

## **Ten years of elemental atmospheric metal fallout and Pb isotopic composition monitoring using lichens in north-eastern France**

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We report on the chemical and Pb isotopic compositions of epiphytic lichens collected from small tree branches in the urban area of the city of Metz (NE France). Lichens were collected in five different years between 2001 and 2009. The data are first compared year to year in order to document any temporal changes and trends in metal atmospheric fallout. The area studied was then subdivided into different zones on the basis of land-use (urban, suburban, rural and industrial) in order to determine potential spatial gradients.

The median concentrations and enrichment factors (EF, normalized to Al) of Pb and other metals (Cu, Zn, Cd, Ni, Cr, Hg, Fe) in lichens from the urban, suburban, and rural zones show no systematic variation between 2001 and 2008. However, the metal EFs show spatial variation and are generally highest in the urban area and lowest in the rural area. Lichens within the industrial zone (collected in 2009), which is dominated by steel industries, are richest in Al, Fe, Cr, Pb, and Zn. Although the Al concentration is high in these lichens, the EFs for the cited metals are several times higher than those measured in lichens from the other three zones. No significant differences were noted for Hg, Cd, Cu and or Ni.

Lead isotopic compositions measured in lichens may be highly variable from year to year and from zone to zone. The variation is primarily interpreted to result from mixing between: (i) Pb added to gasoline (and recycled through re-emission of road dust in the atmosphere); (ii) regional industrial Pb from long-range transportation and/or mixed with urban Pb; and (iii) local industrial Pb. The median isotopic compositions of individual zones are distinct, suggesting variable mixing of these three sources. The annual variations show that 2001 was most affected by gasoline Pb, whereas 2003 and 2006 were more affected by the local steel industry.