SAFETY AND RISK DETERMINED BY VÂRŞOLŢ RESERVOIR, CRASNA RIVER

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Abstract.- Safety and Risk determined by Vârşolţ Reservoir, Crasna River . The drainage basin of the Crasna River is complex organized. Along this river, the reservoir Vârşolţ is the most important objective and has various functions. For the safety of the reservoir, hydrometeorological elements of the drainage basin from upstream side of the river were under continuous monitoring: sediments settling to the lake bed, infiltration through dam and the constriction of the dam materials. The induced risks by the presence of water body derive from generation of dangerous hydrometeorological phenomena, decreasing of lacustrine accumulation capacity, alteration of water quality, collapse of the dam. These phenomena generate flash flood waves of high magnitude and barrage break wave, which affect capacity of drinkable water supply and alter the environment equilibrium. The potential loses are very important and have ecological, economical and human implications. The existence of water retention has many beneficial effects for the social and economical life.

Keywords: hydrographic basin, hydrologic regime, colmatage, water quality, dam, risk, damage

1. Crasna drainage basin

The Crasna drainage basin is located in NV Romania. Its relief has been shaped by friable neogene and quaternary deposits; paleogene sediments appear more obvious in the upper part of the stream. The relief's altitudes decrease gradually from south to north, with heights of less than 200 m. The slope has small values, and the relief ratio is insignificant.

Crasna has few tributaries, with the biggest ones on the right side : Zalău, Maja and Maria. The drainage basin's density is very low – 0.3-0.4 km/km^2. The

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river is 121 km long and its basin has an area of 2120 km^2. It enters the Tisa River in Hungary. Because it is a transfrontier river, it is very important to know the risks induced by the presence of Vârşolţ Dam and its risk management.

The whole drainage basin is fully set up (Pandi, 1988). There are longitudinal dikes on the both sides of the middle and lower basin. They are found also on the lower basins of its main tributaries. Their construction begun in the XIXth century, with last improvements being made between 1979-1985, with an assurance of 2.5-10.0%. Water pumping stations maintain the connection between Crasna River and Someş – Crasna drainage system. The pumps can be found all along the river, after the confluence with Maja River, and maintain the water transfer from river to channels and backwards, depending on the flow. The Moftin non-permanent accumulation lies on the lower river basin and it has been built-up in 1980, with an available storage of water of 6.8 mil. m^3. Its purpose is to hold back some of the water brought by flooding after the confluence with Crasna's main tributaries.

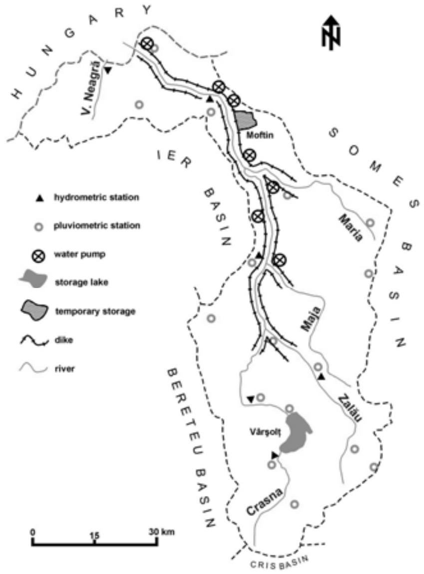

Fig.1. Crasna River drainage basin harnessing

2. Vârşolţ reservoir

The Vârşolţ Dam was built in 1978 from materials found near the dam, especially clay. It has a lenght of 2160 m and a maximum height of 14 m. It is located 13 km from it's brook and it limitates a drainage basin area of 345 km^2.

The water's surface is of 6.5 km^2. The lake is V shaped, with Crasna River arm of 3 km long and 1.3 km wide, and Coliţca arm of 3 km long and 1 km wide.

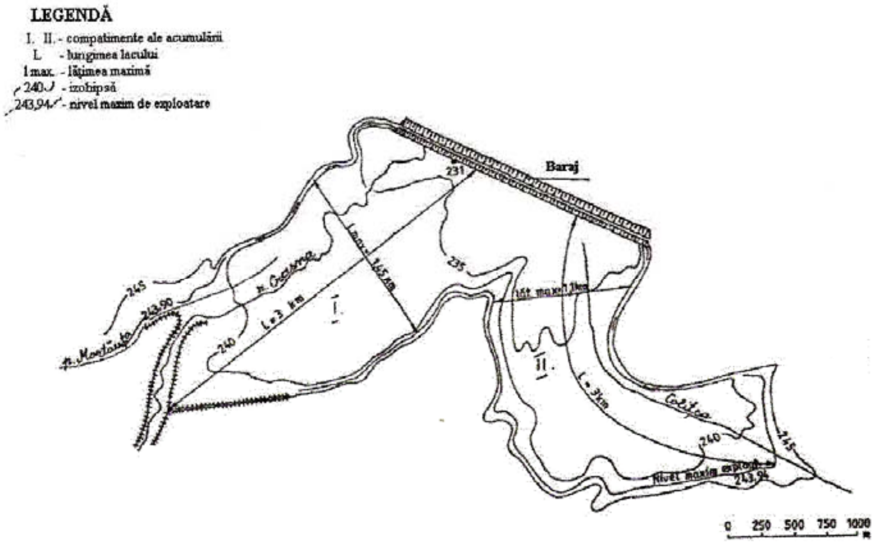

Fig. 2 Lake's shapes and sizes

The initial accumulations purpose was to reduce the flooding, but in time it was also used as a water supply for the towns Zalău and Şimleul Silvaniei, to maintain the river's flow behind the dam, and for fishy use. So, from its volume of 47.8 mil. m^3, the available storage is of 20.9 mil. m^3, the assurance volume of 11.2 mil. m^3 and the protection volume of 14.4 mil. m^3. The subsequent modifications of its functions modified all the running and exploiting accumulation's aspects, including safety and risk.

The hydro-technical equipment that assures dam's exploitation and safety contains :

- Old maneuver tour (1978), with a bottom discharge (30 m^3/s) and a sluice to the water treatment plant;
- New maneuver tour (1997),with a bottom discharge (35 m^3/s) and a water intake;
- Spillway for flooding water's transit (236 m^3/s);
- Collector channel (1860 m) for infiltrated water gathering.

This system also contains a 750 l/s water treatment plant with a pumping station, a pipe system and a lab. This station ameliorates the unprocessed lake water's quality, so it could be used by the people from Zalău and Şimleul Silvaniei.

3. Dam's safety

These safety instruments are based on the hydro-meteorological phenomena around the lake, but also on the dam's monitoring.

3.1 Hydro-meteorological phenomena

The observation and monitoring of hydro-meteorological phenomena and of lake's water are done at the Vârşolţ hydrometric station, with a complex program that includes quantitative and qualitative parameters.

Fig. 3 Crasna hydrometric station

The lake water's level can be monitored with a rod placed on the old maneuver tour. Here can also be monitored the incoming flow from the Crasna River, following a program that contains the daily water and alluvium flow evaluation. On Coliţca River there are made expeditionary flow measurements that are correlated with the Crasna flow measurements. This is how we can know better the lake's inflow, which is a very important thing to know for the dam's safety.

The outflow can be observed by two hydro-technical components : the two maneuver towers and the spillway.

For the measurement of rainfall it is used a pluviometer. There are other pluviometers in other parts of the drainage basin. The quantity of vaporized surface lake water is measured by a evaporimetric float.

From times to times there is made a lake's hydro-topometric survey. Following the comparison of data it can be calculated the silted volume and the silting rate, very important in risk management. Also, there are measured so other parameters, so the water delivered to the people can be drinkable.

3.2 Dam monitoring installations and equipment

For dams constructed with local materials, it is very important the constant observation of water infiltrations into the dam. For this purpose there have been installed some piezometers, to watch the daily level of infiltrated water. This water is evacuated through dumping drills. Downstream and parallel with the dam, classical instruments measure the total infiltrated water into the dam. The oscillations of water level into the drain indicate any dam failures.

The dam's body is under constant monitoring for compactions and movements of material. There are some dilatometric clamps. In the maneuver towers, those survey the movement of these constructions.

4. Reservoir induced risks

There are many types of risks that originate in hydro-meteorological phenomena evolution or into the dam's behavior. These two aspects are strongly connected and are constantly observed.

4.1 Hydroregime

The influence of oceanic climate, storms, lack trees in the drainage basin (16% afforestation) and wide extension of agricultural lands (49%) determine the fast concentration of water and a torrential regime. The multiannual monthly average presents high discharges from the end of winter till the beginning of summer, with a low in autumn.

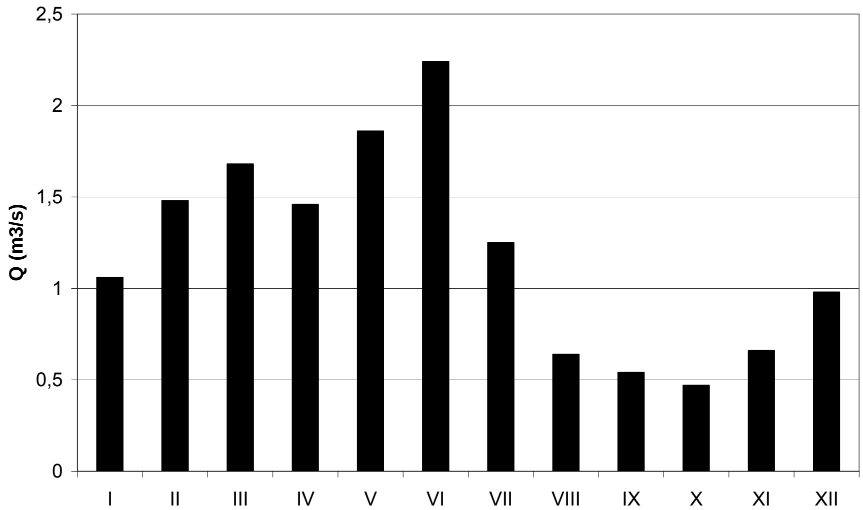

Fig. 4 The variation of multiannual monthly average discharges

The mixed origin flashfloods (from rain and snow) appear mostly in winter and springtime, when the melting snow overlaps the strong rainfalls. In summer, the storm waters concentrate into the drainage basin to become a high speed pluvial flashflood. The spillway starts to work at 0.1% probability flash floods.

4.2 The lake basin's silting

The erosion processes are increased by the flow regime, by soil types, vegetation and land use. They are more present on slopes, with linear and areal erosion, that form torrents. There is a big quantity of alluvium concentrated in the river bed that gets into the reservoir. Of big importance is also the biotic silting, that comes from the abundant aquatic lake flora, because of the small depths and of the pronounced water heating process in the warm season.

From the lakes bed hydro-topometric measurements (surface volumetric keys) can be observed that there exists a continuous decrease of silting capacity and of water surface. The alluvium silting changes from a place to another (Şerban, 2010). The most powerful silting process appears on the Crasna arm. The alluvia are characterized by small specific weight, so they get very close to the dam in time of strong flash floods, also because of the successive remoulding alluvium processes.

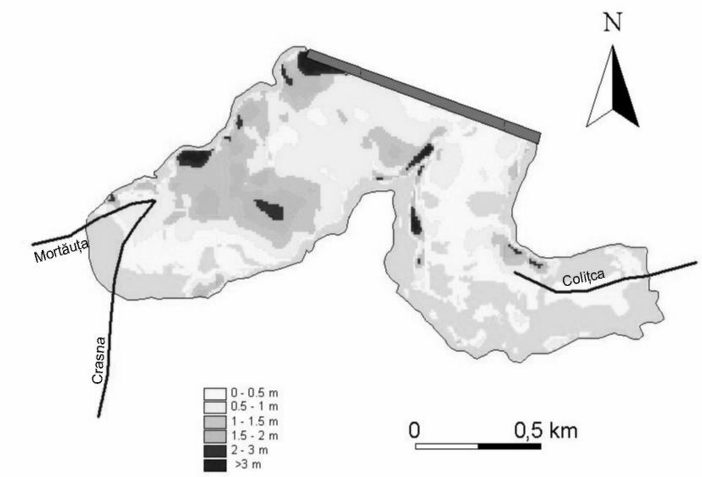

Fig. 5 Silting thickness in Vârşolţ reservoir

The silting process afects differently the reservoir’s characteristic volumes. The most affected is the dead volume, completely filled with alluvium. The problem is that the utile volume is also filled 25%, so the towns’ water supplies are diminished. A 10% diminishing of the damping volume shrinks the *retention capacity of high flooding water volumes*. The total capacity of Vârşolţ reservoir diminished with 18%. The average silting rate is of 0.56% / year. A good thing is that the silting evolution curves present a slower process rhythm ……

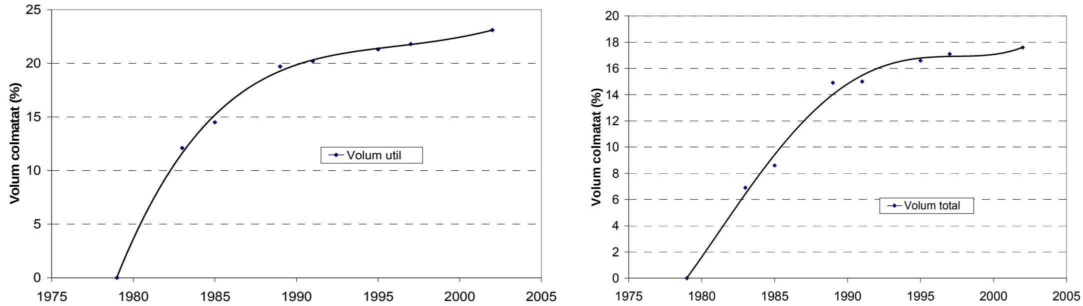

Fig.6. Silting’s evolution of utile and total volume

4.3 Temperature and evaporation

The thermal interchanges between water and air are facilitated by the small water surface and depth. This is why the water warms so quickly and so strong in warm summer times. In summer months, the water’s temperatures exceed 20°C, and in two other months they exceed 15°C. The high temperatures generate a low water quality and the apparition of water blooming phenomenon, which is a risk for people water alimentation.

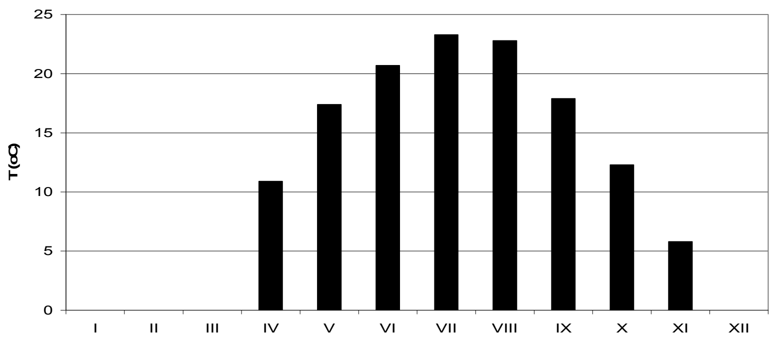

Fig. 7 Water temperature’s variation

In summer droughty months – July and August – a 140 mm water layer evaporates from the water's surface. The loss of water is much greater than the water brought by the tributaries. In July, Crasna River brings 1.71 mil. m^3, and the loss of water through evaporation is of 0.89 mil. m^3. In some days, the loss is greater than the water input from Crasna River.

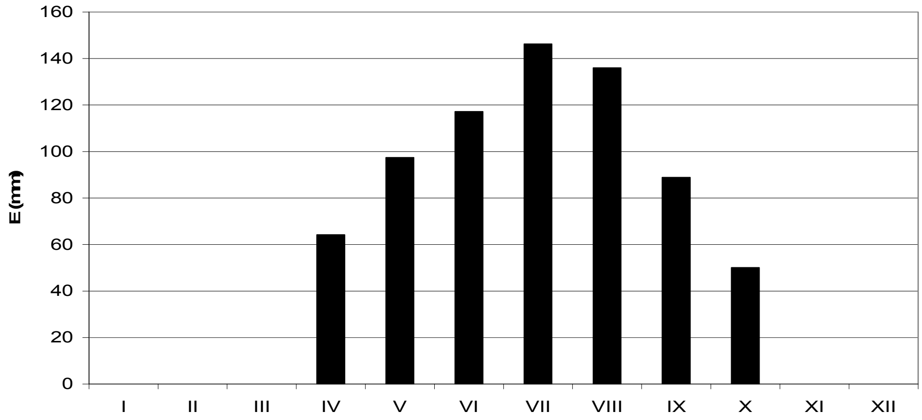

Fig.8. The water layer evaporated from reservoir's surface

4.4 Water's quality

The quality of the water from the Vârşolţ reservoir doesn't totally correspond with the limits of the permissible values. There can be two causes. The main cause is that the drainage basin is situated into a hilly region, and the substratum is formed of easily solvable rocks. So the alluvium volume that comes into the reservoir is great. Also, the areal flow brings a lot of dissolved substances. The second cause is that the lake's water quality is diminished by some external influences. The thermal rays get to the low water levels because of its small depth, so the whole reservoir water volume heats quickly. This phenomenon leads to a exceeding growth of aquatic flora, that decreases the water quality. At the same time, the intense evaporation leads to a growth of dissolved salts.

The values of some indicators show the potential risks of these phenomena. The very low transparence (0.5 m) is caused by the excess of salts and biotic compounds. The dissolved oxygen (5-15 mg/l) and the biochemical oxygen demand (2-6 mg/l) situates water within the IIIth quality class. The fixed residue oscillates between 200-400 mg/l, the total hardeness varies between 10-15 G degrees, and the pH between 7.7-8.2.

The eutrophication indicators, like total phosphorus (0.005-0.07 mg/l) mark the lake as an eutrophic lake, and the total nitrogen (0.5-1.8 mg/l) and the phytoplanktonic biomass (0.1-18 mg/l) mark the lake as hypereutrophic.

4.5 Dam failure

There have been made some prediction about the flash floods and the flooded areas determined by unfortunate dam deterioration, dam breaches or dam failure.

For a hypothetical discharge of 47.7 m^3/s at the dam's section, at the first village downstream (Vârşolţ) the discharge will be of 23.2 m^3/s, with the ripple arriving 30 minutes later. After 150 minutes, the ripple will reach Şimleul Silvaniei, with a discharge of 6.6 m^3/s , that is not a risk for the city. Following the same pattern, the water level decreases from 239.16 mdM to 21.23 mdM.

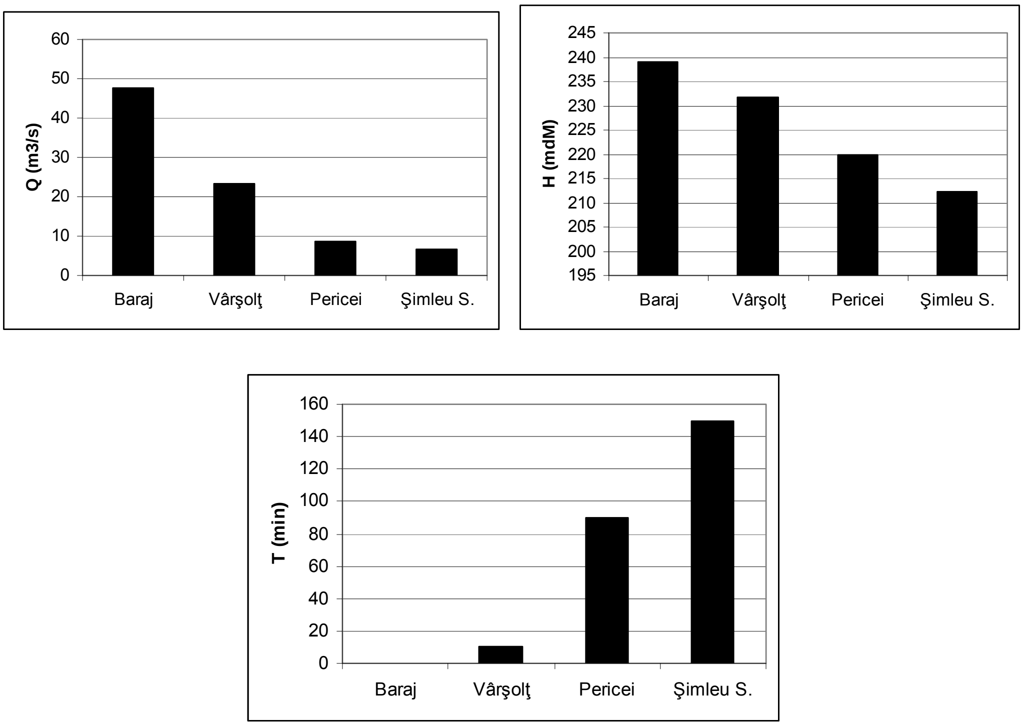

Fig. 9. A model of the elements evolution downstream the dam

After analyzing the dam failure model and the data about the exceeding of riverbed's transport capacity (25 m^3/s), we understand the fact that the entire Crasna Valley will be affected. Following this hypothesis, the downstream ripple's level will exceed the height of longitudinal dikes.

5. A risk component : damages

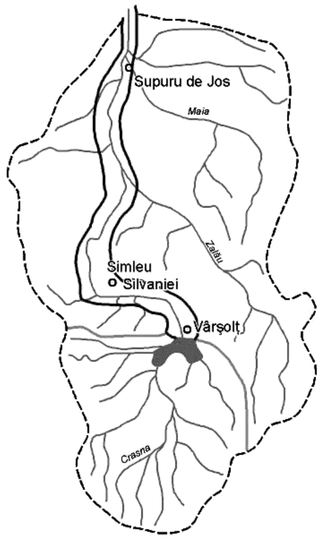

Fig.10. Flooded area in case of dam failure

More risk factors make more potential damages. They can appear in time, when more factors come together to determine dam problems (silting, poor water quality), or spontaneously with prompt effects (flooding, dam failure). The risks affect the economy, the environment and sometimes even the human life.

Risk analysis take into consideration the damages from 10000 households, 200 km^2 agricultural lands, all the river bridges, roads from nearby, electrical network etc. The number of people affected exceeds 50000. Also, it appears a grave unbalance of the nearby environment. The damages reach 200 mil. $.

But also we must say that the existence of Vârşolţ reservoir brings safety to many social and economic aspects. The hydrological regime is under control, most of floods are reduced, some towns and villages have water supplies, it maintains an auxiliary discharge for downstream settlements and it maintains an ecologic equilibrium in the river bed and meadow.

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