**Analysis of Morphological Changes of the Danube on the Basis of Repeated River Bed Surveys**

Analyse von morphologischen Veränderungen der Donau auf Basis von wiederholten Stromschnellenaufnahmen

**Abstract**

The direct monitoring of channel topography offers unique opportunities for developing a deeper understanding of alluvial river behaviour as a complex interplay of numerous processes at different temporal and spatial scales. This study presents a systematic framework for analysing the morphological river bed evolution, expressed as changes in the bed level and bed volume, due to the processes of sediment erosion, transport, and deposition. Bathymetric data acquired by repeated cross-sectional surveys on a half-year basis along the free flowing reach of the regulated Austrian Danube River east of Vienna are used in the analysis. The reference period is 2003-2008 and the August 2002 flood is also analysed.

The overall morphological situation is characterised by the main morphological parameters. The results show a current state of river bed degradation and at the same time significant vertical bed variations. However, the morphological structures are found to remain stable with respect to their location and extent.

A more detailed analysis of topographic river bed variability is performed by evaluating statistical parameters of the bed level changes. The reach-wide averages of local bed level changes along the 47.3 km stretch vary between $-9.5$ and $+3.5$ cm/half-year, representing aggradation and degradation phases. The profile averages of the bed elevations also change from survey to survey and from profile to profile, with fluctuations in the decimetre range. The spatio-temporal standard deviation of the local river bed changes across all profiles and all ten half-year periods is estimated as 22 cm/half-year. The measures of profile shape variability and similarity indicate higher form changes between neighbouring profiles than between subsequent surveys.

The morphological process dynamics are examined in more detail by evaluating bed volume changes. The findings suggest strong space-time variations of the magnitudes of volume changes and the occurrence of trends. A strong sediment withdrawal out of the river reach is evident for the five-year period with an average erosion rate of 1.7 cm/year. A higher erosion rate of 2.4 cm/year is found between stream-km 1910 and 1880, which is deemed to represent the quasi-natural morphological behaviour of the free flowing section.

Various assessment techniques are presented to assess the role of the following aspects: channel course configuration in terms of structural and operational interventions, reference length of the reach, duration of the reference period and the hydrological conditions, survey methodology reflected in the reference width and profile spacing, the morphological approach applied, i.e. the traditional cross-sectional approach versus approaches based on river bed interpolation between the measured profiles.

The bed volume changes are normally obtained by budgeting the positive depositional and negative erosional river bed changes, which masks the variability of the river bed dynamics. The proposed “sediment turnover” concept provides a much better representation of the river bed variations through the sum of the individual quantities of aggradation and degradation, especially in the case of small bed volume changes and short time periods. The data suggest a tendency for an increasing sediment turnover with an increase in the river flow volumes for the half-year periods considering a fixed width related to the active channel. The turnover is much larger than the net volume changes. Depending on the significance thresholds, between 70 % and 95 % of turnover volume changes can be considered significant.

The proposed “sediment turnover” concept provides a systematic and reliable assessment of morphological changes, not only for trends over long-time periods, but also for river bed changes and process dynamics over short-time periods. The insights into the complex morphological and methodological aspects obtained in this thesis improve the basis for the modelling of morphological processes, refinement of monitoring programs and planning of future management activities.