Geophysical Research Abstracts
Vol. 18, EGU2016-2516, 2016
EGU General Assembly 2016

Fine particle retention within stream storage areas at baseflow and in response to a storm event

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Fine particles (1-100 μm), including particulate organic carbon (POC) and fine sediment, influence stream ecological functioning because they have a high affinity to sorb nitrogen and phosphorus, which are limited nutrients in aquatic ecosystems. These particles immobilize within in-stream storage areas, especially hyporheic sediments and benthic biofilms. However, fine particles are also known to remobilize at all flow conditions. The combination of immobilization and remobilization events leads to downstream transport and transient retention, which fuels stream ecosystems. The main objective of this study was to quantify immobilization and remobilization rates of fine particles that influence biogeochemical cycling in sand-and-gravel bed streams. During our field injection experiment, a thunderstorm driven spate allowed us to observe fine particle dynamics during both baseflow and in response to increased flow in the fifth-order stream Difficult Run, Virginia, USA. Solute and fine particles were measured within stream surface waters and porewaters at four different in-stream locations and multiple depths. Modeling of in-stream breakthrough curves (leading edge and initial decline before the storm) with a stochastic mobile-immobile model show that fine particles were mainly transported with the solute, but with additional net deposition. Porewater samples showed that flow paths within the stream sediments are complex and heterogeneous, with varying travel times depending on the in-stream location (i.e. channel thalweg, pool or lateral cavity). Higher filtration coefficients of fine particles were observed within the channel thalweg compared to the pool, and the filtration coefficient increased with sediment depth. Furthermore, we observed the accumulation of immobilized fine particles within hyporheic sediment and benthic biofilms on cobbles during baseflow and retention was evident even after the spate. Approximately 64% of fine particles were retained during baseflow until the onset of the spate. Retention of 16% of deposited fine particles within benthic biofilms on cobbles and 8.6% within hyporheic sediment after the spate indicate both short-term remobilization and long-term retention. Thus, inputs of fine particles have the ability to provide short- and long-term sources of carbon and nutrients to downstream ecosystems.