

Hydrogen Isotope Fractionation During Methanogenic Degradation of Toluene: Potential for Direct Verification of Bioremediation

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BTEX (benzene, toluene, ethyl benzene and m-,p-,and oxylyene), are major groundwater pollutants. Many clean-up efforts have focused on bioremediation and in particular, on in-situ or intrinsic biodegradation.

In addition to current protocol designed to verify the occurrence of intrinsic biodegradation of BTEX (field scale mass balance of contaminants, microbiological evidence of degrading bacterias), the compound specific isotope analysis (CSIA) provides a direct indicator of the effects of biodegradation .

Equilibrium headspace analysis of Toluene for $\delta^{13}\text{C}$ composition by continuous flow CSIA has been determined to have an accuracy and reproducibility of $\pm 0.5\text{‰}$. (1) .

However, anaerobic biodegradation of toluene by a mixed consortium under methanogenic conditions was found to result in a small enrichment in the carbon isotope value of the residual toluene (2‰) (2) .

Recently we demonstrated that the equilibrium headspace analysis of toluene for $\delta^2\text{H}$ isotopic composition by continuous flow CSIA had an accuracy and reproducibility of $\pm 5\text{‰}$ (3) .

Using this analytical approach, the hydrogen isotope fractionation produced by anaerobic biodegradation of toluene was evaluated in laboratory experiments using the same mixed methanogenic consortium than in the previous carbon experiment. A large, reproducible ^2H -enrichment in the residual toluene of 60‰ was observed at 95% degradation.

The very light hydrogen isotope composition of the methane produced during the experiment (around -385‰ SMOW) confirms the preferential biodegradation of molecules containing the light ^1H isotope .

Due to their different sensitivity to biodegradation by mixed consortia, combined application of stable carbon and hydrogen CSIA in an anaerobic groundwater has the potential to provide two important diagnostic tools : stable carbon isotope value may provide information about source of contaminant, while hydrogen isotope values provides an assessment of the degree of biodegradation .

The influence of the bacteriaes density on the isotopic fractionation of both carbon and hydrogen will be discussed.

[1] Dempster HS, Sherwood Lollar B & Feenstra S,