LCA as decision support for remediation of contaminated sites: Assessment of groundwater impacts

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Abstract
Life cycle assessment (LCA) is a well-established methodology for quantification of potential environmental impacts associated with a given product or service e.g. remediation of a contaminated site. The environmental impacts from remediation can be divided into *primary* and *secondary* impacts. Primary impacts cover the local impacts associated with the contamination left in the ground, whereas the secondary impacts are impacts on the local, regional and global scale generated by the remediation activities.

Potential groundwater contamination is an important primary impact from a contaminated site. The primary impacts may differ between remediation methods due to different remedial efficiencies or different timeframes. Evaluating the potential primary impacts within the LCA framework can therefore aid to give a better picture of the overall environmental impacts associated with remediation initiatives. However, impacts in the groundwater compartment have only gained little attention in established life cycle impact assessment methodologies as these generally exclude groundwater or include it in a general freshwater compartment. Therefore we added two new categories to the impact assessment: *Spoiled groundwater resources* and *Human toxicity via groundwater*.

For a case site contaminated with TCE we evaluated the potential primary impacts of the baseline situation (no remediation) and for two scenarios using enhanced reductive dechlorination (ERD). The contaminant mass flux was modeled using a site-specific model of the mass flux from the fractured clay till to the primary aquifer. The accumulated mass input in the different scenarios was used to evaluate the primary impact using the two groundwater-related categories.. The results show that remediation with ERD reduces the primary impacts, but that they may still be significant due to formation of degradation products. The primary impacts were normalized to person equivalents (PE) in order to compare them to the expected secondary impacts of more energy demanding remediation methods. However, the established normalization factors are preliminary and need to be further developed.