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Man versus Rivers: the lost equilibrium of the Tisza River due to engineering works

Timea Kiss (1) and Károly Fiala (2)

(1) University of Szeged, Physical Geography and Geoinformatics, Szeged, Hungary (kisstimi@gmail.com), (2) Lower Tisza District Water Directorate

The direct and indirect human impacts alter the catchment and the channel characteristics, which will result in further hydro-morphological alterations of rivers. The modified fluvial environment will create new hydrological hazards for the society, so for the successful and sustainable hazard and risk management it is important to evaluate the equilibrium and sensitivity of rivers. The aim of the paper is to evaluate the hydrological and morphological effects of engineering works along the Tisza River, Hungary. Based on the trends of the different fluvial processes the equilibrium of the river will be evaluated to ground further engineering works.
The Tisza River, was one of the first systematically regulated rivers in Europe. In the late 19th century artificial cut-offs were made, shortening the river by ca. 30%. The hydrology and the morphology of the Tisza adapted to this, as the channel became temporarily wider and deeper (by 20-25%). The cut-offs had an effect on the channel for ca. 60-70 years.
Simultaneously, artificial levees were built, thus the overbank floodplain aggradation became more intensive (from 0.02-0.07 cm/y to 0.3-0.8 mm/y). The floodplain aggradation became higher by 2-4 times since 1970's, as the vegetation became denser. However, in the 21st c. the floodplain vegetation became so uncontrollably dense, that the pattern and rate of accumulation changed again, and now it is limited just to the banks. So the levee could be considered as continuous disturbing factor, besides, the unmanaged floodplain vegetation appeared as a new disturbing force accelerating the processes.
In the 20th century revetments were constructed to stop the lateral migration of the channel. This resulted in channel distortion, as it became sharper and the cross-sectional area decreased by 28%. As revetments were constructed along ca. 51% of the channel, the meandering channel forms became replaced features characteristic in incising rivers, for example point-bars disappeared and mass movements became common, especially in the 21st c. As the channel becomes too narrow and confined, the landslides erode the revetments too, thus a natural channel-widening will took place.
Thus, the Tisza aligned to the new hydro-morphology after the artificial cut-offs within few decades, and within the given energy and slope conditions the river reached an equilibrium state. However in the 21st c. there are several evidences on the non-equilibrium state: the height and frequency of floods increase, their discharge decreases; the slope of the river declines; and the specific stream power increases. Morphological sign of the lost equilibrium is the vertical and horizontal distortion of the channel (caused by revetments!) and the decreasing flood conductivity of the floodplain (caused by dense, unmanaged floodplain vegetation). The rate of these processes refers to accelerating equilibrium loss. Thus the state of the Tisza could be referred as "non-equilibrium" or "pseudo-equilibrium". Therefore, if further engineering works will be planned, it must be considered that the river might give unexpected hydro-morphological responses on any disturbance.