The Maros / Mures

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River Maros/Mureş is the fourth largest waterflow of the Carpathian Basin after the Danube, Tisa and the Dravarivers. The alluvial fan of the river is among the most extensive geographical units of the region. The river itself has a high energy and changes quickly, thus the understanding of actual processes requires compound investigations.

Before we start to introduce in detail the past, present and expectable evolution of the lowland section of the river it is important to get an overview on the characteristics of its catchment, its hydrology and the most significant human impacts on the basis of the available literature.

The Maros/Mureş is the most significant tributary of River Tisza/Tisa. It drains the water of the Transylvanian Basin into the direction of the Hungarian Great Plains (Fig. 1). Its total length is 769 km, while its so called lowland section from Lipova to Szeged is 175 km. It forms the border between Romania and Hungary on a 22 km section between Nădlac and Apátfalva. From the remaining length 122 km goes for Romania and 28 km for Hungary.

Fig. 1. – page 10

The catchment of the Maros/Mureș

The area of the Maros/Mures catchment is approximately 30 000 km^2, comprising this way one fifth of the entire Tisza/Tisa catchment. The Maros/Mureş watershed is situated mostly in Romania (92%). In terms of its shape it can be divided into two parts (Laczay 1975). The upstream part is rectangular (250x100 km), while the downstream section starting from Deva is elongated (200x30km) (Fig. 2). This feature slightly tempers the ferocity of floods arriving from the mountainous sections, as flood waves flatten when they pass through the long lowland section without significant tributaries (Boga and Nováky 1986). Still, the discharge of the river can be regarded highly fluctuating.

The most elevated point of the catchment is the 2511 m high Peleaga Peak (Retezat Mountains), while the lowest point is at 81 m at the outlet of the river near Szeged

(Boga and Nováky 1986). The two sources of the Maros/Mureş is located on the western slopes of the Hăşmaş Mountains near Izvorul Mureşului at a height of 850 m and 1350 m (Fig. 2).

Fig. 2. – page 11

From the source to the outlet the river can be divided into four different sections on the basis of slope conditions. The almost 110 km Upper Maros/Mureş passes the Giurgeului Basin (Fig. 3/A and 3/B) then it breaks through the Toplița-Deda gorge in between the Căliman and Gurghiu Mountains (Fig. 3/C), built up mostly by volcanic rocks. The slope of this section is very high: in average 370 cm/km (Török 1977).

The next reach between Deda and Alba Julia is the so called Middle Maros/Mures, which has a length of around 260 km. The river passes the Transilvanian Plain, the forelands of the Gurghiu Mountains and the Târnava Hills (Fig. 3/D). Here it flows in a valley as wide as 15 km at certain sections (Fig 3/E and 3/F). This area is built up mostly by sedimentary rocks, average slope is 50 cm/km.

The 225 km long Lower Maros/Mures is stretching between Alba Julia and Lipova along a tectonic fault line separating the Apuseni Mountains and the Southern Carpathians (Fig. 3/G and 3/H). On its way here slope decreases to 30 cm/km. The Lowland Maros/Mures reaches from Lipova (Lippa) to the outlet, has a length of 172 km and a slope of 20 cm/km.

Fig. 3. – page 13

Based on borehole data the Maros/Mureş had started to build its alluvial fan in the Pliocene, some 3–3.5 million years ago (Borsy 1989). During the Quaternary the so called Ancient Maros/Mureş changed its direction frequently and deposited several hundreds of meters of sediment in the unevenly sinking area of the southern Great Plains. The alternation of glacial and interglacial periods determined the quantity of water drained and the amount and type of sediment transported by the river. During the dry and cold glacials low mean discharges and coarse sediments were characteristic as a result of lower precipitation and increased physical weathering. In the meantime warmer and wetter interglacial periods favoured chemical weathering and beside larger discharges the transportation of fine grain sediments increased (Andó 2002). The river has developed dynamically throughout the Pleistocene and in the past 10 000 years of the Holocene period as well, which is reflected by a great number of abandoned paleochannels (Fig. 4).

Fig. 4. – page 15

The hydrological characteristics of the river

The Maros/Mureş and its tributaries are mostly fed by precipitation and overland flow. Due to the geology of the catchment (overwhelmingly volcanic and crystalline rocks) and the high proportion of very steep slopes floods rise relatively quickly, and last for only a short time. Based on the analysis of almost 500 smaller and larger flood waves, peak stages are reached in less than 10 days at Makó, and the passing of flood waves is also fast. Long lasting inundations can only be observed downstream of Makó due to the impounding effect of the Tisza/Tisa.

Since the second half of the 19th century, hydrological measurements have been continuous on the Maros/Mureş. For example daily water level measurements at the Makó and Arad station date back as far as the 1870s (Fig. 5). Stage data are measured from the "0" point of fluvio-meters, which were set to the level of the lowest water observed prior to the start of regular measurements. Later due to the decrease of water levels, as a matter of incision, negative values have also appeared in the records.

Fig. 5. – page 16

Two major floods may develop annually on the river. The first is due to snowmelt in early spring, the second is caused by early summer rainfall usually in June. Boga and Nováky (1986) have demonstrated that the maximum water delivery is characteristic in April (15% of the total amount of water). The greatest flood on record ocurred in 1970 with a peak discharge of 2210 and 2420 m^3/s at Arad and Makó, respectively. The flood caused severe problems on the entire river. Its development was related to heavy spring rainfalls on the mountainous catchment which led to simultaneous snowmelt and thus torrent floods on the tributaries of the Maros/Mureş (Lucaciu 2006). After 1970 significant floods occurred in 1974, 1975, 1981, 1998, 2000 and 2006, thus the recurrence of major flood events is between 5 to 15 years.

Following the April-June floods the rest of the year is characterized by low stages (Fig. 6). The so called low water period lasts approximately 10 months starting in June and terminating in next March, with a minimum water delivery at October (Boga and Nováky 1986). The lowest stage on record was observed during September 2012, -109 cm at Makó equalling a discharge around 30 m^3/s. The decreasing tendency of values during the past 20 years is partly due to climatic changes and increasing reservoir capacity on the tributaries in the upland catchment (Konecsny and Bálint 2009). Recently, incision can also have an effect on water level decrease, however, based on more than 100 low water cross sections taken at Makó between 1987 and 2004, no change could be detected in the level of the riverbed (Sipos 2006).

Fig. 6. – page 18

Compared to other rivers in the region the Maros/Mureş transports a huge amount of sediment. The mean discharge of suspended load is 263 kg/s (8 300 000 t/y). In the meantime the volume of bed load is 0.9 kg/s (28 000 t/y) (Bogárdi 1974). The amount of the annually transported suspended load is almost equal to the values of the Tisza upstream of the Maros/Mureş estuary, while in terms of bed load the river carries as much as the Danube at Nagymaros (Fig. 7).

Fig. 7. – page 19

Human impacts from among the human interventions on the lowland section of River Maros/Mureş, inevitably the regulation works of the 19th c. were the most significant. The Maros/Mureş was the most important commercial and cultural link between Transylvania and the Great Plains. However, sudden and devastating floods and intensive channel development had raised the need of uniform river regulations to protect settlements and agricultural lands. The works had been started gradually from the middle of the 19th c. according to the most up-to-date principles of the time, unfortunately works could never be entirely completed.

In its natural state, just like other rivers of the Great Plains the Maros/Mureş had sustained and year by year flooded an extensive marshland, interlaced by numerous side channels of the river (Tóth 1993, 2000, Somogyi 2000, Ihrig 1973). The wilderness of the area was increasing during the Turkish occupation: previously cultivated lands were left behind and most of the settlements were devastated (Tóth 1993, Somogyi 2000). Among these circumstances shipping and the economic use of the river could not improve (Laczay 1975)

Following the withdrawal of the Turks, life returned to the river only by the middle of the 18th c. (Tóth 1993, Andó 2002). In this period people made their living primarily by utilising the water covered, swampy land for animal breeding, logging and fishing). In the meantime, salt and timber transportation from Transylvania increased continuously. As time passed, however, the improvement of agriculture became indispensable. This and increasing commercial activity induced the first organised efforts for river management (Fig. 8). The same situation was apparent on other rivers as well. Finally, extensive efforts resulted the protection of 21 200 km^2 land on the Great Plains and also the irreversible transformation of the landscape (Dunka et al. 1996).

Fig. 8. – page 21

The regulation of the lowland section of the Maros/Mureş had started with levee construction and the blocking of side channels in order to prevent extensive flooding (Török 1977). The place and track of levees still reflect an important character of the regulation work, namely flood control usually preceded cut-offs and channel training. Consequently, in most of the cases, levees follow the bank lines of original, pre-regulation meanders (Ihrig 1973).

The training of the main river channel also started in the middle of the 18th c., however, interventions were usually local and meant the cut-off of a single meander. From the middle of the 19th c. more extensive and uniform works started (Fig. 9 and 10), but these were time to time hindered by the conflicting interests of municipalities and landlords (Tóth 1993). By the late 19th c., however, 33 cut-offs were completed between Lipova and Szeged (Fig. 11), which resulted that the originally 260 km lowland section was shortened to 170 km (Laczay 1975, Török 1977). The effect of cut-offs was positive in terms of flood prevention as water drainage became faster. The towns of Arad and Makó were relieved of flood hazard. Besides, due to the drastic decrease in length, the slope of the Maros/Mureș doubled (from 14 cm/km up to 28 cm/km) and the river incised at certain sections nearly 1 m (Laczay 1975). Simultaneously the energy of the river also increased, which lead to bank erosion and at the apparent sediment transport rate to the development of large sand bars. These conditions made navigation, a major reason for the regulations, almost impossible (Gillyén 1912).

Fig. 9. – page 23
Fig. 10. – page 24
Fig. 11. – page 25

The stabilisation of the channel and the riverbanks started in the late 19th c., with the aim of facilitating shipping. In this period twice as many boats, and twice as much cargo arrived at Szeged on the Maros/Mureș than on the Tisza/Tisa. Therefore, the initiation of steam shipping was also among the plans (Tóth 2002). Works were started on the Conop–Arad section in 1865. On concave banks stone revetments were applied, on convex banks brushwood groins were installed (Fig. 12). Motivated by the success of the Conop-Arad project and the problems of navigation on downstream sections works were continued on the Makó-Szeged reach. Here, in the lack of stone mostly brushwood was used for the stabilisation of the banks (Bogdánfy 1906). The next plan was to extend bank stabilisation to sections downstream of Arad (Gillyén 1912). Works had been started in 1912 (Török 1977), however, the construction could not be finished as World War I. broke out.

Fig. 12. – page 26

Regulation works were partially restarted only after World War II. In the 1950s and 1960s the Makó-Szeged section was finalised by using stone structures. Meanwhile on the Romanian and the joint Romanian-Hungarian section only small and local measures were implemented, uniform and complex river training seems to be out of reach for a long time (Fig. 13). Consequently, the river can almost freely develop between Pecica and Makó, while upstream of Arad it flows in a quasi artificial channel as a result of intensive mining. Unmanaged river reaches, such as the border section, nevertheless ,provide the means of studying quasi natural processes and the long term reaction of the river to human interventions.

Fig. 13. – page 27

The most important human impacts recently have been reservoir construction on the upland reaches and gravel and sand extraction on the lowland sections. Reservoir construction started in the early 1980s. At present the total water storage capacity equals 700 million m^3 from which 300 million m^3 can be used for permanent storage and flow control (Konecsnyi and Bálint 2009). This quantity is substantial if we consider that the mean annual flow volume of the Maros/Mureş is 5800 million m^3 at Arad. As a result in average years 5%, in low water years 10% of the total discharge can be retained (Konecsnyi and Bálint 2009). As a comparison the total annual water consumption of Hungary and Romania is 5500 and 7300 million m^3, respectively (OECD 2002). Although water release is almost continuous from reservoirs, as the largest ones are used for hydropower generation, water storage has an inevitable role in the decreasing discharges of Maros/Mureş. Besides, during the peak operation of stations small flood waves appear on the river, significantly affecting the low water regime. The largest structures are located on the Strei and Sebeş (Fig. 14), but there are several smaller ones on the Arieş and Târnave. The thermal power stations of Iernut and Deva-Mintia also utilize a significant amount of water, but it is drained back to the river (Konecsnyi and Bálint 2009).

Fig. 14. – page 28
Fig. 15. – page 29

Gravel and sand has been extracted from the river for a long time, however in the past decade the volume of mining increased significantly. For example in 2011 on the Romanian section 920 000 m^3 of sand and gravel were extracted from the river officially (SGA Arad 2012). On the Hungarian section an additional 100 000 m^3 is removed (MBFH Szolnok 2012). The activity is the most intensive on the Pauliş-Mândruloc section, where both the banks and the channel itself are practically mined away (Fig. 15). The possible results of these interventions are not fully explored yet. It is important therefore to investigate the response of the river to different types of human impact. This may also help to develop best practices to monitor the long term development of the Maros/Mureş in order to aid sustainable river management.

Conclusions

In this section we have reviewed the available information on the hydrogeographical and hydrological characteristics of the Maros/Mureş river and its catchment. We also took a glance on the most important human interventions affecting the river. Based on these information the following brief conclusions can be made:

- The river has a high slope even on its lowland sections, which provides a considerable energy for fluvial processes.
- The alluvial fan of the Maros/Mureş also reflects an intensive fluvial development in the past, which was controlled by climatic and tectonic processes. However, the chronology and the dynamics of its evolution have not been resolved yet.
- The discharge of the river is highly variable. The largest floods are caused by the sudden melting of winter precipitation. Low water periods are long lasting. Unfortunately it is not known how hydrology will be affected by climate change in the future.
- The Maros/Mureş delivers a great amount of sandy, gravely sediment, which is of high economic value, but the sediment budget and its short term change has not been assessed so far.
- 19th century regulations changed considerably the morphology of the river. The most obvious consequences of interventions were incision and widening at certain sections. However, the long term morphological responses of the lowland section have not been studied before.
- Present day human impacts can have a significant role in determining the hydrology and morphology of the river, but the detection and modelling of changes need a complex monitoring strategy.

Although there are valuable earlier studies in relation with the river, numerous questions concerning its past, present and future are still unanswered. The assessment of these is only possible by the means of the most up-to date methods. In the next chapters we will attempt to give an insight how we addressed the above mentioned issues in the framework of our scientific research project.

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