Geophysical Research Abstracts
Vol. 20, EGU2018-10009, 2018
EGU General Assembly 2018

Transport in a radially convergent highly heterogeneous flow field

Mariaines Di Dato (1), Felipe P.J. de Barros (2), Alberto Bellin (1), and Aldo Fiori (3)

(1) Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy , (2) Sonny Astani Department of Civil and Environmental Engineering, University of Southern California, Los Angeles, CA, USA, (3) Dipartimento di Ingegneria, Roma Tre University, Rome, Italy

Contaminant transport towards wells is one of the most challenging problems in groundwater hydrology, though handy and accurate solutions would be very beneficial for the high relevance of such transport configurations in applications. Because the difficulties encountered in obtaining analytical or semi-analytical solutions of transport processes in heterogeneous converging flow fields, most of the applications are done by assuming the medium as homogeneous. Up to date, stochastic transport models in 3-D convergent flows are limited to a handful of semi-analytical formulations, valid only for small heterogeneity, while numerical solutions are rarely considered in applications, though the computational burden is not longer an overarching limitation.

Here, we present a model for transport toward wells in a three-dimensional heterogeneous convergent flow field, by using the Multi Indicator Model–Self Consistent Approximation (MIMSCA). The proposed solution is semi-analytical and valid for formations of any degree of heterogeneity. For such model, the porous medium is idealized as an ensemble of inclusions plunged into a homogeneous matrix of effective conductivity. MIMSCA has been widely used for uniform mean flow and this is its first application to convergent flow fields. In order to obtain a simple and closed solution, the mean flow is assumed as locally uniform, such that the flow field can be obtained analytically. Transport is solved by adopting the travel time approach in term of mass arrival times. The semi-analytical character of the solution originates from the need to perform the particle tracking numerically, but with the flow field obtained analytically. This way, the model allows to compute the Breakthrough Curve (BTC) at the well under ergodic conditions and for uniform and flow proportional instantaneous injection representing different release modalities. Results show that the injection modes influences the BTC shape as the medium heterogeneity increases. In particular, a uniform injection produces asymmetric BTCs with longer tails with respect to the flow proportional injection. In addition, it is shown that, even for mild heterogeneous aquifers, ergodic BTC may not develop for the typical thickness natural aquifers (typically tens of vertical integral scales). Numerical validation showed that the semi-analytical model is accurate despite the assumption of local uniformity of the mean flow field.