Geophysical Research Abstracts
Vol. 18, EGU2016-6140-1, 2016
EGU General Assembly 2016

Using ^{13}C-labeled benzene and Raman gas spectroscopy to investigate respiration and biodegradation kinetics following soil contamination

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Soil and groundwater contamination with benzene can cause serious environmental damages. However, many soil microorganisms are capable to adapt and known to strongly control the fate of organic contamination. Cavity enhanced Raman gas spectroscopy (CERS) was applied to investigate the short-term response of indigenous soil bacteria to a sudden surface contamination with benzene regarding the temporal variations of gas products and their exchange rates with the adjacent atmosphere. ^{13}C-labeled benzene was spiked on a silty-loamy soil column (sampled from Hainich National Park, Germany) in order to track and separate the changes in heterotrophic soil respiration - involving $^{12}CO_2$ and O_2 - from the microbial process of benzene degradation, which ultimately forms $^{13}CO_2$.[1] The respiratory quotient (RQ) of 0.98 decreased significantly after the spiking and increased again within 33 hours to a value of 0.72. This coincided with maximum $^{13}CO_2$concentration rates (0.63 μmol m^{-2}s^{-1}), indicating highest benzene degradation at 33 hours after the spiking event. The diffusion of benzene in the headspace and the biodegradation into $^{13}CO_2$were simultaneously monitored and 12 days after the benzene spiking no measurable degradation was detected anymore.[1] The RQ finally returned to a value of 0.96 demonstrating the reestablished aerobic respiration. In summary, this study shows the potential of combining Raman gas spectroscopy and stable isotopes to follow soil microbial biodegradation dynamics while simultaneously monitoring the underlying respiration behavior.

Support by the Collaborative Research Center 1076 Aqua Diva is kindly acknowledged. We thank Beate Michalzik for soil analysis and discussion.

1. T. Jochum, B. Michalzik, A. Bachmann, J. Popp and T. Frosch, *Analyst*, 2015, 140, 3143-3149.