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Speciation of Pb, Cu and Zn determined by sequential extraction for identification of air pollution sources in Syria

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Abstract

Speciation of three trace elements (Zn, Pb, Cu) in air particulates of two Syrian cities (Tartous and Darya) with different climate conditions and industrial emissions has been studied. Air filters were collected during 2000–2001 and extracted chemically using different selective fluids in an attempt to identify the different forms of trace elements. Approximately 60% of lead in air particulates of both cities was found to be associated with organic materials produced by incomplete burning of vehicles fuels and residential heating; the remaining 40% of lead was as lead oxides and mineral acids soluble compounds. Zinc was found in oxides (28–65%) samples collected in Tartous city, indicating that the Tartous cement factory and phosphate loading cargoes are the main source of emissions. In the Darya filters, zinc associated with organic materials (28–49%) was related to the presence of plastic molding industries and corroding car tires. In addition, copper was also found to be in the form of oxides (19–46%) in both cities in the summer periods, while 13–25% and 35% are associated with organic materials and silicates, respectively. Differences in chemical forms of the studied trace elements in air particulates were found to be related to differences in air pollution sources and differences in human behaviour throughout the year. Therefore, chemical fractionation of trace elements in air particulates using sequential leaching can be used for identification of air pollutions sources in urban and industrial areas.

Keywords: Chemical forms; Trace elements; Air pollution; Tartous; Darya; Syria

1. Introduction

One of the major forms of pollution in urban and industrial areas is particulate matters. These particulate matters consist of finely divided solids or liquids ranging in sizes from $\leqslant 1$ nm to coarse particles of 100 μm (Boubel, 1994). They have serious environmental and related health consequences because they contain a wide range of toxic metals and toxic organic contaminants (Noghissi, 1997; WHO, 1987; Seiler et al., 1988; UNEP & WHO, 1992). Heavy elements in the atmosphere originate from natural and artificial sources (Sternbeck et al., 2002; Galli Parghart et al., 1990; Infante and Acosta, 1991; Beavington et al., 2004; Bem et al., 2003; Fernandez et al., 2000; Bilos et al., 2001; Pacyna, 1986). Natural sources include dust raised by winds (resuspension of soil particles), volcanic activity, forest fires and sea salt aerosols, while industrial plants burning oils, residential heating, cement industry, smelting industry, traffic fuel combustion, industrial metal production and

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waste incineration are considered the main artificial sources. These artificial sources are often highly localized especially in urban and industrial areas and local high concentrations can be expected. Different industries may emit one element and several elements can be emitted by only one industry. Therefore, some industries can be identified as a potential source of one element and this element can be used as a specific source type; Cu for smelting industries, oil combustion and wood smoke (Song et al., 2001; Wang et al., 2005; Al-Maomani et al., 2005). Measurements of metals in the collected particulate matters not only lead to better deposition estimates but could also be used to provide useful information for the identification of the origin of ambient pollutants. In addition, chemical characterization of air particulates matter can provide information for explaining specific events of air pollution, atmospheric transport, transformation and deposition processes (Boubel, 1994). Recently, Utsunomiya et al. (2004) have used high-angle annular dark-field scanning transmission electron microscopy combined with conventional high resolution TEM technique to investigate metal speciation in aerosol samples from Detroit urban area, Michigan. Poykio (2002) has used sequential leaching on airborne particles to assess industrial pollution in the Kemi Toranio region, Oulu where the soluble fraction and environmentally mobile fraction of trace elements in air particulates being determined. More detailed description on the extraction procedures are described by Hlavay et al. (2004). However, most studies (Harrison and Jones, 1995; Noghissi, 1997; Sternbeck et al., 2002; Galli Parghart et al., 1990; Infante and Acosta, 1991; Beavington et al., 2004; Bem et al., 2003; Fernandez et al., 2000; Bilos et al., 2001; Van Putten et al., 1998; Des-Jardins et al., 2004; Han et al., 2005; Quiterio et al., 2005) in different parts of the world refer to air pollution by mass concentrations of particulate matters and trace elements provide information on the levels of contaminants and related health and environmental effects in comparison with national and international standards for air quality. Potential sources of contaminants are usually identified in each case including the Syrian studies for air quality (Al-Oudat et al., 1999; Othman et al., 1996). Local studies include mass concentrations of suspended particulate, heavy elements, dust fall, toxic gases, and radioactivity in air particulates. Distribution of airborne particulate according to aerodynamic diameter and correlation with meteorological parameter (rain, snow, wind speed and seasonal wind) was also determined. However, there was no attempt to investigate the speciation of the trace elements in particulate air pollution that could be used for further studies such as emission source identification, pollutants transport and deposition processes. Therefore, the aim of the present study was to characterize chemically the suspended solids in the air of two Syrian cities with different climate conditions and investigate the possibility of using these data as a tool for identification of air pollution sources by trace elements.

2. Materials and methods

2.1. Area of study

Two cities were selected for this study, namely Tartous and Darya. Tartous is a costal city situated at the eastern coast of the Mediterranean Sea. The relative humidity can reach up to 80% in summer. Main sources of air pollution in the city are traffic, a cement factory as well as phosphate and coal loading activities into ships. Darya is situated at around 10 km south west of Damascus. It has a dry climate in comparison to Tartous city and the highest value of relative humidity in summer is about 15%. Sources of air pollution include traffic and many small industries such as plastic molding, cosmetics, paint, metal electroplating, lead batteries recycling and metal melting.

2.2. Sampling

High volume air samplers (Grasby General Metal Works, USA) with EPM 2000 Watman fiber glass filters (20 cm × 25 cm) have been used to collect total suspended particulates at a flow rate of $1.7\,m^3\,min^{-1}$. The samplers were placed in the center of each city at 1 m height above the ground, 5 m distant to the street and any surrounding buildings and trees. Pollution sources at each city are located at different distances from the location of the samplers, but within 2–3 km radius. Sampling was performed every 2 months from October 2000 and October 2001 for four days of each sampling campaign; three samplers were simultaneously operated at each site. Total suspended particulate (TSP) was determined using climate controlled weighing technique.