



Co-occurrence and correlations of PFASs and chlorinated volatile organic compounds (cVOCs) in subsurface in a fluorochemical industrial park: Laboratory and field investigations



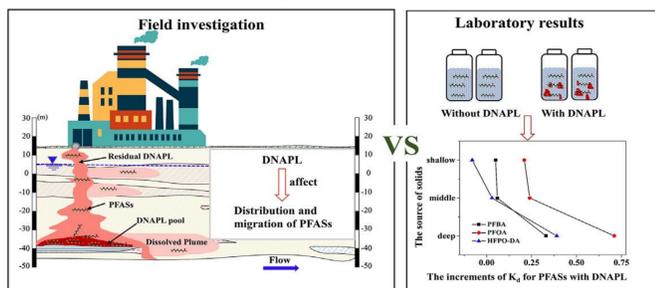
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Motivation



Fluorochemical industrial park (FIP) represents an important source of PFASs and cVOCs. However the effect of aquifer solids on PFAS fate in the presence of DNAPL are still unclear under natural conditions. Therefore, the occurrence and distribution of PFASs in groundwater and aquifer solid at various depths and their correlations were studied. And the influence of DNAPL on the occurrence and migration of PFASs in subsurface was explored in the field, which was further investigated via laboratory adsorption experiment under more controlled conditions.

Material and methods

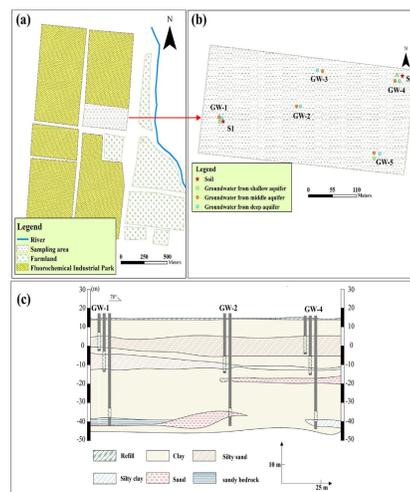


Fig. 1. Map of the sampling locations for soil and groundwater (a and b) and cross-section (c).

A total of 13 groundwater samples and aquifer solids in 5 different depth of two sampling locations were collected from a FIP. All the samples were analyzed PFASs, cVOCs and other properties. Moreover, a Lab sorption experiment was conducted to investigate the effect of cVOCs in the form of DNAPL on the distribution of PFASs. This study also explore the impact of cVOCs on the $\log K_{d-field}$ of PFASs at various aquifers in the field. Solid-water distribution coefficients ($K_{d-field}$, L/kg) for PFASs were calculated by the paired groundwater and aquifer solids according to Eq:

$$K_{d-field} = \frac{C_s \times 10^3}{C_w}$$

Results

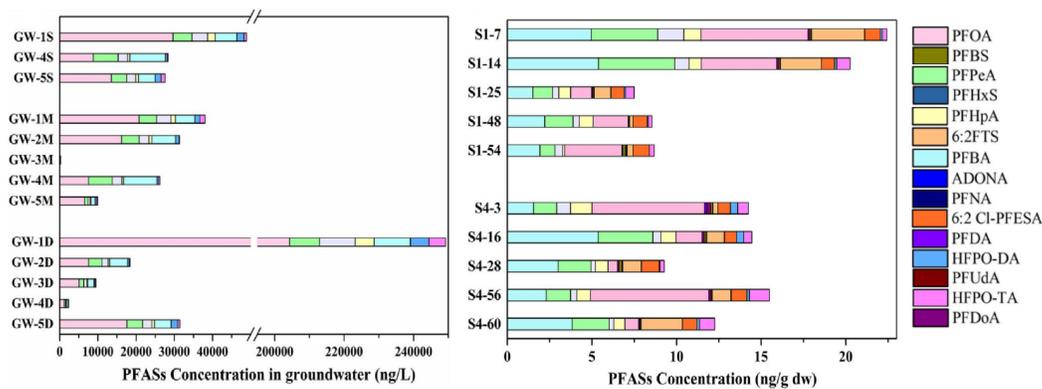


Fig. 2 The concentrations distribution of PFASs from collected sampling location in groundwater (a) and aquifer solids (b).

The \sum_{17} PFASs concentrations in groundwater ranged from 0.48 $\mu\text{g/L}$ to 249.21 $\mu\text{g/L}$, and PFOA was the most dominant PFASs, followed by short-chain PFCAs (C4-C7). In addition, HFPO-DA and HFPO-TA were detected frequently at high concentrations. HFPO-TA concentration (4,808 ng/L) was the highest concentration reported so far. The concentrations of \sum_{17} PFASs in soil were 7.49- 22.42 ng/L, and PFBA and PFOA were the dominant PFASs. The relative abundance of 6:2 FTS and 6:2 Cl-PFESAs were higher than those of HFPO oligomers. The usage of PFOA and PFOS shifted toward the applications of short-chain or emerging PFAS substitutes.

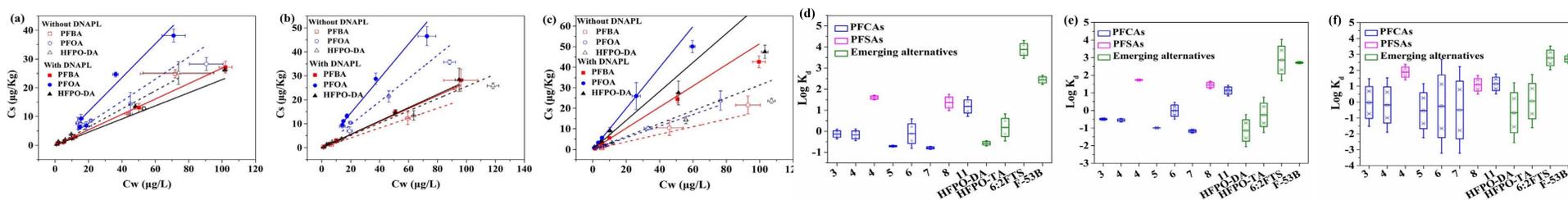


Fig. 3 Sorption isotherms of PFBA, PFOA, and HFPO-DA to solids collected from the shallow (a), middle (b), and deep (c) aquifers in the absence/presence of DNAPL. The $\log K_{d-field}$ values of individual PFAS in the shallow (d), middle (e), deep (f) aquifers.

The $\log K_d$ values, determined in the laboratory, were found to increase in the presence of DNAPL. Specifically, PFOA had a higher potential to participate into DNAPL, which can migrate with DNAPL to the deep aquifer.

Conclusions

The presence of DNAPL led to high concentrations of PFASs and relatively high abundance of PFOA in the deep aquifer, which was confirmed by the increased K_d values in the presence of DNAPL observed in the laboratory investigations. No significant correlations ($p > 0.05$) were found between $\log K_d$ values and chain-length of PFCAs at various depths in the field, even the $\log K_{d-field}$ values of PFBA and HFPO-DA were higher than that of PFOA, indicating that in the field, PFASs distributions were a result of composite factors, such as the presence of DNAPL, aquifer solids parameters, groundwater geochemistry properties, and PFASs structures.

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