Periodic alterations of the hydrological exchange in hyporheic sediments: colmation, hyporheic fauna and abiotic parameters in a second order stream during one year

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In this study, the temporal variability of the hydrological exchange between stream water (SW) and groundwater (GW), colmation, hyporheic invertebrate fauna, organic matter (OM) and physicochemical parameters were examined for the period of one year. Sampling and measuring were conducted monthly from May 2019 to April 2020 at the Guldenbach river, a second order stream in Rhineland-Palatinate, Germany. All hyporheic samples were extracted from a depth of 15 cm below stream bottom. Colmation was measured quantitatively in the same depth.

Following the biotic and abiotic patterns found, three temporal stages of different hydrological conditions can be described:

- 1) Strong floods, in February and March 2020 caused hydromorphological alterations of the river bed, leading to a decolmation of the hyporheic zone, a wash out of OM and hyporheic fauna. Due to high GW tables the vertical hydrological gradient (VHG) was positive indicating upwelling GW.
- 2) In the months of Mai to August 2019 and April 2020, precipitation and stream discharge were lowest. Predominantly exfiltrating conditions were observed, while the amount of fine sediments (clay and silt) increased as well as colmation. High densities of hyporheic fauna, dominated by fine sediment dwelling taxa, were assessed.
- 3) From September 2019 to January 2020 stream discharge was low. The VHG became increasingly negative, indicating downwelling SW. In accordance, colmation increased continuously, while densities of hyporheic invertebrates decreased and sediment dwellers became more dominant.

Precipitation, discharge events and GW table were found to be the driving factors for the annual dynamics of the hydrological exchange as well as for colmation, fauna and hydrochemistry. Electric conductivity seems a suitable indicator for the origin of water with high values in months of low precipitation and lower values after extensive precipitation events, respectively. Hyporheic fauna displayed a significant seasonality and the community structure was correlated with colmation and changes in the VHG.
This pronounced seasonality seems to be typical of many streams and should be considered for the monitoring of sediments and hyporheic habitats: Seasons with lower stream discharge are probably the most critical periods for sediment conditions.

We assume that the basic patterns of the dynamics observed basically reflect the natural situation in the catchment. However, the strength of surface run-off and the amount of fine sediments are mainly the result of anthropogenic activities and land use in the catchment.

These findings underline the significance of dynamical processes for the assessment and implementation of the Water Framework Directive.