Measurement of fine sediment infiltration and deposition rates within a gravel bed: a pilot study in the Geul River, the Netherlands

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1. Introduction

Transient storage of fine sediments in the river bed determines the fine sediment residence time in gravel bed streams at intermediate time scales between days and a few years. We measured the infiltration of fine sediment into the gravel bed at four locations in the Geul River, the Netherlands (mean discharge = 2 $m^3 s^{-1}$) (Fig. 1).

Fig. 1 Location and overview of the study site

2. Field sampling

Sediment infiltration rates were meausured using two methods:
1) a gravimetric method and
2) a metal concentration-based method.

Both methods involved the placement of sediment traps, consisting of cylindrical mesh cages with a diameter of 15 cm and a height of 10 cm, in the gravel bed.

Method 1: clean gravel > 12.5 mm (the size of the mesh openings) collected from the local river bed (D50 ≈ 19 mm)

Method 2: gravel + approx. 700 g of 'clean' fine sand. During the sampling period, this 'clean' sand was contaminated by deposition of metal-contaminated fine sediment.

Fig. 2 Sediment trap

2. Field sampling (continued)

After 4-8 days, the sediment traps were removed. A bag around the cage, which had been lowered during sampling, prevented the fine sediment to wash out from the sediment traps during removal. The fine sediment was washed from the sediment traps (Fig. 3)and subsequently dried and weighed. For the second method, the zinc concentrations of the fine sand and the fine sediment collected from the sediment traps were measured using a Thermo Fisher Scientific Niton® handheld XRF analyser.

Fig. 3 Removal of a filled sediment trap

3. Results

The sediment infiltration or deposition rates were then calculated from the differences between the zinc concentrations in the sediment samples and the 'clean' sand:

$$M_1 = M_3 \times (C_3-C_2) / (C_1-C_2)$$

Where M_1 is the added mass through sedimentation; M_3 is the mass of the mixed sample; C_1 is the concentration of the added mass; C_2 is the concentration of the "clean" sand; C_3 is the concentration of the mixed sample (Fig. 4).

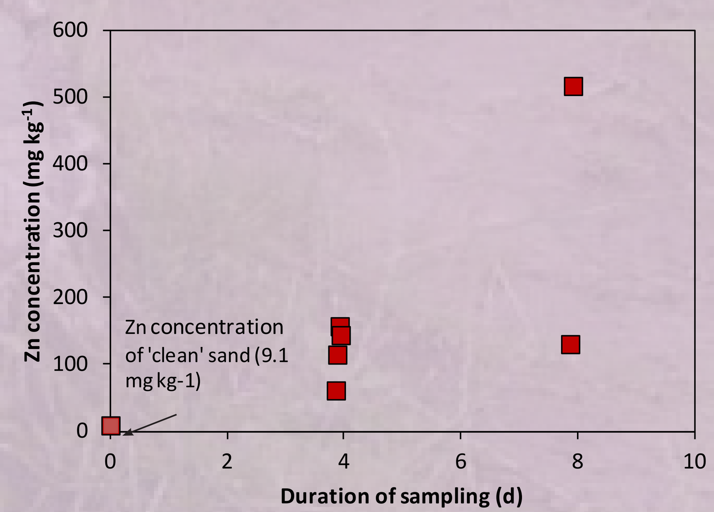

Fig. 4 Increase of Zn concentration due to deposition of metal-contaminated sediment

3. Results (continued)

The fine sediment deposition rates measured using the concentration-based method (0.49 ± 0.20 kg m-2 d-1 [mean ± 1 st. dev.]) were consistent with those measured using the gravimetric method (0.54 ± 0.22 kg m-2 d-1). The mean and variation of the fine sediment deposition rates increased with stream discharge during the sampling period (Fig. 5).

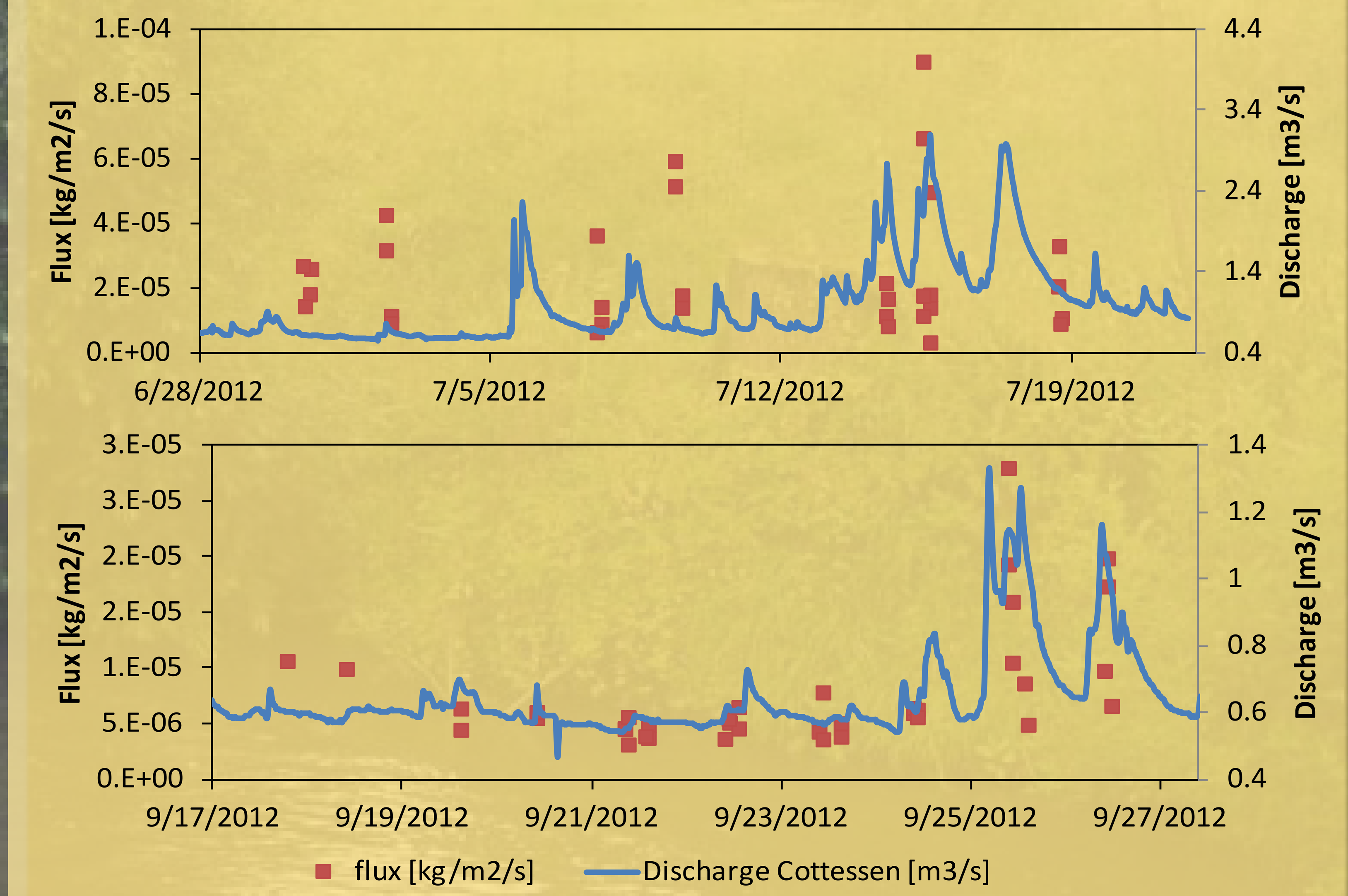

Fig. 5 Measured sediment deposition fluxes and discharge

5. Conclusions and implications

- The relatively high sediment infiltration rates imply an intensive interaction and exchange between sediment in transport and gravel-stored bed sediment, which increases with discharge.
- This, in turn, suggest that on the one hand, sediment is considarably delayed during transport due to frequent storage in the gravel-bed. On the other hand, the storage time in the gravel bed is relatively short (on the order of days).
- The results imply that sediment infiltration into the gravel bed comprises a substantial portion of the sediment budget of the Geul River.