

4.3.42

The importance of fringe processes for natural attenuation of phenoxy acids in landfill leachate plumes

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Micropollutants such as phenoxy acid herbicides are frequently present in leachate from old landfills, and have been found in significant concentrations in many landfill leachate plumes. Phenoxy acids are expected to be recalcitrant under anaerobic conditions but are degradable under aerobic conditions. Therefore, it is hypothesised that mass removal of these critical compounds occurs mainly at the fringe of landfill leachate plumes, where aerobic groundwater mixes with the otherwise anaerobic plume.

The aim of the present study is to clearly identify and quantify both, the physical and biochemical processes that occur under such conditions by combining measurements of high-resolution vertical concentration profiles, microbial degradation experiments and reactive solute transport modelling for a landfill leachate plume near Sjoelund/Denmark.

Field data were obtained from three multi-level-samplers (MLS) (30 sampling points each, 10 cm increments) that were newly installed in addition to the existing 42 1-meter screens. Chloride was monitored and used as an inert leachate indicator together with redox sensitive parameters (oxygen, nitrate, manganese, iron etc.) and phenoxy acids (MCP, dichlorprop, 2-CPP, 4-CPP). Undisturbed sediment cores were collected across the plume fringe adjacent to one of the MLS and divided into 5 cm pieces. Those samples were used for phenoxy acid degradation experiments that are thought to mimic the intrinsic conditions in the aquifer.

A three-dimensional chloride transport model was setup and calibrated, demonstrating that very small vertical transversal dispersivities must be used (< 2-3mm) in order to produce the steep observed concentration gradients. For the integration and interpretation of the complete hydrogeochemical data set, a suitable reaction module was formulated for the biogeochemical transport model PHT3D (coupled MT3DMS/PHREEQC-2 model) and two-dimensional reactive transport simulations were carried along flowlines that were extracted from the three-dimensional nonreactive transport model.

From the combination of all results it was concluded that highly reactive zones indeed exist at the fringe of the contaminant plume and in particular that rapid degradation of phenoxy acids occurs in those zones, confining the extend of the phenoxy acid plume to an acceptable distance.

4.3.43

The influence of oxic conditions on mineralization rates of organic matter in lake sediments

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Introduction

The oxic condition in the bottom water and surface sediments play a key role in mineralization processes. In very active sediments, the hydrodynamic conditions control strongly the transport of solutes in and out of the sediments and therefore an in-situ approach is required to quantify these processes most reliably. With a profiling lander system equipped with ion-selective electrodes for O₂, NH₄⁺ and NO₃⁻ we investigated the mineralization of organic matter in the sediments of the eutrophic Lake Zug (Switzerland) under different oxic conditions.

Results and Discussion

Anaerobic mineralization of organic carbon in the sediment was estimated from the release of NH₄⁺ (Fig. 1) and the C:N ratio of the sediment. It revealed an increase from 13 to 25 mmol C m⁻² d⁻¹ from oxic (35m) to anoxic (120m) conditions of the bottom water. At the oxic sites, however, an extremely high fraction of organic carbon was mineralized aerobically, although the oxic layer was very narrow (~100-200 µm). Here, oxic mineralization ranged from 10-28 mmol C m⁻² d⁻¹ whereby the lower and upper ends were estimated with and without oxidation of reduced species.

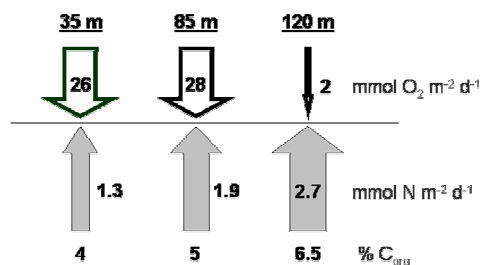


Fig. 1 Overview of NH₄⁺ release, O₂ uptake and C_{org} content of the sediment from oxic (35 m) to anoxic (120 m) sites.

The content of organic carbon determined in sediment cores (Fig. 1) increased - similar to the NH₄⁺ release - from oxic to anoxic bottom water conditions. Hence, total mineralization rates have to be higher at the oxic sites confirming a high fraction of oxic mineralization and very intense rates in the thin oxic sediment layer.

Nitrate is not an important electron acceptor in terms of organic matter mineralization but denitrification is nonetheless an important pathway of nitrogen elimination in Lake Zug (0.3-0.8 mmol N m⁻² d⁻¹).