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SIRIU RESERVOIR, BUZAU RIVER (ROMANIA)

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Abstract

Siriu reservoir, owes it`s creation to the dam built on the river Buzau, in the town which bears the same name. The reservoir has a hydro energetic role, to diminish the maximum flow and to provide water to the localities below. The partial exploitation of the lake, began in 1984; Since that time, the initial bed of the river began to accumulate large quantities of alluvia, reducing the retention capacity of the lake, which had a volume of 125 million m^3. The changes produced are determined by many topographic surveys at the bottom of the lake.
Keywords: river, accumulation, sediments, bathymetric, basin

1. GENERAL CHARACTERISTICS OF SIRIU RESERVOIR

Siriu Lake came into being, due to the construction of a dam on the Buzau river, 18 km upstream from Nehoiu village. The dam was built with local materials and reaches a height of 122 m.

The dam's crest reaches an elevation of 588.50 m above see level, and creates a reservoir with a total volume of 125 million m^3 of water. The main purpose of the lake is to produce electricity (120.6 GWh / year with an installed power of 42 MW), to attenuate the waves of the freshets, to provide drinking water for the downstream localities and to irrigate an important agricultural area.

Construction started in 1974 and the partial exploitation of the lake began in September 30, 1984; the projected quota of the dam's crest was reached in 1989.

Due to the physical and geographical conditions found at the chosen location, it was decided to build a specific type of dam, using local materials, namely a core made of a mixture of rubble and 20 - 30% clay (concrete clay).

The dam is provided with two filters upstream and downstream from the core, one for preventing the suffusion and clogging of eventual cracks in the core and the second

(outside the first one), having the role of capturing and rerouting infiltrated waters. The prisms on the sides are made of rubble - in the immediate vicinity of the core - and of rip-raps, in the exterior areas.

The controlled area of the reservoir totals 680 km², with an average flow of this river section of 9.6 m / s.

The top values used in the blueprint are: $Q_{max\ 0,01\%}$ = 2900 m^3/s, $Q_{max\ 0,1\%}$ = 1720 m^3/s, $Q_{max\ 1\%}$ = 980 m^3/s şi $Q_{max\ 10\%}$ = 465 m^3/s.

Although the surface of the hydrographic hollow of Buzau River totals 5505 km^2, the controlled area of the Siriu reservoir, represents roughly 80% of the annual volume of water, the specific flow being about 14 l / s / km².

The dam's spillway can transit a maximal flow of 2000 m^3/s, and the semi-deep exhauster can transit a maximal flow of 1000 m^3/s, assuring the transit of flood-waves in case their retention is not possible.

Photo 1. Siriu reservoir

The flow of alluvial deposits in a river section is the result of erosion and solid transport from the entire surface of the receiving basin, which also explains the great variation of solid flow in time.

The Nehoiu section of the Buzau river is characterized by an alluvial debit of R 5.5 kg / s and a medium specific debit r 1.1 t / ha /year, the water showing an average value of turbidity of 284 g/m^3.

Unfortunately there are areas where uncontrolled lumbering, plus the seismic waves starting in the Vrancea seismic center, led to an accentuated mobility of the land. The stone quarries that that have fueled the construction of the dam, add to this mobility by producing large quantities of alluvia.

2. THE HYDROLOGICAL REGIMEN OF WATER

Siriu Lake is a lake with standing regimen, being supplied by the Buzau river and its tributary streams.

Average flow and its yearly recurrence, varies around the value of 5.68 cm/s (Sh. Sita Buzăului, 1955-1994). The graphic of average monthly flows indicates that the richest discharge is recorded in March, April and May, at the opposite side being the months of November, December and January (Figure 1).

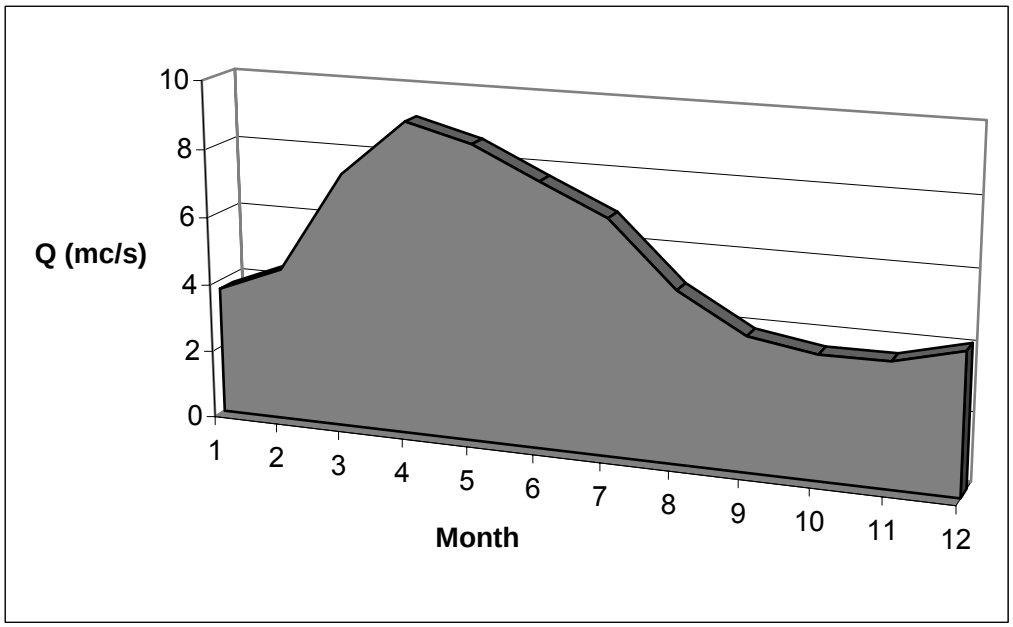

Fig. 1. The variation of the average multi-annual flow downstream of Sita Buzăului (1955-1994)

On average, tributary flow is approximately equal to the actual water flow, only the recurrence of the water volumes being adjusted, thus keeping a permanent reserve of water in the lake. Significant changes occur only when the climate variations reach extreme points: rainy or droughty years, which determine an accumulation or diminution of the water in the lake, but usually a constant water volume is maintained

The variation of the water level (Figure 2), shows an oscillation around the value of 530 m, the difference between the two extreme values, maximum and minimum being

13.79 m. The graphic representation of the water level variation in the period 1995-2004, indicates that the water level is growing, but the water volume is generally consistent, which means that there is a significant accumulation of alluvia in the basin of the lake.

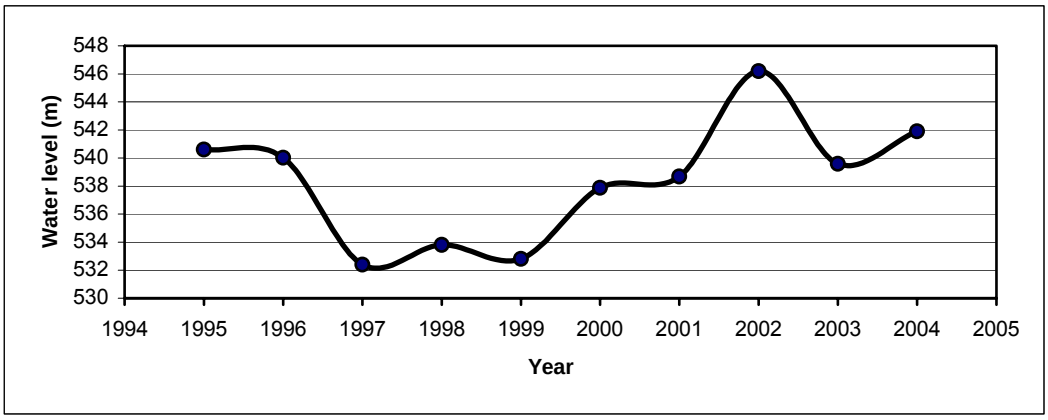

Fig. 2.. Multi-annual variation of the water's level in the case of Siriu reservoir (1995-2004).

Significant quantities of alluvia are brought to the bed of the lake by landslides that occur particularly during periods of abundant precipitation, correlated with the melting of snow. This occurrences most often determine the blocking of the main road and its closing for an undetermined period of time.

In this regard, at the beginning of May 2006 there was a massive landslide (photo 2) on the right bank of the lake, detached from Culmea Soimilor. The transported alluvia reaches the basin of the lake and partially blocks its bed. This phenomenon also occurred years ago on a tributary of the River Buzău, called Bâsca. This landslide represents a serious threat: it can not be stabilized and will generate large quantities of alluvia in the basin of the lake.

3. EVOLUTION OF THE RESERVOIR DURING 1993-2002

The outline of the lake and its original volume was established through measurements based on topographic maps and the maximum level of water retention inside the reservoir. The profiles which are scanned with the check rod, for the assessment of bathymetric profiles and morphological details of the basin, will be established at a later time.

Profiles are established starting from the dam towards the lake's tail, and they are numbered from P1.... Pn. The bays formed through flooding the river mouths of the tributaries (Tehereu, Siriu Mare, Giurca), shall be divided into secondary sections, marked: A, B, C.

In case of reservoirs, the water volume and depth are continuously changing due to the accumulation of sediments. This is shown in the successive ascensions of the longitudinal profile of the lake (the years 1985, 1993 and 2002 for Siriu Lake), which highlights the accumulation of sediments in the dam area, but it is also shown through scanning of the profiles with the check rod, which proves that the water discharge and the water inlet for the power-station does not carry alluvia over more than a small area around them.

Photo 2. Land slide on the right side of Siriu reservoir

The lake's artificial reservoir starts at a point where the valley floor reaches the quota of 585 meters above see level. Flooding is a very improbable occurrence, since this quota is higher then the maximum level of water that can be retained in the reservoir. The valley maintains a letter "V" shape with a rather narrow opening (66 meters). In the point where the valley opens, reaching 192 meters, the height of the valley floor achieves the maximum quota of about 580 m above see level. In this section we can't speak of lacustrine deposits, the water flow presenting rather natural characteristics, without any

accumulation phenomena, but only erosion and transportation. Even if the valley floor's altitude decreases, reaching 569.5 m, the natural appearance of the river and of the river bed will not change. The high water mark in the reservoir is maintained at such a level that the water would not frequently stay in this superior part of the lake.

The situation is radically changed in the area where the river regimen becomes lacustrine. In the section where the valley floor quota reaches 546.2 m above see level, there is a trend of massive deposits of sediments. (Figure 3 - year 2002). Nine years ago, on a previous bathymetric assessment, the quota was about 543 meters above see level, and the surface of the clogged up section was approximately 180 m^2.

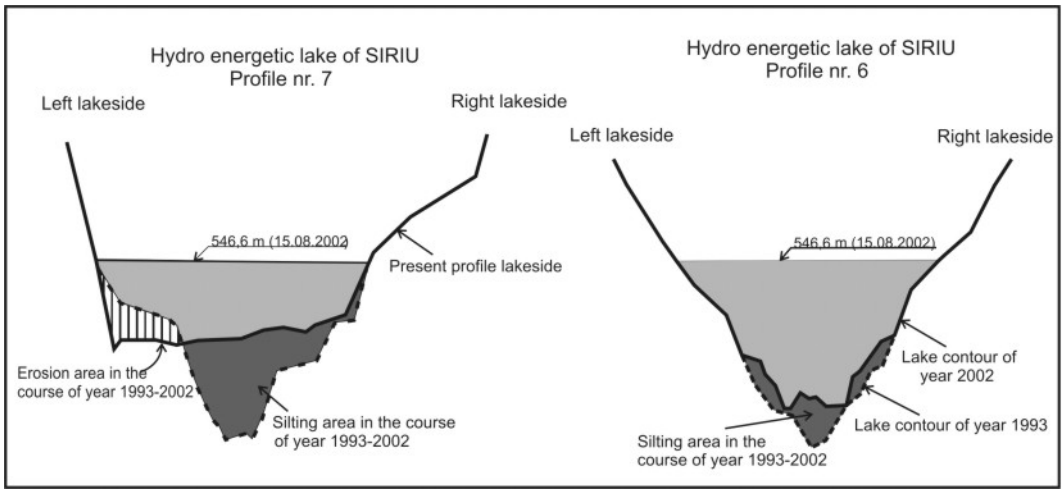

Fig. 3. Cross sections of the Siriu reservoir, profiles 7 and 6

The so-called "tail of the lake" can be easily identified through the specific vegetation developed here (reed, rush) and by the strong bending of the water course, as opposed to the upstream area.

The process continues as spectacular, so where the minor bed of the lake used to reach 537 m above see level, today, the lowest rate is 542 m, which means a difference of 5 m. Under the circumstances, the valley opening was also reduced to 279 m. The quantity of alluvial deposits in this section is important, and, correlated to the phenomena of erosion identified on the left side, it leads to the flattening of the bottom of the ancient river valley.

The process is still accentuating, but unlike in the other analyzed sections, where only the phenomenon of accumulation of sediments was encountered, in this section, the letter "V" profile tends to change in a letter "U" profile, even if the valley floor's level increased by 12 m. This means that on the left side of the mountain there is a large eroded area.

The clogging of the basin still continues, but at a slower pace, and as we get closer to the dam's profile we record a deepening of the lake bed of approximately 1 m. The phenomenon of erosion accompanied by a partial clogging is present on the left side

of the lake, phenomenon explained by the existence and the position of the dam's water inlets. The phenomenon still persists, the quota of the valley floor reaching 511.8 m above see level, as opposed to 515 m since 1993.

From this section onwards, until we reach the dam, we register a tendency of clogging, accompanied by small eroded areas (Figure 4).

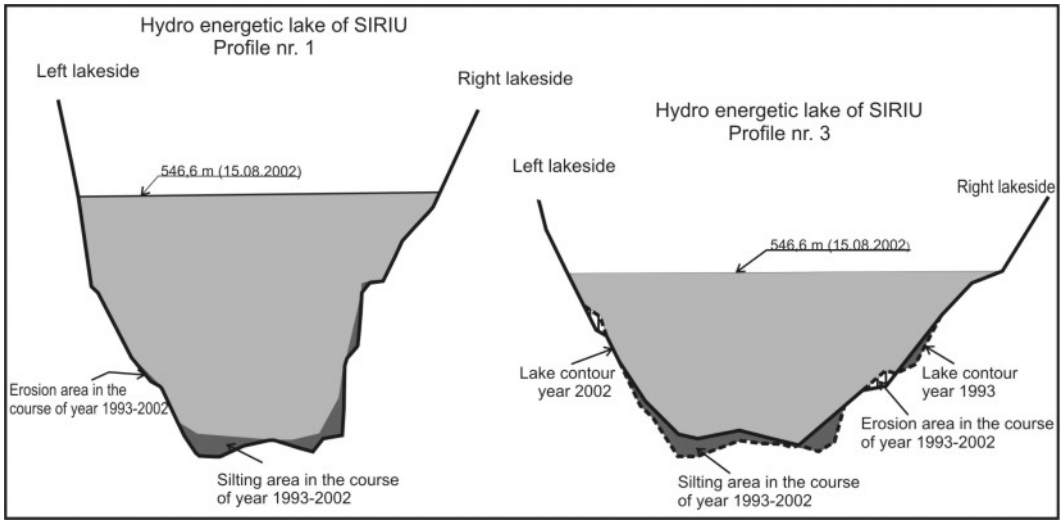

Fig. 4. Cross section of Siriu reservoir, profiles 1 and 3

The draining outlets at the bottom of the lake, can carry the alluvia only over a small area around them, since once the alluvia is deposed it tends to be more difficult to carry and discharge it.

The type and position of the water inlets have a significant role in the alluvia's evacuation, so when a dam is designed, this aspect must be taken into account. In some cases this issue has not been given due consideration.

We can thus say, following these quantitative observations, that the clogging process of Siriu lake is active, and is especially present at the extremities of the lake. The exception being the median side of the lake, where the alluvia carried by the river and it`s tributaries does not settle, and the erosion of the initial layer of alluvial, deposited prior to the construction of the dam, is significant.

The number and position of the tributaries, whose valleys have been overtaken by the lake, can not exert a great influence in training the alluvia brought by the river Buzau. The tributaries can only react in their own way to change the level of local erosion. So we can observe eroded areas, but also clogging in the same valley (Figure 5).

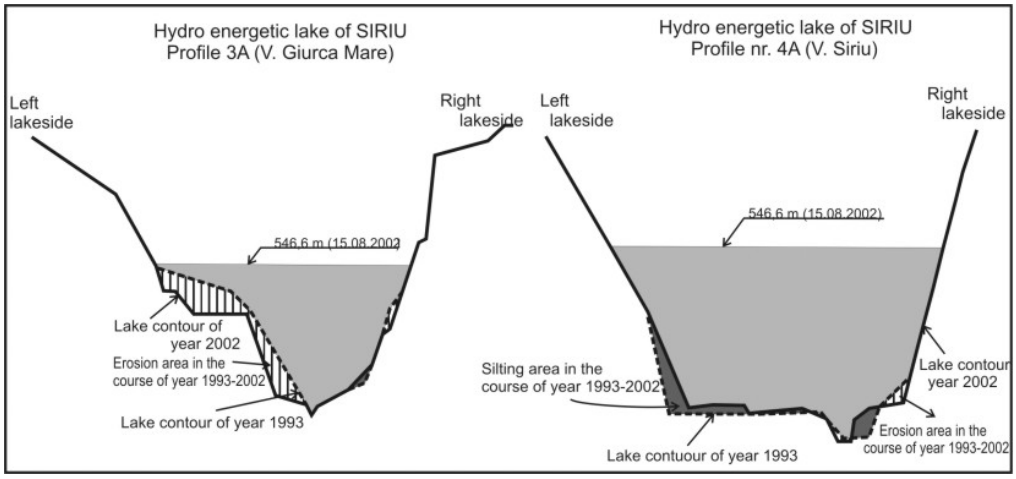

Fig. 5. Cross Section of Siriu reservoir, profiles 3A and 4A

4. CONCLUSIONS

The quarries for materials used in building the dam, located on the valleys adjacent to the lake and the lumbering in the area, are generating materials found in the alluvia accumulated in the basin of the lake.

The general trend observed in the Siriu reservoir is the accumulation of important quantities of alluvia, thus gradually reducing the amount of useful water in the lake, though the phenomenon does not threaten the actual set-up.

Monitoring the development is especially important and should be correlated with the factors that influence the process of generation and carrying of alluvia in the hydrographic basin, controlled by the reservoir. But it is equally important to find solutions to reduce the clogging, by exploiting the regimen of the river floods and improving the hydro-energetic exploitation.

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Figure 6. The Bathymetric Draft of Siriu Reservoir