SOIL CONTAMINATION IN THE SEINE RIVER BASIN: AN ATTEMPT TO RELATE LAND-USE TO PERSISTENT AND EMERGING METALLIC POLLUTIONS

Sophie Ayrault, J. Gaspéri, B. Muresan, R. Moilleron

Climate and Environment Sciences Laboratory (LSCE), Gif-sur-Yvette, France
Sophie.ayrault@lsce.ipsl.fr

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Introduction

Soils play an important role in metal transfer in a river basin as they behave as sources and sink for pollutants. Different processes occur in soils that influence the pollutant adsorption, retention, accumulation, dissipation and transfer to rivers. Soil contamination depends on the anthropogenic drivers, which are mainly associated to human activities (agriculture, industrialization, river basin network activities and others) as well as the natural drivers (erosion, geochemical background,…). Most of the available databases on soil monitoring and the literature focused on a limited set of well documented metals (Cd, Cr, Cu, Hg, Ni, Pb and Zn) because of their legacy characteristics (e.g., Charlesworth et al., 2011). Besides, there are very scarce data on the occurrence in urban soils of Sb, considered as an emerging metal (e.g., Krachler et al. 2005) and Ag, with both emerging and legacy characteristics. Furthermore, the contamination status of these soils is of great interest for the implementation of new urban policies ("greening the city"). The Seine River basin presents a mixture of agricultural, industrial and urban activities that are typical of the developed European countries. The first purpose of this study was to document concentration in soils for a large range of elements. Hence, the content for 23 metals, metalloids and major elements was monitored in the soils of the Parisian conurbation, from rural to densely urbanized sites. Furthermore, the soil parameters, including particulate organic carbon (POC) that may affect the contaminant sequestration in soil were investigated. The last objectives of this paper were to assess the soil contamination (urban vs. rural soils) to eventually identify specific markers of urban land-use.

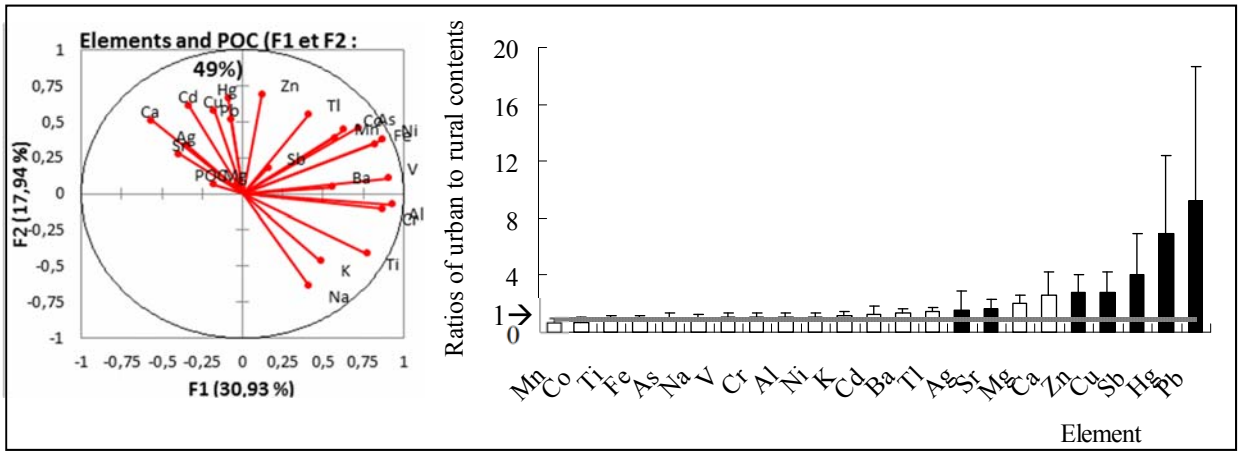
Methods

Rural (n=12) and densely urbanized (n=20) soils were collected in the Seine River basin, covering an area of about 12,000 km^2 including Paris Megacity. They were sampled in 2009-2010, using an auger to collect the first 10-cm layer. Freeze-dried samples were stored in the dark. POC was analyzed after mineralization (HCl 3%) using an elemental analyzer (Shimadzu TOC-Vws). Most of the elements were analyzed by inductively coupled plasma mass spectrometry (ICP-MS XII+ ThermoElectron). Total mercury (Hg) was analyzed using an automatic mercury analyzer (AMA 254 from Courtage Analyses).

Results

On the whole, metal contents in Parisian soils were in the middle or in the upper part of ranges reported in the literature. As an example, the Pb content (21-118 mg/kg.dw, d10-d90) were in accordance with values reported by Marcheselli et al. (2010) but lower than those quoted by Rasmussen et al. (2001). Relatively increased contents were equally found for Cu (12-45 mg/kg.dw, d10-d90), Cd (0.2-0.6 mg/kg.dw), Mn (277-592 mg/kg.dw) and Ni (11-28 mg/kg.dw). Hg instead, was characterized by relatively lower levels in the Parisian soils (0.05-0.51 mg/kg.dw) than in other European conurbations (Rodrigues et al. 2006). The measured Sb contents in the urban soils (0.5-4.6 mg/kg.dw) were notably higher than the scares published values for urban soils (Rasmussen et al. 2001; Atapour, 2015). The measured Ag contents (0.09-0.58 mg/kg.dw) are similar or lower than the contents measured in urban soils worldwide (Atapour, 2015; Norra et al., 2006) and significantly higher than the global and local geochemical background (0.05 mg/kg)

Figure 1. Left-hand panel: principal component analysis of the elements and particulate organic carbon (due to their high Hg or Pb contents, samples #U107 and #U109 were excluded from statistical analyses). Right-hand panel: ratios of urban to rural mean contents by tested elements (filled bars = pollutant ratios > 1.5).



When comparing urban to rural soils, higher Cu, Zn and Hg contents were observed in urban soils (Figure 1, right). Trends also appeared for Sr and Sb but they are not statistically significant (Man-Whitney test, α=0.05). It thus seems feasible to regroup several metallic pollutants which are symptomatic of different land-uses and/or pollution types. Further research is therefore needed in order to examine in details the biogeochemical factors that control the fate of these elements once released into the environment. This would allow to reformulated and refine the indicators for emerging pollutants. It would ultimately help to predict the pollution of soil from local land-use and to propose adapted solution for urban land-use management.

Conclusions

Overall, our results highlighted the importance anthropogenic of sources for Ag, Cd, Cu, Hg, Pb, Sb and Zn to the Parisian soils. Cu, Hg and Zn are significant markers of (not mining, not smelting) anthropogenic activity.

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