The ever changing river

György Sipos, Tamás Právetz, Orsolya Katona, Florina Ardelean, Fabian Timofte, Alexandru Onaca, Tímea Kiss, Ferenc Kovács, Zalán Tobak

River Maros/Mureş has been active not only in the past, but it is still one of the most dynamically changing rivers of the Carpathian Basin. No wonder, since it has a huge sediment load, its slope is relatively high and floods are fierce even on its lowland sections. The Maros/Mureş is one of the most important natural resources of the region. Its water maintains natural habitats and agriculture, the gravel and sand extracted from its channel are important building materials, furthermore, it has got outstanding natural values. People have always intended to make an economic use of the river, but usually have not considered the long term consequences. This happened during the regulations in the 19th century and currently as well, when the river is subjected to intensive mining (Fig. 1).

What factors do determine the recent development of the river? How has it responded to the different human interventions? What changes characterise its channel in the short and long runs? In this phase of the research we were mainly looking for the answers of these questions. The investigations were focused on the 175 km long lowland reach of the river. However, at four representative sections channel development was monitored by regular surveys. Based on our research results, expectable future changes and key points of intervention can be determined to support sustainable river management. Besides, the fundaments of a multi-stage, long-term monitoring activity were laid down, which can provide further data for management and planning.

Fig. 1. – page 66

Methods

The most straightforward way to monitor river evolution and river response to human interventions is to analyse maps and aerial photographs. Sometimes the spatial and temporal resolution of these data sources is not adequate to reconstruct changes in detail, but they are definitely suitable for studying longer term tendencies (Laczay 1982, Hooke 1995, Lóczy et al. 2012).

With the help of maps, aerial photographs and satellite images the history of the Maros/Mureş channel could be investigated in the perspective of 180 years. We aimed to collect all available data sources from each date possible (Table 1). The earliest maps which could be used for partial reconstruction date back to 1829. However, the maps of the Second Military Survey, made in the 1860s, were chosen to be the uniform starting point. These maps have several advantages: they are fairly precise, pre-regulation meanders can be identified on them easily and they are available for the whole Lipova–Szeged section. Unfortunately, concerning further data sources only the latest satellite images from 2005 and 2006 are accessible also for the entire section. In many cases maps are not detailed enough for precise analysis, and measurements can be better done by using aerial photos and satellite images (Sipos 2006). The earliest available aerial photos for the Romanian section are from 2005, however, the common border section and the Hungarian section has been photographed in every decade from 1950. Thus, the most detailed evaluations were carried out mainly on these sections (Fig. 2). Nevertheless, there were so intensive changes on the Romanian section in the last 50 years that less detailed maps were still adequate for the analysis.

Finally, data sources were available from 6 and 13 dates for the Romanian and Hungarian sections, respectively (Table 1). Data were integrated into a uniform geoinformatical system, i.e. maps and photos were georeferenced. During the analysis the changes of bank line, centre line, channel width and the area of islands were investigated. By the help of these measurements it is possible to reveal the dynamics of the river at different sections, and conclusions can be drawn in terms of the direction of future changes.

Fig. 2. – page 69

The geocorrection of the aerial photos and satellite images were made by ERDAS Imagine 8.6 and ArcGIS 9.3 softwares. Topographical maps from the early 1980s were applied as reference maps on both the Romanian and Hungarian sections. The maps were of 1:25 000 and a 1:10 000 scale, respectively (Fig. 2). Aerial photos and all historical maps were geocorrected to these map series. The precision of certain data sources (Table 1) were calculated by the deviation of well-identifiable fix points, on both the base maps and the other data sources (e.g. road intersections, corners of buildings).

As a next step key features were vectorised by using ArcView 3.2 and ArcGIS 9.3 softwares. Data were then transformed into the same projection system (UTM34) for enabling the joint analysis and management of Romanian and Hungarian data. River development could be assessed by overlaying these layers and quantifying differences.

Table 1. – page 71

People living near the Maros/Mureş know quite well that the channel of the river changes rapidly. Sand bars emerge at different locations year-by-year and their form is also changing. The reasons for such dynamic processes are the significant amount of sediment and the vast energy of the river (Fiala et al. 2007, Sipos et al. 2008).

The bedload of the river, composed of sand and fine gravel, is a widely renowned building material in the region, and used extensively in both countries. The supply is seemingly continuous: pits created during the extraction of the sediment are filled up quickly during the next flood. It is a question however, how much sediment can be removed from the channel without further consequences, and what changes can be induced by the visible overexploitation? The answer to these questions is not simple; it requires the continuous surveying of the river channel and the monitoring of the sediment load. These conditions are not met in case of the Maros/Mureş, that is why we consider the investigations below very important.

The most intensive quarrying activity on the lowland section of the river is apparent just upstream of Arad (Fig. 1). The location of study sites (Lipova–Arad–Pecica–Apátfalva) were chosen in order to be able to assess channel processes and changes of the annual sediment budget upstream and downstream of the mining activity (Fig. 3). The length of each site was around 2 km, they were similar in having a wide and shallow so called riffle section and two adjacent deeper, pool sections upstream and downstream (Fig. 4). The surveys were made with the help of professionals and equipments of the Lower-Tisza Water Directorate. During the project time 4 measurement campaigns could be carried out, at Apátfalva further two surveys were made. The mapping of the channel was made either by motorboat or by wading but always along the same cross sections to ensure the comparability of data and results.

Using the above method only the annual changes of the sediment household, or changes related to one flood event can be assessed. The estimation of short term sediment transport requires a different approach. Traditionally, measurements are made with sediment traps placed on the surface of the riverbed (Kiss et al. 2008). In the present research an attempt was made to monitor short-term sediment transport by performing frequent cross-sectional surveys. The investigations were made at the Makó gauging station along a fixed steel wire, occasionally in 5 minute intervals (Fig. 5).

Fig. 3. – page 73
Fig. 4. – page 74
Fig. 5. – page 75

The spacing of cross-sections at the study sites was in average 40 m, i.e. less than the half of the width of the river (100–150 m) (Fig. 4). Longitudinal sections were also measured during the investigations. The route of the first survey was folllowed during further measurements, tracking was accomplished using a Trimble Juno GPS, having a 2–5 m accuracy. Measurements were made both at high water (June 2011 and 2012) and at low water (September 2011 and October 2012). During high water surveys mapping was made with the help of a motorboat and using an ADCP RioGrande current meter and a river bed profiler (Fig. 6). The operational characteristics of ADCP is described in detail by Goda and Krikovszky (2002). The exact measurement track and the absolute height of the water level were recorded by a Topcon Hyper Pro differential GPS having a cm range accuracy in both horizontal and vertical terms. At low water, however, sand bars emerged and parts of the river bed got over the water level. These areas were surveyed by a Sokkia Set650rx total station, the exact position and altitude of which was also determined by the differential GPS, thus measurements on water and dryland could be coupled (Fig. 6).

Since the investigations were carried out on both Romanian and Hungarian river sections, the GPS data were uniformly transformed to UTM, while height values were determined with reference to the WGS 84 ellipsoid. From the surveyed data digital elevation models (DEM) were made by using software ArcGIS 9.3. Interpolation was made by kriging at a spatial resolution of 2 m. DEMs were then subtracted to determine the amount of volume change. During the analysis survey to survey change, i.e. net sediment volume difference, aand the sum of erosion and accumulation, i.e. total or absolute sediment volume difference were calculated and normalised to 1 river kilometer. In order to determine the amount of the total error related to different measurement equipments, GPS tracking and digital terrain modelling a 500 m river section was measured twice within a few hours at low water. Based on the comparison, approximatelly 1000 m^3 measurement error was estimated for a one km section.

The measurement of short term bedload transport was carried out at the Makó gauging station by the help of a GSSI ground penetrating radar equipped with a 200 MHz antenna and an ADCP StreamPro, both mounted on a plastic boat (Fig. 5 and 6). The entire cross section was surveyed in every 30 minutes, while the 30 m wide thalweg was assessed in 10 minute intervals. The ground penetrating radar enabled high accuracy measurements, from which the changes in cross sectional area could be precisely calculated. With the help of the ADCP the movement of river bottom could also be measured. The amount of bedload moving through the cross-section in unit time was estimated by combining these two methods. The measurements, however, need to be calibrated by traditional sediment traps in the future.

Fig. 6. – page 77

Results

180 year evolution

In its pre-regulation state the lowland section of the Maros/Mureş could be divided into 10 units on the basis of flow-direction and the degree of meandering. These units had different channel pattern and dynamics (Fig. 7). On the 175 km lowland reach 5 very active sections, affected by sudden slope change, can be identified. This can be important from the aspect that on these areas increased channel dynamics can be suspected at present and also in the future.

The first very active section could be identified between Pauliş and Mândruloc. Bifurcating channels, sand bars and islands marked the border of the upland and lowland zones, where the slope of the river decreased suddenly (Fig. 7).

Between Mândruloc and Arad the river developed mild bends indicating lower slope and less energy. Going downstream, mature meanders appeared again, some of them were asymmetric and over-developed, signing slope change and the eastern edge of the Battonya High (Fig. 7). A little more downstream, between Zădăreni and Pecica, evenly spaced, stable and well developed bends appeared.

The third very active section can be found downstream of Pecica (Fig. 7), here meanders were congested and signed the western edge of the uplift zone. The river compensated slope increase by growing large meanders. Between Semlac and Nădlac the Maros/Mureş changed its direction and followed a fault line (Laczay 1975). Mostly braided features could be identified here, bends were slightly developed and the river course was fairly stable. The same was true for the Nădlac–Cenad section, but bends were more mature.

The fourth section with increased energy and activity could be identified between Cenad and Makó (Fig. 7). This zone developed as that the river reached the edge of its alluvial fan, where slope and energy increased again. Forms were similar to those near Pauliş and Mandruloc. Downstream of Makó, well developed mature bends were characteristic, but near the estuary several distorted meanders could be identified. These developed as a matter of very moderate slope conditions (Fig. 7).

Fig. 7. – page 79

Concerning the Semlac–Szeged section we found that on the basis of 1829 and 1865 maps the difference in the values of certain horizontal parameters reached as much as 8–10%, due to natural cut-offs and meander development (Sipos 2006). This can be taken as the natural variability of the river in the investigated 30–40 year time span.

Forms and processes were significantly changed however by river regulations in the 19th century. Channel slope and energy increased considerably, which lead to erosion and channel widening at several locations (Török 1977). Sections which were stabilised later in the 20th century by revetments, such as reaches downstream of Lipova, near Arad, Pecica, and downstream of Makó have changed only a little in the past 50 years. However, there were some sections which faced considerable changes after the regulations. Especially those areas developed dynamically where banks were not stabilised and channel activity was high before the regulations as well (Fig. 8).

Fig. 8. – page 80

A very good example for accelerated change is the section between Păuliș and Mândruloc (Fig. 8). On this section cut-offs and regulation resulted a considerable, 30% loss in river length (from 25.5 km to 18.6 km). The Maros/Mureş gave a sensitive answer to human intervention and started to develop new meanders, first at a higher pace, then by the 1980s the process slowed down (Fig. 8). In the past 30 years the rate of change doubled, and between 1980 and 2006 the length of the Păuliș–Mândruloc reach increased from 20.9 to 23.1 km, equalling a nearly 100 m annual length growth. The acceleration of meander development can clearly be related to intensive in channel mining and consequently increasing bank erosion. At certain sections artificial diversion also contributed to length increase. The present length of the river has not reached pre-regulation values, thus further erosion can be suspected in the future, which can mostly endanger the village of Mândruloc.

Increased fluvial activity could be identified on the Pecica–Semlac section as well (Fig. 9), however here the most dramatic changes occurred rather between the regulations and the 1950s. In its natural state the section was 29.1 km, then its length was reduced by more than 50% to 13.9 km. Meander formation started here as well, but mostly downstream of Pecica where the river was less controlled (Fig. 9). By the 1950s river length grew to 19.3 km, which meant more than a 100 m annual length increase. Since then changes only affected the reactivating meandering zone, where one of the meanders by now is close to a natural cut-off (Fig. 9). Compared to the Păuliș–Mândruloc section the effect of gravel and sand extraction is much less visible, i.e. cut bank erosion was less vigorous here in the past 30–40 years.

Concerning the entire Romanian section a general river length increase can be detected since the regulations in the 19th century. This is due to the natural response of the river, attempting to return to its original pattern and morphology. Other parameters, such as river width and extension of mid channel islands also showed significant changes, but these will be more precisely shown in case of the third unit introduced: the border section between Romania and Hungary.

Fig. 9. – page 82

The 22 km long border section has a unique history, as from the time of its regulation in the 19th century it has just slightly been affected by human intervention. It is therefore a good indicator of hydrological and morphological changes determined by both natural and artificial processes (Fig. 10). In its natural state, this section had a meandering, anastomosing pattern, the total length of the main channel was 40,5 km, which was reduced to 23,8 km by the regulations. As opposed to the previous sites river length hardly increased since then, though this section was untouched and could develop almost freely. Slight meander development could only be detected on the originally meandering, highly stable section between Nagylak and Čenad (Fig. 11).

Why did meanders not start to develop on the previously meandering and anastomosing reach near Apátfalva in the past 150 years? The reason is that river pattern and probably sediment dynamics were changed so dramatically, that Maros/Mureș reached a new equilibrium state (Sipos and Kiss 2007). This state is characterised by braided features, such as a wide and shallow channel, and actively changing mid-channel sand bars and islands, which greatly contribute to the stability of present day energy conditions of the river. The dynamics of braided features were investigated in more detail with the help of aerial photographs from each decade since 1950.

Fig. 10. – page 84
Fig. 11. – page 85

Based on our present and previous investigations (Sipos and Kiss 2003, Kiss and Sipos 2009), we found that the formation of islands in the channel is a compound process. The core of vegetated islands develop when high rising bar surfaces, formed during major floods, are colonised by poplar and willow seedlings. The final stabilisation of bar surfaces can occur if long lasting low and medium water periods follow colonisation and seedlings can grow. This way the form will be resistant to further floods (Fig. 12). In general approximately 4–5 years pass between the colonisation and the stabilisation of islands (Sipos 2006).

The stabilised forms, however, will develop further fairly dynamically. They can migrate in the channel as their upstream end is eroded and their downstream end is built further, as the island generates further sediment deposition at its lower end (Fig. 12). The migration of islands can be as much as 10 m/year in average.

Fig. 12. – page 86

Growing islands in the end can be attached to the banks when their side channels are silted up (Fig. 11). This process is important in influencing the hydraulics of the main channel and generates bank erosion and further island formation. These phenomena can be understood as part of a cyclic evolution in which there are phases of island initiation, migration and assimilation (Fig. 13). Cyclic changes are mostly related to 1–2 km reaches where the river is extremely wide: 200–250 m from bank to bank (Sipos et al. 2007). These widened units are called braids, and have a key role to preserve the longer term stability of the river reach, since braids are dissipating a large part of the river's energy, which anyway would be used for meander formation (Sipos and Kiss 2004, Kiss and Sipos 2007).

Fig. 13. – page 87

As a consequence of the above, the number and extension of islands and the width change of braided units is a good indicator of river stability (Sipos et al. 2007). Our aerial photo based analysis has shown that on the border section between Nădlac and Makó the number of mid-channel islands decreased from 26 to 21, while their average area increased significantly from 0.5 ha to 1.2 ha in the past 60 years. This is due to the low water, low energy periods of the 1990s and 2000s, enabling the colonisation of emerging bar surfaces. In the meantime an overall channel narrowing can also be detected, which affects mostly braided units (Fig. 14). On the border section average width decreased from 180 to 156 m between 1953 and 2006 which is more than a 10% narrowing.

Fig. 14. – page 88
Table 2. – page 89

In case of the Pecica–Nădlac section narrowing was also detectable, here average width decreased from 170 m to 165 m between 1980 and 2006 (Table 2). Similarly, the number of active islands also decreased. These processes are apparent thus on the entire lowland reach of the Maros/Mureş, of course with the exception of areas where mining is present.

As a consequence we suggest that the role of island systems and braids is constantly diminishing in controlling the energy conditions of the river. This can lead to accelerated erosion processes and finally a return to the original form and pattern at sections where the river can develop freely (e.g. the Nădlac–Apátfalva section). Nevertheless, based on the rate of changes detected, we can assume that these processes can lead to a significant rearrangement only in the long run.

As it was shown, the trend of changes is similar, however, their rate is variable at different sections of the river. Mostly those units are developing actively, where tectonic processes are apparent. However, less rapid changes on more stable sections may also lead to unwanted erosion at river control structures or other human infrastructures (e.g. the Pecica bridge) and the loss of some natural values. Therefore, in the long run there is an increasing strong need for monitoring changes, in order to develop the best strategy for preserving both river stability (lack of erosion) and natural values (islands and braid systems).

In the framework of the present project we generated therefore a uniform GIS system from all available Romanian and Hungarian map and image resources. This database will serve as a reference for the further monitoring of future river development.

Short term channel development

As it was mentioned before, River Maros/Mureș transports a huge amount of bedload. Sediment movement in the form of dunes and bars has a key role in sustaining the stability and the morphology of the river, since a portion of the energy of the flowing water is used for the transportation and reallocation of these forms. Besides, the sandy gravely bedload, being a first class construction material, is one of the most important natural resources in the region. These were the most important reasons why we investigated the sediment household and sediment budget of the Maros/Mureș at different sections.

The first survey site was located just upstream of the main quarrying activity, near Lipova (Fig. 3). On this section the slope of the river, determining its energy and sediment transporting capacity, is around 20 cm/km. The riverbed is mainly composed of gravel, subordinately sand and silt are also present.

At this site the architecture of the riverbed has hardly changed between the measurement campaigns. Significant bed load pulses could be detected (Fig. 15). Over the four measurement campaigns the net variation in sediment quantity was minimal and no overall erosion or accumulation could be detected (Table 3). Absolute changes, i.e. the quantity of sediment reworked in the form of bars, did not exceed 20 000 m^3 per river kilometre (Table 3). This means that the amount of bed load entering the lowland section of the Maros/Mureș river was probably not significant during the period of investigation.

Fig. 15. – page 92
Table 3. – page 93

Near Arad, downstream of the main mining activity, slightly greater changes were experienced. Due to its 20 cm/km slope the energy of the river remains relatively high at this section. The riverbed is mainly built up by consolidated gravel and clay. Erosional features, both lateral and vertical, are clearly identifiable. However, during the two years of our measurements no significant incision was detected, rather net accumulation was experienced (Table 4). This was mainly related to the continuous silting up of left behind quarrying pools (Fig. 16). Measurement to measurement absolute changes were higher than in case of Lipova and reached 30 000 m^3 per river kilometre. However, no bedload pulses moving through the system were identified (Fig. 16). In all, the site did not experience significant changes, nevertheless the amount of the transported and reworked bedload is estimated to be higher than upstream. One reason can be increased sediment production due to the erosion of disrupted banks resulted by mining activity.

Fig. 16. – page 94
Table 4. – page 95

At the Pecica site changes and riverbed dynamics were similar, although as a matter of decreasing water surface slope (10 cm/km) the energy of the Maros/Mures is lower. The reason for higher activity is that the river bed is composed of medium and coarse sand which can be reworked and transported by the river more easily. During the measurement period the situation and dimension of sand bars did not change, morphology was more variable at the thalweg (Fig. 17). Concerning the sediment balance an insignificant net accumulation was detected, being close to measurement error (Table 5). Absolute changes were little bit lower, than at Arad and were around 25 000 m^3 per river kilometre (Table 5). Along the Pecica section, therefore, we experienced moderate channel dynamics and sediment transport.

Fig. 17. – page 96
Table 5. – page 96

Going even more downstream channel changes became much more remarkable. At the last measurement site, near Apátfalva, water surface slope is around 15 cm/km while the river bed is composed of medium and coarse sand. As a consequence, the energy and sediment entrainment capacity are higher compared to the Pecica site. Nevertheless, channel dynamics and morphological variability was far more significant, than expected on the basis of the sediment balance at upstream sites (Fig. 18). Large sediment pulses could be identified on the basis of successive surveys: sand bars shifted downstream, and new forms appeared in the channel (Fig. 18). All these mean that a large amount of bedload must have passed along this section. Based on the surveys, a massive net accumulation can be detected (Table 6), which is due to the development of a large sand bar during the high water season of 2012 (Fig. 18).

Absolute changes, i.e. the sum of erosion and accumulation reached 50 000–70 000 m^3 per river kilometre (Table 6), which is twice as much as in case of the other survey sites. This means that minimum 100 000–120 000 m^3 of sand can be moved along the Apátfalva system annually. Naturally, at the thalweg, where sediment movement is continuous even at low waters, a significant amount of additional bed load can be transported. The question may arise: What can be the source of this increased sediment supply?

Fig. 18. – page 98
Table 6. – page 99

As we have seen, where the Maros/Mureş enters the plains the sediment household is balanced and a moderate amount of material moves in the river bed at average floods and at low water. The large scale sediment extraction on the Pauliş–Măndruloc section results large artificial pools in the channel, which trap bed load arriving from upstream. By reaching Arad and Pecica only a slight, at Apátfalva an abrupt increase can be detected in the amount of the transported sediment. The later can only be explained if the river, freed from its bed load artificially, produces a significant amount of additional sediment somewhere on the Pecica–Apátfalva reach. In this respect the actively developing meanders upstream of Semlac can have a key role (Fig. 3), since here by the erosion of the outer banks a significant amount of sediment can be introduced to the channel. Based on the above, it is obvious that the development of the river is greatly influenced by intensive sand extraction, resulting erosion at certain sections and consequent accumulation on others.

Another question is, how the sediment supply of downstream reaches can change in the future? In order to determine if there is a decreasing trend in bedload volume further investigations are necessary. However, we can compare the present results at Apátfalva to our previous measurements (Kiss and Sipos 2007), since between 2003 and 2005 this site was already surveyed along the same cross-sections like now. Based on earlier and present average depth values, normalised to the same water level, we can see that 2011–2012 depths are generally greater, i.e. the channel is seemingly incising. Though the trend is not obvious, as by the development of large sand bars lower values can also occur (Table 7). In all however, we can expect a decreasing trend in sediment supply even at Apátfalva in the long run, which can result a gradual incision and bank retreat as a matter of erosion.

Table 7. – page 100

The measurements started in this project must be continued in order to monitor the sediment household of the Maros/Mureș River. This is important not only because of economic reasons, but as we have seen earlier, channel sediments are crucial in maintaining the morphological stability and the natural values of the river as well. As a matter of fact we will continue to survey the Lipova, Arad, Pecica and Apátfalva sites in the future, but from now on with a newly purchased sonar system.

With the help of the monitoring activity above only longer term changes and trends can be detected, the investigation of short term sediment movement requires more frequent measurements. These can help to finally calculate the amount of bed load transported in the form of dunes. This would be crucial in controlling sediment extraction and in the sustainable management of resources.

Therefore, as a part of the research we attempted to elaborate a survey procedure which allows high resolution and fast at-a-station (one cross-section) measurements. The tests were made at the Makó gauging station along a fix cable, using a georadar and an acoustic device. The surveys were made during a small flood wave (water level: 120 cm) and at low stages (water elvel: -70 cm). During the flood we used only the georadar for measurements, and an average 6 m^2 change was experienced in the cross-section in 30 minutes (Fig. 19). The movement of 10–20 cm high dunes was clearly identifiable (Fig. 19). At low water not just the cross-sectional change but the velocity of the riverbed "movement" was also measured with the help of the acoustic device. This time we experienced an average 0.6 m^2 change in 30 minutes in the total cross-section, and a 0.2 m^2 change in 10 minutes concerning the thalweg. The velocity of riverbed movement was around 1.2 cm/s. Based on this we estimated a 20–25 m^3 sediment delivery in one day. Results are therefore promising and indicate realistic values, however, the technique should be calibrated to classical sediment trap methods.

Sediment discharge values definitely show a great fluctuation in response to water level and river energy. Therefore, in the future day-to-day measurements are planned at different water levels combining georadar and acoustic techniques. These tests will hopefully result a fast and effective way of sediment monitoring on River Maros/Mureş.

Fig. 19. – page 102

Conclusions

In this section we have introduced the results of our analysis on the evolution of the Maros/Mureş since the great regulation works of the 19th century. By using field measurement techniques we also attempted to investigate short term river bed dynamics and the sediment budget of the river at different sections. The most important conclusions of our work are the following:

- The pre-regulation course of the river on its lowland reach was greatly determined by tectonic processes. The most active sections developed where slope conditions changed significantly: at the entrance to the plains, near the Battonya High, at the rim of the alluvial fan and near the estuary.
- Following the regulations and the shortening of the river, incision and widening occurred. The Maros/Mureş responded to these changes in different ways.
- At previously active, tectonically affected sections the length of the river has grown considerably by the development of new bends. Here the river gave a robust answer to human interventions and returned to its original morphology in a short time.
- On the Cenad–Apátfalva section the river was more sensitive to interventions and a new equilibrium state developed with a much different pattern, than before. This section is a good indicator of changes in hydrological and morphological processes, since it has remained fairly intact since the regulations.
- The evolution of islands is a cyclic process controlled by hydrological regime of the river and colonising vegetation.
- In the past 30-50 years the number of islands and the average width of the river have been continuously decreasing on the lowland section. This means a slow but steady return to the original morphology and heralds an intensifying erosion on uncontrolled sections.

- Channel and bedload dynamics upstream of the most intensive mining activity were moderate during the monitoring activity of the past 2 years, sediment pulses could not be identified.
- Downstream of the mining activity the bedload budget varied more intensively since more sediment is produced by the river as a matter of erosion induced by mining.
- The greatest changes were realised on the border section, where significant bedload pulses were detected, suggesting an increased sediment discharge, which is explained by erosion on upstream sections.
- Longer term investigations of the sediment budget at Apátfalva indicate, however, that there is a decreasing sediment supply from upstream.

These changes underline the secondary effects of human interventions on the development of the river and the possibility of intensifying channel processes in the future. However, the investigations and results outlined above can serve as a good start to follow channel changes along the lowland reach of the river. We laid down the framework of three monitoring activities to detect the horizontal development, sediment household and short term sediment delivery of the river. These measurements and results can highly contribute to the sustainable management of the Maros/Mureș. We do hope besides that in spite of the changing environment and conditions expected in the future the river's hydrological, ecological and economic resources can be maintained by the joint efforts of the two neighbouring countries.

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