RESERVOIR SEDIMENTATION IN THE SEBEȘ HYDROGRAPHIC BASIN

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Abstract. Reservoir sedimentation in the Sebeş hydrographic basin. The hydro-energetic potential assessment of Sebeş River from the Southern Carpathians through the construction of several dams led to the appearance of Oaşa, Tău, Obreja de Căpâlna and Petreşti Reservoirs. The study of quantitative and qualitative characteristics of lake water was the subject of many articles. This study wants to identify the particularities of the lake sedimentation because the sedimentation rate influences the water quality and the lake's water volume, in fact the electric energy produced in the lake. For this were analysed the sedimentation sources and the indicators of the sedimentation rate, the sedimentation pace, the dynamic of sedimentation process and the characteristic volumes of each reservoir. Using the measurements made, sedimentation areas with maximum development sectors were highlighted. At the end, was analysed the influence of sedimentation process on the lake's morphometric elements.

Keywords: Sebeş River, sedimentation rate, sediment dynamic.

1. INTRODUCTION

A tributary of the Mureş River on the left side, the Sebeş River has its sources at an altitude of about 2000 m, below the Cindrel Peak, and develops its hydrographic basin at the contact between the Şureanu, Cindrel, Ştefleşti, Lotru and Parâng mountains.

The river network in the Sebeş hydrographic basin has an approximately symmetrical shape; the Sebeş River, the main collector of the basin has a length of 95 km and a basin area of 1289 km^2. The hydrographic network in the Sebeş basin totals approx. 483 km, to which are added the torrential systems that double this value.

The main development work is represented by the Oaşa dam, located on Sebeş River, in the depression of the same name; it has an area of 4.6 km^2, which allows a total accumulation of over 130 million m^3.

At the exit from the Sebeș gorge, downstream of the confluence with the Bistra Valley, the Tău reservoir stretches, with a length of 2.5 km along the valley line and a total accumulated volume of 21 million m^3, and the multi-annual inflow into the lake is 7.5 m^3/s.

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The Obreja de Căpâlna Lake has a length along the valley line of 2.0 km and a multiannual average inflow into the lake of 9.2 m^3/s. The surface of the lake at the level of normal retention is 35.2 ha.

Downstream from the confluence with Răchita is the Petreşti Lake, of smaller proportions, finalized in 1982. It has a total volume of 15.8 mil. m^3 and a length along the valley of 1.0 km (Fig. 1).

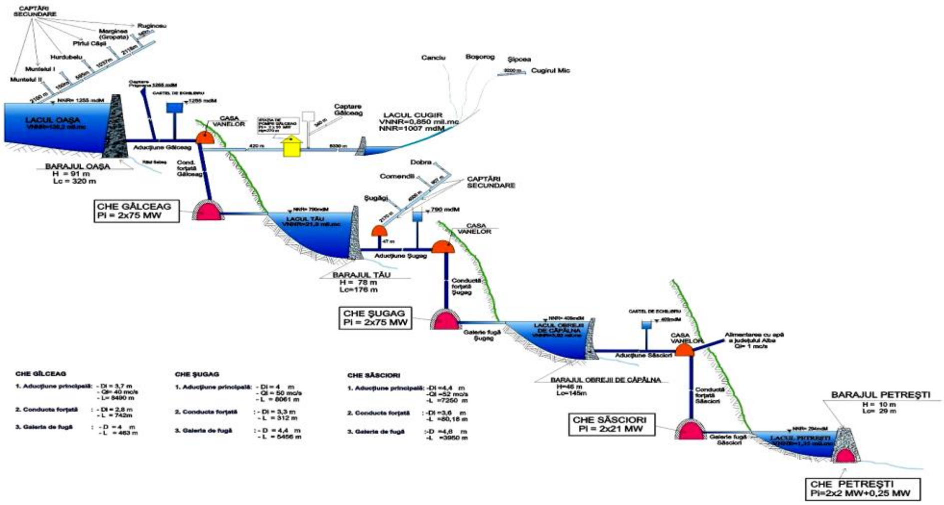

Fig. 1. *The hydropower development of the Sebeş River*

2. DATA AND METHODS

The data necessary for the elaboration of the work came from observations and measurements carried out by Peteren or taken from different specialized institutions. The suspended solid flows were determined based on direct data from hydrometric stations in the Sebeş river basin. The information collected from the field was processed using the following calculation programs:

- MAP SOURCE – specialized GARMIN program, for downloading data from the echo sounder, planning Way-points and navigation routes;

- MAP INFO PROFESSIONAL – GIS SOFTWARE, used in the digitization of old situation plans, the transformation of coordinates into the STEREO 70 projection system, the creation of current situation plans.

Programs were used for the creation of interpretation graphics and creation of bathymetric maps, graphics programs for the final creation of the plates.

3. RESULTS AND DISCUTIONS

3.1. The evolution of the sedimentation phenomenon

The reservoirs are set up in the Sebeş hydrographic basin on the main course of the Sebeş River and are affected by the clogging processes that have the final effect of reducing or cancelling some of their functions.

Through the creation of reservoirs, the transport of suspended, semi-suspended or dragged alluvium stops within the area where the speed regime changes. This fact leads to the successive deposition of alluvium, to the sedimentation of reservoirs. The clogging process is accelerated in the case of the tributary rivers from the area between the reservoirs.

The clogging of lakes is determined by a sequence of factors, among which we list: the extent of erosion processes, transport and deposition of materials resulting from erosion, the physical-geographical characteristics of the hydrographic basin, the method of exploitation of the lands on the surface of the hydrographic basin, the abrasion processes of the banks, the rate of exploitation of the lakes, etc.. The movement of alluvium in the lakes occurs due to the daily variation of the levels in the lakes, through hydropower exploitation, a variation that produces erosions and surprises of banks and the movement of alluvium towards the dam.

For a cascade system like that of the Sebeş River, the evolution of the clogging process differs from one lake to another, depending on the position of each one in the hydrographic basin, the lithology of the related hydrographic basin, the morphology of the lake bed, the natural and artificial evolution of liquid and solid flows which flows into the lake.

Oaşa and Tău reservoirs are not particularly monitored in terms of the clogging phenomenon, the topographic elevations being only the initial ones of the lake bed due to the very low rate of clogging.

Some economic needs of the Nedeiu and Petreşti lakes (drinking water supply in the micro-regional system or of the Sebeş locality) required topographic surveys to be carried out in order to know the position of the bottom of the lakes in relation to the water catchment installations.

The clogging process is the result of erosion and accumulation, the main role being played by accumulation. Due to the flow regime, which varies from year to year, the alluvium moves towards the dam and is clogged. The hydraulic size of the alluvium varies in the longitudinal profile, being smaller towards the dam and larger towards the tail of the lake.

Clogging of accumulations is favoured by:

- abundant rainfall in the area: 800-1200mm;
- lack of anti-erosion works on the slopes;
- lack of thresholds management to retain alluvium on tributaries and torrents;

- friable covering rock: sand, gravel, clay;
- not using bottom drains during floods;
- the low velocity of the accumulating water;
- the increase of water turbidity, of the solid flow, especially the dragged one;

The clogging of the riverbeds downstream of the dams can reduce their flow capacity and can even give rise to floods. A consequence of stopping the flow in suspension in the lake is the deprivation of agricultural lands affected by floods of fertilizing substances (clay), contained in these periodic overflows of water. Another important effect is stopping the processes of restoring natural ballast reserves

The suspended solid flows were determined based on direct data from hydrometric stations in the Sebeş River basin.

The entrained solid flow, since there are few measurements, was determined with the Collet relation:

$$Vt = 523\overline{Q}\,i$$

where:

Vt – volume of dragged alluvium (mc/year)

$\overline{Q}$ - multiannual average liquid flow (mc/s)

i – river slope (‰)

Table 1. Solid flows under natural conditions

Section	F (Km^2)	H (m)	Rs (Kg/s)	Q (gr/m^3)	Rt (Kg/s)	Rtot (Kg/s)	V (t/an)	V (m^3/an)	$\overline{Q}$ (m^3/s)	Regime
b. Obrejii de Capalna	619	1340	1.88	200	2.07	3.95	124567	78228	9.41	N
	619	1340	1.32	200	0.74	2.06	64964	40797	9.41	A
b. Petreşti	679	1265	1.95	200	2.14	4.09	128982	81000	9.64	N
	679	1265	1.37	200	0.37	1.74	54873	34467	9.74	A

Topo-bathymetric surveys were carried out through the Nedeiu and Petreşti reservoirs and elevations of transverse profiles on the Sebeş River downstream of the Petreşti dam and dissipater.

In the Nedeiu Reservoir, 27 topo-bathymetric profiles were erected (of which, for analysis, five profiles were taken, dam-middle/lake-tail/lake). The length on which the topo-bathymetric surveys were carried out is 2818 m. The distance between the profiles varies between 12 m and 225 m. The distance between the profiles was chosen in such a way as to keep the distance between the chosen profiles in the other measurement instalments and to the capacity curve is determined as accurately as possible.

A number of 15 topo-bathymetric profiles were erected in the Petreşti reservoir (of which four profiles were analysed). The distance between the profiles varies between 10 - 119 m, at smaller distances towards the dam and towards the tail of the lake. The length on which the topo-bathymetric surveys were carried out is 1075 m. The slope of the Sebeş River in the Petreşti lake area is 7.6 ‰.

On the Sebeş River, downstream of the Petreşti dam, 19 transverse profiles were erected, having the same position as the profiles erected by ISCE in 2001. The distance between the profiles varies between 7 m and 221 m. The length over which the transverse profiles were erected is of 1395 m (between upstream of Petreşti bridge and downstream of Petreşti dissipater). The slope of the Sebeş River in the area downstream of Petreşti is 3.53 ‰.

The topo-bathymetric profiles and the situation plans with the position of the topo-bathymetric profiles are presented in the annexes, these profiles being raised in Black Sea elevations.

The situation plans were drawn up by integrating the measurements made with the echo sounder and the theodolite as well as based on the existing situation plans in the area. The topo-bathymetric measurements by accumulations were carried out with the help of an echo sounder with DGPS, type GARMIN 238, mounted on the boat, with the tank fixed at a constant depth of 25 cm. The morphology of the thalweg of the accumulation beds was followed on the echo sounder screen, during navigation at low and constant speed, in order to capture all changes in elevation in the bed.

In the important points of water depth variation, the x and y coordinates in the UTM (Universal Transverse Mercator) projection system, on the WGS 84 ellipsoid, 35 north axis, as well as the depth, were memorized. Later, all the coordinates were transformed into the STEREO 70 system (Pulkovo 1942) and the absolute elevations of the talveg were determined by applying the depth correction to the water elevation in the lake on the date of the surveys.

The data were also recorded during the navigation between the bathymetric profiles, in order to obtain a larger number of points, which would allow the drafting of topo-bathymetric profiles as correct as possible.

3.2. The reservoir sedimentation rate

In the Oaşa reservoir, the most important lake in the Sebeş hydrographic basin, the reduction of the characteristic volumes does not exceed 3% of the design value, the capacity and surface curves falling within the proposed errors. The most important blockages are carried out in the confluence area in the lake of the main tributaries: Frumoasa, Curpăt, Sălane, Valea Mare

(Fig. 2). The resulting dejection cones are reduced in size and do not affect the initial volumes of water in the lake.

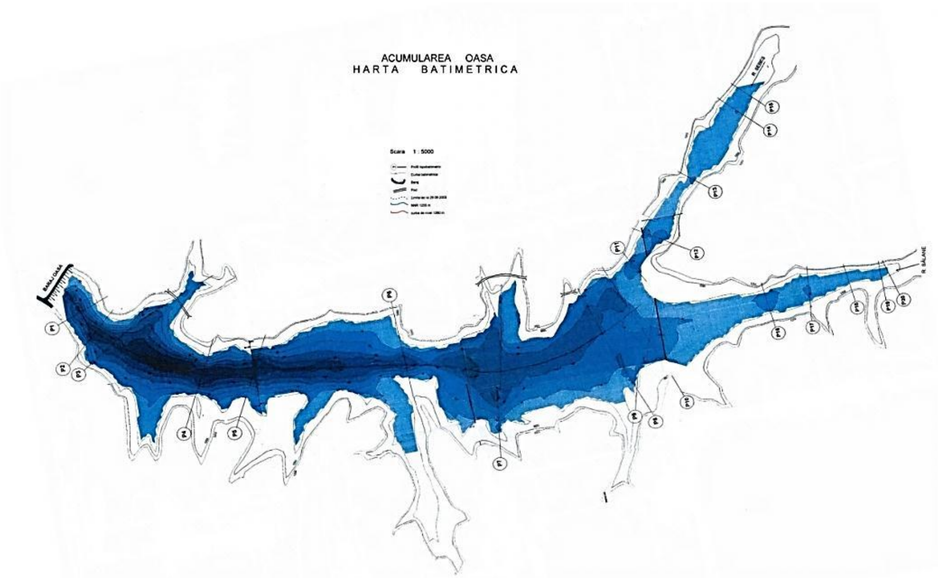

Fig. 2. The relief plan model of the Oaşa reservoir basin

- In the area of the shores, the phenomenon of abrasion and surging due to the level fluctuations in the lake, created a relief of accumulation of small dimensions - width 2-2.5 m - in the immediate vicinity of the shores. The amount of materials accumulated during the operation of the lake is due to a very low rate of clogging, this is due to the resistance to the erosion of the rocks. Some personal verifications, carried out on the initial profiles of the lake indicate a very slight change in the transverse profile.
- The accumulations from the tail of the lake on the Frumoasa and Sălane tributaries covered the excavations carried out here during the construction of the reservoir, blurring them. The phenomenon is visible in situations of lake emptying or minimum accumulation levels. The thickness of the deposited layer does not exceed 15 cm, being made of fine and very fine silt.
- Tău accumulation is the second largest on the course of the Sebeş River, the reduction percentages by accumulation of the characteristic volumes are below 5%, the clogging values not exceeding 2.5%; the dead volume does not exceed 3% of the variation, the values being included in the calculations proposed by the designer.

The very slow sedimentation rate is due to the following:

- Tău Lake, located downstream of the Oaşa reservoir where the most important amounts of alluvium are deposited;
- the hydrographic basin related to the lake consists of hard rocks, resistant to erosion, present today or covered by a very thin blanket of grassy soil (5-10 cm), or covered by forests, pastures, which reduce the erosion phenomenon;
- the courses of some important tributaries are captured and directed (Prigoana, Ciban) towards the Oaşa Reservoir, either through underground galleries or in the force gallery so that part of the alluvium is deposited in the Oaşa lake;
- the lake tributaries do not present discharge cones, the confluences being made, most of the time, in cascade (Gâlceag and Miraş rivers) (Fig. 3);
- no bottom or surface emptying of the Oaşa Lake was carried out, which would carry the solid material from the bed, towards Tău accumulation.

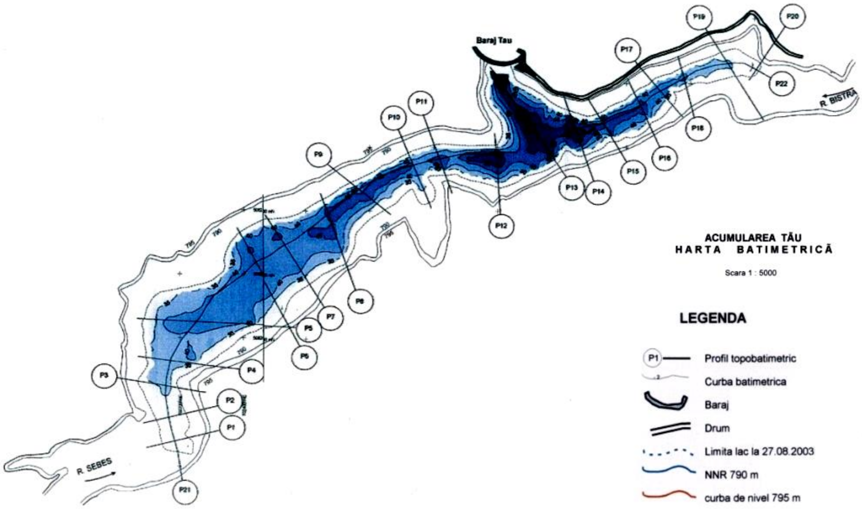

Fig. 3. The relief plan model of the basin of Tău accumulation

The phenomenon of abrasion prevails on the entire lake basin without causing major amounts of alluvium, due to the presence of hard rock "up to date" on the shores of the lake. Being a transit lake, it is maintained for over 75% of the year, at minimal exploitation levels.

The clogging rate is very slow, without producing changes in the structure of water accumulated in the lake. The Nedeiu reservoir located downstream from the Tău reservoir, in an area made up of the same hard rocks as the rest of the basin, covered by a layer of soil, on which tree vegetation, deciduous forests and pastures grow. The high degree of vegetation cover gives the soil high resistance to erosion.

In the Nedeiu reservoir is the catchment for drinking water from the regional system of Alba County. Because of this, the accumulation is subject to very strict protection regarding the possibility of pollution and human intervention.

The degree of clogging is generally accentuated, especially at the tail of the lake, where, until 2007, a ballast tank, belonging to the ICH, operated. Part of the washed ballast materials were deposited in the tail of the lake, above the NNR, which affected the volumes in the accumulation (Table 2). The clogging rate is accentuated, some characteristics of the accumulation being modified.

Table 2. The characteristic volumes of the Nedeiu accumulation

The name of the characteristic volumes	**Volume mil. m^3**		**Modification (%)**
	Project	**2007**	
Global volume	4.70	3.76	8
Total volume	4.12	3.23	7.9
Protection volume	0.580	0.53	
Attenuation volume	0.295	0.22	
Available volume	1.715	1.657	9.5
Spare volume	1.52	1.102	
Maximum theoretical available volume	3.235	2.759	
Regularization volume	2.01	1.877	
Volume that can be used for high waters' management	3.99	3.202	
Dead volume	0.590	0.251	42.5
Lake length (km)	3.30	2.90	

Compared to the basic topographical survey, a new topographical survey was carried out in 2007, resulting in the following characteristics:

- the most important clogged areas are those on the tail of the lake, the former ballast area of the ICH;

- due to the accentuated clogging, there is a differentiation in the characteristic volumes in the accumulation, so that the overall volume is reduced by approx. 8 5 compared to the initial one; in the same percentage of the total volume and over 9% of the useful volume;

- the dead volume has a reduction of over 42%, the high degree of clogging in the tail of the lake being due to an artificial action, produced during the construction period of the reservoir,

- the lake tributaries are not important in the evolution of clogging;

- at the tail of the accumulation is the outlet from the Şugag power station. Because the flows are important, over 50 m^3/s, the river, artificially, created a bed submerged in the initial clogging, over a length of approx. 300 m in the accumulation.

The clogging rate calculated on the basis of the profiles raised during a period of 20 years of exploitation of the lake is 40,750 m^3/year. If we compare the topo-bathymetric profiles raised in 1998, 2001 and 2007, it is found: the fact that in 2007 the deposits of alluvium they increased compared to 1998 as well as compared to the situation at the start of operation (1986) or the situation in 2001 (Table 3).

Table 3. The rate of clogging of the Nedeiu accumulation

Years	W (mil. mc)	Deposits (mil. mc)	ΔW (mil. mc)	%
Project	3.825	0	0	100
1998	3.16	0.665	-0.665	17.4
2001	3.202	0.623	+0.042	16.3
2007	3.01	0.815	-0.192	21.3

In 2007, compared to 1998, the deposits of alluvium increased by 0.60 - 1.20 m in the area of profiles 1-14 and by 1.00 - 4 m in the area of profiles 15-27. The largest deposit of alluvium is between profiles 16-20 and is 3.40 - 4.40 m. The deposits occurred both in longitudinal and transverse profile.

It should be mentioned that the intake from which they pass through the turbines of all power plants are not loaded with solid material, their contribution in clogging the downstream lakes being insignificant. The same thing is mentioned in the drinking water supply outlet from the micro-regional system of a part of Alba County.

The Petreşti Reservoir. The last of the reservoirs on the Sebeş River, it was partially put into use in 1978 as a pressing necessity for the supply of drinking water to the municipality of Alba Iulia and the neighbouring areas, the water collection systems being located in the dam.

The accumulation is characterized by large amounts of deposited materials, in the lacustrine basin, on one side and the other of the axis of the water current, between the Petreşti outlet and the two spillways in the body of the dam.

The Petreşti reservoir is a transit lake for flows from the three upstream dams, the energy activity here being correlated with those upstream. Because of this, clogging is obviously high, the differences between the accumulated volumes being obvious.

The difference in volumes between the design phase and 2007 is around 50% (Table 4). Because of this, the specific accumulation curves are modified in the same percentage. As the dam is equipped with flat weir spillways, the accumulation of volumes in the lake is conditioned by the percentage of their opening.

Table 4. Characteristic volumes of the Petreşti accumulation

Characteristic volumes	**Volume (mil. m^3)**		**Alteration (%)**
	Project	**2007**	
Permanent gross volume	1.27	0.637	50.2
Global volume	2.27	1.178	
Maximum theoretical gross volume	1.27	0.637	
Total volume	1.68	0.877	52.3
Protection volume	0.59	0.301	
Attenuation volume	0.41	0.24	
Usable volume	1.26	0.637	50.2
Dead volume	0.00007	0.000002	2.6
Lake length (km)	1.35	1.10	
Lake surface at NNR (ha)	37.0	23.3	
Lake surface at maximum level (ha)	41.0	24.5	

The largest amounts of alluvium are due to the contribution of the Săsciori tributary but also to the slope runoff from the agricultural area located on the left bank before the damming of the Sebeş river bank and later, the Petreşti reservoir.

At the start of operation, no topo-bathymetric surveys were carried out. Due to this fact, the capacity curve was undersized, the volume of the lake being in reality larger and due to the excavations carried out through the lake for the material that was deposited in the right bank dike, as well as the excavations for the realization of the Sasciori CHE escape channel.

During the period 1983-1998, the permanent gross volume of the lake decreased by 0.517 mil. m^3. The average rate of clogging was 34,467 m^3/year. The lake is 40.7% clogged.

During the period 1998-2001, the permanent gross volume decreased by 0.025 mil. m^3. The average rate of clogging was 8333 m^3/year. The lake filled up with another 3.3%.

During the period 2001-2007, the permanent gross volume decreased by 0.091 mil. m^3. The average rate of clogging was 15167 m^3/year. The lake has become clogged with another 12.5%.

If we take into account the entire period of operation (1983 - 2007), the volume of the lake was reduced compared to the project by 0.663 mil. m^3. The lake is 49.8% clogged. The average clogging rate of the accumulation during the entire period of operation was 26,375 m^3/year.

3.3. Sectors of maximum sedimentation

They broadly correspond to the confluences of the important tributaries in the accumulations. In the case of the Oaşa accumulation, the most important areas are given by the confluences of the Frumoasa, Curpăt, Sălane and Valea Mare rivers, the deposits having thicknesses between 15-25 cm, covering like a uniform blanket, the tail of the lake (Fig. 4).

Fig. 4. Deposits and levelling at Oaşa Lake's tail

Fig. 5. Abrasion levels on Bistra Valley, Tău Reservoir

They are formed by fine silts in which, in the area of the banks, there are large coarse elements resulting from sudden collapses or the abrasion effect of the banks.

In these deposits, the bed of the Sebeş River and its tributaries is highlighted, similar to a drainage channel during the periods of maximum emptying of the lake.

The Tău accumulation does not have discharge cones of the tributary rivers; they either converge in a cascade or have a reduced flow, therefore, a reduced hydraulic capacity to transport solid materials (Fig. 5).

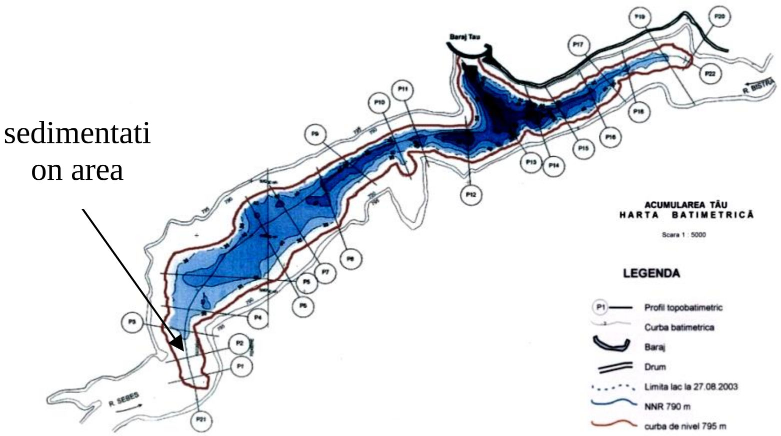

Fig. 6. Tău accumulation - clogging areas

The most important accumulations of materials are in the area of the banks (right) and are due to the phenomenon of their erosion (Fig. 6). Their thickness does not exceed 0.5 m and the width 3.5 - 4 m.

Their structure is complex in the thin blanket of mud being deposited coarse materials over 5 cm in diameter.

The Nedeiu reservoir has an important area positioned in the tail of the reservoir and is due to the operation period of the ballast during construction.

Fig. 7. Alluvium deposits at the tail of Nedeiu lake

The waste cone has a length of over 400 m and a surface of over 3500 m^2. The alluvial materials are deposited in chaotic alternation, fine silts with pebbles of various sizes. Evacuated into the lake, after washing them in advance, they were carried by the current of water coming from the CHE Şugag turbines up to more than 400 m downstream, creating cones of manure. Because of this, the length of the lake was reduced by approx. 400 m.

Other materials deposited in the lake come from existing collapse areas, especially from the right bank of the lake. They are large, over 50 cm in diameter. Since the accumulation is under strict phyto-sanitary protection, the levels and/or volumes in the lake are maintained at fixed but high levels, the water input from the upstream in the event of turbines is passed directly into the escape gallery of the Săsciori hydroelectric plant, turbined and evacuated in Lake Petreşti.

The main clogging in the Petreşti reservoir occurs in the marginal areas of the lake. It is the accumulation most affected by clogging, because of which the configuration of the lacustrine basin underwent essential changes. There is an obvious discrepancy regarding the intensity of the clogging, the compartment on the left bank being more loaded with alluvium.

Closing the floodgates of the dam led to the calming of the waters and the deposition of materials. Then the contribution of the tributaries from the agricultural area that deposited alluvial materials through slope runoff. In the determined stratigraphic columns, the deposits exceed 1.5 m towards the left bank where the lithological succession reflects the rhythm and intensity of the alluvial deposits.

Dusty sands of 0.5 - 0.7 m are present above the base deposits, over which, 0.4 - 0.5 m of agricultural muds are deposited; fine silts of 0.2 – 0.3 m follow. Currently, the blockage of the Petreşti reservoir, 10 m upstream of the dam, has reached a level of 285.19 mdM, exceeding the level of the spillway threshold (284.00 mdM) by 1.19m. A critical slope was created between the spillway dam, which continues upstream.

If one compares the clogging of the accumulation in 2007 with the situation in 1998, it can be seen that the largest deposits of alluvium occurred in the immediate vicinity of the dam of 0.30 - 2.20 m and in the middle of the lake of 1.20 - 2.40m. The deposits of alluvium occurred along the entire length of the lake, both in the longitudinal profile and in the transverse profile. The river flows sometimes to the left bank, sometimes to the right bank or on a bed created in the middle of the lake. The new route is created in the deposits of alluvium, the bed having a width of 4-82 m. In the outlet of the Răchita stream, a discharge cone was formed, which during floods is driven downstream, towards the dam. At the beginning of the lake, a larger amount of alluvium was deposited, especially the dragged ones, which, due to the daily variation of the level in the lake, moved downstream. The downstream movement of the alluvium from the tail of the lake also occurred due to the installed flow of the Săsciori HPP (52 m^3/s), which discharges through the escape channel into the tail of the Petreşti Lake.

3.4. Dynamics of morphometric elements under the influence of clogging

The accumulation of alluvial materials in the lacustrine basins led to the modification of some morphometric parameters of the accumulations as follows:

- changes in the structure of the capacity curves, of the curve of the surfaces in the sense of their reduction compared to the design phase. The most important changes occur at the Obrejii de Căpâlna and Petreşti reservoirs, where the clogging values are the highest. In the respective graphs, the curves "go up" in direct proportion to the clogging of the toilet.

The "raising" of the capacity curves has as consequences the reduction of the accumulated volumes and their use in the production of hydropower is affected percentageally with the difference in values. Example for Obrejii de Căpâlna Lake, the accumulation of 40,750 m^3/year of solid material, in a period of 20 years, means the reduction of volumes by 815,000 m^3. The amount passed through the turbines is equal to the production of 15,673 MW at the drop and maximum load with water volumes in the dam and the turbine condition of the maximum installed flow (52.0 m^3/s).

The reduction of the length of the lake in the case of the Nedeiu reservoir is 400 m compared to the design phase of the dam construction (Table 5).

Table 5. The dynamics of the main morphometric elements and the volume of accumulations

No. crt.	Element	Nedeiu		Petreşti	
		1983	*2007*	*1983*	*2007*
1	Area (ha) at NNR	35,2	32,4	37,0	23,3
2	Length (km)	3,3	2,90	1,35	1,10
3	Volume (mil.m^3)	4,12	3,23	1,68	0,877
4	Maximum depth (m)			7,5	3,0

The increase in clogging led to the reduction of the depth of the Petreşti Lake. In this situation, the initial expansion of the accumulation is preserved, but the depth is reduced in some profiles by up to 4.4 m. Because of this, the initially accumulated volume has obviously decreased compared to the current situation by more than 50%. The graph of the storage capacity confirms the stage and the increased rate of clogging by the very position of the curve from the year 2007 in relation to the one built in the design phase of the storage.

The slopes undergo important changes both in the longitudinal and in the transverse profile at the contact with the banks. Thus, much reduced values can be distinguished on the hearth of the accumulation and in the upper half of the cuvette; almost the same steepness were preserved in the lower compartment, where small amounts of alluvium arrived and the clogging phenomenon is less felt.

From following the transversal profiles in the accumulations, a change in the slopes in the area of the banks is found due to the deposits at the base of the slopes as a result of their erosion by the shocks or collapses of various materials.

The changes in the transverse profiles are specific to all accumulations in the Sebeş basin, but the amount deposited at the base of the banks is important.

The Oaşa and Tău reservoirs have kept their banks' conformation, sometimes slightly inclined and sometimes steep. Likewise, the morphometry of the lakes in the area of the reservoir dams has not changed, as the alluvium cannot be carried to this sector. At the Oaşa reservoir, through construction, in order to prevent the clogging of the lake in the area of the outlet for the power line and the dam, 3 other earthen dams were built - for the clogging of alluvium. When the waters were withdrawn from the situation of minimum levels, no developments were reported towards the clogging of any of the respective dams (Hydroelectrica information).

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