Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.7405

Impact of physiology and climate on foliar mercury uptake by European forests

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Uptake of gaseous elemental mercury (Hg(0)) from the atmosphere by tree foliage represents a pivotal flux within the terrestrial Hg cycle. To date, however, physiological and climatic factors controlling foliar Hg(0) uptake remain poorly understood. Here we present Hg measurements of 3831 foliage samples to statistically identify parameters regulating Hg uptake rates. Foliage samples originated from a wide range of tree species and locations in Central and Northern Europe comprising 247 Level II Plots of the European ICP Forests biomonitoring network and 757 sampling sites of the Austrian Bio-Indicator Grid from the years 2015 and 2017. Normalized for time period until sample harvest and sample dry weight, median foliar Hg uptake was approximately 3 times higher for deciduous tree species (ash, beech, hornbeam, oak) than for coniferous tree species (douglas fir, fir, larch, pine, spruce).

Leaf nitrogen content has been widely used as a proxy for leaf physiological activity (photosynthesis, transpiration). Linear regression of time-normalized foliar Hg uptake rates per dry weight on leaf nitrogen content revealed a positive correlation across all tree species (R^2 = 0.69; $p < 0.001$). This finding suggests that foliar Hg uptake aligns along an evolutionary spectrum of tree species, ranging from low to high leaf nutrient contents, from low to high rates of leaf physiological activity, and from long to short leaf life spans. Within tree species, leaf Hg uptake and nitrogen content partially correlated in a multiple linear regression that took specific leaf area values of respective samples into account. We thus hypothesize that foliar Hg uptake can be described by an interplay between leaf physiological activity and leaf structure. Climatic parameters (temperature, precipitation, vapor pressure deficit) and geographic characteristics of sampling sites (latitude, altitude) did not or only marginally correlate with time-normalized foliar Hg uptake rates. We conclude that it is foremost tree physiological activity driving foliar Hg uptake and has to be primarily considered when predicting trends of foliar Hg fluxes in response to anthropogenic emission scenarios.