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AIR PASSIVE DOSING OF TOLUENE INCREASES ACCESSIBILITY OF PAHs FOR MICROBIAL DEGRADATION

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ABSTRACT

Background information

Polycyclic Aromatic Hydrocarbons (PAHs) and heterocyclic PAHs are hydrophobic contaminants with a strong tendency to sorb to soil constituents such as black carbon with high affinity adsorption sites. As a consequence, these contaminants are retained in soil and become inaccessible for microbial degradation. Competitive sorption can be used to release a share of inaccessible PAHs from high affinity sites so increasing pollutant accessibility (Humel et al., 2017). In this study a novel air passive dosing setup was used to introduce toluene into soil as a competitive sorbent. The working hypothesis is that toluene provided via the gas phase will release desorption resistant PAHs so making them accessible for microbial degradation whereby competitor concentrations remain below growth inhibiting levels.

Setup

Prior to use, industrially contaminated soil was exposed to microbiological degradation. The residual PAH concentration of so pretreated soil amounted to 325 ± 6 mg kg^{-1} (Σ 16 US EPA PAH). The share of desorption resistant PAHs in this soil amounted to 192 ± 10 mg kg^{-1} (Σ 16 US EPA PAH; quantified using the contaminant trap, Mayer et al., 2011). Toluene was provided to pretreated soil via the gas phase by passive dosing for one week. Microbiological activity after air passive dosing of toluene was verified by the detection of the 16S ribosomal RNA.

Main results

Air passive dosing of toluene maintained a constant toluene concentration of about 150 mg L^{-1} in soil slurry. After 7 days of air passive dosing, no significant change in total PAH concentration was observed. However, the share of desorption resistant PAH decreased significantly within 7 days (Figure 1). In particular, competitive sorption of toluene reduced the desorption resistant fraction of

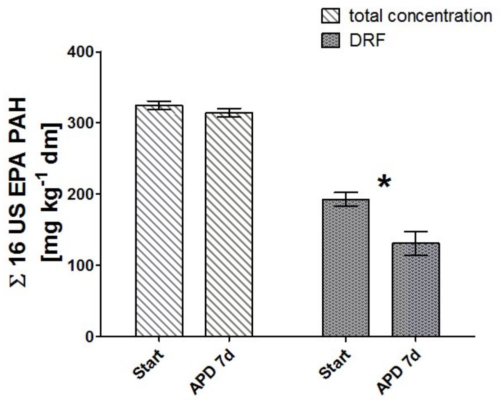

Figure 1: Total PAH concentrations (Σ 16 US EPA PAH) and desorption resistant fraction (DRF) in microbiologically pretreated soil before and after air passive dosing (APD) of toluene for 7 days. Columns represent mean value, error bars indicate standard deviation (n=3). Significant differences in PAH concentrations have been determined by Student's t-test (P < 0.05) and are indicated by an asterisk.

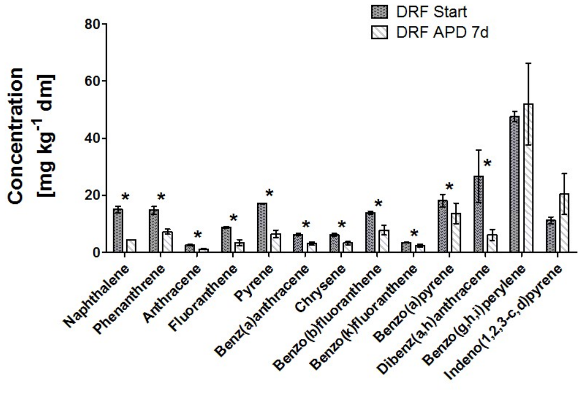

Figure 2: Desorption resistant fractions (DRF) of individual PAHs before and after air passive dosing (APD) of toluene for 7 days. Columns represent mean value, error bars indicate standard deviation (n=3). Significant differences in PAH concentrations have been determined by Student's t-test (P < 0.05) and are indicated by an asterisk.

all individual PAHs, except benzo(g,h,i)perylene and indeno(1,2,3-c,d)pyrene (Figure 2). Analysis of the 16S ribosomal RNA revealed microbiological activity before and after air passive dosing of toluene, as toluene remained below critical concentrations (Heipieper and de Bont, 1994).

Conclusions

The current work demonstrates that a high but sublethal concentration of a competitive sorbate can be maintained in soil slurry by passive dosing via the gas phase. Although competitor concentration and exposure time in this study were lower compared to previous work (Humel et al., 2017), competitive sorption of toluene significantly reduced the desorption resistant fraction of PAHs in soil. Microbial activity (16S RNA) after toluene exposure indicated ongoing degradation of PAHs so suggesting that the application of competitors, possibly of less environmental concern compared to toluene, may support bioremediation efforts in meeting remediation goals for PAH contaminated soil.

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