

RESEARCH ON MINOR RIVERBED MORPHOLOGY IN THE PRESENCE OF ANTHROPOGENIC RISK FACTORS

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Abstract

The change in the morphological parameters of the minor bed takes place under the influence of natural and anthropogenic modelling factors. The minor river beds located in the urban areas are intensively affected by the presence of anthropogenic risk factors. The research carried out on the Bahlui River in the area of the city of Iasi highlighted important changes in the minor river bed determined by the regularization works carried out asymmetrically in the river bed. The presence of rainwater drains is an important anthropogenic factor of erosion of the minor bed. In this case, in the minor river bed, there is an important differentiation in the cross section between hydraulic parameters (maximum velocities, roughness, erosion force), a situation that leads to the intense erosion of the right bank.

Key words: degradations, erosion, form, riparian zone

Correct exploitation of a river bed for various purposes must not disturb its hydrodynamic balance in longitudinal and transverse profile. The minor riverbed is included in an extensive research program at the current stage regarding the initiation and development of erosion and deposition phenomena, as well as solutions to limit destructive actions.

The minor bed of the rivers is constituted by the land surface with a low elevation where the continuous flow and free surface of the water from the springs to the discharge into the upper water course takes place (Manoliu I.A. *et al*, 1970, Ichim I. *et al*, 1989). The formation flow and transported by the minor bed is a topic of continuous research at the current stage on a national and world level (Manoliu I.A. *et al*, 1970, Ichim I. *et al*, 1989, Opreșan E., Tecuci I., 2014, US Army Corps Eng., 1993).

The research of morphological transformations of natural or regularized riverbeds under the action of natural / anthropogenic risk factors, in the presence or not of some constructions in the bed and the riparian zone is in continuous development in the current period (Ichim I. *et al*, 1989, Avram M., 2020, Bolati I.M. *et al*, 2014, Neuhold C., *et al*, 2009, Rinaldi M., 2003 and others).

The issue of the use and protection of riverbeds together with the riparian area is a continuous concern of the state administration (OM 326, 2007, Order 2115, 2021). The mode of

protection of the bed and the riparian zone in Romania is deficient at the current stage and is far below the European level.

The expansion of the areas occupied with various economic and social objectives in the riparian area contributes to the morphological modification of the riverbeds and the disturbance of the aquatic environment. The research of the cooperation of the bed with the new environmental conditions is carried out directly in the field. The data taken from the field can be entered into simulation programs of various bed degradation phenomena (Wang W. *et al*, 2014, Neuhold C., *et al*, 2009, Avram M., 2020, Luca M., Avram M., 2021, Bohorqueza P. Anceyb C., 2015).

The protection of the objectives in the riparian area against the destructive action of the water is carried out through works to regularize the riverbed and protect the banks. These works change the morphology of the river bed in transverse and longitudinal profile, but also disturb the aquatic and riparian ecosystems.

Recent climate changes have modified a number of natural and anthropogenic risk factors that intervene in the functioning of coastal defences (Luca *et al*, 2012). This situation has also determined a change in the concepts of carrying out river bed regularization works (Avram M., 2020, Luca M., Avram M., 2021).

A problem that needs to be solved currently refers to the legal and real estate status of the bed and the riparian zone. Knowing the exact type of

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property on riparian land areas would allow good management of maintenance and environmental protection works.

The aim of the work was to research the morphological transformation of the minor bed of the Bahlui River on the trunk adjacent to the "Era Park" Commercial Complex following the action of natural and anthropogenic risk factors. Also, the influence of the way of operating the rainwater outlets within the commercial complex on the morphology of the bed was analyzed. The research section presents very different regularization works on the two banks.

MATERIAL AND METHOD

The researches were carried out on the lower course of the Bahlui River, on a section located between the towns of Letcani and Iași (figure 1). The research sector is in contact on the right bank with the platform of the "Era Park" Commercial Complex in the outskirts of the city of Iași (Luca M., 2019).

The Bahlui River has an average slope between the town of Letcani and the city of Iași of 0.35 m/km. The major river bed on the research sector is wide, but with local narrowing determined by the presence of some economic and social objectives. The minor bed has a cross-sectional shape characteristic of the plateau area; respectively it tends towards a relatively stable parabolic shape. The minor bed shows local erosion phenomena on limited lengths.

The foundation of the river is made up of cohesive rocks, which reduces the erosion of the bed on the watered perimeter (Luca M., 2019).

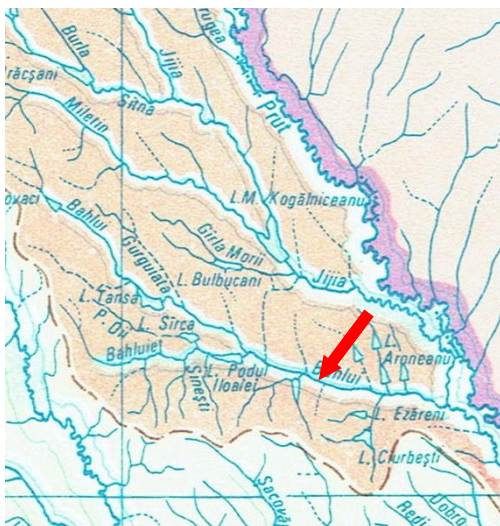


Figure 1 Hydrographic characteristics in the research area of the Bahlui River (Atlasul geografic al României, 1985)

The research was carried out on a river section with a semi-regularized bed over a length

of 600 m. The regularization works were partially degraded in the last period of time.

The research methodology was differentiated by fields of study: hydrological, hydraulic, resistance and stability of the banks, the influence of natural and anthropogenic factors on the minor bed and the way of producing the erosion phenomena of the bed. The hydrological data (average and maximum flows) are determined in the research site and correlated with those taken from the hydrometric stations on the Bahlui River located in the research area (Podu Iloaei and Iași).

On the research sector, data were taken on the cooperation of the bed with the outlets of rainwater collected on the platform of the commercial complex. The state of the rainwater drainage works and their contribution to bed erosion in the contact area were also analyzed.

The collected data sets were completed with photo reliefs by study sectors and type of degradations. All technical data were stored in "databases" and processed on the study areas.

RESULTS AND DISCUSSIONS

A commercial complex consisting of several buildings is located in the research area on the Bahlui River. Rainwater collected from the platform of the complex and the roof of the buildings is transported with a sewage network and stored in two tanks. Rainwater from each reservoir is discharged into the Bahlui River by gravity and pumping (figures 2). The discharge mode is used according to the water level in the river bed in the discharge section. The water from the reservoir is taken by a channel located on the slope of the bed and which connects to the bed of the Bahlui river through an outlet (GV2 – GV3) (figure 2) (Luca M., 2019).

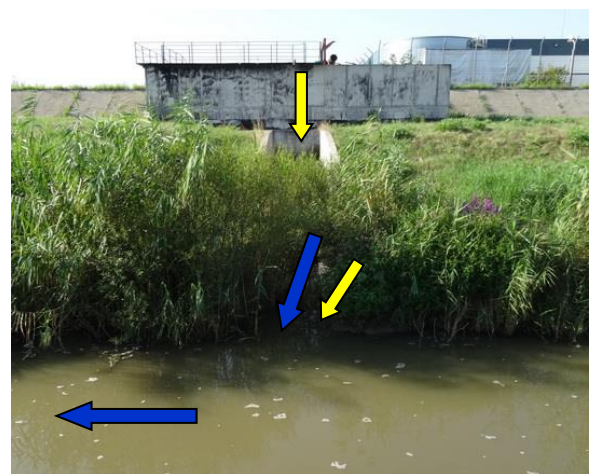


Figure 2 The location on the bank of the Bahlui river of the rainwater storage and drainage tanks (Luca M., 2019)

Rainwater from part of the platform of the commercial complex is collected by perimeter

channels. The two canals discharge rainwater into the Bahlui River through two outlets (GV1 and GV2) (Luca M., 2019).

The Bahlui River presents an approximately linear bed on the section at the border of the Commercial Complex, with a section formed that ensure the transit of average flows under normal conditions, but with intense erosion phenomena at maximum flows.

The river section considered in the research has a length of about 600 m and a slope of 0.0015%. The riverbed was partially regularized on the research sector by calibrating and arranging the right bank. The regularization works of the left bank were reduced, and in the current period the bank tends towards the natural state.

The applied regularization works formed a bed with a mixed shape: at the base, the bed has a relatively parabolic shape for low flows; the bed has a trapezoidal-rectangular shape for medium flows (figure 3). The width at the bottom is approximately constant along the length.

The riparian area of the right bank is laid out in steps. The slope of the right bank is arranged unevenly along its length (natural and regularized) and has a slope of 1:1. The slope is interrupted by a berm on which the four storage tanks with pumping stations are located. The berm continues with a profiled slope with a 1:1 slope and protected

with large concrete slabs according to the norms in force (GE 027, 1997). At the top of the slope are a road and the concrete platform of the shopping complex (figure 4).

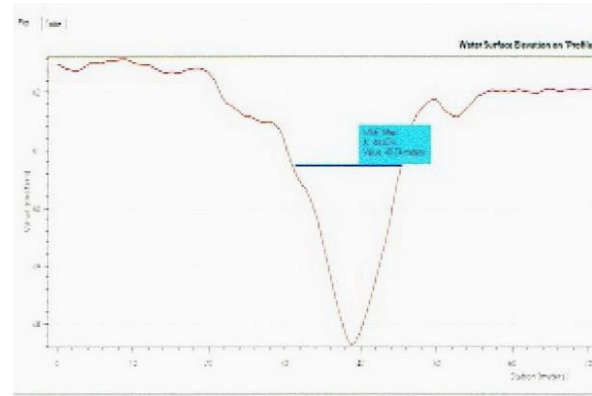


Figure 3 Simulation of the transverse section through the bed of the Bahlui River in the first third of the research section (Water Basin Administration Prut – Barlad, 2016 - 2021)

The left slope of the bed has preserved its natural shape, with areas of erosion, and on the non-watered side there is diverse and intensively developed vegetation.



Figure 4 General downstream view of the research sector on the Bahlui River (Luca M., 2019)

The calculation rate of regularization works on the research section is $Q_{1\%}$, and that of verification $Q_{0.1\%}$ (table 1, figure 4) (Luca M., 2019, Water Basin Administration Prut – Barlad, 2016 - 2021). The calculations performed on the research section highlighted the values presented in table 1. The variation of the flow rate (Q) according to the water depth (h) was calculated and represented graphically.

Table 1
Flows with calculation probability per sector of research of the Bahlui River (Luca M., 2019)

Section	$Q_{5\%}$ (m^3/s)	$Q_{1\%}$ (m^3/s)	$Q_{0.1\%}$ (m^3/s)
Era Park	60	150	420

The change of roughness on the perimeter of the bed through erosion and clogging phenomena, but also through the presence of vegetation determines the continuous change of the water level and the transported flow.

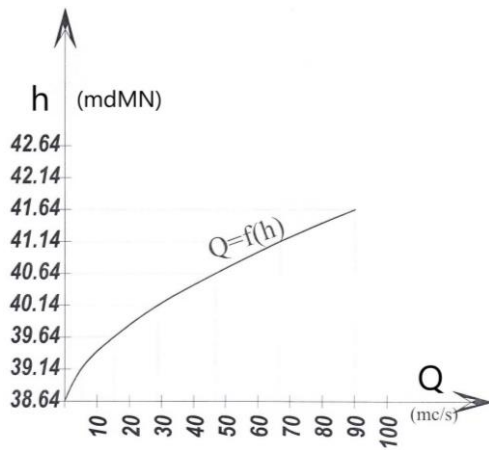


Figure 5 The limnometric key of flows on the research sector on the Bahlui River (Luca M., 2019)

The variation of the water level on the investigated section has an important influence on how the rainwater is discharged from the storage tank. At high water levels in the river, the gravity drainage pipes are blocked, in which case rainwater drainage is used through the use of pumping stations.

The morphology of the minor bed of the Bahlui River on the research section was influenced by the following risk factors:

- natural factors are represented by the floods produced in the last period of time and the rapid variation of the flow in the flow section;

- the significant anthropogenic factors are represented by the bed regularization works, the rapid discharge of rainwater flows, the deficiencies of the drainage construction and the absence of maintenance and remedial works.

In the first research stage, the influence of the regularization works on the hydrological and hydraulic parameters of the minor riverbed was analyzed. The field research revealed the following:

- The regularization works, with the role of stabilizing the right bank and allowing the rapid evacuation of rainwater flows, changed the geometric shape of the minor bed. The minor bed in the initial stage had a mixed shape, where the lower part was an elongated parabola, which continued with a trapezoid (figure 6). The regularized minor bed has approximately the same shape, except that the right slope is terraced at a lower slope (figure 7).



Figure 6 General view of the minor bed downstream of the research section (Luca M., 2019)



Figure 7 General view of the regularized minor bed on the research section (Luca M., 2019)

- The left bank of the minor bed is affected by erosion phenomena and clogging in the middle level area. The bank is grassy and covered by a vegetation of shrubs and trees specific to the riparian area (figure 8). The way of structuring the left bank influences its roughness coefficient during the transit of average and maximum flows.



Figure 8 General view of the left bank at the minor bed of the Bahlui River on the research section (Luca M., 2019)

In the second stage of the research, the influence of rainwater drainage works on the morphology of the minor bed was analyzed. The drainage of rainwater from the site of the commercial complex is carried out through the two outlets and two perimeter channels. The field research revealed the following:



Figure 9 The structure of the right bank of the Bahlui River bed on the research section and the location of rainwater storage tanks (Luca M., 2019)

- The shape of the right slope of the bed is fragmented along its length by the presence of the four outlets of rainwater into the river (figure 9). The spillways were made with a reduced length, a situation in which the water current evolves on the unprotected slope of the bank. This situation determined the appearance of local erosions of the bank, continued with the degradation of the canal and the outlet (figure 9).

- The evacuation of rainwater from perimeter channels 1 and 2 into the Bahlui River is carried out without the existence of an adequate hydrotechnical construction. In this case, the jet formed by the exit of the water from the canal produces an erosion of the right bank (figure 10).



Figure 10 Intense phenomenon of erosion on the right bank of the Bahlui River bed at the outlet of perimeter channel 2 (Luca M., 2019)

- The bank of the Bahlui river in the GV1 area shows local erosions, which over time advanced the bank and caused its loss of stability. The water from the river eroded the foundation of the drainage channel causing the concrete to crack and parts of the channel to collapse. The discharged water inflow caused the formation of abundant bank and aquatic vegetation, which also obstructs the flow of water in the canal (figure 11).



Figure 11 State of the evacuation sector (GV1) on perimeter channel 1 (Luca M., 2019)

An active erosion phenomenon is registered in the location of the two bridges bordering the research section. Erosion is intensified by the unsatisfactory structural condition of the perimeter rainwater drainage channels (Luca M., 2019).

From the analysis of the previously presented data, the strong influence of the anthropic factor in the continuous modification of the Bahlui River bed on the section adjacent to the commercial complex is found. The natural river bed was modified into a semi-regularized bed to ensure two requirements:

- flood protection of the location of the commercial complex according to the importance category of the objective and the check flows on the affected bed section;

- taking the rainwater collected from the platform of the commercial complex and discharging it intermittently (gravitationally or by pumping) into the river.

The right bank is degraded locally, especially near the hydrotechnical constructions for the drainage of rainwater, through erosion phenomena and the advance of the river bank. The presence of poorly executed outlets creates eddy zones, a fact that intensifies the phenomenon of erosion of the bank and the outlet channel. The high velocities of rainwater emitted from the tank caused the degradation of the protection of the outlet channel.

On the left bank, natural risk factors predominate, which locally produce erosion, bank collapses and silting. The riverbed of the river maintains its flow transit capacity, but requires annual maintenance.

An indicative element of the need for the application of rehabilitation works is represented by the fact that the four mouths/rainwater drainage channels have not been structurally completed in their entirety up to the minor bed of the Bahlui River. This situation caused the collapse of the GV1 and GV4 concrete channels and the erosion of the bank, but also of the discharge channel near the GV2 and GV3 empties from the rainwater pumping stations (Luca M., 2019).

The minor bed of the Bahlui River and the riparian area in the area adjacent to the commercial complex must be arranged according to OM 326/2007 and Order 2115/2021 for a correct delimitation of the land belonging to the public domain or the private domain. Through the application of the legislative documents, the obligations of those who exploit the land in order to apply the maintenance and rehabilitation works of the minor bed and the riparian area result.

CONCLUSIONS

The research carried out on a section of the Bahlui River in the area adjacent to a commercial complex highlighted the combined action of natural and anthropogenic factors in the morphological modelling of the bed.

The flow section of the river at low and medium waters has an approximately parabolic shape, and at high waters it tends to a mixed parabolic + double trapezoidal shape, regularized in the area of the right bank (lower slope + berm + upper slope) and with a natural appearance on the bank left.

In the area of the four spillways (GV1 - GV4) there is an active phenomenon of bank erosion determined by the discharge of the rainwater jet. This erosion is corroborated with that produced by the high velocities of the water in the river during the transit of the floods.

In the area of the left bank, alluvial deposits were formed due to the decrease in flow speed influenced by the greatly increased roughness of the bank.

Reducing the phenomena of erosion and clogging of the Bahlui riverbed requires the design and execution of works to rehabilitate and modernize the outlets for rainwater collected from the premises of the commercial complex.

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