Sediment dynamics in semi-alluvial urban streams

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Abstract

Urban rivers are often characterized by a flashy flow regime and irregular sediment supply that may cause widespread erosion and incision. In many urban streams in the Greater Toronto Area, local incision has led to the removal of alluvium and the exposure of the underlying glacial till.

The formation and stability of mobile alluvial cover (gravel) material is an important element of channel design for both geomorphic and ecological components of stream restoration. In supply-limited channels the possibility of maintaining or forming alluvial cover by some form of artificial feeding (e.g. laterally erodible deposits or 'slug' inputs) is a possibility. Conversely, for hydraulic efficiency or other concerns, some designs may seek to restrict the possibility of in-channel sedimentation. At present little is known about cover formation processes that could form a basis for resilient-channel design practices.

We used a large physical model to simulate alluvial cover evolution in a till-bed stream and to explore the influence of sediment supply, channel morphology and bed roughness on cover stability and sediment flux, at constant discharge actively transporting bed material. The fixed bed channel comprised a straight section and a meandered section and was fed with graded sand to simulate gravel bed material at reduced scale. We tested a range of feed rates and different initial configurations including fully uncovered and fully covered beds, and beds with large roughness elements representing boulders. Bedload flux was sampled at regular intervals and cover evolution was reconstructed from high-resolution images. Model runs show that the system tends to a steady state characterized by sediment input/output balance regardless of sediment input rate, but with cover area and volume dependent on feed rate: higher feed rate give larger equilibrium cover area and larger stored volume. Equilibrium cover area is only slightly sensitive to initial (un)covered state. In the straight channel, a complete cover is attained at very high feed rate. In the meandered channel, deposition forms a series of point bars at low feed rate, while at high feed rate the bars coalesce into a continuous strip, resembling bar morphology of fully alluvial gravel-bed channels, but patches of exposed bed are always present along the outer bank of channel bends. Roughness elements promote sediment retention, increasing the proportion of covered bed and bar thickness.

Biography

Peter Ashmore is Professor of Geography at the University of Western Ontario with specialty in fluvial geomorphology. His research is focussed on bedload transport and channel morphology especially in gravel-bed rivers and effects of environmental change of river morphology including applications to geomorphic practice and channel restoration.

Matilde Welber was a postdoctoral fellow at University of Western Ontario with primary responsibility for this research project. She is now a lead researcher, at the University of Trento, for a project on sediment waves in glacier-fed rivers. Matilde received her degrees in Civil and Environmental Engineering from Trento, including PhD research on large wood dynamics in braiding rivers using both field and experimental data.