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Virus transport through fissured limestone: A collision course?

Raymond Flynn & Michael Sinreich

Hydrogeology Centre, University of Neuchâtel, Emile Argand 11, Neuchâtel 2007, Switzerland.

Attenuation resulting from interactions between particles and fixed surfaces is generally viewed as consisting of two steps, quantified by terms expressing the frequency of collision with a fixed surface and the associated sticking efficiency. Collision frequency in fractured rock is believed to be largely controlled by the physical properties of particle-surface systems, including fissure aperture, while the value of the sticking efficiency is largely a function of the systems hydrochemistry. In many fractured rocks, including karstified formations, it is difficult to distinguish the role of each of these parameters to determine whether particles have had sufficient opportunity to collide with surfaces. A short pulse comparative tracer test investigated particle and conservative solute transport and attenuation through the top 10 metres of the vadose zone of a fractured limestone. Injection of a tracer cocktail of similarly sized bacteriophage (bacterial viruses) with different surface charge characteristics resulted in 2 % recovery of one bacteriophage type (T7) and 13 % recovery of a second more negatively charged type (H40/1). A subsequent test at the same location employing a more prolonged injection interval used the same tracers. A dramatic decline in the concentrations of both bacteriophage types was observed at depth during the tracer injection interval, with H40/1 levels dropping after those of T7. These responses were associated with gradually rising ionic strength values in the effluent, which are believed to permit enhanced particle attenuation. The results of this experiment indicated that more than 99.9 % of the bacteriophage tracers could collide with the walls of the fissures that transmitted water from the ground surface to monitoring points. However, the higher recoveries observed at lower ionic strengths during the first test demonstrated that not all collisions between the bacteriophage and the fixed surfaces

resulted in adsorption, thereby highlighting the important role of hydrochemical conditions in controlling particle attenuation in fissured media. The results of this study are also consistent with phenomenological observations from tracer tests in saturated karstified media.