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MRI measurements and modelling of colloid transport and adsorption in porous medium

Presenter: Alizée LEHOUX

AUTHORS

Alizée LEHOUX (1), Eric Michel (2), Paméla Faure (3), Denis Courtier-Murias (4), Stéphane Rodts (5), Francois Lafolie (6), Philippe Cousot (7)

1. PhD student, INRA, IFSTTAR, Domaine Saint Paul, Site Agroparc, 84914, Avignon Cedex 09, FR
2. Researcher, INRA, Domaine Saint Paul, Site Agroparc, 84914, Avignon Cedex 09, FR
3. Researcher, Université Paris-Est, Laboratoire Navier (CNRS-ENPC-IFSTTAR), 6-8 avenue Blaise Pascal- Cité Descartes, F-77455, Marne-la-Vallée cedex 2, FR
4. Researcher, Université Paris-Est, Laboratoire Navier (CNRS-ENPC-IFSTTAR), 6-8 avenue Blaise Pascal- Cité Descartes, F-77455, Marne-la-Vallée cedex 2, FR
5. Researcher, Université Paris-Est, Laboratoire Navier (CNRS-ENPC-IFSTTAR), 6-8 avenue Blaise Pascal- Cité Descartes, F-77455, Marne-la-Vallée cedex 2, FR
6. Researcher, INRA, Domaine Saint Paul, Site Agroparc, 84914, Avignon Cedex 09, FR
7. Researcher, Université Paris-Est, Laboratoire Navier (CNRS-ENPC-IFSTTAR), 6-8 avenue Blaise Pascal- Cité Descartes, F-77455, Marne-la-Vallée cedex 2, FR

ABSTRACT

The ability to predict transport and retention of colloidal particles is a major environmental concern as such particles can carry adsorbed pollutants towards the groundwater or be pollutants themselves. The models currently used to predict the fate of colloids in soils are based on mechanisms inferred from breakthrough curves (evolution of concentration as a function of pore volume or time) after injection of particles into a column of porous media. For this reason, the porous media with regards to colloid transport is a kind of “black box” system.

We carried out MRI (Magnetic Resonance Imaging) measurements which provide the spatial distribution of colloidal particles in time along the sample axis during a transport experiment through a model porous medium.

We found that both adsorbed and suspended particles have an effect on the MRI signal. For this reason, we first calibrated the effect of each kind of particle on the MRI signal. Then, we followed two injections of a pulse of particles in a sand column by MRI and measured the breakthrough curves. The first injection of negatively charged particles showed a recovery of 95% of the particles at the outlet because the porous media is negatively charged in these conditions of pH and ionic strength. In that case, MRI data show the transport of the pulse and its dispersion. For the second injection, with positively charged particles, none of the particles were recovered at the outlet. MRI data show a very fast adsorption in the first centimetres of the column, and at the end of the experiment, a final profile of only adsorbed particles in the material.

A classical advection-dispersion model describes well the profiles of the first experiment. The same model was used for the second experiment but now a blocking function (a function that limits the number of available sites for adsorption) needs to be added. Two blocking functions were tested: one based on a Langmuir equation and the other on Random Sequential Adsorption. We found that both described well the adsorption dynamics but the RSA describes best the evolution of the maximum of coverage.

In fact, our concentration profiles of both suspended and adsorbed particles obtained by MRI gives us a good idea of the dynamics of particles in a porous media. These data together with the modelling approach is a powerful tool to understand and describe the mechanisms of transport and retention of colloids in a porous media.

GRAPHICS