

PFAS Leaching Test and Soil Threshold Calculations by Means of Analytical Models

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Background/Objectives. A study was carried out to quantify per- and polyfluoroalkyl substances (PFAS) leaching from the vadose zone to groundwater. The approach is based on the application of Leaching Environmental Assessment Framework (LEAF), developed by the US Environmental Protection Agency (EPA). The objective of this work was the definition of site-specific soil cleanup levels in order to achieve the downgradient groundwater quality standard (at the site boundary). The groundwater quality standard was set equal to 50 ng/L toxic equivalent quantity (TEQ) based on relative potency factors (RPFs) as defined in the RIVM Report 2018-0070, National Institute for Public Health and the Environment, The Netherlands.

Approach/Activities. Soil investigations were performed at a site where significant groundwater PFAS contamination was detected. Source areas impacted by PFAS were identified based on the historical uses of the site and confirmed by soil investigations and groundwater monitoring studies. The investigation included the collection of unsaturated soil samples submitted for leaching tests and to determine site-specific parameters (i.e., pH, organic carbon content, grain size), laboratory percolation column tests (EPA method 1314), and the equilibrium-based leaching test (EPA method 1316) at three test source areas. Leaching tests were also conducted with water (S/L = 2) throughout the entire site. Analysis of the leaching test results allowed for the identification of the most significant constituent of the mixture (i.e., PFOS) and the partitioning coefficient. The leachate concentrations were used in an unsaturated analytical transport model to groundwater to calculate the expected PFAS concentrations in groundwater at monitoring wells located in the source areas. The modelled concentrations were compared to measured concentrations at monitoring wells located in the source areas. The migration pathway was estimated with the Domenico transport analytical model to the point of compliance (POC), located at the site downgradient boundary. The concentration of PFOS modelled at the POC was validated with the use of a finite elements numerical model (Feeflow® code) calibrated in 2021 for the most representative source area and compared with concentrations calculated with the numerical model. Given the good agreement of the analytical and numerical model estimated concentrations, the target PFAS concentrations in the source area both in the leachate and in soil (dry matter) were then back-calculated with site-specific partitioning coefficients and compared with the concentrations detected in the leachate over the course of a two-year period from 2020-2022, for the identification of impacted soil for remediation.

Results/Lessons Learned. Based on the experimental leachate concentrations, partitioning equations, site-specific geological parameters, and PFOS chemical properties gathered from international sources, the site-specific PFOS Log K_{oc} was calculated. The value agrees with the median values derived from laboratory sorption experiments published in international studies. Despite many conservative assumptions and uncertainties embedded in the analytical model, the modelled concentrations in groundwater at the POC showed a high correlation with the average PFAS concentrations measured in groundwater between 2020 and 2022. The analytical model matches also with the predicted numerical model concentration of PFOS at the POC. In the light of these findings, the described methodology based on leaching test performed with EPA Method 1314 and 1316 could be used to define soil target concentrations to reach acceptable concentrations in groundwater at the site's downgradient boundary.