Physically-based groundwater vulnerability assessment using sensitivity analysis methods

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Management of water resource systems requires adequate decision making to protect the water-related functions of fundamental importance to human life, ecosystem preservation and economic development. Groundwater vulnerability assessment (GWVA) studies are useful tools for land-use planning and groundwater protection. A general and physically-based method is proposed for evaluating and quantifying the potential impact on groundwater resources to external pressures, both in terms of quantity and quality, using numerical models of groundwater flow and solute transport. The originality of the concept is based on (1) the definition of groundwater state sensitivity coefficients reflecting the magnitude of changes in impacts on groundwater quantity or quality to given changes in the pressures exerted on groundwater and (2) the definition of groundwater vulnerability coefficients that extends the concept of sensitivity coefficient by introducing a ratio that reflects the “distance” between the current state of degradation of the water resource system and the “damaged state”. Different numerical methods are proposed to compute the sensitivity coefficients: the perturbation, the sensitivity equation, and the adjoint operator method. The possible uses of these concepts in the context of risk assessment for groundwater resources are discussed and the computation algorithms are illustrated using a simplified case study.