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Assessment of chloroethene degradation rates based on ratios of daughter/parent compounds in groundwater plumes

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Chlorinated solvent spills at industrial and urban sites create groundwater plumes where tetrachloro- and trichloroethene may degrade to their daughter compounds, dichloroethenes, vinyl chloride and ethane. The assessment of degradation and natural attenuation at such sites may be based on the analysis and inverse modelling of concentration data, on the calculation of mass fluxes in transsects, and/or on the analysis of stable isotope ratios in the ethenes. Relatively few work has investigated the possibility of using ratio of concentrations for gaining information on degradation rates. The use of ratios bears the advantage that dilution of a single sample with contaminant-free water does not matter. It will be shown that molar ratios of daughter to parent compounds measured along a plume streamline are a rapid and robust mean of determining whether degradation rates increase or decrease along the degradation chain, and allow furthermore a quantitation of the relative magnitude of degradation rates compared to the rate of the parent compound. Furthermore, ratios of concentration will become constant in zones where degradation is absent, and this allows to sketching the extension of actively degrading zones. The assessment is possible for pure sources and also for mixed sources. A quantification method is proposed in order to estimate first-order degradation rates in zones of constant degradation activity. This quantification method includes corrections that are needed due to longitudinal and transversal dispersivity. The method was tested on a number of real field sites from literature. At the majority of these sites, the first-order degradation rates were decreasing along the degradation chain from tetrachloroethene to vinyl chloride, meaning that the latter was often reaching important concentrations. This is bad news for site owners due to the increased toxicity of vinyl chloride compared to its parent compounds.