Sustainable In-situ Treatments of PFAS in contaminated Soil and Groundwater, Washing with Protein Bio-polymers and Stabilization by GAC high pressure Injection

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Due to their high chemical stability, mobility in the environment and bioaccumulation potential, poly- and perfluorinated alkylated substances (PFAS) represent a highly relevant pollutant group with regard to their hazard potential. Across Germany and other countries, numerous sites with PFAS contamination have been identified, some of which cover extensive areas, such as the contamination of topsoil on several hundred hectares of arable land in the Rastatt area (Baden-Württemberg, GER), where PFAS containing paper composting sludge was used as fertilizer. At present, no in-situ remediation technology for PFAS-contaminations in the vadose zone was available. State of the art remediation strategies mostly comprise traditional and very expensive methods like excavation of contaminated soil (& thermal treatment or dumping) or pump-and-treat as a hydraulic containment measure for contaminated groundwater.

The objective of the joint research project "Fabeko" was the development and implementation of an alternative in-situ and on-site technology for the remediation of PFAS from the vadose zone and/or excavated soil using a soil washing process with biodegradable polymer compounds (cf. Fig. 1). Specially developed surface active biopolymer compounds are used to effectively separate the PFAS from the soil. The resulting leachate is transferred to the groundwater and subsequently hydraulically removed from the aquifer by means of a drainage system. The developed technology enables in-situ-/ and on-site mobilization of poly- and perfluorinated compounds from topsoil without destroying the physical structure of the soil and without separating the soil into different grain size fractions.

During extensive process development, the effectiveness of this technical remediation approach was proven first in small scale soil column tests, then in soil lysimeters and eventually in a 3 week pilot application in the field.

In the lysimeter as well as pilot-scale test new analytical methods, such as TOP, AOF and EOF analyses were used in addition to PFAS single parameter analysis to comprehensively quantify the effectiveness of the developed remediation technique.

The results show that short-chain perfluorinated carboxylic acids can be leached from the topsoil simply by using water as percolate. However, carboxylic acids with a chain length > C8 and sulfonic acids proved to be less mobile. The study provided strong evidence that these substances can be mobilized by means of the specially developed biopolymers. During the lysimeter tests a 95%-reduction of the PFAS concentration of the soil was achieved by applying the newly developed method. In the field test PFAS concentrations were reduced by > 80% within a 3-week application.

As part of the process development, technical solutions have been created to inhibit the accompanying geochemical reactions (especially with regard to the non-specific binding of polyvalent cations) and the biomass growth when using the readily biodegradable polymer structures. The effectiveness of these accompanying measures has successfully been tested in the lysimeter.

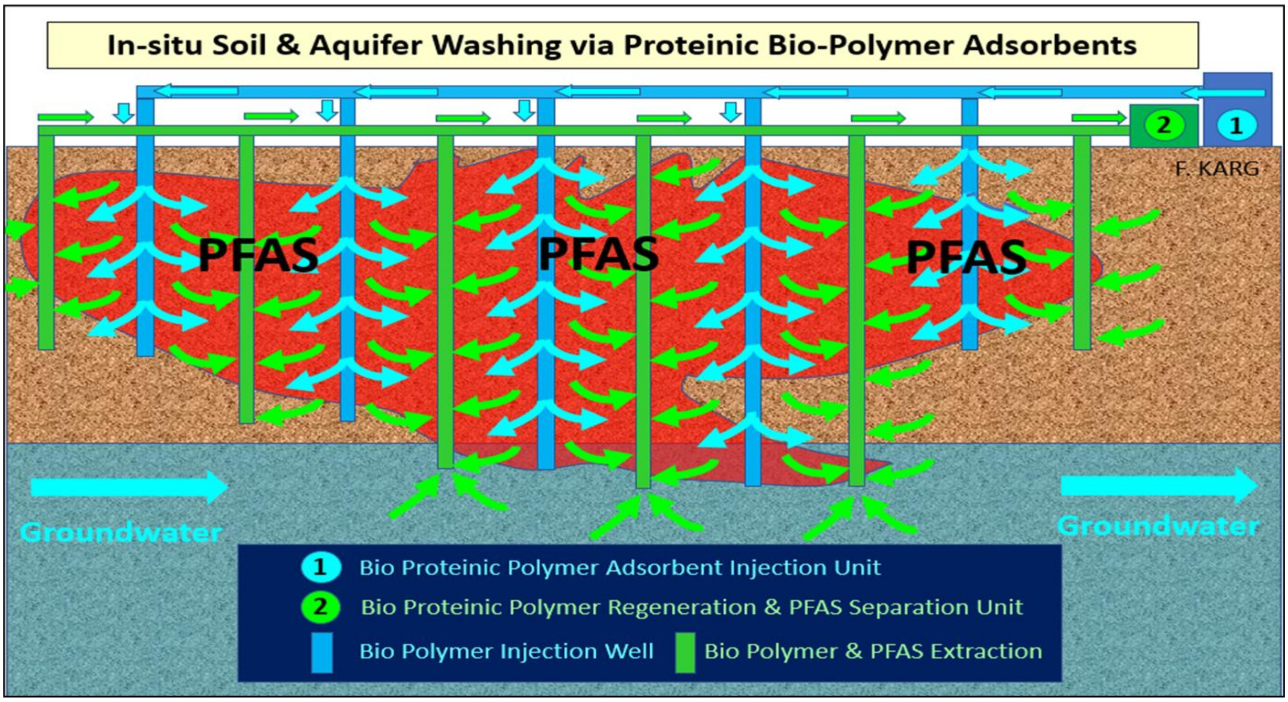

Fig. 1: In-situ soil washing for PFAS decontamination with proteinic Bio-polymers.

The developed process offers the possibility to treat PFAS-containing soils in-situ within the vadose zone by mobilizing PFAS and subsequently treating the groundwater using state-of-the-art technology. A further possible application of the developed method that is currently applied in the field is the ex-situ treatment of excavated PFAS-containing soil materials by applying the biopolymer in washing cycles.

The soil washing technology may well be combined with the in-situ PFAS stabilization technology by injection of solid activated carbon matter. The application options for this technical approach are discussed in the presentation.