Geomorphological effects of sediment retention on downstream river reaches in mountain torrents

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PROBLEM AND OBJECTIVES

Structural measures protecting life, assets and infrastructure from debris flows and sediment transport exist in numerous mountain torrents in the Swiss Alps. Sediments are trapped and periodically removed from many of these structures. Closed dams cut the transport of solid material (Schöberl 1992) and the active removal of sediments leads to massive disturbances and often to a deficit of bedload transport in the downstream reaches (Schälchli et al. 2005). The consequences of this deficit are erosion of the channel bed (Romang 2004) or the scouring of bridge piers affecting the stability of infrastructure (Schälchli et al. 2005). These direct effects of the sediment retention are relevant in many torrents in Switzerland. The focus of this study is on detecting the rarely investigated geomorphological effects of retention basin on the downstream reach of the technical measure.
The Database Solid (DB Solid) from the Federal Office for the Environment (FOEN), which contains information on the bedload management of more than 100 dams and related retention basins, features a valuable dataset to detect causes for geomorphological changes in the lower reaches of these torrents. The gained knowledge and identified indicators of this study will improve the monitoring of managed torrents. If negative effects are detected in an early stage, relatively small adjustments can reduce or prevent these unintended consequences (Habersack et al. 2014).

APPROACH

The DB Solid document the yearly sediment volume of 108 retention basins in various geographical settings of Switzerland and provides long-term information and opportunities for statistical analysis regarding sediment delivery of torrential watersheds and the behaviour of channel beds downstream of the retention structures. The study is structured in four main steps. In a first step suitable downstream reaches are selected by the following criteria: (i) existence of a dam-type structure, (ii) downstream reach of more than 200 m, (iii) more than 10 years observations and (iv) more than four times an excavation within the observation period. In the second step the erosive channel reaches are identified by the visual interpretation of aerial images. The analysed criteria are: the size of the scour, the width of the river course, the occurrence of gravel bars and other accumulation phenomena along the channel until the receiving water. The downstream reaches of the retention basins are classified in erosive, bedload transport reach and accumulation. Classification is limited when channels are not visible in the aerial image. These channels will be classified in the field in a later stage. The erosive reaches are examined in a third step to identify channel erosion, bank erosion and scouring by means of geomorphological mapping. The product is a classification of the severity of the erosion. In a fourth step, the reaches are analysed by a semi-quantitative approach using a multi-temporal comparison of longitudinal and cross-section profiles. The difference between these channel profiles allows the interpretation of the extent of the bedload deficit. Moreover, it is analysed whether the diverse types of retaining structures (with differing permeability for the sediments) and the excavated volume can be related to the extent of the deficit.

FIRST RESULTS

The first results of step 1 highlights that according to the four criteria out of the 108 channels from the DB Solid, 51 channels can be selected for the analysis. These 51 reaches downstream have different hydraulic structures like check dam series, channelization and stabilisation of the bed with ground sills. A first visual identification of aerial imagery indicates that limited sediment supply is observed in about 60% of the 51 reaches (Fig. 1).

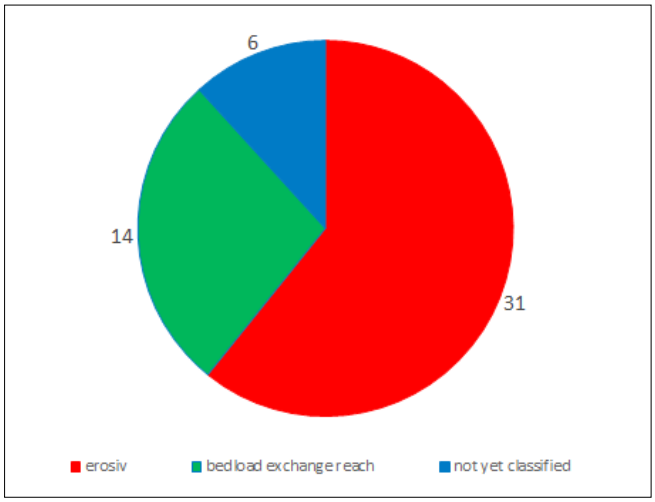

Figure 1. Reaches downstream the sediment retention basin

Thus, at these erosive reaches the geomorphological mapping (step 3) will highlight the effects of retention basin in more detail. It is also expected that with step 4 a differentiated picture of the effects of retention and excavation of bedload can be illustrated.

CONCLUSION

The challenge for constructing prevention measures includes unifying the interests of different stakeholders concerning torrents: providing enough risk reduction and implementing the smallest possible solution (Habersack et al. 2005). The identification of current state of torrent channel is crucial in order to provide information about the effects of retention and excavation of sediments because the torrent bed adjusts dynamically. The first results show, that more than 60% of the downstream reaches of the analysed sediment retention dams can be classified as (highly) erosive. The results of step 3 and 4 will provide more detailed insights in these cumulative effects. The expected results contribute to a better understanding of the effects of the retentions basins on channel bed and bank erosion as well as scouring and provide insights for the implementation of the Federal Act on the Protection of Waters (GSchG).

LITERATURE

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KEYWORDS

mountain torrent; bedload transport; database solid; sediment retention basin

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