

Heavy metals accumulation in spruce needles indicating fine particulate matter pollution along traffic routes through the Swiss Alps

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Human emission of pollutants into the air implies forest changes of various kinds, such as indirect effects from climate change or direct effects from local pollution. Fine particulate matter (PM) is to a large extent re-deposited in relative vicinity of the emissions sources. Model estimations show that large parts of the PM<10 µm origin from traffic. However, composition of the PM varies by the source and possible effects on ecosystem elements are not well known.

In this study, we used the element composition of Spruce (*Picea abies* L.) needles as an indicator to investigate the effects of PM traffic emissions on the forests in the Swiss Alps. This indicator has already been recommended in the 1980's and numerous data were available for comparisons (Landolt et al., 1989). We sampled and analyzed spruce needles of two trees at 4 to 69 sites along two major traffic routes through the Alps (Gotthard and San Bernardino) and control areas in autumn of 1983, 1992, 1995, 1999, 2003, 2004, and 2005.

Concentrations of Pb and S have decreased during the observation period. However, heavy metal concentrations of the needles along the traffic routes were still in the upper part of the range found in other European studies. In Alpine valleys, the concentrations of Co, Cr, Fe, Pb were elevated at sites close to the traffic routes compared to control areas with much less traffic and fitted nicely to a Gaussian distribution. In addition, we found an increase of the concentrations with increasing needle age for Cr, Fe, and Pb indicating that these elements are accumulated in the needles. After washing away the wax layer, the concentrations in the remaining needles were almost not elevated. Hence, peak concentrations were in the wax layer which indicates that the main pollution pathway was deposition of fine particles from the air onto the needle surface. With a statistical analyses using a Gaussian distribution function, the concentrations in the needles could to a remarkable extent be explained with rail and road traffic counts, PM emission factors and the distance of the sites to the routes.

Reference:

Landolt, W., Guecheva, M., Bucher, J.B., 1989. The spatial distribution of different elements in and on the foliage of Norway spruce growing in Switzerland. *Environmental Pollution* 56, 155-167.