Geophysical Research Abstracts
Vol. 21, EGU2019-316, 2019
EGU General Assembly 2019

Undisturbed measurement of sediment infiltration masses in laboratory flumes using gamma ray attenuation

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Infiltration of fine sediment in the interstices of gravel beds plays a vital role in river's ecology and hyporheic exchange behavior. The process alters interstitial habitats for benthic organisms and also for the reproduction habitats of gravel-spawning fish. The sediment infiltration and subsequent accumulation in the pores reduce the pore space and thus the hydraulic conductivity of the river. For understanding this phenomenon, most laboratory and field investigations utilized destructive methods. A limited number of the existing methods are able to determine the vertical distribution of infiltration sediments and none of the existing techniques is able to investigate the dynamic behavior of clogging processes.

This study aims to investigate a non-destructive method for measuring infiltrated fine sediment masses using gamma ray attenuation (GRA). The general setup of GRA measurements includes a gamma source, which emits a collimated gamma beam through the penetrating media and a scintillator to detect the gamma quants after passing the absorber. The received quants are converted to electrical signals by a photomultiplier that are finally counted. The experimental setup consists of a laboratory flume with a simplified riverbed using 4cm spheres in a central cubic packing arrangement. The flume is equipped with a constant sediment feeding machine and a steady flow pump. Different sediment particle sizes with various feeding rates but identical total masses were supplied to the flume for measuring infiltrated sediment masses in a specific position.

The verification of this method was done using measurements of a small box with a similar structure and adding a known amount of sediment. The results showed deviations of 1-5% between gravimetric and GRA measurements, which is in the range of statistical error (given to the decay of the radiation).

Based on these experiments with promising results, it is concluded that GRA represents a valuable opportunity to measure sediment infiltration masses without disturbing the riverbed in hydraulic laboratory conditions. The current set-up of GRA measurement provides a higher resolution time-integrated infiltration measurement results comparing to the traditional methods; and open the way for time-resolved or dynamic investigation of infiltration and clogging processes.