Transport of bacteriophage PRD1 through saturated clean sand columns as a function of Calcium concentration

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Introduction

•The two most significant processes controlling virus mobility in the subsurface environment are virus attachment and inactivation.

• The concentration of divalent cations, in particular calcium, have been identified to impact virus attachment.

•A quantitative relation between calcium concentration and virus attachment rate is not available.

Virus retention in porous media can be described by using these parameters: k_{att}= Attachment rate coefficient, α= Sticking efficiency, k_{det}= Detachment rate coefficient, μ_s= inactivation rate coefficient of attached PRD1 phage particles.

Objective

• To investigate effects of Ca^{2+}-concentration on virus attachment, detachment and inactivation in columns with saturated, clean quartz sand and to obtain empirical formulas for those effects.

Material and Methods

•50-cm saturated columns with clean quartz sand

•Calcium concentrations representative of natural conditions:

0, 20, 60, 120 mg/l

•Conservative model virus: Bacteriophage PRD1

• pH=7

• Ionic strength= 10 mM

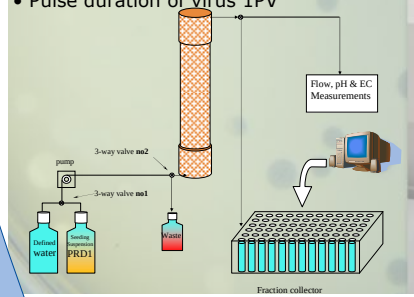
from $CaCl_2$+NaCl salts in all columns

• Quartz sand with average diameter of 0.4mm

• Porosity=0.36

• Average velocity 2m/day

• Pulse duration of virus 1PV



Results

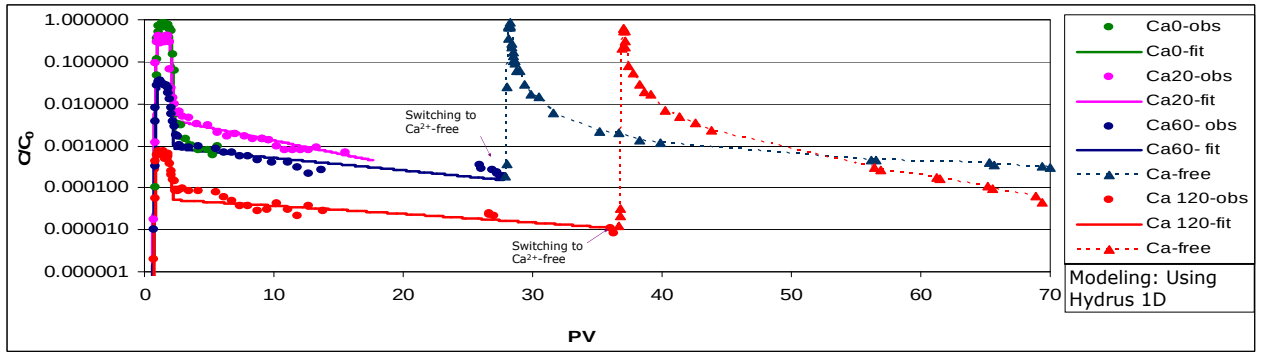


Figure 1 Breakthrough curves of PRD1 at four [Ca2+].

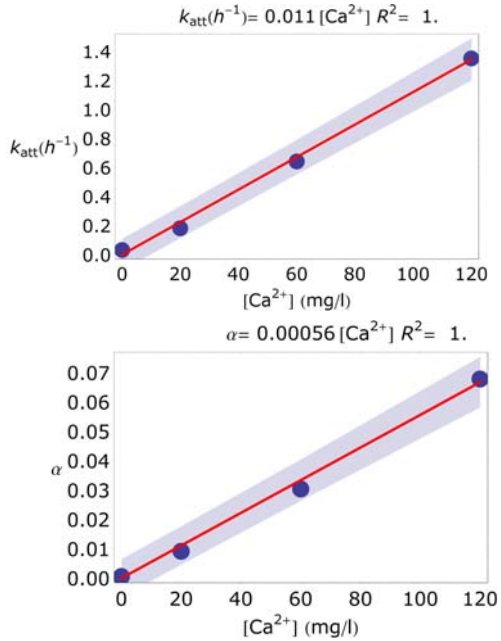


Figure 2 Attachment rate coefficient k_{att} and sticking efficiency α as a function of $[Ca^{2+}]$.

Observations: blue dots; Regression line: red line; 95% prediction interval: light blue area; Top: Empirical formula and R^2.The intercepts are not significantly different from zero.

Conclusions

•Maximum breakthrough concentrations of PRD1 decrease with increasing $[Ca^{2+}]$: increasing attachment.

• Attachment of PRD1 is higher in the presence of Ca^{2+} than in Ca^{2+} free buffer with the same ionic strength.

• Switching from 60 and 120 mg/l to Ca^{2+}-free buffer with ionic strength of 1mM leads to release of retained PRD1 phage particles.

• Virus attachment (k_{att} and α) increases significantly and linearly with increasing $[Ca^{2+}]$ in the range of 0-120 Ca^{2+} mg/l.

• Empirical formulas for virus attachment (k_{att} and α) as a function of $[Ca^{2+}]$ have become available.

• Virus detachment and inactivation of attached virus particles are not found to be significantly, affected by $[Ca^{2+}]$.

• The applicability of the empirical formulas at field scale requires further investigation.

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