Normalization and extension of single-collector efficiency correlation equation

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The colloidal transport and deposition are important phenomena involved in many engineering problems. In the environmental engineering field the use of micro- and nano-scale zerovalent iron (M-NZVI) is one of the most promising technologies for groundwater remediation. Colloid deposition is normally studied from a micro scale point of view and the results are then implemented in macro scale models that are used to design field-scale applications.

The single collector efficiency concept predicts particles deposition onto a single grain of a complex porous medium in terms of probability that an approaching particle would be retained on the solid grain. In literature, many different approaches and equations exist to predict it, but most of them fail under specific conditions (e.g. very small or very big particle size and very low fluid velocity) because they predict efficiency values exceeding unity.

By analysing particle fluxes and deposition mechanisms and performing a mass balance on the entire domain, the traditional definition of efficiency was reformulated and a novel total flux normalized correlation equation is proposed for predicting single-collector efficiency under a broad range of parameters. It has been formulated starting from a combination of Eulerian and Lagrangian numerical simulations, performed under Smoluchowski-Levich conditions, in a geometry which consists of a sphere enveloped by a control volume. In order to guarantee the independence of each term, the correlation equation is derived through a rigorous hierarchical parameter estimation process, accounting for single and mutual interacting transport mechanisms.

The correlation equation provides efficiency values lower than one over a wide range of parameters and is valid both for point and finite-size particles. A reduced form is also proposed by elimination of the less relevant terms.

References

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