Comparative methodologies for hydro-geochemical sampling plans for contaminant plume monitoring under uncertainty

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Applying simulation-optimization models to hydro-geochemical sampling designs can achieve substantial cost savings by eliminating unnecessary samples while ensuring the risks to human health and environment being properly managed. This study introduces and compares two methods, Monte Carlo simple genetic algorithm (MCSGA) and noisy genetic algorithm (NGA), for plume monitoring design under uncertainty regarding the hydraulic conductivity (*K*) field. Both methodologies couple a genetic algorithm (GA) with a numerical flow and transport simulator and a global plume estimator to identify the optimal sampling design for plume monitoring. The MCSGA approach yields one optimal design each for a large number of realizations generated to represent the uncertain *K* field. A MCSGA-based composite design is developed on the basis of those potential sampling locations that are most frequently selected by the individual designs for different *K*-field realizations. The NGA approach relies on a much smaller sample of *K*-field realizations and incorporates the average of objective functions associated with all *K*-field realizations directly into the GA operators, leading to a single optimal design. The efficacy of the composite design and the NGA-based optimal design is assessed by applying them to 1,000 realizations of the *K* field and evaluating the relative errors of global plume estimation between the plume kriged from a sampling design and that output directly by the transport model. For the synthetic application examined in this study, the results indicate that NGA can be used as a useful surrogate of MCSGA for optimal hydro-geochemical sampling strategy under uncertainty. Compared with MCSGA, NGA reduces the optimization runtime by a factor of 6.5.

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Numerical modeling of land subsidence in Shanghai

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Land subsidence caused by overdraft of ground water occured in Shanghai city in 1921. The average land subsidence is more than 1.9m now. It is very necessary to develop a good mathematical model of land subsidence to predict land subsidence.

There are six aquifers and six aquitards in Shanghai. It's found that the deformation characteristics of soil layers are rather different from each other, and the deformation characteristics of some soil layers are different at different time and in different place. So the regional land subsidence model of Shanghai should be properly developed according to the deformation characteristics of every soil layer.

The mathematical model of land subsidence in Shanghai is proposed based on the hydrogeology conditions and the deformation characteristics of soil layers. The model is very complicated. The concrete flow equation and subsidence equation are different for soil layers with different deformation characteristics. The ground water flow model is three dimensional. The flow equation and subsidence equation are nonlinear, because the parameters vary with subsidence. The land subsidence model is a coupled two step model.

Multiscale finite element method(MsFEM) [1] is applied to solve the land subsidence model of Shanghai with observation data from 1986 to 1998. After model calibration, the numerical results agree well with the observation data. It indicates that the model is able to describe the land subsidence caused by overdraft of ground water, and it can be used to predict land subsidence in Shanghai.

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Reference

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