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Evaluating the fate of organic leachate contaminants by use of multiple chemical tools in a clay till setting

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Leachate from old landfills situated in the vicinity of surface water bodies may affect the groundwater and subsequently surface water quality. It is suspected that the transition zone between groundwater and surface water can attenuate landfill leachate compounds, but the attenuation processes for organic leachate has not been studied in detail so far. Landfills are complex pollution sources and in particular in heterogeneous geologic settings evaluation of attenuation processes is the major challenge.
The aim of this study was to evaluate the fate of key organic contaminants by use of chemical assessment tools in the anaerobic subsurface in the close vicinity of a local stream at Risby Landfill.
The landfill leachate was mostly methanogenic and sulphate reducing or iron reducing with high concentrations of inorganic species. Phenoxy acid pesticides, chlorinated solvents and petroleum hydrocarbons (mainly BTEX) were identified as key contaminants beneath the landfill, but only pesticides were found in the leachate plume, in the groundwater/surface water transition zone and in the local stream. Analysis of metabolites, enantiomers and compound-specific isotopes (CSIA) (13C/12C) were used to assess attenuation processes and anaerobic degradation potentials, whereas aerobic microbial degradation was investigated for pesticides in a parallel study.
The phenoxy acid 4-CPP, a potential transformation product of the pesticide dichlorprop, migrated to the aerobic stream sediments in high concentrations, where the parallel microbial study showed high degradation potential. Interestingly, 4-CPP/dichlorprop ratios were far higher than expected if 4-CPP originated as impurity in dichlorprop production. This indicates that in situ transformation of dichlorprop to 4-CPP or other unidentified compounds took place. Enantiomer fractions, measured along the groundwater flowpath, were associated with stable anaerobic conditions when >0.5, whereas values <0.5 in shallow groundwater samples were potentially caused by occasional oxygen intrusion. The same evidence was given by CSIA: redox conditions appeared to be the governing factor for anaerobic degradation of pesticides. Perchlorethene and trichlorethene were indicated as the initially deposited chlorinated solvents and strong evidence for their anaerobic dechlorination was obtained using CSIA and metabolite concentrations. The degradation of BTEX could not be quantified. The study showed stable anaerobic conditions and high availability of electron donors in the pollution source, which together provide favourable environment for potential anaerobic transformation of phenoxy acids.
Multiple chemical assessment tools added a quantitative value to the identified attenuation processes at the Risby Landfill site with multiple sources and a complex geology. CSIA was a strong chemical assessment tool whereas measurement of enantiomer concentrations and evaluating the fate along the groundwater flow were only possible for phenoxy acids because of their chiral structure and low sorption coefficients, respectively.