Effect of channel bed sediment on the transport behaviour of superparamagnetic silica encapsulated DNA microparticles in open channel injection experiments

Yuchen Tang[1], Fay van Rhijn[1], Ahmed Abdelrady[2], J.W. Foppen[1], and Thom Bogaard[1]

[1]Technische Universiteit Delft Department of Geoscience & Engineering
[2]Wetsus

March 14, 2023

Abstract

Recently, superparamagnetic silica encapsulated DNA microparticles (SiDNAFe) were designed and in various experiments used as a hydrological tracer. We investigated the effect of bed characteristics on the transport behaviour and especially the mass loss of SiDNAFe in open channel injection experiments. Hereto, a series of laboratory injection experiments were conducted with four channel bed conditions (no sediment, fine river sediment, coarse sand, and goethite-coated coarse sand) and two water qualities (tap water and Meuse water). Breakthrough curves (BTCs) were analysed and modelled. Mass loss of SiDNAFe was accounted for as a first-order decay process included in a 1-D advection and dispersion model with transient storage (OTIS). SiDNAFe BTCs could be adequately described by advection and dispersion with or without a first-order decay process. Mass loss of SiDNAFe increased as a function of the surface roughness of the beds. Retention of SiDNAFe due to surface roughness was 1-2 orders of magnitude greater than gravitational settling rates, as determined in Tang et al. (2022). We speculate this was due to boundary layer kinetic attachment. The dispersive behaviour of SiDNAFe generally mimicked that of NaCl tracer, although SiDNAFe traveled faster on average due to a smaller effective cross-sectional area. No pattern was observed between SiDNAFe mass recovery and water qualities used. DNA concentration data uncertainty was mostly associated with lower SiDNAFe concentrations in the BTCs. This research highlights that riverbeds are important sinks, and the surface roughness affects the fate and transport characteristics of SiDNAFe when in proximity to the water-sediment interface. SiDNAFe possess promising potential as a surrogate for multi-tracing micro-contaminants (e.g., microplastics) in large rivers, which could be a promising tool for enhancing understanding of hydrological processes.

Hosted file

`Manuscript_YTang_submission_HP.docx` available at https://authorea.com/users/497795/articles/629507-effect-of-channel-bed-sediment-on-the-transport-behaviour-of-superparamagnetic-silica-encapsulated-dna-microparticles-in-open-channel-injection-experiments