

Monitoring of Mercury in Tree Foliage in Austria

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Introduction:

In forest ecosystems, tree foliage is a key parameter for estimations of mercury inputs to soil and water. The Minamta Agreement regulates mercury emissions and was started in 2017 (in Austria on 10 September 2017). One of the most important mercury sinks are vegetations, especially forest ecosystems. In Forests, elemental mercury is fixed via the stomata of needles or leaves and is fixed in a stable way into the matrix there.

The Austrian Bio-Indicator Grid took place in 1983 and in 1995 20 sites were chosen for ICP-FORESTS intensive monitoring (Level II; reduced to 16 sites in 2010). For six of these Level II plots, mercury in tree foliage (needles/leaves, seeds or fruits, twigs and other biomass) is monitored since 2016.

Mercury in forest foliage:

Accumulation of Mercury in leaves and needles occurs by direct uptake from the air. In the Austrian forest Ordinance "Zweite Verordnung gegen Forstschädliche Luftverunreinigungen", BGBl. Nr. 199/1984, threshold values are specified for the concentrations of several pollutants in leaves and needles, but not for Mercury. From the results of the Austrian Bio-Indicator Grid (Fürst 2009, 2019) a threshold value of 0.017 mg Hg kg⁻¹ in leaves and needles was derived, and above this value mercury pollution is assumed. More detailed results of this derivation are depicted in Table 1. Tree foliage is the major pathway how mercury enters the soil in forest ecosystems.

Rating	Hg content (mg kg ⁻¹)
Low natural content	up to 0.012
Slightly elevated content	> 0.012 to 0.017
Incipient Hg pollution	> 0.017 to 0.022
Significant Hg pollution	> 0.022

Table 1 (Fürst, 2009): Derived values of the thresholds for Mercury (Hg) for *Picea abies*, *Pinus sylvestris* and *Pinus nigra*.

Method of determination:

The samples were collected in the upper part of the crown each October. Mercury contents in foliage samples were determined with an AMA 254 Advanced Mercury Analyzer & Autosampler. The samples were combusted with oxygen at 750°C and following the evolved mercury was transported to the amalgamator. Following the amalgamator was heated up to 900°C and the released mercury was determined by Atomic Absorption at 253.7 nm.

Typical Hg emission sources in Austria:

In Austria, a typical source of Mercury emissions are areas with pig-iron and steel production, especially around Linz and Leoben/Donawitz. Over the years, due to considerable reducing measures a clear decrease of Mercury concentrations in foliage could be observed. Other examples for sources where Mercury is released are facilities with chlorine alkali electrolysis (e.g. Brückl/Carinthia or Hallein/Salzburg, both sources were eliminated by technological changes or shut down in the end of the nineties), cement production, former mining sites (e.g. former silver mining in Schwaz/Tyrol), copper smelting (Brixlegg/Tyrol) or combustion of waste or coal (Smidt et al. 2012, Fürst 2019).

Level II Plot	Height above Sea Level	Tree species	Total mercury input via litterfall (g Hg ha ⁻¹ a ⁻¹)	Contents in the foliage fraction (mg Hg kg ⁻¹)	Contents in foliage - needle set 1 (mg Hg kg ⁻¹)
Unter-pullendorf	290 m	Oak	0.14 – 0.22	0.035 – 0.049	–
Klausen-Leopoldsdorf	510 m	Beech	0.16 – 0.22	0.046 – 0.052	–
Mondsee	860 m	Spruce	0.07 – 0.32	0.053 – 0.071	0.010 – 0.013
Mürzzuschlag	715 m	Spruce	0.11 – 0.29	0.047 – 0.073	0.009 – 0.014
Murau	1540 m	Spruce / Larch	0.10 – 0.19	0.062 – 0.113	0.010 – 0.015
Jochberg	1050 m	Spruce	0.12 – 0.26	0.050 – 0.068	0.010 – 0.011

Table 2: Minima and maxima of the mercury inputs and mercury contents in litterfall and in foliage (needle set 1) from 2016 – 2019.

Mercury contents 2019 in the bulk Austrian Bioindicator Grid, whole Austrian territory (all tree species included):

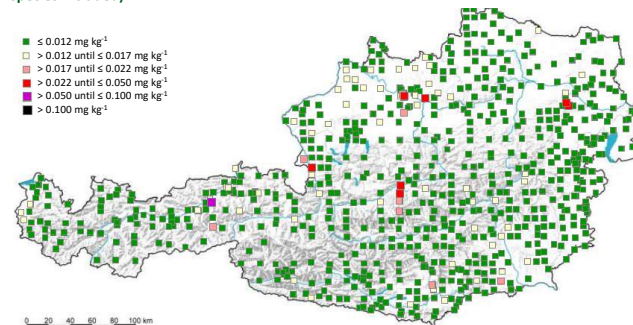


Figure 1: Mercury contents in foliage (Austrian Bioindicator Grid - sampling 2019)

Results:

Figure 1 shows the foliage mercury results of the Austrian Bioindicator Grid, sampling year 2019. With only few exceptions, the mercury contents in foliage were at natural levels.

The mercury inputs via litterfall on the level II plots are shown in Figure 2. The most important fraction for the total mercury input is the litterfall foliage fraction. All six level II plots are located on non-polluted sites. The total input of mercury on these background plots by litterfall is between 0.07 and 0.32 g ha⁻¹ a⁻¹. A background load of 750 kg of mercury per year gives a rough calculation for the total input of mercury by litterfall in Austria's forests.

But on polluted areas, the mercury levels in foliage (from the Bio-Indicator Grid) are 10 to 20 times higher. However, this means that these sites have also higher mercury inputs from litterfall till several grams/ha⁻¹ a⁻¹. To test this hypothesis, the litterfall in polluted areas would also have to be investigated.

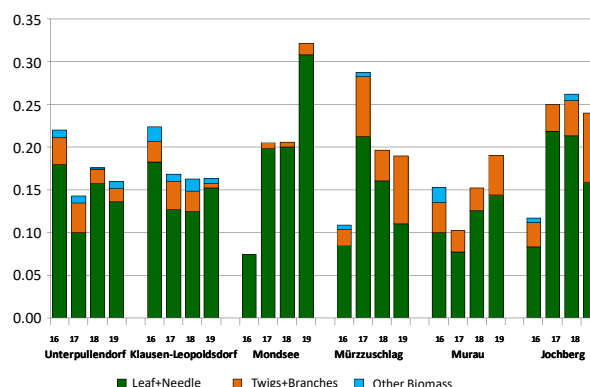


Figure 2: Inputs of mercury deriving from litterfall on the Level II plots sampling period 2016 to 2019 (g Hg ha⁻¹ a⁻¹).

Literature:

- Fürst, A. 2009. Reference Values for Mercury Concentrations in Foliage. Forstschutz Aktuell 47, p. 29-31.
- Fürst, A. 2019. 35 Jahre Österreichisches Bioindikatornetz: eine Erfolgsgeschichte der forstlichen Bioindikation. Gefahrstoffe - Reinhaltung der Luft (2019), Düsseldorf, 79(4): 137-141.
- Smidt, S.; Jandl, R.; Bauer, H.; Fürst, A.; Mutsch, F.; Zechmeister, H.; Seidel, C. 2012. Trace Metals and Radionuclides in Austrian Forest Ecosystems. In: The Biosphere/Ishwaran, N. (Ed.), InTech: Rijeka, (5), pp. 93-118.
- Austrian Forest Ordinance: accessible via <https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10010456>

Recommended links:

- <https://bfw.ac.at/rz/bfwcms2.web?dok=3687> or
- www.bioindikatornetz.at