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Intercalation of TCE and PFAS Into Interlayer Spaces of Montmorillonite Clay and Sediment-Associated Clay Minerals

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TCE (trichloroethylene), PFAS, and other chlorinated solvents are common contaminants at hazardous waste sites, both in the United States and globally. These compounds pose significant risks to human health due to their toxicity and persistence in the environment. TCE enters the subsurface from industrial operations such as aircraft cleaning, metal degreasing, and improper disposal of industrial waste. PFAS is introduced into the subsurface from fire training and firefighting operations as well as fluorochemical manufacturing facilities.
Field investigations at multiple hazardous waste sites have shown that higher concentrations of PCE (tetrachloroethylene) and TCE can exist in clay lenses in contamination source zones or contaminant plume areas at hazardous waste sites. At a hazardous waste site in Arizona, plume remediation efforts caused a significant difference in the mass removal between a gravel unit and a clay unit and this suggests that the clay unit at this site is serving as a long-term back diffusion source of TCE. The clay layers at such sites often contain montmorillonite, a smectite clay mineral that intercalates molecules into the interlayer spaces present in these minerals. These interlayer spaces typically intercalate exchangeable cations such as calcium, sodium, and magnesium, but studies have shown that TCE can also intercalate into these interlayer spaces in conditions where this contaminant is present in the subsurface. At a hazardous waste site in Arizona, the intercalation of TCE has been found to occur in field clay samples. TCE intercalation was also found to occur with specimen clay samples that were evaluated in the same study. In addition to TCE, multiple other types of organic contaminants have been shown to intercalate into clay interlayer spaces. It has also been suggested that TCE intercalated into interlayer spaces may contribute to extensive elution tailing observed in column experiments examining TCE mass removal.
Recent research in this area has included more experiments to examine intercalation of TCE into interlayer spaces of clays, in combination with other contaminants that exist at hazardous waste sites. Mixtures of TCE waste, PCE waste, and surfactants have been studied to determine if these compounds intercalate into the montmorillonite interlayer spaces. At a hazardous waste site in Arizona, PFAS contamination exists with TCE contamination. While PFAS intercalation into interlayer spaces of clays has been studied, no research to date has investigated intercalation behavior when clays are exposed to a combination of contaminants that include TCE and PFAS. Future research will include measuring changes in montmorillonite interlayer spacing in clays exposed to a mixture of aqueous TCE and PFAS using specimen clays and field samples. These experimental conditions are representative of the field conditions at a hazardous waste site in Arizona.

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References

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