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Geochemical characterization of PM_{10} emitted by glass factories in Murano, Venice (Italy)

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Abstract

The atmosphere in Venice, like in other European cities, is influenced by complex PM_{10} multi-emission sources with a net tendency to exceed the limits fixed by the directive 99/30/EC. This study investigated the composition of an ensemble of similar industrial sources, the Murano Glassmaking Factories (MGFs), and their influence on the Venice air quality, using a modelling approach, statistical analysis and geochemical considerations.

Preliminary modelling simulations were conducted to select three sampling sites along the way of preferential transport of pollutants from source between February and April 2003. Subsequently, a sampling campaign was carried out in the same period of simulations. Concentrations of PM_{10}, eight major elements (Al, Ti, Ca, Mg, Na, K, Fe, Mn), 20 minor and trace elements (Li, V, Cr, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Ru, Rh, Cd, Sb, Ba, Ce, Pt, Pb) and four PAHs (BaA, BbF, BkF, BaP) were quantified. The analytical results were statistically processed for exploring the relationships between inorganic elements and organic compounds, and results were interpreted using geochemical considerations. Results show a MGF component of PM_{10} characterised by two different fingerprints: the first linked to glass raw material composition and the second mainly related to glass additives. Particularly, Cd, Se, As and Li preserve their ratios in all study area, and are interpreted as principal components of the MGF emissions. Other fingerprints can be traced to urban sources from the Venetian mainland.

Keywords: PM_{10}; Trace metals; Polycyclic aromatic hydrocarbons; Lagoon of Venice; Glass manufacturing

1. Introduction

Atmospheric particulate matter with aerodynamic diameter less than 10 μm (PM_{10}) is recognised having a severe impact on the environment and health. Latest epidemiological and experimental data have evidenced a strong correlation between increased PM concentrations—especially for the finer fractions—and increased mortality (Englert, 2004), lung injury and respiratory symptoms (MacNee and Donaldson, 2003), and even reduced lung growth in children (Brunekreef et al., 1997).

Although PM_{10} concentration is considered closely associated to adverse health effects, its chemical composition and especially its content in toxic substances may not be disregarded (Harrison and Yin, 2000). Toxicity and/or carcinogenic effects of several elements in atmosphere have been evidenced recently: Pb (EC, 1997), As, Cd, Ni (WHO, 2000), $Cr^{(VI)}$ (Talebi, 2003), Mn, Pt and V (WHO, 2000), Zn and Ni (Burnett et al., 2000) and other transition metals (Soukup et al., 2000; Dye et al., 2001; Ghio and Devlin, 2001). Polycyclic aromatic hydrocarbons (PAHs) are "semi-volatile" organic compounds, which are

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persistent and ubiquitous in the environment and have been shown to be carcinogenic (WHO, 2000).

Venice is located in the northeast of Italy between the Adriatic Sea and an intensively and industrialized mainland (Fig. 1a). The Venice atmosphere is affected by a variety of emissions from both point and diffuse sources, as the city is in the middle of a ~550 km^2-wide lagoon, close to the Adriatic Sea and not far from cultivated fields and a heavily populated and industrialized mainland with: (i) chemical, metallurgical and oil-refinery industrial plants in Porto Marghera (almost 12 km^2); (ii) Glass Factories in Murano; (iii) a Coal Power Plant; (iv) a medium-size urban area with more than 270 000 inhabitants; (v) several heavy traffic roads; (vi) a motorway; (vii) commercial and industrial harbours.

Murano is composed of nine small islands separated by canals, and its total surface is about 2 km^2 wide. Glass production is documented in Venice since the 7th century, and since the 13th century it was transferred in the islands of Murano to protect the town from fires, and preserve the technological secrets. In 2003 the glass industries in Murano were more than 100, 84 having a

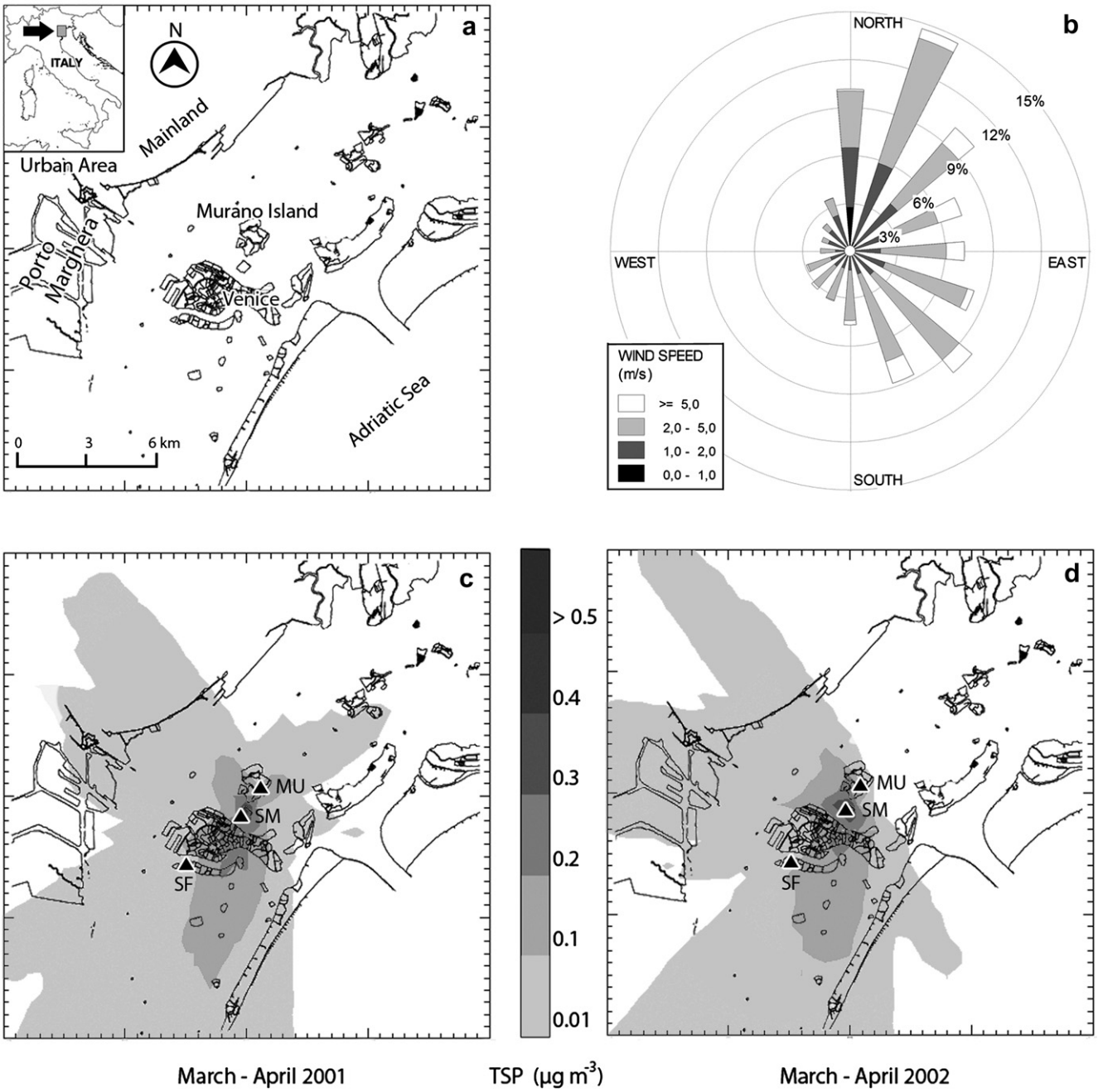

Fig. 1. (a) The three selected sampling sites. MU = Murano island (15 m); SM = Cemetery of San Michele (3 m); SF = Sacca Fisola island (3 m), (b) wind rose for the investigated period, (c) results of ISC3ST model simulation for the period March–April 2001, (d) results of ISC3ST model simulation for the period March–April 2002.