Immobilisation of PFAS Contaminants in the Subsurface for the Protection of Groundwater: the Case of Hügelsheim

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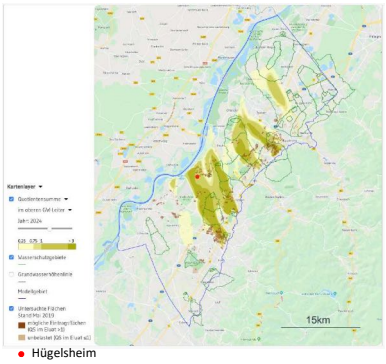
PFClean

Background & Motivation

PFAS (per- and polyfluoroalkyl substances) contamination in agricultural soil is an emerging environmental problem. PFAS are toxic, man-made chemicals widely used to waterproof products like pans, paints and packaging. These chemicals are highly persistent in the environment, earning them the nickname "forever chemicals."

One unexpected source of PFAS contamination is compost made from paper industry waste. When this compost is used on agricultural fields, PFAS can leach into the soil and eventually reach groundwater. PFAS-contaminated soil can act as a long-term source of PFAS pollution to groundwater.

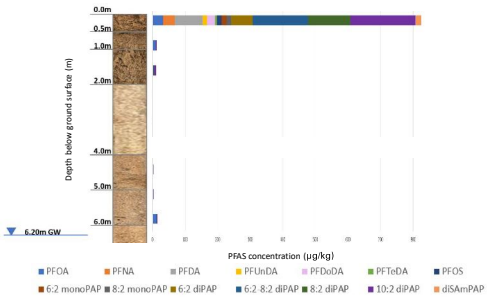


Hügelsheim

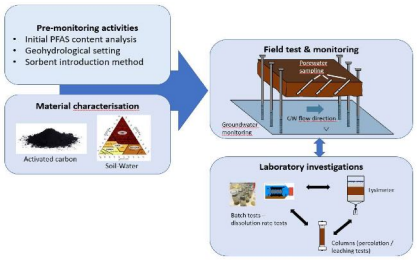
Inventory and forecasts of PFAS concentrations and distribution in the Rhine River valley.
Source: https://www.lubw.baden-wuerttemberg.de/wasser/pfc-karten-online

- **Aim**: To minimize the movement of PFAS from contaminated soil to groundwater, hence reducing the risk of PFAS leaching into and polluting groundwater resources, thus protecting drinking water and the surrounding ecosystem.
- **Hypothesis**: Immobilizing PFAS within the source zone, i.e. the upper soil layer, by applying activated carbon (AC), a highly porous material that acts as a sorbent agent, helps to contain the contamination at the surface and therefore reduces the likelihood of PFAS chemicals being leached and transported downward into groundwater.

Materials and Method



- Large un-stationary source of PFAS in the upper soil layer (sandy, soft, brown soil), i.e. 0-0.5 m depth
- Dominant contaminants are long-chain PFAS, carboxylic acids (PFCA) and (di-)PAP precursors



- Monitoring of field soil, soil porewater & groundwater (up to 6m below ground surface) pre- and post-remediation of the treated field and in comparison with 2 reference fields nearby
- Batch tests, leaching tests (columns) and variably saturated lysimeter experiments to investigate sorption, leaching and transport behaviours of PFAS
- Analysis of > 50 PFAS compounds and precursors
- EOF, AOF and TOP-assay to assess reactive transport

Pilot Test Field Remediation and Monitoring

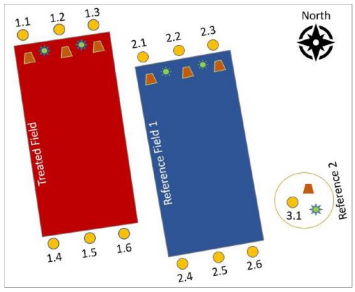
- Pilot test field: 10 m x 20 m
- Mass of soil immobilized: ca. 160 tons (0.5-1.0 m depth)

- Water added: 14 m³ (≈ 40% of pore volume)
- Activated Carbon: 4 tons (or 2.5% w-w of soil mass)

- Mixing by Wirtgen WR 240i
- Compressing by Tamping foot roller HC 200i CP

Top- and sub-soil (0-50 cm depth) were placed back on respectively to cover the treated layer;

Treated layer as the "**filter barrier**"



Installing groundwater monitoring wells

Data logger for soil moisture sensors

Soil porewater sampling (suction cups)

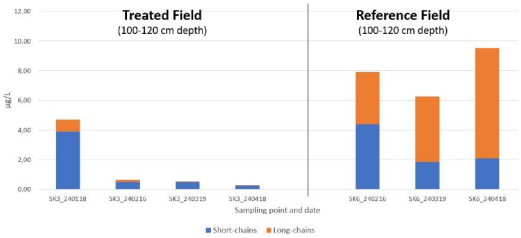
Column and Lysimeter Experiments

Saturated elution tests (columns):
- Effects of differing residence time & liquid/solid ratios
- Transformation products of precursors

Lysimeters under unsaturated conditions:
- Effects of varying soil moistures
- Air-water interfacial adsorption
- Hysteresis effects (drying/wetting cycles)

Preliminary Results

- Decreases in total PFAS concentrations in soil porewater samples for field soil depths underneath the activated carbon filter barrier
- No changes in total PFAS concentrations in groundwater samples



Total PFAS concentrations in soil porewater samples (AC was applied on 23.01.2024)

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FONA Forschung für Nachhaltigkeit
LURCH Grundwasser nachhaltig bewirtschaften
Wasser:N
DVGW TZW Technologiezentrum Wasser
LANDKREIS RASTATT
geiger
WIRTGEN