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Environmental factors affecting the transport of DNA-tagged particle tracers in saturated porous media

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Particles tagged with synthetic DNA are a promising tool for tracing transport and defining the fate of biological and engineered colloids in the vadose zone and groundwater bodies. This tracing technique offers several advantages over conservative hydrological tracers because: i) it facilitates investigation of multiple hydrological pathways by using various distinct DNA tagged tracers that have identical transport properties, ii) it gives the opportunity to repeat the tracers test in one place without misleading or convoluting the signal of new tracers concentration with previous tests, iii) it gives the opportunity to enhance our understanding about temporal variation of flow pathways in highly dynamic hydrological system, iv) it can potentially provide spatial information to enhance validation of fully distributed geo-hydrological models.

Although the application of the synthetic DNA as a tracer has been investigated in several recent studies, the understanding of the effect of physicochemical environmental factors that might affect transport and stability of a DNA-tagged tracer particle remains unknown. In this work we conducted a series of systematic laboratory tests to investigate the dynamic behavior of synthetic submicron DNA tracers, under a broad range of physicochemical environmental conditions. The synthetic DNA tracers are composed of a magnetic core, covered with ssDNA and encapsulated with a protective silica shell layer. In this approach, the tracers are distinguishable from each other through synthetic DNA that acts as "barcoding" and the quantification of encapsulated DNA concentration is based on real-time polymerase chain reaction (qPCR).

The primary goal of this work is to evaluate the advective-dispersive transport properties of the proposed DNA-tagged tracer at saturated column experiment compared with the transport properties of engineered silica particles and a conservative tracer. Furthermore our results demonstrate if a systematic change in environmental condition through soil column can influence the properties of the breakthrough curve and retention profile. We also investigate the effect of environmental conditions on the stability of DNA-tagged tracers in batch experiments.