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Uptake and fate of organic contaminants in plants of constructed wetlands

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Introduction

Constructed or natural wetlands may act as buffer strips for polluted groundwater with high metabolic activity between groundwater and rivers. Experimental wetlands established in Leuna and Bitterfeld, Germany [1] in the presence of plants, a significant stimulation of substance removal (e.g., benzene, MTBE) was observed.

Wetland & simulation studies

Horizontal flow subsurface wetland, planted with reed (Phragmites australis) & unplanted controls [1]

Model details

Inhomogeneous linear ordinary differential equations (ODEs) for the change of concentration in substrate, root and shoot. Multi-cascade approach [3,4]: analytical solution of the ODEs, principle of superposition to obtain the dynamic solution: simulation subdivided into 24 periods with constant conditions (concentration vector C(t) at the end of specific period serves as initial conc. vector for next period in all compartments); the model follows flow of water through wetland, each of the 24 periods cover 1/24th of hydraulic retention time.

Example results - BENZENE in the Leuna wetlands

Simulated

Summer no plants (% of inflow)

Plant uptake
Aerogenesis flux (phytovolatilisation)
Aerobic degradation
Anaerobic degradation
Rhizome degradation
Volatilisation

Winter no plants (% of inflow)

Plant uptake
Aerogenesis flux (phytovolatilisation)
Aerobic degradation
Anaerobic degradation
Rhizome degradation
Volatilisation

Summer (% of inflow)

Plant uptake
Aerogenesis flux (phytovolatilisation)
Aerobic degradation
Anaerobic degradation
Rhizome degradation
Volatilisation

Winter (% of inflow)

Plant uptake
Aerogenesis flux (phytovolatilisation)
Aerobic degradation
Anaerobic degradation
Rhizome degradation
Volatilisation

References


Conclusions & outlook

Important indirect effects identified: plants enable exchange between wetland substrate and air (O₂, aerenchyma). Significant plant uptake in summer; probably plants degrade groundwater contaminants (benzene, TCE, chlorobenzene, MTBE). Further studies on plant uptake and degradation are on-going (including the support of plants for degrader microbes). Models for estimating the phytoremediation potential (including soil and groundwater contamination) will be further developed. Future work will also include coupling of the plant uptake model to MIN3P for dynamic simulations of the whole system.