The Sorption of Per- and Polyfluoroalkyl Substances (PFASs) in Australian Soils

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Background/Objectives. Emerging contaminants, such as per- and poly fluorinated alkyl substances (PFASs), are of increasing concern in the environment due to their stability, longevity, bioaccumulation and potential toxicity. These attributes have led perfluorooctane-sulphonic acid (PFOS) to be placed on the Stockholm Convention for persistent organic pollutants (POPs) and perfluorooctanoic acid (PFOA) is currently being considered. Concentrations of PFASs in soils vary greatly from pg/L to mg/L in the literature but are particularly high in contaminated sites such as fire-fighting training grounds and airfields (mg/L). Once released in the environment their behavior and interactions with soil are not completely understood.

Approach/Activities. We studied commonly detected PFASs, PFOS, PFHxA and ^{14}C-perfluorooctanoic acid (PFOA) for their partitioning coefficients, K_d (soil-water partitioning coefficient) and K_{oc} (organic carbon-water partitioning coefficient), in 100 characteristically different soils from an Australian national soil archive. The soils were selected to provide a wide range of properties such as pH, total carbon content, cation exchange capacity and clay content. Using batch equilibrium methods, soil samples were spiked with PFASs of concentrations of 20 to 40 ng/mL, placed on an end-over-end shaker for 48 hours and then centrifuged before extractions and/or subsamples were taken and partitioning coefficients calculated.

In addition, we also investigated the properties responsible for the sorption of PFASs in soils by using multiple linear regression (MLR) to model multiple soil characteristics in relation to the sorption of PFASs in soils and partial least squares regression (PLSR) to model with diffuse reflectance Fourier transform infrared (DRIFT) spectra, to determine if soil spectra could be used to predict partitioning.

Results/Lessons Learned. The K_d for PFOA varied from 0.6 to 14.7 which is in a similar range to currently used pesticides and other organic contaminants.

The K_d value significantly decreased with depth in soil profile, suggesting that sorption of PFOA is likely to be much lower in subsurface soils which means that leaching into ground water is possible in contaminated sites.

Singular soil characteristics, including OC, clay content and pH, indicated weak linear regression coefficients, $r^2 > 0.3$, indicating that no individual soil characteristic is responsible for the sorption of PFOA in soils. A MLR model was produced for the surface soils, 0-15cm, in relation to K_d, $r^2 = 0.49$. The soil properties included in the model were OC, Ca^{2+}, sand content (%) and pH. The MLR model for surface soils also indicated that OC and sand content (%) were significant for the model, $r^2 = 0.81$. The PLSR model, $r^2 = 0.54$, indicated that the K_d in soils was highly inversely correlated with soil carbonates and quartz (sand) and positively correlated with OC. Carbonates in the soil are related to depth of the soil and this association was observed with further investigation.