THE ROLE OF TEMPERATURE IN THE PROCESS OF EROSION, TRANSPORT AND SEDIMENTATION IN ANTHROPOGENICALLY DESIGNED RIVER COURSES

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Abstract: This paper tries to establish regularities of the processes of erosion, sedimentation and transport and river-specific courses designed by anthropogenic hydro (through dams, rapids). The existence of these regularities unique for the natural courses of rivers has been inferred by observations made on a landscaped urban sector, in Cluj - Napoca, on Someşul Mic River. The importance of this study is translated into the possibility of developing criteria of protection and preserving the aquatic as well as the riparian biodiversity. At the same time it has a great technical significance for draft dredging the river bottom, an also for small dams handling. Last but not least, it is prominent in elaborating anthropogenic development functional projects of the landscaped area. The research method used is largely a classic one, using hydraulic ratchet, topographic rod (ruler), as well as the turbidmeter HI98703. A special situation was the case of granulometric determination of eroded sediments, transported and deposited in this area according to the functional state (active or inactive) of the small dam. The biography support is extremely poor, both nationally and internationally, there is only one reference paper, with applicability for the middle course of the Danube River.

Introduction:

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This paper has started based on the direct observations of the landscaped sector of Someşul Mic River from the urban area of Cluj-Napoca. Observations were related to the migration of the islets from one sector to another, between two small dams from this area. These migrations imply aquatic ecosystem changes, changes in the functionality of such a sector (Ichim and Rădoane 1986). Implications are also important for the existing hydraulic structures and for their functionality. By functionality we refer to the role of aquatic retention of small dams. The present research aims to establish the factors that determine the mentioned changes, given that the natural regularities of flow river are mostly altered due to these landscaping shifts (Carabogdan and Brătianu 1986). Such studies with the

same biological and geographic topic have not been carried out in Romania. Hydraulic studies refer only tangentially to the ecosystem changes. However, there are ecological projects assessing the functionality of such landscaped aquatic environments. The latter will refer to as.
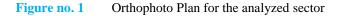
Materials and methods:

To achieve the goals of this paper, namely the fact that temperature is the main factor that determines the erosion, transport and sedimentation of river deposits in anthropogenic modified areas, we have chosen a sector between Garibaldi Bridge and Grigorescu Micro-hydro Power Station Bridge (Fig.1).

This sector was selected because it shows only one meander and is well

disposed, having only a few additional hydraulic works (high voltage pylons, suspended bridge). The only impediment is the six sewage spill channels. The banks are well fixed in concrete, which recommend this sector for the research conditions that we have required. In the basin of Someşul Mic River the sector is located downstream being featured by a variety of works, such as: Gilău Lake, Fântânele Lake and Floreşti Lake no.1 and no. 2 (Fig. 2).

There were selected 3 research profiles from this sector (P1, P2 and P3; Fig. 1). These profiles were measured, according to the measurement sheet prepared; some variables were chosen so as to help in developing the relational construction of the work subject.

Figure no. 1   Orthophoto Plan for the analyzed sector
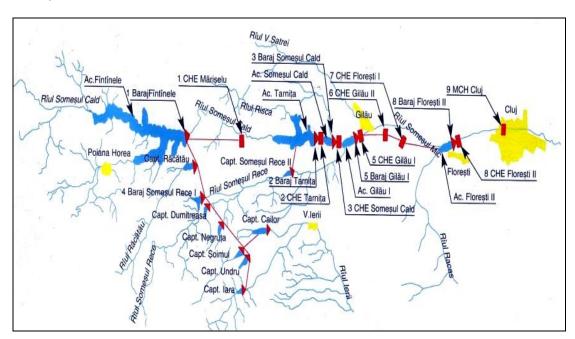

Note: 1 - Garibaldi Bridge; 2 - Grigorescu Micro-hydro Power Station Bridge; P1, P2, P3 - research profiles.

Measurements have been undertaken for the 3 profiles, on significant verticals. On each vertical were measured the variables, marked as follows:

- on the rod of the hydraulic propeller it was measured the water depth on the mentioned verticals, in 2 situations: with the dam raised and

with the dam down (the river flow control dam from Garibaldi Bridge);

- with the special air-water thermometer attached on the rod we determined the air and water temperature at 5 cm off the bottom of the riverbed (and the water speed at the same depth);
- in the maximum, minimum and medium velocity points we have ascertained the turbidity, with the HI98703 device, measuring the pelitic suspensions (Fig. 3);
- for the sediment sorts, sand and gravel graded with the diameter of 0.3-0.4 mm and gravel with the diameter of 0.5-1.0 mm we have used a system of 4 containers with calibrated volume (Fig. 4);
- for the relevance of the obtained data, we alluded to a comparison

with a sector from the river with the same demeanour (on the Nadăş River), where the measurements were carried out in July 10, 2013 and July 12, 2013;

- to verify the correctness of the conclusions, a pattern of the real situation was built, in order to achieve what we have sensed in the first phase, that the erosion, the transport and the sedimentation are firstly influenced by the temperature;
- the instrumental novelty consists of envisaging an equipment formed of 4 calibrated containers of 250 cm^3, out of which an empty one and 3 others filled with 3 size sorts (sand, gravel with 0.3-0.4 mm diameter and gravel with 0.5-1.0 mm diameter);
- there was carried out a strict inventory of the hydraulic structure.

Figure no. 2   Works on Someşul Mic River upstream from the researching sector (Şerban and Bătinaş 2005)

Figure no. 3   Collecting samples for turbidity determination
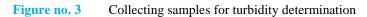

Figure no. 4   Calibrated containers with sediment types graded sand, gravel, with diameter of 0.3-0.4 mm and gravel with the diameter of 0.5-1.0 mm

Results and discussion:

Based on the performed measurements, we analyzed them in a deductive chain which allows verification of what we have forecast with this work.

In a first phase we have established a synthesis of the obtained data. Then there were calculated the speeds measured with the hydrometric propeller, using the propeller connections. In case of n < 0.63 rotations we used the following equation:

$$V = 0.207 \times n + 0.013$$

In case of n > 0.63 we have:

$$V = 0.2193 \times n + 0.005$$

It was found that the maximum velocities were obtained in the axial measurement points of the bed (10, 7, 5, 6, 8, 5), whilst the minimum velocities on the marginal points of measurements (toward Iuliu Hațieganu Park in points 6, 13, 12, 11, 11, 11). Average values are recorded in the starting points of the measurements (1, 2, 10, 3, 1). That is conspicuous when the dam is raised, so there is an increase of the water level, the minimum, average and maximum values holding a steady level. Extremely important is the correlation with the temperature values from air and from the bottom of the riverbed in the maximum average and minimum velocity points. In this case it is extremely significant to outline the profiles.

According to the obtained data we can say that:

- concerning the atmospheric temperatures, both measurements from February and March feature 3 maximum values on the edge of the cross profile and in the area of the maximum velocity (and maximum depth);
- temperatures on the bottom of the riverbed have the same variation, but with much more mitigated values;
- there is a correlation between the atmospheric temperatures and the temperatures from the river bed, to such an extent that in the areas with maximum velocity there is a thermal maximum;
- axial maximum migrates toward the right bank, at the same time with the raising of the atmospheric temperature;
- on the 2nd March the temperature from the riverbed exceeds the atmospheric temperature, explained by the increased sewage spill with stressed endothermism and high density.

Maximum velocities are recorded in the axial area, but it can be observed a latency out of phase of the endothermic sewage, which causes migration off the area with maxim velocity toward the geometrical axis of the cross profile and the return of these maximum velocities to their center-right location when endothermic sewage spill stops.

Important for this paper is to establish a correlation between the atmospheric temperature, the water temperature from the bottom of the riverbed and the process of the erosion, transport and sedimentation (Adler and Ioan 1992). In this regard it is agreed, according to literature on the Physics of liquids, that the maximum density of the water or of the biphasic liquid water-sediments the temperature recorded is 4 ^{o}C (Fig. 5). We have the same direct proportional variation for the water temperature, depending on the specific weight of the water, knowing that:

$$\gamma = p \times g \text{ (Pandi 1997)}$$

It can be noticed that the measured values of the turbidity in maximum average and minimum velocity points, according to the temperature, have the same variation as the density and temperature diagram. This demonstrates that the transport of suspension matter is determined first and foremost by

the temperature of the biphasic mixture. Bibliography mentions a dependence of suspensions according to the river flow and velocity (Ichim 1989). The indicated flow in the hydrometric station in Cluj is relatively constant (Tab. 1; Fig. 6).

These constant flows permit to operate with other variables, being able to consider the flow constant.

The relations below show that the value of density and of the specific weight interfere, which we have demonstrated as being close in terms of temperature. When the temperatures from the riverbed (bottom) exceed a threshold of 7 ℃, turbidity, it does not vary directly with the temperature. In this case variations are produced with higher percentage of flow velocity and flow.

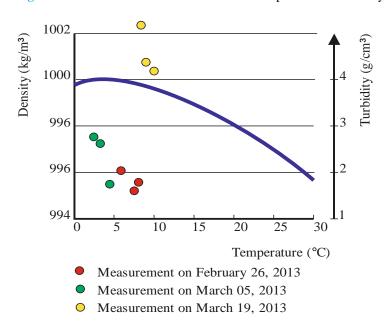**Figure no. 5**   Correlation between water temperature and density

Measurement on February 26, 2013
Measurement on March 05, 2013
Measurement on March 19, 2013

Table no. 1   The value of flow recorded in Cluj hydrometric station

Measurement no.	Date	Hour	Q (m³/s)
1	12.02	11:00	4.70
2	16.02	14:00	4.36
3	23.02	11:00	4.36
4	26.02	11:00	4.70
5	02.03	11:00	4.70
6	05.03	11:00	4.36
7	09.03	11:00	4.36
8	12.03	11:00	4.70
9	19.03	11:00	5.06
10	30.03	11:00	5.06
11	03.04	11:00	4.70

Figure no. 6   Hydrograph for Someşul Mic River in between measurement at station Cluj (official data, hydrometric station Cluj)

Pandi (1997) mentions the dependency of erosion, transport and sedimentation on the competence and capacity of the river. The river competence is determined by the flow velocity and an 'A' parameter depending on specific weight, and the river capacity is determined by a dimensional parameter and the river flow, which, in turn, is dependant on the velocity. It has been demonstrated that velocities vary according to the water temperature.

River capacity:

$$G = A \times \upsilon^6$$

G = the weight of the particle in gravitational field;

A = dependent parameter on the specific weight of the water and particle, friction and gravitational acceleration;

υ = flow velocity, which by the power of six shows its special role in case of movement of large diameters alluvium.

River competence:

$$R_s = K \times Q^n$$

K = dimensional parameter;
Q^n = the power of fluid flow.
The kinetic energy of the river:

$$E_c = \rho \times \upsilon \times \Delta H$$

ρ = water density;
υ = water velocity;
ΔH = level difference.

Related to the coarse sediments, as we said, their transport is produced by the vortex flow, also determined by Reynolds number. Reynolds number is directly proportional with the density and specific weight, which, in turn, depend on the temperature.

Reynolds' number:

$$Re = \rho \times wxl/\mu$$

ρ = water density;
w = fluid velocity;
l = characteristic dimension of the particle;
μ = viscosity.

Reynolds number defines the flow type: laminar or vortex. It is distinguished that the density of the multiphase fluid affects

directly proportional, respective inversely proportional Reynolds number. In other words, a higher density produced by a temperature near 4 ºC results in a greater Reynolds number, therefore, a vortex flow which produces the lifting of coarse sediments. But high viscosity produced by pelitic suspensions decreases Reynolds number, which means that in the moments with high pelitic suspensions, produced by water temperatures close to 4 ºC, viscosity is high and cancels the increase of density. This fact theoretically leads to the conclusion that in case of coarse sediments, their movement is produced by the flow velocity and by the roughness of the riverbed's bottom.

Our measurement confirm the above observations as real, which can be noticed in Table 2.

As it was mentioned, granulometric sediment variable and the washing degree in containers are closely tied to the flow velocity and not to the temperature.

In this context, the ETS (Emissions Trading System) problem in semi-closed river systems, dependent on temperature, arises only in case of pelitic suspensions and is not valid in case of sand and gravel sediments.

In case of suspended sediments, the closer the temperature approaches – from smaller or larger values – to the value of 4 ºC, the amount of suspended sediments is higher, so erosion is more powerful and pelitic sedimentation is lower. Should the calculation of transport capacity indicate higher values than the amount of suspensions, powerful erosion will take place at pelitic level. In other words, at a temperature of 4 ºC, if turbidity is low, the biphasic liquid will have an erosive role. When the temperature increases or decreases above or below 4 ºC, sedimentation will be prevalent. In case of course sediments, the erosion, transport and sedimentation will be under the flow rate and river flow.

Table no. 2

Velocity (m/s)		Temperature on the riverbed bottom (ºC)	Sand (0.3 mm)	P_1 (2 mm)	P_2 (7 mm)	Empty container
05.03. 2013	maximum	4.2	Total wash	3 cm wash	1 cm wash	Deposition of excerpts P_1
	average	4.4	2 cm wash	0.5 cm wash	-	-
	minimum	4.8	-	-	-	-
19.03. 2013	maximum	7.1	3 cm wash	2 cm wash	1 cm wash	-
	average	7.1	3 cm wash	1 cm wash	1 cm wash	-
	minimum	7.6	-	-	-	-

Conclusions:

The above data analysis allows us issuing conclusive points:
- in semi-closed river systems, with sectors characterized by low level differences, the transport and erosion of pelitic sediments occurs under the influence of atmospheric temperature, and thus, the temperature on the bottom of riverbed;
- the temperature control is climate or weather and by the sewage flows through the discharge of the 6 channels on the right bank;
- this process is decided by the classical factors: velocity, flow,

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lithologic structure etc., as suggested by the measurement results on Nadăş River.

This paper and the conclusions can be used in case of complementary planning, as a function of certain river sectors.

Major utilities of this paper:

- the pelitic sediments can be distributed on such courses by adjusting the temperature (thermal electrodes), which will create different aquatic environments;
- with thermal electrodes we could eliminate excessive sedimentation of pelites near the mobile dams, which could lead to obstruction;
- the pelitic sediments could be exploited, using agglomeration with thermal cathodes;
- the hydrothermal works in these sectors could be protected against such pelitic depositions;
- the processes of islets can be eliminated with the help of thermal electrodes.

The above are verified just partially, by a developer pattern.

Substantiated findings of this study entitle us to determine the actual extent of it, but above all, the socio-economic anthropogenic applicability and utility. The study proves the fact that in winter and spring, when the atmospheric and water temperatures are below 7 ℃, through antropogenic technical intervention (thermal electrodes) the sediment quantity of suspensions can be adjusted, as well as the erosion of the riverbed alluvium. Thus the sediment sorting according to the granulometry on the bottom of riverbed can be adjusted. In the meantime, the possible clogging of the dam from the downstream can be eliminated.

The major applicability of this study is related to complex projects of ecological redevelopment/reconstruction of these river sectors, strongly thermal modified, from the anthropogenic areas.

Rezumat:

ROLUL TEMPERATURII ÎN PROCESUL DE EROZIUNE, TRANSPORT ŞI SEDIMENTARE PE CURSURILE DE RÂU ANTROPIZATE

Lucrarea de faţă încearcă să stabilească legităţi ale proceselor de eroziune, transport şi sedimentare specifice cursurilor de râu amenajate antropic prin hidroconstrucţii (prin diguri, baraje, praguri, maluri protejate). Existenţa acestor legităţi aparte faţă de cursurile naturale ale râurilor a fost intuită prin observaţii făcute asupra unui sector urban amenajat din municipiul Cluj-Napoca, de pe Someşul Mic. Importanţa acestui studiu se materializează în posibilitatea elaborării unor criterii de protecţie şi conservare a biodiversităţii acvatice, precum şi a celei ripariene. În acelaşi timp, are o importanţă tehnică deosebită pentru elaborarea proiectelor de dragare a fundului râului, precum şi de manevrabilitate a minibarajelor. Nu în ultimul rând este importantă în vederea elaborării unor proiecte de amenajare funcţională antropică a sectorului amenajat. Metoda de cercetare utilizată este în mare parte una clasică, utilizând morişca hidrometrică, stadia topografică, precum şi turbidimetrul HI98703. O situaţie specială a fost în cazul determinării granulometrice a sedimentelor erodate, transportate şi depuse în acest sector în funcţie de starea funcţională a microbarajului (activ sau inactiv). Bibliografia de sprijin este extrem de săracă, atât pe plan naţional cât şi internaţional, existând doar o lucrare reper apropiată ca scop, aplicată pentru cursul mijlociu al Dunării.

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