHs) (Iavicoli et al., 2007; Lai et al., 2013). Concern about the fraction of ultrafine particles (UFP) emitted was also raised.

The emissions of the sole aircraft source can be estimated by means of dedicated inventories using International Civil Aviation Organization (ICAO) emission factors issued for different pollutants. CO, HC, NO_x and smoke number emission indices for different engines are reported in the Aircraft Engine Emissions Databank (http://easa.europa.eu/environment/edb/aircraft-engine-emissions.php).

These indices are widely used in emission models for airports, but little work has been done so far to test them under real in-use conditions. Popp et al., 1999 and Herndon et al., 2004 estimated NO and NO_x emission indices for different thrust levels, but compared only a few engines with ICAO data. Schäfer et al., 2003 did this comparison systematically for idle thrust and found differences between measured and certified values. The NOx emission indices were usually about 50% lower than those provided by ICAO, whilst CO emission indices were slightly higher, because thrust settings were usually lower than those defined by ICAO for idling. Mazaheri et al., 2009 have also observed differences in thrust levels during idle and taxi modes, which are considered equivalent by ICAO (7% of total thrust).

The limits and uncertainties in the estimation of airport-related emissions and the growing concern caused by increasing aircraft traffic can be overcome by direct monitoring in/or nearby airports.

In the present paper the results of in-field campaigns carried out at two international airports over several years are reported and discussed. The survey was performed by applying a network of diffusive samplers specific for gaseous species (NO_2, SO_2, BTX, i.e. benzene, toluene and xylenes, and O_3). During 2012 PM_{10} and polycyclic aromatic hydrocarbons (PAHs) were also measured.

Basic meteorological parameters and a proxy (i.e. natural

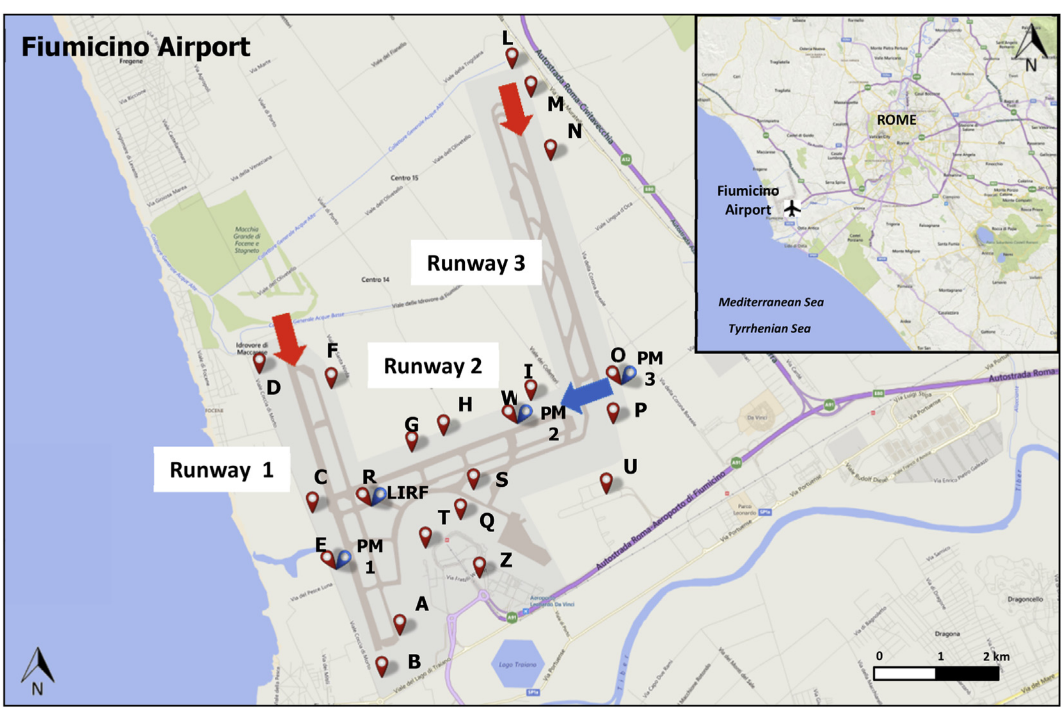

Fig. 1. Monitoring network implemented at "L. da Vinci" (airport A) (red arrow: landings, blue arrow: take offs). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)