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Change in hyporheic zone residence time under different surface flow states

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Hyporheic zone (HZ), which is the ecotone immediately below or adjacent to a stream, plays an important role in a stream ecological system. One of the most common metrics in evaluating the functioning of an HZ is residence time (RT) which is the duration a water molecule or a solute remains within the HZ. Many factors, such as meandering of a stream, heterogeneity of streambed, can influence the RT of an HZ. Stream discharge is another governing but less discussed factor. Different discharge values produce different flow states (i.e.; subcritical, critical and supercritical) and alluvial stream bed forms. This study examined the changes of RT in discharges of different states and their corresponding induced bed forms. It employed a toolbox developed by Stonedahl et al. (2015) within Netlogo to simulate the RT of an HZ, considering three discharge values in each of the supercritical, critical and subcritical states. It approximated the bed forms as sinusoidal waves with amplitudes and periods selected for each flow state. The simulated results suggest that the RT is minimum when the flow is critical, and it is longer for both subcritical and supercritical flows. For subcritical flow, the RT, as well as the fraction remained within the streambed during particle tracing, increases with the increase in discharge value. However, there is no such variation among the different discharge values of supercritical flow. Therefore, for supercritical flow, one combination of discharge value and bed form might be sufficient and representative. However, for subcritical flow, the variations of discharge values and their induced bed forms should be considered.

Reference:
Stonedahl, S.H., Roche, K.R., Stonedahl, F., & Packman, A.I. (2015). Visualizing Hyporheic Flow Through Bedforms Using Dye Experiments and Simulation. J. Vis. Exp. (105), e53285. doi: 10.3791/53285