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Estimating Bedload Transport in Large Gravel-Bed Rivers Using the Virtual Velocity Approach

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In large gravel-bed rivers bed material transport estimation is a challenging task since bedload formulas often fail to predict sediment fluxes, and it is difficult to carry out either direct and indirect field measurements. A viable alternative is provided by the virtual velocity approach which represents a hybrid solution to calculate the bedload transport based on empirical relations, derived from field data, between the water flow (specifically shear stress) and the sediments mobility conditions, the velocity of grains, the percentage of mobilized streambed material and the active layer thickness. This study aims to improve the virtual velocity methodology and to assess its performance in the Parma River (Northern Apennines, Italy). Two tracer types (i.e. painted particles and passive integrated transponders) and scour chains were deployed at four cross-sections in a 4-km study sector bounded upstream by a retention basin dam. Data on water level, transport processes, particle travel distance and active layers thickness were collected over 17 months (January 2016 - May 2017). Using derived reach-specific relations, the bedload transport that occurred during two events of different magnitude was calculated applying seven model configurations and two theoretical formulas. Using the most complete model configuration, at the most upstream cross-section (section 1) bedload transport ranges from 3 ± 3 m^3 to 158 ± 74 m^3 for the lowest (RI $<$ 1 year) and highest flood (RI = 2.1 year), respectively. At section 3, located in the downstream part of the study sector, estimates were 107 ± 54 m^3 and 746 ± 230 m^3, respectively for the lowest and the highest flood event. Using the Meyer-Peter and Müller formula, bedload vary from 0 $m^3$to 2845 m^3 at section 1 and from 2 $m^3$to 3590 m^3at section 3, considering the lowest and the highest floods, respectively. Results indicate also that (i) the bedload volumes tend to increase moving away from the dam (i.e. from upstream to downstream) and (ii) the virtual velocity approach gives estimates that are considerably lower than those provided by traditional formulas. This study pointed out that it is crucial to collect and process data at reach and morphological unit spatial scale and to combine different types of tracers. Since model configuration affects significantly bedload estimation it is advisable to reproduce as much as possible river features (e.g. local grain size) and processes. Finally, this study has confirmed the need to use alternative methods for estimating bed material load in gravel-bed rivers, in order to overcome the low reliability of theoretical formulas.