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„Investigations of the influence of nitrogen fertilisation on the treatment effect of a chlorinated hydrocarbon contaminated groundwater in a constructed wetland "

Summary and outlook

Aim of the study was the spatial and seasonal characterisation of a pilot-scale constructed wetland in Bitterfeld treating a contaminated groundwater contaminated with a mixture of chlorinated hydrocarbons for the decontamination. The contaminants were monochlorobenzene (MCB), dichlorobenzenes (DCB) and tetrachloroethene (PCE). Possible correlations between the contaminant concentrations and the pore water parameters were analysed and interpreted. Additionally, the influence of a nitrogen fertilisation on the removal efficiency should be analysed and compared to previous data without nitrogen addition.

During the filter passage of the planted treatment system the mean MCB removal was up to 53 % in the upper soil layer. This is less than in 2005 and 2006 (up to 65 %). The reason is inappropriate conditions for the microbial aerobic MCB degradation in terms of not enough oxic zones. For PCE the removal rate was 100 % after 1 m flow path already and in total it was 10 % higher compared to 2006. A higher removal rate is caused by less oxic conditions. The decrease resulted from microbial PCE degradation, as the transformation products of the anaerobic PCE degradation sequence were retrieved. It can be concluded that PCE was reductively dechlorinated in both treatment systems due to the presence of ethene.

Emissions of the highly volatile chlorinated hydrocarbons from upper soil layers is a further potential removal process. Further processes leading to the removal are physiological metabolisation and dispersion with contribution of the plant and sorption processes depending on the season and air temperature. Degradation performance is probably caused mainly by microorganisms which use the contaminants as substrates under the prevailing pore water conditions; these conditions are also influenced by the plants.

The higher mean MCB concentration decrease of up to 45 % at the passage of the planted treatment system compared to the unplanted one can be led back to a stimulation of

the microbial activity due to plants. A better MCB removal rate could be achieved by optimal plant activity.

By means of the pore water parameters possible microbial degradation processes were analysed. The redox potential showed in the planted basin (-98 to -10 mV) sulphate reducing conditions whereas in the unplanted system at 0.5 m distance from the influent sulphate reducing conditions(-41 to -59 mV) and in the later course of the flow path iron reducing conditions (14 to 105 mV) existed. This is an evidence for oxygen limited conditions. In a surface near layer and at the root surface of the marsh plants oxygen exists and therefore aerobic degradation is most likely occurring in the systems as well. The stoichiometric calculations concerning the electron acceptors showed that the microbial degradation under usage of ferric iron, nitrate and sulphate as electron acceptors had probably only a low influence on the MCB concentration decrease.

The constitution of the plants and their nutrient supply affect the removal processes. Nutrient limitation in the wetland strongly limits plant development and therefore microbial degradation processes as well. The highest MCB degradation rate was observed at 3 m distance from the influent and was assigned to an effect of more pronounced stimulation by the plants due to a high plant density and plant pigment concentration.

The observed spatial gradients of efficiency (highest removal at 3 m distance from the influent and at 30 cm depth) and the nutrient limitation suggest potentials for improved treatment of contaminated groundwater. A more aerobic wetland design can be recommended since the removal efficiency is low for DCBs and MCB in the deeper, more anaerobic zones of the wetland sediment. Further investigations should be focused particularly on plant uptake, phytovolatilisation and soil emission of chlorinated benzenes and ethenes. The influence of the pH-value, sulphate and ferric iron as electron acceptors for MCB degradation should be investigated in additional experiments.

In conclusion, the construction of near-natural wetlands may provide an effective remediation approach for endangered river flood plains as rising groundwater tables may transport pollutants and their metabolites to near-surface layers at contaminated mega-sites.


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