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Atmospheric pollution in an urban environment by tree bark biomonitoring – Part II: Sr, Nd and Pb isotopic tracing

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ABSTRACT

The harmful effect of manmade particles on natural processes and human health is documented by a large number of studies showing a positive correlation between particulate matter (PM) concentration and health effects. Diminution of this health risk necessitates among others the precise knowledge of the particle sources, their physical and chemical properties and their dissemination in the environment. Pb isotope ratios have been successfully used during the past decades as tracers of anthropogenic Pb disseminated in the biosphere. Here we show that tree bark biomonitoring with lead (Pb), strontium (Sr) and neodymium (Nd) isotope ratios as tracers allow a thorough analysis of the impacts of industrial and other anthropogenic emissions on the urban environment. This is the first comprehensive multi-isotope tracer study of atmospheric pollution in an urban environment allowing to identify and to integrate the different plume paths of emissions in a digital map system. This innovative approach might become an important tool for environmental management and policy-making processes dealing especially with risks and surveillance of air quality in the urban environment.

1. Introduction

Geoaccumulation indices (I_{GEO}) (Müller, 1981) derived from trace metal concentrations in tree barks allow to analyze the degree of past pollution of a studied site. However, they do not allow to discriminate between various sources of pollution. Pb, Sr, Nd, C isotopes ratios, however, are appropriate tools to identify different sources of pollution in soil, barks, water and atmospheric dust (Monna et al., 1997; Widory et al., 2004, 2010; Grousset and Biscaye, 2005; Hissler et al., 2008; Lahd Geagea et al., 2008a; Sivry et al., 2008). With the development of a new generation of mass spectrometers (MC-ICP-MS, see below), new isotopic systems have been tested to trace sources of pollution (e.g. Zn, Cd) (Cloquet et al., 2006a; Shiel et al., 2010). Pb isotope ratios are powerful tracers of leaded gasoline in the environment (Bollhöfer and Rosman, 2001; Martínez Cortizas et al., 2002). Since it was banned in Europe in 2000, Pb isotope ratios of airborne particles tend towards more industrial ratios (Monna et al., 1997). However, Pb isotopes alone do not allow to clearly distinguish between different industrial emissions (Grobéty et al., 2010). It has been shown that especially the combination of Sr, Nd and Pb isotope ratios is a powerful tool to discriminate between traffic and industrial emissions such as those from smelters, steel plants, coal and wood burning (Lahd Geagea et al., 2008a). Other isotopic ratios such as C isotopes are still used to differentiate between various organic sources such as diesel emissions (Widory et al., 2004). Zn isotope determinations have been more recently performed on lichens and ombrotrophic peat cores to monitor atmospheric depositions in urban and rural environments and to observe isotopic fractionation especially close to smelting emissions (Franssens et al., 2004; Cloquet et al., 2006a,b; Dolgopolova et al., 2006; Weiss et al., 2007; Mattielli et al., 2009; Shiel et al., 2010).

In the present study, Sr–Nd–Pb isotopes ratios were determined on tree bark samples which have been previously analyzed for trace elements and PCB's (Guéguen et al., 2011). The aim of this bark-biomonitoring was to identify main sources of pollution in the urban environment of the cities of Strasbourg and Kehl, situated in the Rhine Valley, on both sides of the Rhine River. This region suffers from substantial air pollution due to the topography of the Rhine Valley, which provides an adverse situation in respect of ventilation and dispersion of pollutants (Lahd Geagea et al., 2008b). The specific topography forces the winds in SW–NE direction. The industrial harbors of the two cities accommodate: a steel plant (SP), a thermal power plant (TPP), a bio-mass heating power station (BHPS), a paper producer (PP), chemical and domestic waste incinerators (CWI and DWI). Sr, Pb and Nd isotopic distribution maps will be presented to illustrate different polluting emissions paths and the atmospheric depositions in urban environment of the cities of Strasbourg and Kehl.

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2. Material and methods

2.1. Sampling sites

Barks of mainly *Tilla* tree were collected in industrial, urban and rural areas of the cities of Strasbourg and Kehl (Fig. 1). Two samples are from remote environments (#34 and #65) in the Vosges Mountains. The patented drill used for sampling (Hofmann et al., 2001) allows to collect only the outer thin layer of bark (<1 mm) where airborne particles are trapped in the bark structure. All trees were sampled at 150–200 cm height above ground. The bark sampling has been performed during dry periods in spring, summer and autumn. Barks were taken all around the tree in order to avoid sampling of only the prevailing wind direction.

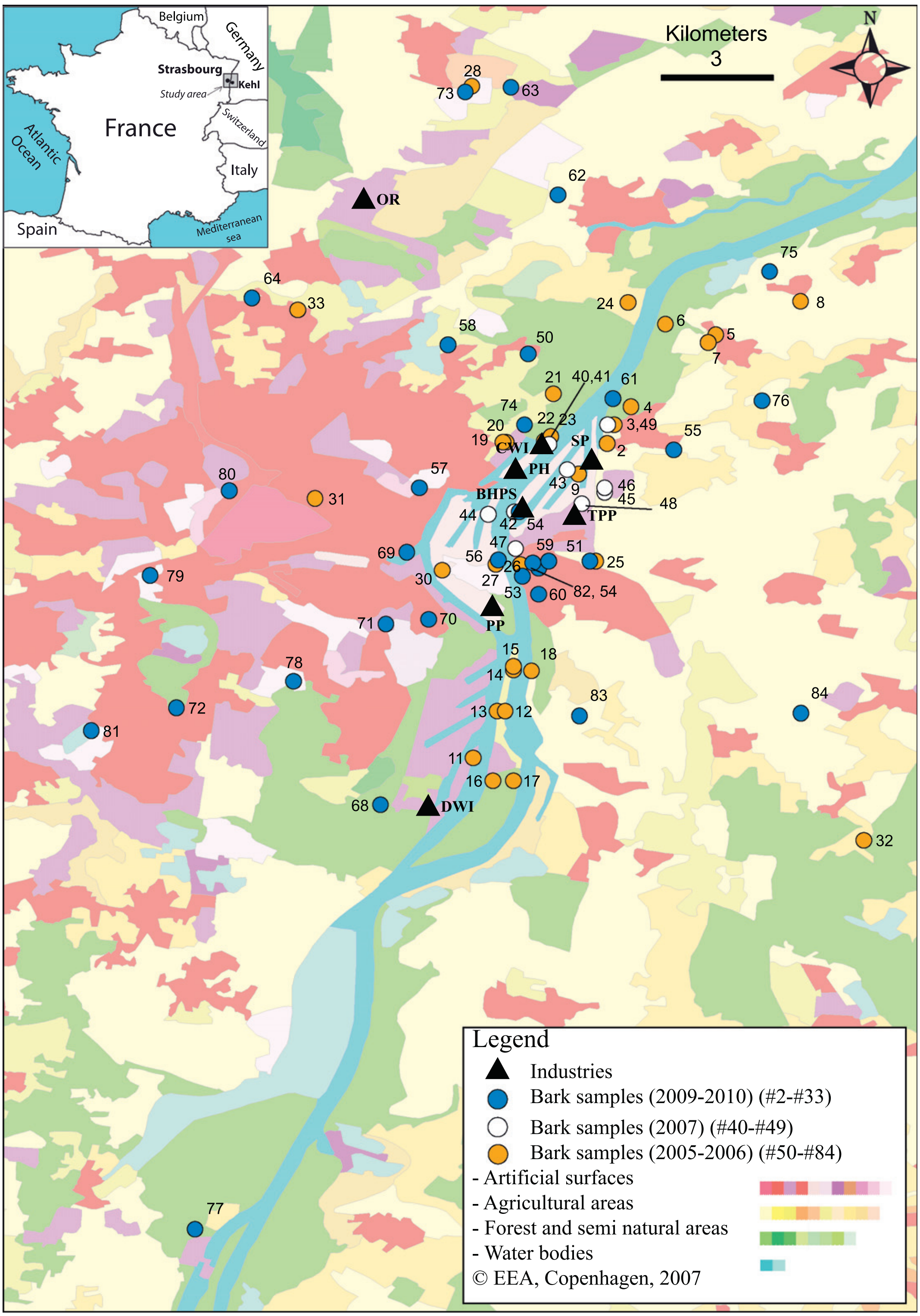

Fig. 1. Map showing sampling sites of tree barks (circles) and industrial sites (triangles). CWI: chemical waste incinerator, DWI: domestic waste incinerator, TPP: thermal power plant, SP: steel plant, BHPS: bio-mass heating power station, OR: oil refinery, PP: paper producer. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)