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Mass discharge estimation from contaminated sites: Multi-model solutions for assessment of conceptual uncertainty

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Mass discharge estimates are increasingly being used in the management of contaminated sites. Such estimates have proven useful for supporting decisions related to the prioritization of contaminated sites in a groundwater catchment. Potential management options can be categorised as follows: (1) leave as is, (2) clean up, or (3) further investigation needed. However, mass discharge estimates are often very uncertain, which may hamper the management decisions. If option 1 is incorrectly chosen soil and water quality will decrease, threatening or destroying drinking water resources. The risk of choosing option 2 is to spend money on remediating a site that does not pose a problem. Choosing option 3 will often be safest, but may not be the optimal economic solution. Quantification of the uncertainty in mass discharge estimates can therefore greatly improve the foundation for selecting the appropriate management option.

The uncertainty of mass discharge estimates depends greatly on the extent of the site characterization. A good approach for uncertainty estimation will be flexible with respect to the investigation level, and account for both parameter and conceptual model uncertainty. We propose a method for quantifying the uncertainty of dynamic mass discharge estimates from contaminant point sources on the local scale. The method considers both parameter and conceptual uncertainty through a multi-model approach.

The multi-model approach evaluates multiple conceptual models for the same site. The different conceptual models consider different source characterizations and hydrogeological descriptions. The idea is to include a set of essentially different conceptual models where each model is believed to be realistic representation of the given site, based on the current level of information. Parameter uncertainty is quantified using Monte Carlo simulations. For each conceptual model we calculate a transient mass discharge estimate with uncertainty bounds resulting from the parametric uncertainty. To quantify the conceptual uncertainty from a given site, we combine the outputs from the different conceptual models using Bayesian model averaging. The weight for each model is obtained by integrating available data and expert knowledge using Bayesian belief networks.

The multi-model approach is applied to a contaminated site. At the site a DNAPL (dense non aqueous phase liquid) spill consisting of PCE (perchloroethylene) has contaminated a fractured clay till aquitard overlaying a limestone aquifer. The exact shape and nature of the source is unknown and so is the importance of transport in the fractures.

The result of the multi-model approach is a visual representation of the uncertainty of the mass discharge estimates for the site which can be used to support the management options.