CHANNEL DEGRADATION IN CROATIAN RIVERS

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Abstract: Sava, Drava and Danube are three large Croatian rivers. Beside being major water recipients of large Croatian areas, water management's relevance of these rivers is great. In the past they were the subject of many regulation actions and river modifications. In the 70's and 80's significant decrease of the water surface elevation was measured. All rivers are navigable on these sequences, and channel geometry changes have a large impact on navigability purpose. On the river Sava additional issue is water level degradation, which causes problems in the use of rivers. It is possible to make strong relation between river bed degradation and water-level degradation. Additional river bed degradation is caused by gravel exploitation and dredging for increasing waterway depth.
Keywords: river degradation, Sava, Drava, Dunav, river regulation, morphological changes

1. Introduction

Sava, Drava and Danube are two large Croatian rivers. By regulation level, in water management mean, they belong to the group of “heavily modified water bodies”. As well as being major water recipients of large Croatian areas, water management’s relevance of these rivers is great. For that reason, in the past (and nowdays but less) they were the subject of many regulation actions, which made changes on water body and water regime. Nowdays these river embankments are stabilized by themselves or with regulation structures. Current condition is mainly kept by scheduled regulation actions. More obvious changes on watercourses are caused by the river depth changes. Consequently, there are changes in water regime.

2. Morphological changes on the river Drava

In the past, the river Drava was the subject of many human activities for various water management purposes. Regulation of the river began in 18th century. Throughout 20th century a few hydropower plans were built in the upstream section, and nowdays energetic value is generally used. There were 12 weirs constructed in Austria by 1988, 8 weirs in Slovenia by 1978, and 3 weirs in Croatia by 1999. Today there are great commercial appropriation of the river Drava related to sand and gravel exploitation. Many regulation actions were also undertaken, mainly meander cutting and bank protection.

Morphological changes on the river Drava are introduced on the 22 km long river reach from mouth to Osijek. It is indisputable that constructed energetic and regulation structures disturbed natural balance of the river. One of the noted results is length decrease (cca. 40% of the whole watercourse). The progression of the length decrease process is presented in Figure 1.

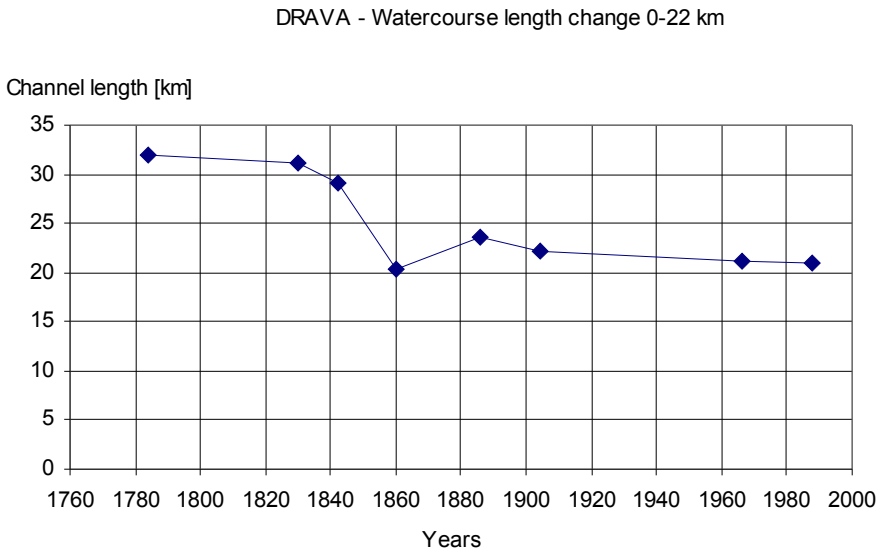

Figure 1. Length change of the river Drava from mouth to Osijek.

Due to the constructed regulation structures on this river reach, river banks are nowdays stabile. Under this morphological condition, another noted result is bed degradation process. This process is evident in cross section area increase (Figure 2). Calculation is made according to the permanent cross section soundings. A cross section state in 2002 was taken as a reference for the analysis. Comparing that state to the state in the last 42-years, the average increase of the cross section profile for the whole distance is cca. 225 m^2 (the average annual is 5,3 m^2).

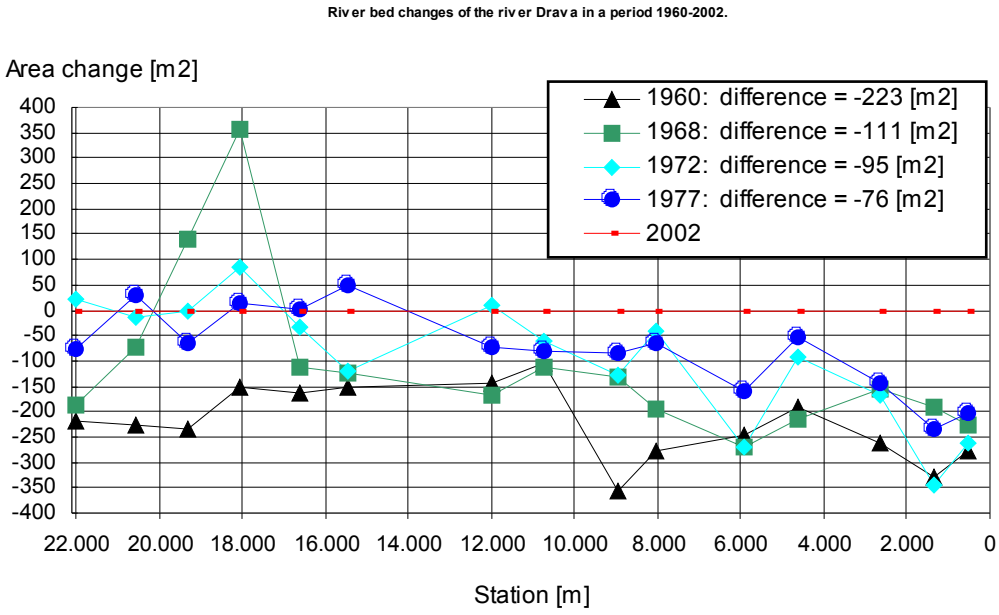

Figure 2. Cross section area changes of the river Drava during the period 1960-2002.

River bed degradation process is also evident in the depositional zone, near the mouth into Danube. Water levels in this section are strongly influenced by backwater of the river Danube. Nevertheless, river bed erosion process is evident (Figure 3).

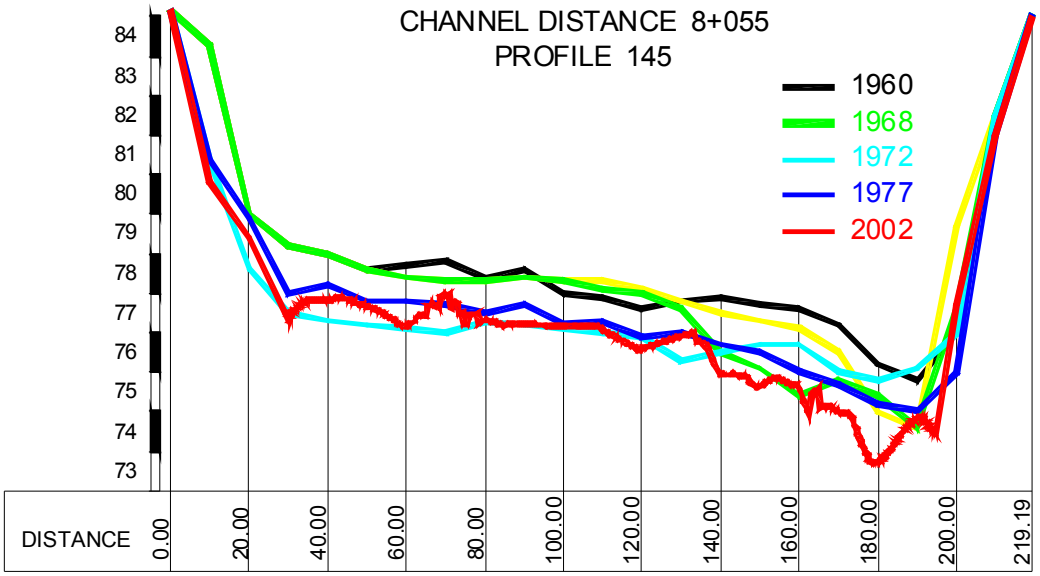

Figure 3. Characteristic cross section in the depositional zone of the river Drava.

Morphological changes made influence on hydrological state of the river, which consider changes of the water surface elevation and ground waters. The continuous decrease of low waters (Figure 4) was identified in the long-term measurements on water ganges on the river Drava (Biondić, 1998).

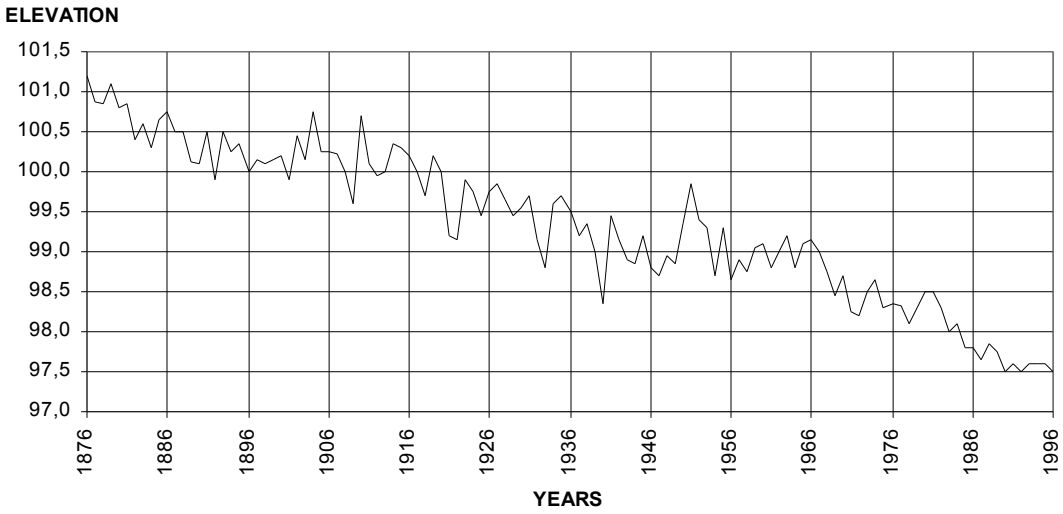

Figure 4. Annual low water levels on the water station Terezino polje.

3. Morphological changes on the river Sava

Similar hydromorphological process is evident on the river Sava, which is presented on a transfer zone reach. In the mid 70‘s significant water level changes were noted on a serial number of water ganges. During the period of 20 years (1970-1990), measurements of water levels showed permanent decrease of low, mean and also high water levels (Figure 5). Cross section area were also observed. A 20 year change is estimated according to cross section soundings (Kratofil, 2000).

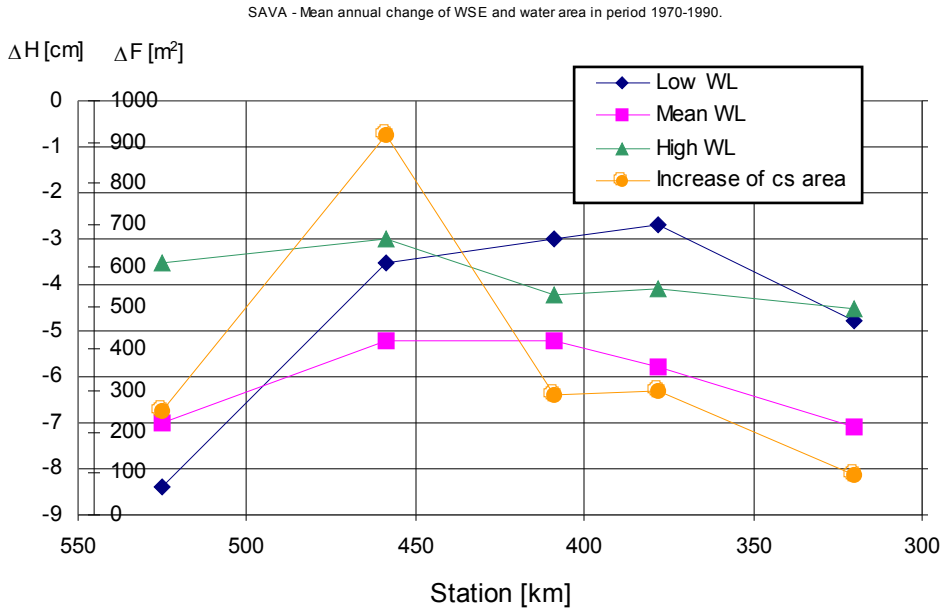

Table 5. Mean annual change of water levels and water area for the period 1970-1990.

Hydromorphological trends are explained by many hydrotechnical actions, mostly done in the 70’s and 80’s of the last century, whose main purposes were flood protection and partially the use of water for thermo and nuclear plant. The exploitation of construction materials (sand and gravel) from the river banks also made a significant influence.

To estimate the influence of each previously mentioned parameter on the water level decrease is very difficult. On one hand water levels are decreased due to the changes of water regime, and on the other due to the river bed degradation. This degradation is the consequence of the hydrological change or the commercial sand and gravel dredging.

For the 30 km long river reach, from Šamac to Županja, a hydraulic analysis was performed (Bekić, 2000). in the period of 20 years (1981-2000), cross section soundings were used in the analysis, and confirmed river bed degradation. Water surface elevations were calculated for different characteristic discharges (discharge duration 30%-95%). Relative water depths change dh.rel are presented in Figure 6. It can be pointed out that the river bed degradation has influenced water level decrease up to 20 %, which is absolute 37 cm for the 95% discharge duration.

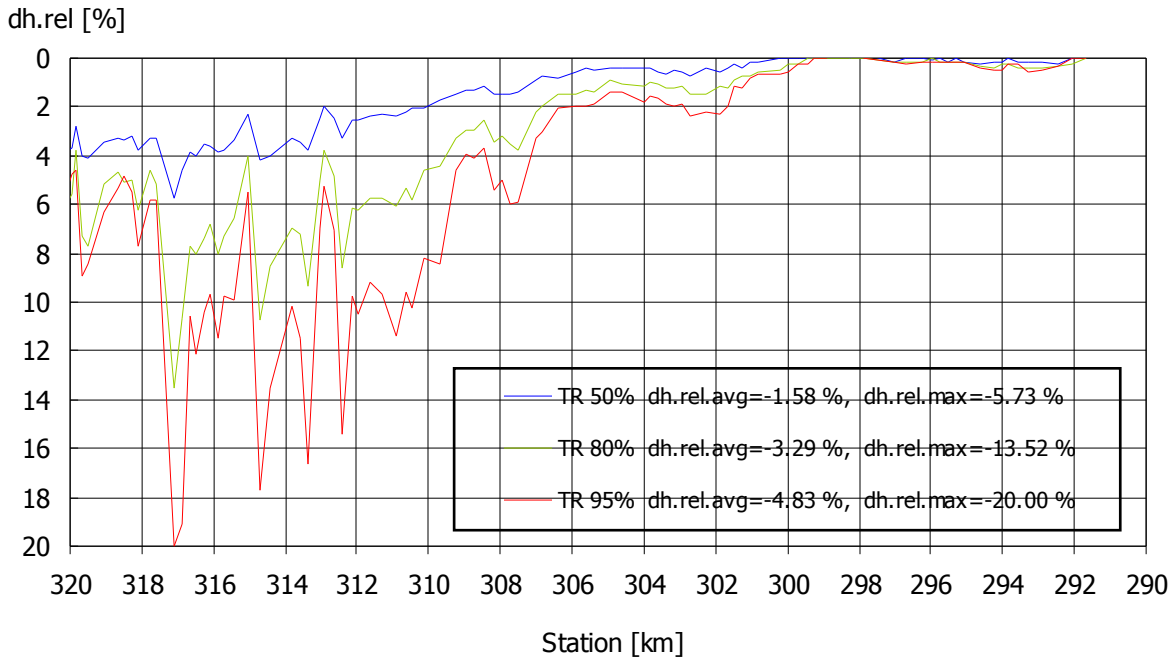

Figure 6. Relative water depth change of the river Sava section from Šamac to Županja.

4. Morphological changes on the river Danube

Morphological changes on the river Danube are presented on a 12 km long river reach from km.1412,0 to km.1396,8. To characterize morphological changes, cross section area under lowest elevation of navigation $F_{E.N.}$ was taken as a reference. According to the cross section soundings in the period 1964-1986, calculation of the cross section area change $\Delta F_{E.N.}$ was made (Figure 7). River state in 1986 was taken as a reference.

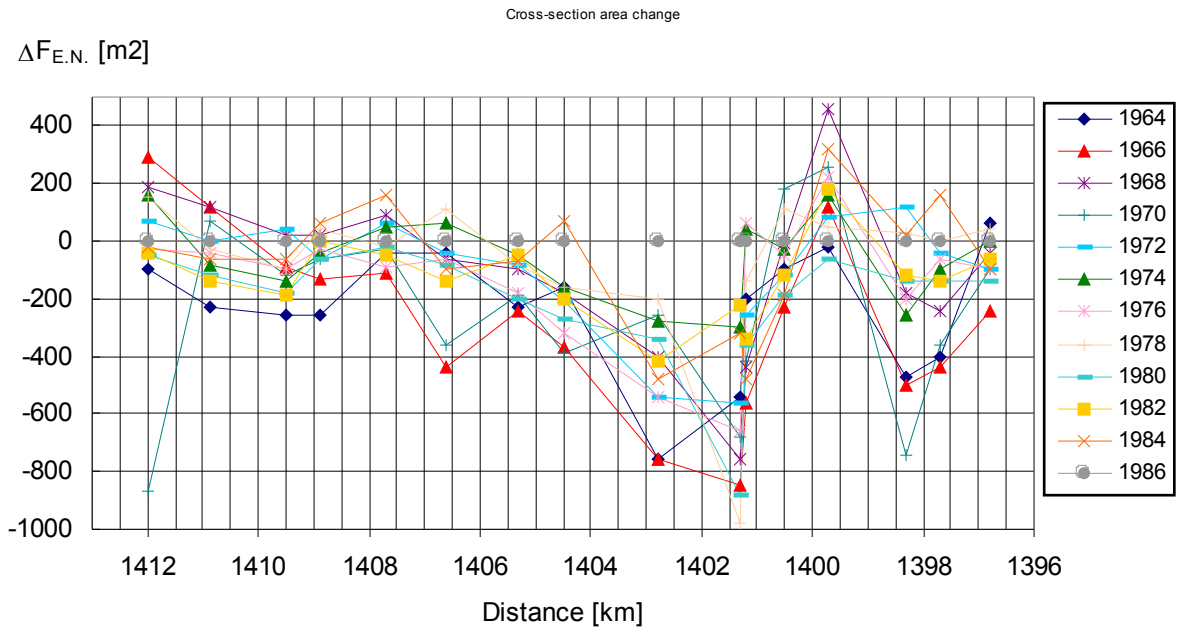

Figure 7. Annual cross section area change on the river Danube.

Various natural and human parameters influence river morphological state, and it is difficult to estimate the influence of each one. Furthermore, the period of 22 years is too short for the precise definition of causes of boundary deformations. Taking into account discharges of Danube and Drava in this period, it can be pointed out that major morphological changes occured in years with extremely high discharge of Danube (1965-1966). Major changes also occured in years with simultaneous apperance of mean dicharges of Danube and low discharges od Drava (1970, 1971, 1977), which is the case of high energy slope. Major morphological changes along analysed section occured in 1970, at the time of average discharges of Danube.

Morphological changes were also examined through another parameter - summarized cross section area changes for the whole river reach (Figure 8). In the early period (1964-1977) erosion process is evident, which is in accordance with previously constructed river regulation structures. Mean relative deformation od river bed $\Delta F/F$ is about +10% for the whole reach. Larger deformations ($\Delta F/F$=+20%) occured on sections with regulation structures, and counstructed weirs led to the expected erosion. Later (1977-1986), relative balance of changes was established. Amplitudes of deformations were smaller, and in a longitudinal sense, in the upsteam section depositing occured and eroding in the downstream section. Eroding processes occured on sections in accordance with constructed regulation structures (weirs).

Chronological analysis of cross sections indicates frequent morphological changes of the Danube boundary. According to the summarized deformations (Figure 8), eroding and depositing processes are commutating. Duration and occurance of processes are variable along the section, as well as amplitude variations. Thus, morphological changes trends in general cannot be noticed.

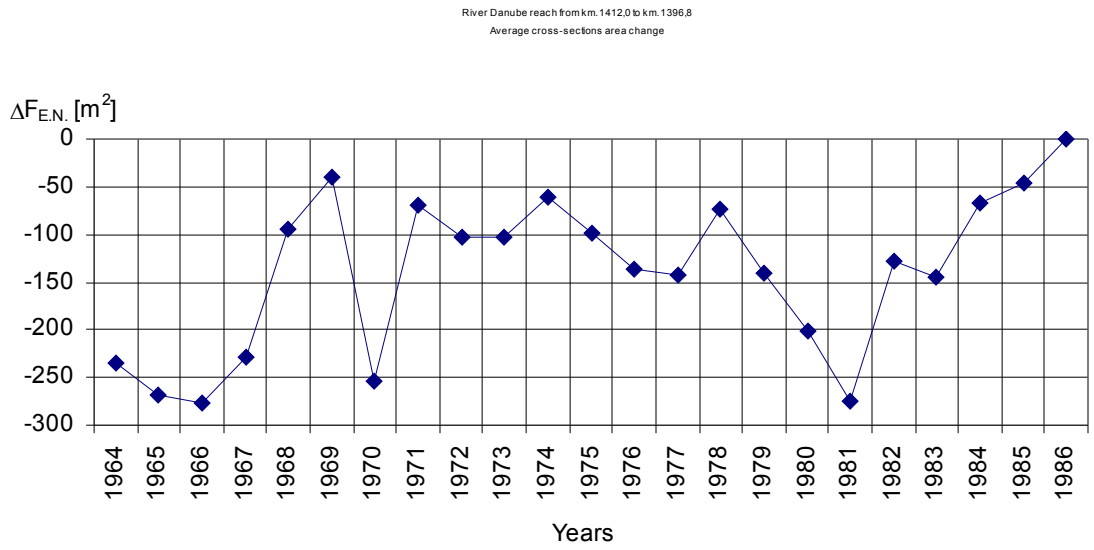

Figure 8. Chonological cross section area change for the whole reach from km.1412,0 to km.1396,8.

It can be pointed that deformations of the Danube boundary are natural process under the influence of hydrological, hydraulical and morphological parameters of the river. Major morphological deformations on the analysed Danube section are changes of the river width along the river reach.

5. Conclusion

Morphological changes, as a natural process, are evident on major Croatian rivers Sava, Drava and Danube. Their river banks are mostly stabile nowdays, although there are certain changes of banks on Danube. The most relevant morphological change on all three rivers is bed degradation, and as a consequence water level decrease. The dynamics of these changes correspond to the human influence on watercourses and their watershed. The changes cause difficulties in the expolitation of the rivers. There is a question of finality of these processes. It refers to the depth at which the boundary dynamic stability will be reached. Further issue is time needed for the reach of this dynamic stability.

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