Hydromorphology of Mures River (Romania, Hungary)

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1 Introduction

The EC Water Framework Directive (WFD) introduced hydromorphology as a necessary supporting quality element to assess the good status of surface water bodies. In the Danube River Basin Management Plan (DRBM) and the Joint Programme of Measures (JPM) of the ICPDR hydromorphological alterations are listed amongst the significant pressures (ICPDR 2009). The hydromorphological assessment is also one of the key elements in the Monitoring Networks to elaborate the final design of HMWBs (Heavily Modified Water Bodies). Hydromorphology is shaped by the hydrological regime and geomorphological processes and, hence, provides the basics for the habitat mosaic in riverine landscapes.

The hydromorphological conditions of almost 75% of all European rivers are impacted by man. Therefore, the EU countries are under pressure to prepare respective inventories and assessments. However, method development and surveys are still incomplete and, presently, in many CEE countries only so-called rapid risk assessments of hydromorphological characteristics exist.

Recent studies in the Lower Mura and Drava Rivers (Schwarz 2007, 2008) as well as along the Danube River (ICPDR 2008) exemplified the importance of continuous and harmonized assessments across the Danube River Basin (DRB) to support regional and transboundary river management. Our Mures investigation adds another IAD contribution to the long-term river development in the DRB (Schwarz 2010).

2 Approach and methods

The Mures River (largest tributary of the Tisza River, 760 km long, catchment area 28,000 km², mean discharge 180 m³/s, Sandu & Bloesch 2008) was investigated from its headwaters to the mouth by a CEN conform hydromorphological method (assessment of channel, banks and floodplains, CEN 2004). Field work by boat and on land was supported by excellent historical maps (beginning from 1780 with first Austrian Military Survey, Arcanum Edition Budapest) and high resolution satellite images (GoogleEarth 2005-2010). Moreover, recent literature (Schwarz 2007, 2008; ICPDR 2008; Sandu 2008) and WFD assessment (ICPDR 2009) were considered.

At the beginning, the historical data as well as the general geomorphological characterisation of the river result in a large-scale subdivision of the river in upper, middle and lower sections and respective main characteristics such as slope, channel geometry (planform – straight, braiding, meandering, and width variability), substrate as well as discharge. The river was further subdivided according to the status of channel, banks and floodplains, individually for right and left bank (the average length of segments is some 2 km with high variability from 250 m to some 18 km, according to significant changes). In total about 1,430 individual segments of channel, banks and floodplains were assessed and mapped (exemplified in Figure 1).

An access database was developed hosting the continuous survey data which can easily be connected to the GIS application showing the individual assessment values or even single parameters (e.g., in-channel features such as bars and islands).

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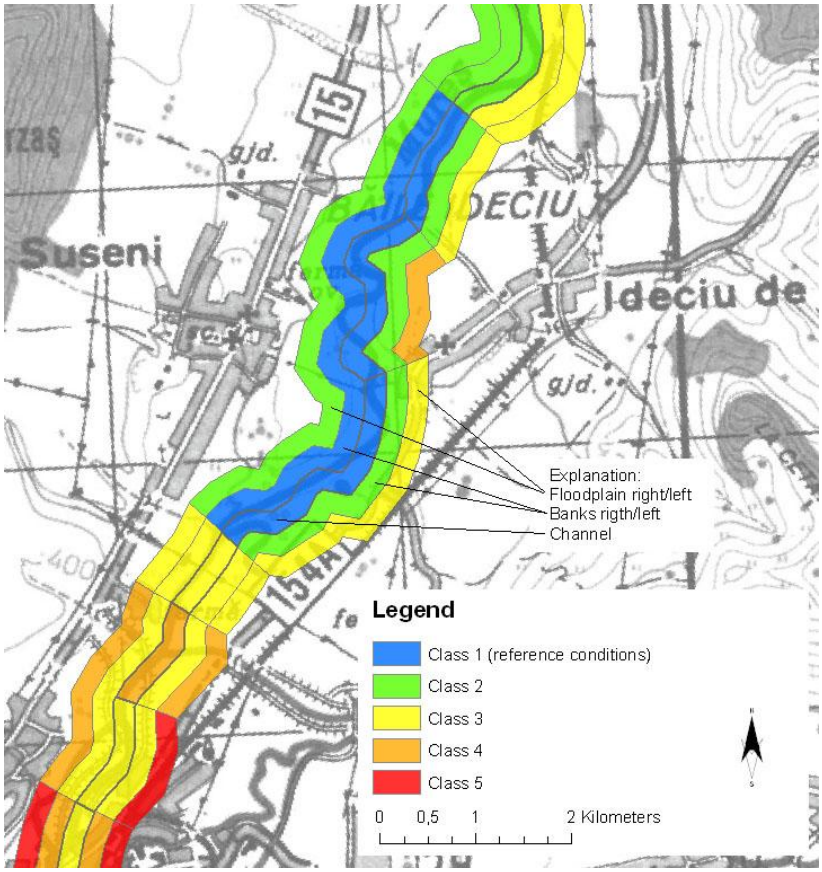

Figure 1. *Hydromorphology in a stretch of the Middle Mures River. Color ribbon visualisation for the assessment in five classes (described in detail in figs. 2-5). Maps for the whole river are given in Schwarz (2010).*

3 Results and discussion

Channel – The Mures is still a relatively natural (80% in class 1 and 2, Figure 2) and homogenous river (mostly meandering, only one mountain breakthrough in the upper catchment with short anabranching/braided reach). Only four dams influence water and sediment regime; however, the most important sediment recharging rivers such as the alpine Strei and tributaries as well as the very upper Aries are impacted by hydropower dams.

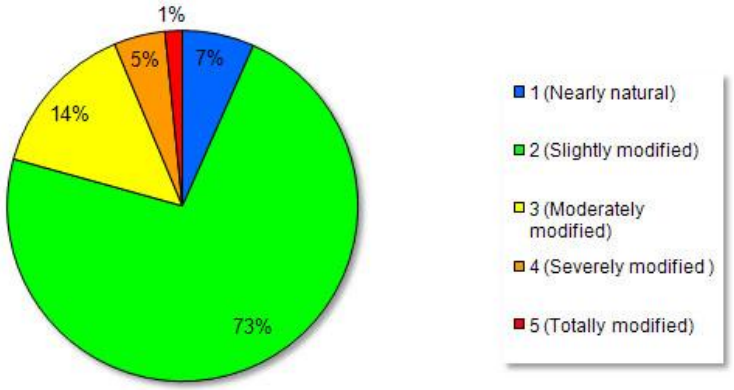

Figure 2. *Mures main course over 760 rkm: Channel assessment in five classes. The assessment classes 2-5 explain/illustrate the present status and indicate the deviation from class 1 (reference conditions). Strong impact on the channel amounts to 6% of the total length.*

The strongest hydromorphological alterations were found in stretches through towns (flood protection) and the straightened lower course (70 km in Hungary, navigation). Recent river regulation projects for flood protection are evident in the middle course (in total some 50 km). However, the strongest impact is by far commercial sediment extraction along the middle and lower sections (e.g. between Arad and Lipova (50 rkm) 11 mining sites in the main channel); this potentially favours channel incision, which is under-represented in the assessment due to still near-natural planform (sinuous and meandering channels with gravel bars). Historical analysis calculating former river length (sinuosity), width variability, bars and islands with pioneer habitats indicates a rather limited lateral shift of main channels in the middle still meandering course and a decline of fluvial dynamics since the beginning of 20th century.

Banks – The river banks are enforced in Hungary as well as downstream of the Mures Nature Park west of the city of Arad in Romania. But also along steep banks meanders are protected where infrastructure is nearby (railway, road, flood protection dike) leading to uniform banks on the entire middle course of the river (and obviously in town stretches). In total there are still remaining variable banks typical for meandering rivers with steep banks and point bar banks indicated by the occurrence of class one and two (43%, Figure 3). During the survey several new river engineering projects (river regulation, flood protection) along the middle course were observed intensifying the pressure on the system. Such measures should be restricted to absolutely necessary stretches (only constructing on right or left bank, not the whole channel and banks); compensation measures should provide substantial improvements (e.g., channel widening and lateral connectivity) in close vicinity of these impacts.

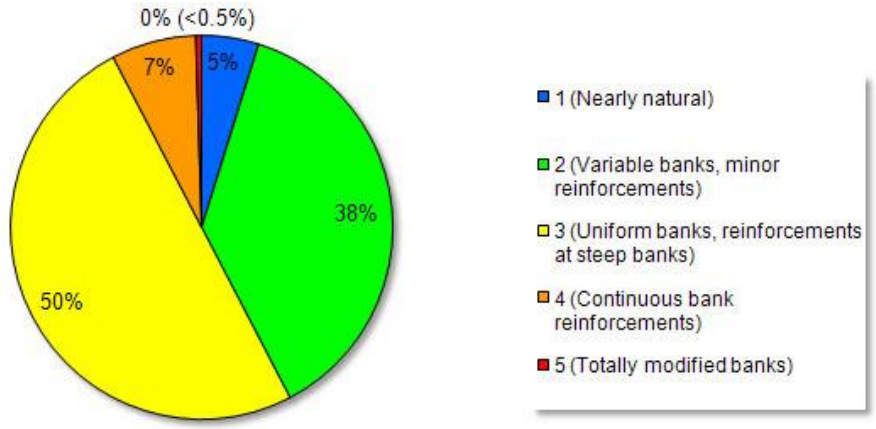

Figure 3. *Mures main course over 760 rkm: Bank assessment in five classes. Strong impact on the banks amounts to 7% of the total length.*

Floodplains – Larger forested floodplain areas have nearly disappeard; however, significant parts of the remaining floodplain are pastures (particularly in the middle course). The loss of floodplains amounts to some 67% (morphological floodplain area is 213,920 ha, remaining active floodplain is 70,660 ha, Figure 4) which is much less than for the Danube River with 72-95% (Schneider 2002). Main reason for the loss was the construction of floodprotection dikes along the lower 100 km of the river partially in Romania but mainly in Hungary. The hydromorphological situation of floodplains should be subject of further research. Although fine sediments accumulate, the channel deepens (mainly due to gravel over-exploitation) and floodplains gradually dry out. Sediment supply is diminished as the still meandering river has no major lateral erosion due to bank protection and, hence, incision is significantly increased. In total (18%) there are still many remnants, paleochannels and oxbows in the floodplains which should be subject of protection and restoration. However, compared with the historical situation the ecological potential and hydromorphological dynamics of the active floodplain is strongly reduced. The still remaining floodplains should be used as pasture (keeping where ever possible the current level of grazing) and the connectivity between river and floodplain should be improved.

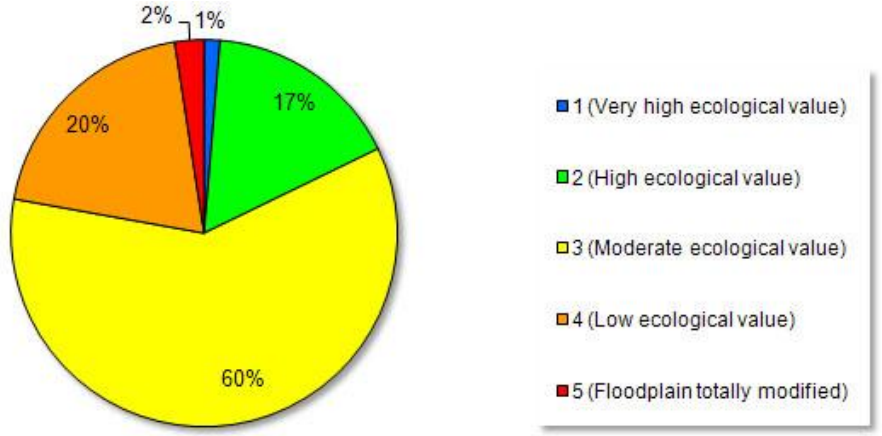

Figure 4. *Mures main course over 760 rkm: Floodplain assessment in five classes. Strong impact on the floodplains amounts to 22% of the total length.*

Overall hydromorphological assessment – In total only 9% of the river are strongly altered (Figure 5, corresponding WFD class 4 and 5), 45% are moderately changed (class 3) and 46% are in good or near natural condition (class 1 and 2).

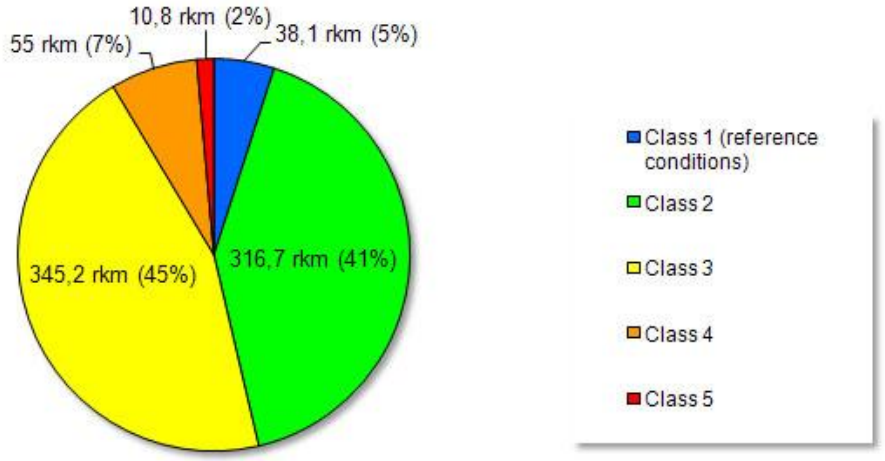

Figure 5. *Mures main course over 760 rkm: Overall total hydromorphological assessment in five classes (mean of channel, banks and floodplain evaluation) coloured in WFD classification scheme.*

The overall assessment indicates the rather good hydromorphological status for half of the river and the still minor part of artificial sections (only 10%) which is an impressive low value compared with many western European rivers. However, the slow degradation of the whole river system, evident through the assessments of banks and floodplains, is mostly driven by gravel over-exploitation and, hence, unbalanced sediment budget.

4 Outlook and conclusions

With our survey and maps (Schwarz 2010) we have successfully applied European methods for the hydromorphological assessment for a large river in Romania. This allows the inter-comparability of assessments by other countries. Since natural and anthropogenic changes are a permanent process we propose to update the assessment every six years, but in many cases it would be sufficient to analyse only selected stretches or even single parameters after restoration measures or respective impacts. The long-term development of the river can be well assessed based on historical records and the derived reverence conditions.

For the Mures River, the situation presents as follows:

- The river still hosts some near-natural stretches with highest protection priority. In this respect, soft eco-tourism could help to sustain the local people.
- Larger stretches still have typical meandering characteristics that need to be protected, in the long term, by adequate spatial planning. The Hungarian stretch, protected by Natura2000, has a great potential for river and floodplain restoration.
- In general, we find a sustainable river and floodplain use; however, local anthropogenic impacts cannot be overlooked (few existing dams and ramps as well as intensive river regulation work within settlements and along infrastructure).
- Infrastructure concepts like the construction of a highway through the lower Mures valley, new hydropower plants as well as development of settlements and infrastructure are the most important future threats for the riparian landscape.
- Excessive gravel mining is currently the most negative factor impacting the sediment household of the river; in addition, sediment supply from tributaries is reduced by reservoirs.
- The CEN assessment does not respect appropriately the intensive sediment extraction and the complex reaction of the channel/substrate and banks. Hence, gravel extraction causing channel incision must be considered much better in hydromorphological inventories.
- Sustainable sediment management in gravel bed rivers (including tributaries) is highly recommended. Erosion and accumulation of sediments are important functions of the riverine ecosystem and influence flood protection to a great extent.

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