THÜNEN

Project *brief*

Thünen Institute of Forest Ecosystems 2021/24a

Techniques for the measurement of wet mercury depositions under forest canopy

Frauke Geppert [1], Tobias Schad[1], Nils König[2], Michael Krinninger[2], Marieanna Holzhausen[1], Tanja Sanders[1], Gudrun Schütze[3]

- **Measurement of wet mercury depositions is principally possible.**
- **Established bulk deposition samplers can be adjusted for mercury measurements.**
- **Measurement results of the new developed samplers are within the range of conventional samplers.**
- **The project shows a close connection between precipitation amount and measured mercury input.**

Background and objective

The heavy metal mercury is a widely distributed pollutant. It is subject to concerns due to its high toxicity and accumulative characteristics in the environment. Therefore, mercury is listed as one of the three priority substances in the protocol on heavy metals of the Convention on Long-range Transboundary Air Pollution (LRTAP), which must absolutely be monitored and reduced.

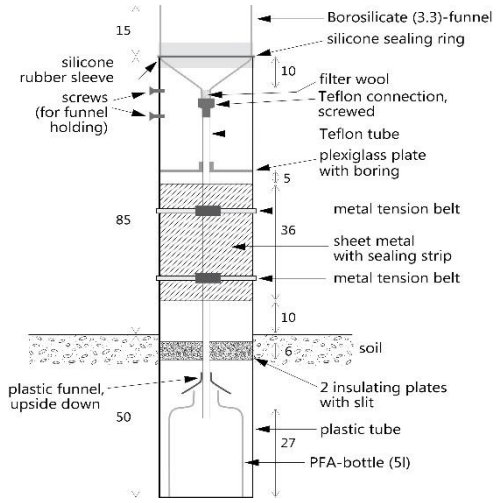
In Germany and Europe, the critical loads of mercury for terrestrial ecosystems calculated via the LRTAP method, are exceeded. According to the guidelines of the protocol on heavy metals, contracting parties are committed to lower their emissions below the level of 1990.

Currently, corresponding studies for the acquisition of wet depositions under canopy of forest ecosystems are still missing. The objective of the project is to develop and evaluate a technique for the determination of wet mercury deposition under forest canopy. Besides a principal testing of practicability, the intention is to receive at most significant results with the developed technique using preferably simple methods. Only then, measurements of mercury depositions can be broadly integrated into already existing measuring programs like the Intensive Forest Monitoring (Level II).

Method

Based on a literature study on already tested methods for the determination of wet mercury depositions in forest stands a measurement system for the capture of wet mercury depositions under forest canopy has been developed, tested in the field and documented in the report. For this study, bulk deposition samplers, developed by the Northwest German Forest Research Institute (NW-FVA), have been used. They are constantly open and do not only capture inputs with precipitation, but also a non-quantifiable amount of dry deposition. Figure 1 shows the self-built bulk deposition sampler, especially adjusted for mercury measurements, without temperature regulation and demand for an external power supply. Nevertheless, the sampler is equipped with an evaporation protection and sample bottles are cooled by digging the sampler into the soil along with an insulating layer above the sample bottle.

Figure 1: The new developed bulk deposition sampler and its size in cm.



Source: NW-FVA

For the mercury measurements, twelve of these self-built deposition samplers (three in the open land and nine in the stand) have been installed on already implemented Level II plots in the Göttinger forest (beech stand) and in the Solling (spruce stand) each. For comparison, a temperature-controlled bulk- and a temperature-controlled wet-only sampler were also installed in the same areas. The sampling frequency varied in the beginning to capture specific climate events and to test the effect of the filter cotton in the funnel. In regular operation, the sampling frequency is fortnightly. According to the standards of DIN EN ISO 17852, resp. EPA 1631, deposition samples were analysed and interpreted according to international

standardised methods by atomic florescence spectroscopy and ICP-MS. Possible contamination by materials, fallen into the funnel, were determined by rinsing- and leaching tests.

Results

In sum, the obtained results are plausible. The inputs in the open land are well comparable with the measured results of the years 2018 (projected) and 2019 at three reference stations in northern Germany, operated by the Umweltbundesamt. The analysis of the measurement results of the beech stand shows a strong correlation (> 0,93) between precipitation amount and mercury input. This applies for the leafy phase as well as for the leafless phase of the year.

The input per precipitation amount in the spruce stand is comparable with the input per precipitation amount in the leafy beech stand. The mercury inputs per precipitation amount of the leafless phase of the beech stand are comparable with the inputs in the open land. Mercury inputs per precipitation amount in the leafy phase are almost four times higher compared to the leafless phase. The reasons are on the one hand the wash-off effects in the canopy and on the other hand the increase in concentration by evaporation. Referring to the results of the rinsing tests, possible evoked errors due to interfering materials like needles and leaves can be classified as low.

Beech stand, Göttinger Forest

In the period from 08/07/2018 till 12/02/2019, an average mercury input of 3,8 µg/m²/year has been measured in the open land of the Göttinger forest. With the use of funnel rinsing, an average input of 4,1 µg/m²/year has been measured in the stand in the same period. This result is insignificantly higher compared to the input in the open land. The marginal higher input in the stand is attributed to the lower precipitation amount, reaching the soil in the stand. This lower precipitation amount can be ascribed to the high evaporation in the canopy under treetop.

Spruce stand, Solling

In the period from 07/15/2019 till 02/14/2020 an average mercury input of 9,5 µg/m²/year has been measured in the Solling. Due to the significantly higher precipitation amount in the Solling during the study period, inputs in the spruce stand are more than two times higher compared to the beech stand. The inputs of 1,4 µg/m²/year in the open land in the Solling are notably lower than in the stand. However, this value refers to only three measurement dates and has to be verified by longer measurements.

Comparison of the samplers

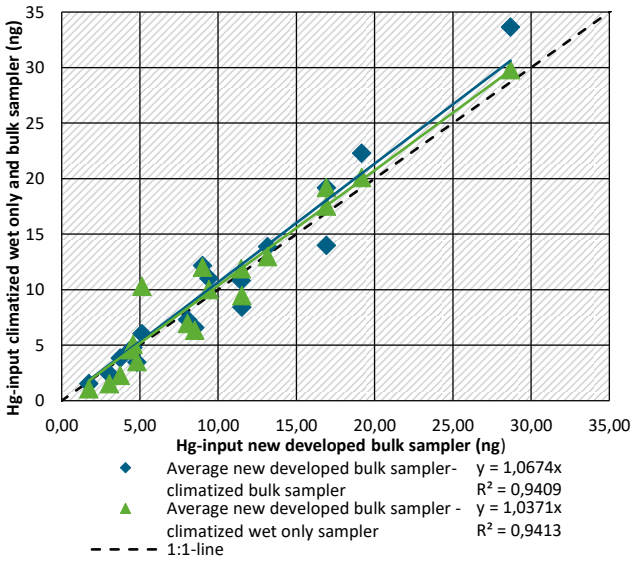
The results of the deposition measurements with the two temperature-controlled samplers were compared with the average of the nine newly constructed bulk samplers. The measurement period for this comparison was ten months (02/11/2019 till 12/02/2019). The results show a good accordance between the three sampler types (Figure 2). The deviation of 4 to 7% is significantly below the dispersion between the self-built samplers (16,9%).

As the results of the temperature-controlled wet-only sampler are also in accordance with the results of the temperature-controlled bulk sampler, there is reason to assume that dry deposition through sedimentation hardly matters for mercury input.

The samplers developed during this study are suitable for the spring-, summer- and autumn period. For the winter period with snow fall and freezing samples, no evaluation has been possible during this project period. There has only been some snowfall in one sampling period.

Therefore, further comparative studies with the heated and temperature-controlled samplers are necessary. A follow-up project with wet deposition measurements at altogether three sites with different stress background in Germany has already started.

Figure 2: Comparison of the entry data of the three sampler types.



Source: NW-FVA

Further information

Contact

[1] Thünen Institute of Forest Ecosystems

Frauke.Geppert@thuenen.de
www.thuenen.de/wo

[2]Northwest German Forest Research Institute

[3] Umweltbundesamt

Period

06.2018 - 02.2021

Funding Number

3717 51 256 0

Project-ID

1990

Publications

König, N.; Krinniger, M.; Schad, T.; Gepert, F.; Sanders, T.G.M.; Holzhausen, M. (2021): Entwicklung und Test von Methoden zur Messung der nassen Quecksilberdeposition unter dem Kronendach von Wäldern. (The report is available on demand at the Umweltbundesamt (UBA), contact: gudrun.schuetze@uba.de)

Funded by

Umwelt Bundesamt

DOI:10.3220/PB1629705718000