Using Dynamic Flux Chambers to Estimate the Natural Attenuation Rates in the Subsurface at Contaminated Sites

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Background/Objectives. The occurrence of aerobic biodegradation in the subsurface by ubiquitous soil microbes has been shown to reduce and in some in cases eliminate the impacts of petroleum hydrocarbon vapours on indoor and outdoor air quality. Unfortunately, biodegradation is typically not included in the simplified non-reactive models used in risk assessment guidelines and tools, which account only for the diffusion of contaminants from the source zone. To evaluate the significance of aerobic biodegradation, field investigations are usually carried out by employing multi-level soil-gas nested probes to evaluate the vertical profiles of vapours and oxygen in the subsurface and hence to evaluate the attenuation factors in terms of reduction of soil-gas concentrations. In this work, natural attenuation rates occurring in the subsurface were estimated in a versalis site located in Sarroch (Sardinia, Italy), using dynamic flux chambers, characterized by a continuous flow of an inert gas. The site is characterised by the presence in the subsurface (mainly in groundwater) of BTEX and light petroleum hydrocarbons.

Approach/Activities. The flux of volatile organic compounds (VOCs) from the subsurface was estimated using 14 “dynamic” chambers, by measuring with a canister the concentration of vapors collected over a period of approximately 6 hours. Before starting the measurement, the achievement of steady-state conditions inside the chamber was assured by purging at least three to four chamber volumes of an inert gas. The measurements in the 14 sampling points were repeated in three seasonal campaigns and the measured fluxes were compared with those predicted using a non-reactive model, starting from the source concentrations. Besides, by coupling the measured data with the fluxes estimated with the diffusive non-reactive model, it was possible to perform a mass balance to evaluate the natural attenuation loss rates of petroleum hydrocarbons during the migration from the source to ground level. Specifically, the loss rate of petroleum hydrocarbons was estimated as the difference between the diffusive flux estimated with the non-reactive model from the contamination present in the source underlying the flux chamber and the flux effectively measured at the surface.

Results/Lessons Learned. The fluxes measured in the different campaigns were quite similar, leading always to acceptable risks from vapour inhalation and showing that in the investigated site the seasonal effects on VOCs emission were quite limited. The obtained results showed that, in line with other recent studies, the results provided by the non-reactive model, starting from the source concentrations, overestimated the effective outdoor concentration of petroleum hydrocarbons in some cases up to four orders of magnitude.

The mass balance to evaluate the natural attenuation loss rates, showed that the estimated BTEX loss rates were up to 0.5 kg/year/m^2. These rates are in line with the values reported in the recent literature for natural source zone depletion and are not far from the rates reported for some active remediation options.

In short, the method presented in this work can represent an easy-to-use and cost-effective option that can provide a further and reliable line of evidence of natural attenuation rates expected at contaminated sites.