# Investigation of the transformation products formed during thermal desorption of PFAS (Session HS8.1.1)

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## Motivation

**PFAS**

▶Used worldwide in various industrial products because of unique properties[a]

▶Threat to environment and human health because of their toxicity, ubiquity, resistance to microbiological and chemical degradation[b,c]

▶Need for remediation technologies

**Thermal Desorption**

▶Has been reported to remove PFAS from soil at temperatures from 350°C to 550°C[c,d]

▶Concern of emitted fluorinated compounds

**In our studies, we investigate the transformation products formed during the thermal desorption of PFAS by heating artificially contaminated sand in a stainless-steel column**

## Preliminary Results and Discussion

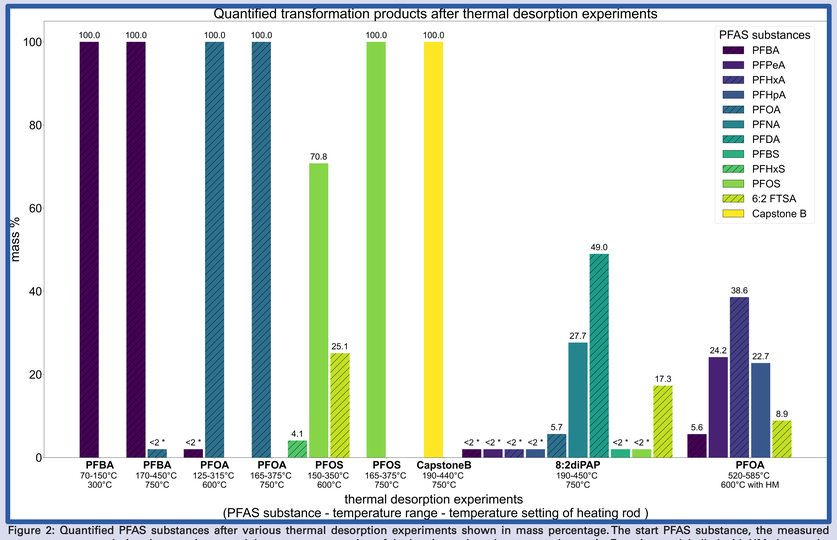



Figure 2: Quantified PFAS substances after various thermal desorption experiments shown in mass percentage. The start PFAS substance, the measured temperature range during the experiment and the temperature setting of the heating rod can be seen on the x axis. Experiments labelled with HM also used a heating mantle. Data marked with * were below 2%. For better visibility, the bars were set to a minimum height of 2.

1. We detected **short-chain transformation products**
2. Usage of **heating mantle** and heating rod increases the maximum temperature in the column leads to a **more uniform temperature distribution.** During the first experiment with HM more transformation products were detected
3. Contary to our expectations we detected some **long-chain transformation products.** This could be due to the limited number of detectable PFAS substances in the target analysis.

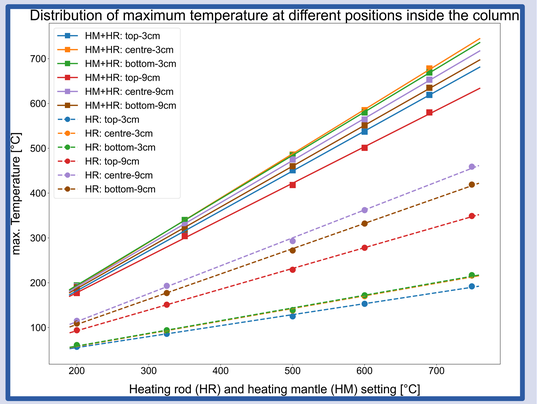



Figure 3: Measured temperature data from six thermocouples during different heating settings of the heating rod (HR) and the heating mantle (HM) (see figure 1 for corresponding colors of the thermocouples). Usage of HM and HR leads to higher maximum temperatures and a smaller temperature range inside the heated column.

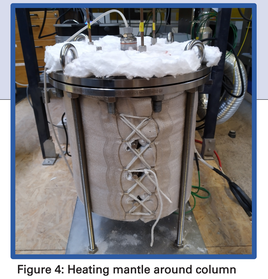


Figure 4: Heating mantle around column

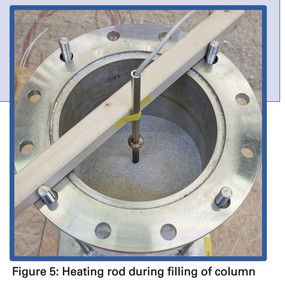
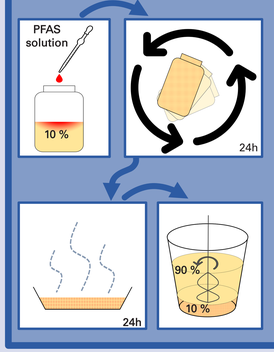


Figure 5: Heating rod during filling of column

## Methods

**Spiking of the sand** → **Thermal desorption experiment** → **Sampling and analysis**

**Spiking Procedure**




**Preparations**

▶Filling of column with PFAS spiked sand

▶Installing six thermocouples for monitoring of temperatures

▶XAD cartridges and impingers for sampling of gas stream

**Thermal desorption experiment**

▶Starting air flow through column

▶Heating of column over 3 days

▶Monitoring of temperatures at different points inside the column

**Sampling**

▶Sampling of sand and glass beads inside the column

▶Extraction of sand and glass bead samples, XAD cartridges and surface of column lid (for condensated PFAS) with methanol

**Chemical Analysis**

▶Target-Analysis of sample extracts and impinger liquids via HPLC-MS/MS (University of Tübingen)

▶Fluoride analysis of impinger liquids

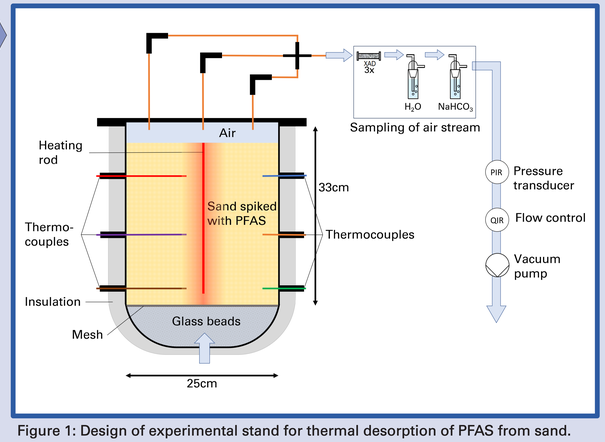



Figure 1: Design of experimental stand for thermal desorption of PFAS from sand.

## Outlook

▶ Varying porous media (increasing complexity)

– Spiked soil experiments to investigate the difference between sand and soil as contaminated porous medium

– AFFF-contaminated soil used in experiments with a mixture of substances present

▶ Chemical analysis

– High resolution mass spectrometry for non-target screening (Orbitrap Exploris 240)

**By understanding the transformation processes happening during thermal desorption of PFAS, it will be possible to make well informed decisions and improve the application of thermal remediation strategies for PFAS contaminated soils.**

## References and Acknowledgments

a) Alinezhad, Ali; Challa Sasi, Pavankumar; Zhang, Ping; Yao, Bin; Kubátová, Alena; Golovko, Svetlana A. et al. (2022): An Investigation of Thermal Air Degradation and Pyrolysis of Per- and Polyfluoroalkyl Substances and Aqueous Film-Forming Foams in Soil. In: ACS ES&T Engineering 2 (2), S. 198–209. DOI: 10.1021/acsestengg.1c00335.

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c) Sörengård, M.; Lindh, A-S; Ahrens, L. (2020): Thermal desorption as a high removal remediation technique for soils contaminated with per- and polyfluoroalkyl substances (PFASs). In: PloS one 15 (6), e0234476. DOI: 10.1371/journal.pone.0234476.

d) Crownover, Emily; Oberle, Daniel; Kluger, Mark; Heron, Gorm (2019): Perfluoroalkyl and polyfluoroalkyl substances thermal desorption evaluation. In: Remediation 29 (4), S. 77–81. DOI: 10.1002/rem.21623.

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