Isotopic fractionation during biodegradation of brominated aliphatic flame retardants

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Brominated organic compounds are widespread pollutants in air, water, soil and sediments. In order to determine whether these compounds are biodegraded in the environment, we tested the application of multi-dimensional compound-specific isotope analysis (CSIA) combining carbon ($^{13}C/^{12}C$) and bromine ($^{81}Br/^{79}Br$). Testing isotopic fractionation of carbon and bromine under controlled biodegradation experiments following isotopic analysis of field samples will enable to assess the transformation processes of these compounds in the environment. Two brominated compounds were used as model compounds: Dibromoneopentyl-glycol (DBNPG) and tribromoneopentyl-alcohol (TBNPA), both found in the groundwater underlying the Neot Hovav industrial site in the northern Negev, Israel.

In laboratory batch experiments, both compounds were aerobically biodegraded by indigenous bacterial consortia enriched from contaminated groundwater. Complete debromination of both compounds was observed within a few days, suggesting that bromine-containing intermediates do not accumulate in the medium. Abiotic hydrolytic degradation under alkaline conditions was also observed for both compounds albeit at slower rates.

The isotopic fractionation of $^{13}C/^{12}C$ and $^{81}Br/^{79}Br$ revealed that the biotic and abiotic degradation mechanisms are different. While debromination was assumed to be the rate limiting step in both processes, only in the abiotic degradation isotopic fractionation of both carbon and bromine was detected, with a εBr of -0.4 ± 0.1‰ and εC of -10.4‰ for TBNPA. In the biotic degradation an isotopic fractionation of only carbon was observed with εC = -8.9 ± 1.5 ‰ for TBNPA, and εC = -5.8 ± 0.6 ‰ for DBNPG.

Microbial consortia were identified using MiSeq next-generation sequencing. The main genuses found were *Paracoccus; Brevundimonas; Pseudomonas; Delftia; Sphingobacterium; Flavobacterium; and Ochrobactru*m. In both consortia's the dehalogenation gene *dehI* was detected.

This work provides the basis for the development of an isotopic fractionation based tool for assessing the biodegradation of brominated organic compounds in contaminated environments. These results set a firm basis for data interpretation in our planned field study.