Emission-free groundwater treatment technology (SmartStripping®). Optimization of the technology performance by means of mathematical modelling and simulation

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The green remediation of groundwater with the technology called SmartStripping® is an innovative process for groundwater in-situ remediation that reduces concentrations of organic volatile compounds (chlorinated aliphatic hydrocarbons and BTEX) dissolved in groundwater, without air emission, wastewater or chemical injection into the soil.

The process can be defined as an innovative combination of air sparging and soil vapour extraction: groundwater remediation occurs by enabling a transfer of contaminants from a saturated zone (groundwater) to an unsaturated zone (vadose) by blowing air from existing wells, which then enables groundwater stripping from the aquifer. The stripping allows the separation of volatile organic compounds from groundwater that vent up to the unsaturated zone which is under a continuous vacuum status, whereby the soil vapour is extracted. Vapours are treated with granular activated carbon adsorption filters before being re-injected into the groundwater to start the stripping process again, through a continuous closed air-cycle system.

Each SmartStripping® application is supported by of a comprehensive modelling for an optimal design of removal of volatiles as a function of operational parameters, from which air flow is the most relevant. In the present work, a combination of hydrodynamic and mass transfer model was developed and calibrated with specific laboratory tests.

Numerical simulation by means of the finite elements method (CFX-ANSYS®) was used to simulate the hydrodynamic behaviour of the technology considering the well configuration, the soil properties and the operating parameters as input parameters. A study of the effect of each parameter to the size and shape of the zone of influence (ZOI) was performed in order to identify the relevant properties in the performance of the stripping process. Output parameters of the hydrodynamic model were then fed to the mass transfer model. The mass transfer model was based on the assumption that the stripping takes place in the ZOI and that the diffusion is the most relevant process in the area surrounding the ZOI. Developed mass transfer model considered two main transfer coefficients, the first one regarding mass transfer in the stripping process and the second one regarding the diffusion process.

An experimental setup at bench scale was designed and built in order to calibrate the mass transfer parameters for each contaminant for specific soil properties.

Developed model will be useful for the design of the remediation strategy for new case studies and to predict the remediation duration and efficiency.

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