Iron Oxide Colloid Mobility as Affected by DOM

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INTRODUCTION

In soil and groundwater, iron oxide colloids can function as "shuttles" for the transport of contaminants. Colloid transport and retention is strongly influenced by biogeochemical interface characteristics such as iron oxide and organic matter (OM) coatings on the solid matrix.

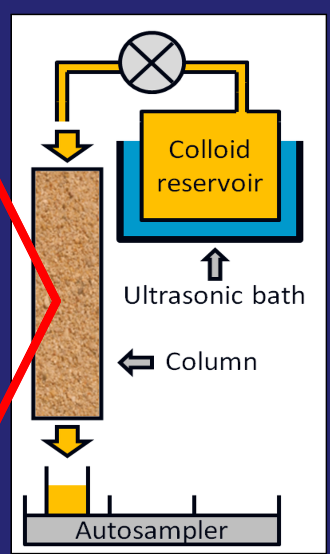
THE OBJECTIVES OF THIS STUDY:

(i) To determine how dissolved organic matter (DOM) adsorption on goethite-coated quartz sand influences the mobility of OM-coated goethite colloids
(ii) Estimation of DLVO interaction energies to ascertain their capability of predicting OM-coated goethite colloid mobility

MATERIALS & METHODS

FLOW COLUMN EXPERIMENTS

Goethite-coated quartz sand:
HCl cleaned before coating;
covalent Fe-O-Si bonds



Goethite accumulations in quartz grain surface depressions

Injection of colloid pulses:
Preliminary to injection, goethite colloids were coated with OM to reverse surface charge from positive to negative. Otherwise, colloids would be attracted by negatively charged clean quartz surfaces.

+ Goethite colloid, → - OM-coated Goethite colloid

OM: IHSS Pahokee Peat Fulvic Acid Standard

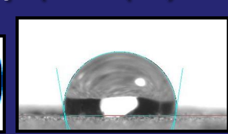
Colloidal goethite: Bayferrox 920 Z

Ionic strength: 0.1 mmol $CaCl_2$

DLVO INTERACTION ENERGIES

Lifshitz-van der Waals *($\Delta G(h)^{LW}$)* interactions are determined via sessile drop method (SDM) contact angle measurements.
Electrostatic interactions *($\Delta G(h)^{EL}$)* are calculated from zeta potentials. Summation of the two components provides the total interaction energy *($\Delta G(h)^{TOT}$)*.

$$\Delta G(h)^{LW}_{132} = -4\pi R_C \frac{h_0^2}{h}\left(\sqrt{\gamma_3^{LW}} - \sqrt{\gamma_2^{LW}}\right)\left(\sqrt{\gamma_3^{LW}} - \gamma_1^{LW}\right)$$



SDM

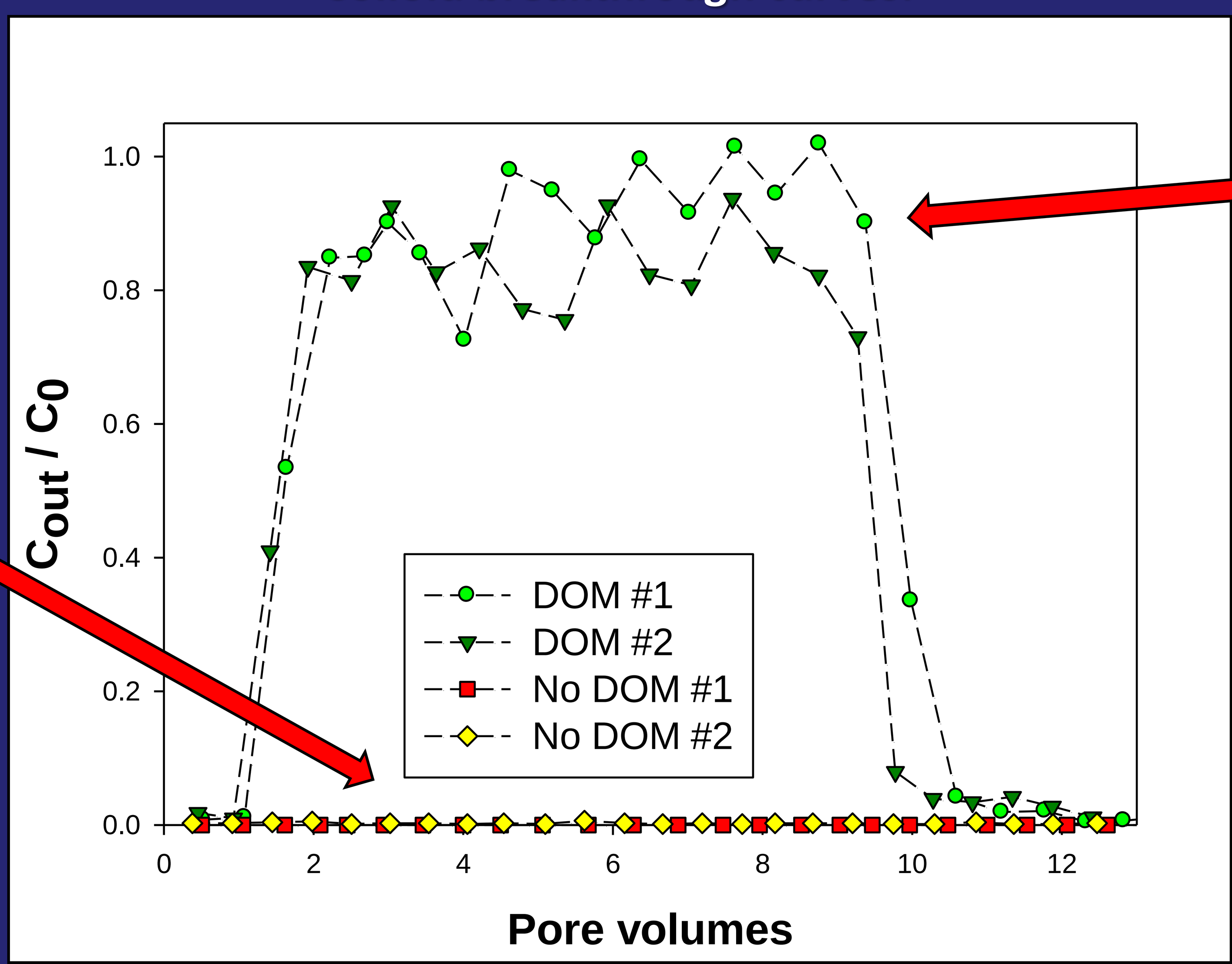
$$\Delta G(h)^{\mathrm{EL}}_{132} = \pi R_c \varepsilon_r \varepsilon_0 \left(\psi_1{}^2 + \psi_2{}^2\right)\left\{\frac{2\psi_1\psi_2}{\psi_1{}^2+\psi_2{}^2}\ln\left[\frac{1+\exp(-\kappa h)}{1-\exp(-\kappa h)}\right] + \ln\left[1-\exp(-2\kappa h)\right]\right\}$$

$$\kappa^{-1} = \sqrt{\frac{\varepsilon_r \varepsilon_0 k_B T}{2 N_A e^2 I}} \qquad \psi = \zeta\left(1+\frac{z}{R_c}\right)\exp(\kappa z)$$

$$\Delta G(h)^{TOT}_{132} = \Delta G(h)^{LW}_{132} + \Delta G(h)^{EL}_{132}$$

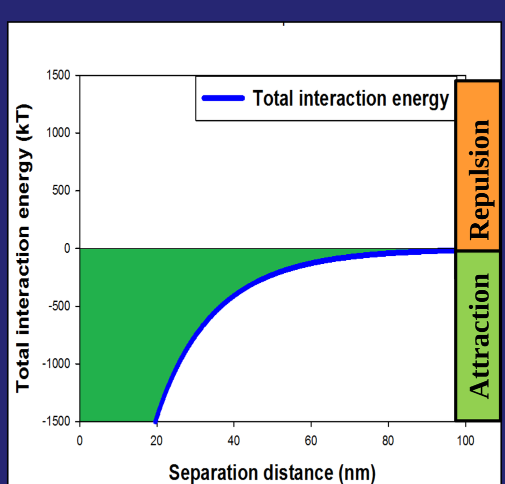
RESULTS & DISCUSSION

Colloid breakthrough curves:

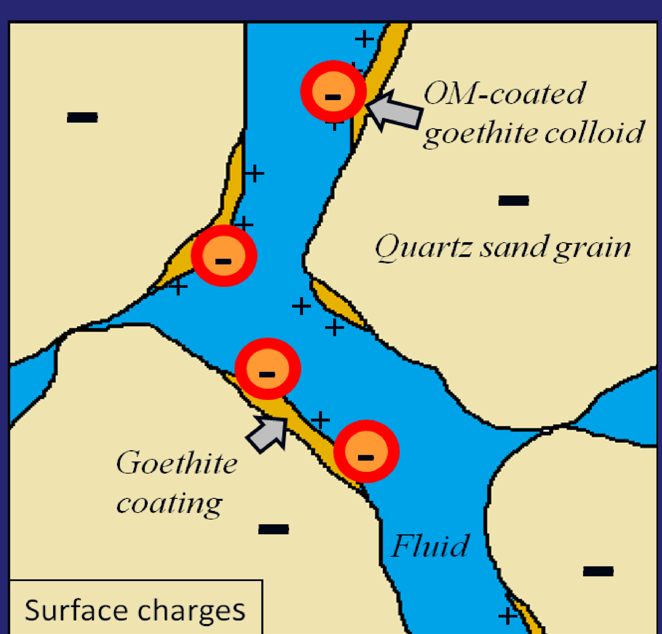


NO DOM PERCOLATION PRIOR TO COLLOID INJECTION

Colloid breakthrough: 0 %



DLVO:
Attractive interactions between goethite coatings on sand grains and OM-coated goethite colloids

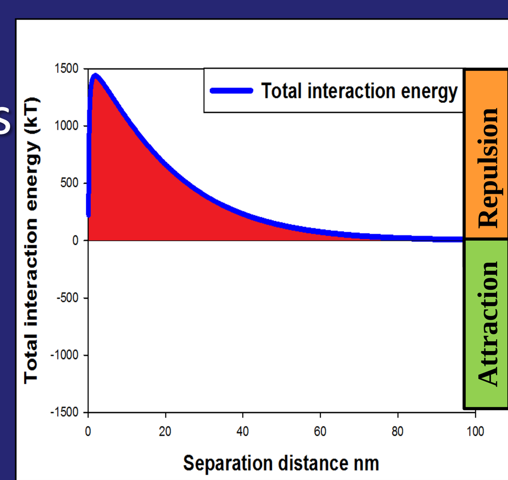


Pore scale:
Negatively charged OM-coated goethite colloids are retained on positively charged goethite coatings on the quartz grains

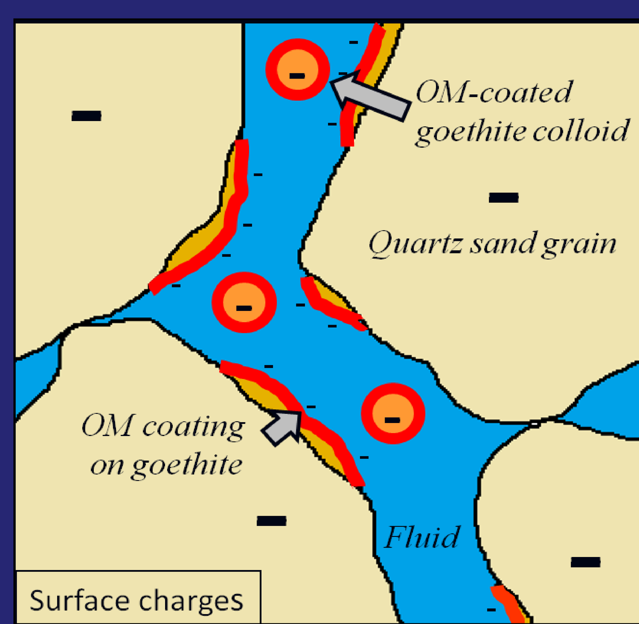
DOM PERCOLATION PRIOR TO COLLOID INJECTION

Colloid breakthrough: 89 %

DLVO:
Repulsive interactions between OM-coated goethite coatings on sand grains and OM-coated goethite colloids



Pore scale:
OM adsorbs on goethite coatings and reverses surface charge to negative; thus, negatively charged OM-coated goethite colloids are highly mobile



CONCLUSIONS

Our results show: (i) DOM percolation prior to OM-coated goethite colloid injection significantly affects colloid transport, i.e. from 0 % to 89 %
(ii) DLVO interaction energies are capable of predicting these OM-coated goethite colloid transport behaviors

We conclude that physicochemical surface properties of biogeochemical interfaces, determined by site-specific OM and DOM contents, govern transport and retention of iron oxide colloids in the environment. Future studies are planned in undisturbed natural soil samples at partial water saturation.

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