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A physically based Lagrangian procedure for the push-pull test analysis in heterogeneous aquifer

Maria Rita Maggi, Anna Di Gialleonardo, Laura Perrotta, Giovanni Petrella, Federico Sperati, and Antonio Zarlenga
University of Roma Tre, Department of Engineering, Rome, Italy (mariarita.maggi@uniroma3.it)

Many previous studies showed how the single well push-pull (SWPP) tracer test is a widely used in situ approach to define the aquifer characteristics. The SWPP test usually consists in two main phases: during the first one, the push phase, a tracer solution is injected into the aquifer through a single well; during the second one, the pull phase, the flow is inverted and the solution is extracted from the same well. The solute movement through the aquifer is driven by different phenomena advection dispersion mixing and dilution.By the analysis breakthrough curves (BTCs) obtained in the pull phase is possible to estimate significant transport parameters such as the dispersion and sorption coefficients. The more common approaches for the BTC interpretation assume the aquifer as homogeneous.

We propose a semi-analytical physically based Lagrangian procedure for the SWPP analysis, mimicking the transport processes taking place in heterogeneous aquifer by a particle tracking procedure. We consider the well fully penetrate a stratified aquifer unbounded laterally. The isotropic log-hydraulic conductivity is normally distributed $log\ K=Y \sim N(0,\sigma_Y^2)$ with given vertical integral scale $I_{Y,V}$ and unbounded horizontal integral scale $I_{Y,H}= \infty$. The flow field is assumed to be steady state in both phases. The advective transport is driven by the local flow velocities different for each layer; the pore scale dynamics are modelled as Wiener process. Our procedure can be applied to a wide range of heterogeneity degrees Peclet numbers and test duration; the results emphasise how by different test set up it is possible to get different aquifer parameters: for instance a short test duration allows the estimate of the pore-scale dispersion while for longer test duration the solute experiences more formations emphasizing the effects of the macrodispersion. Finally despite its simplicity our procedure is a useful tool for the SWPP interpretation in heterogeneous aquifers.