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SILTING OF THE BOUHANIFIA RESERVOIR, ALGERIA

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Following increased degradation of the vegetation cover on the upstream watershed, reservoir sedimentation remains a major problem in northern Algeria, with the main factor being sediment in runoff whose spatial distribution is controlled by precipitation, lithological characteristics and physiography. The western part of the country is the most affected, followed by central and eastern areas. The erosion loss ranges from 20 to 40 t/ha/yr with a rate of silting often exceeding 15%. Algeria is one of the countries most threatened in the world by this phenomenon. The objective of this study is to show the rate of silting in the Bouhanifia Dam in western Algeria, and to analyze the consequences. The results were used to classify the dam among the most endangered, having reached a level of unprecedented silting. Priorities are also defined for removing sediment and reducing erosion within the scope of a sustainable development policy.

INTRODUCTION

Designed in 1930 for a storage of 70,000,000 $m^{3,}$ and reaching pool level in 1940, the reservoir takes its name from the village of Bou-Hanifia located nearby. It is a rock dam 460 m in total length; it stands at 56 m above the trough; its width at the top is 5 m increasing to 125 m at the base. The total volume of rock is 700,000 m^3. The area is semiarid, and the phenomenon of silting of reservoirs is an issue of national significance. Surface runoff carries the products of the disintegration of rocks in the highland regions to the low lying areas and ultimately to the sea (Elahcene, 2006).

This section is a brief introduction to the problems of solids transport whose study has become essential in many fields, the study of processes of erosion and sedimentation (Abaoui et al., 2005) with those on the pollution of water. In an attempt to lessen the magnitude of these phenomena and to act in an efficient manner to safeguard the physical environment, it is necessary to know and master the basic processes (Touaibia et al., 1999). Once this knowledge is gained, it is possible to generate a model (high-capacity curve and surface-height) which quantifies the sediments transported by the wadis and more specifically by the wadis of Hammam the main tributary dam Bouhanifia located in the western part of the national territory. The location of the dam is shown in Figure 1.

MATERIALS AND METHODS

Based on the available literature at the Agency National of the Dams (AND), data collection and processing focused on the condition of silting of the Bouhanifia Dam. The method of curves-heights relative to the capacity and size of the dam has been used. For this dam, a file is created with the name, the wilaya, the initial capacity (CI), the ability of the latter sounding survey (LSS), the rate of silting (RS), the volume regularized (VR) and destination. In this regard, the data for the period 1973 to 2003 were used to quantify the silting on of the dam. The bathymetric surveys have been prepared by the company LSM (Laboratory study of Maritime).

RESULTS AND DISCUSSION

Up to a height of 282 m the evolving capacity of the dam storage is relatively insignificant (Boualem and Mederbal, 2007). Indeed this value up to the current capacity of the dam remains below 1 hm^3. Above this height, the increase in capacity is quite sustained and over 2 m difference between 282 m and 284 m, the volume is multiplied by 3.6.

Figures 2a shows the exponential growth of the capacity between 282 m altitude that of the RN located at 295 m.

It should be noted, however, that between 1973 and 2003 the dam has lost capacity by the phenomenon of silting (assuming that the 2 surveys are comparable in terms of precision). The evolution of the loss of capacity for the retention of the dam (RN) is summarized in Table 1.

Since 1973, the dam has lost about 29% of its capacity. By comparing the evolving capacity of the dam from 1985 to 2003, it appears that the gap increases with the elevation of the water level. But in percentage terms, we find that the difference between the volumes of these two periods is greater for the lowest heights. This leads to the conclusion that silting would be more important downstream from the dam. The evolution of the difference between the amounts of 1985 and 2003

Figure 1. Location of the study area.

is 10% for the low heights while it is 1.6% for higher heights.

Regarding developments in the area of dam water surface as a function of altitude, the 2003 survey shows that the increase is faster beyond lm height of 288 m (see Figures 2a and 2b).

This is a rapidly reassembled fund that we see on the profiles in long and mostly in the area around the summits of the profile.

Figures 2a and 2b represent analysis of developments in the area between 1985 and 2003. It indicates that the differences are less important to heights near the RN. The difference in size is about 15 hectares at the RN while it is 75 hectares at a height of 288 m.

Table 1. Evolution of loss in capacity of the Bouhanifia dam.

Period	1948 (entered service)	1973	1985	2003
Capacity (hm3)	/	53487	51565	3811
Loss (hm3)	/	/	1922	15377
% Loss	/	/	3,6	28,75

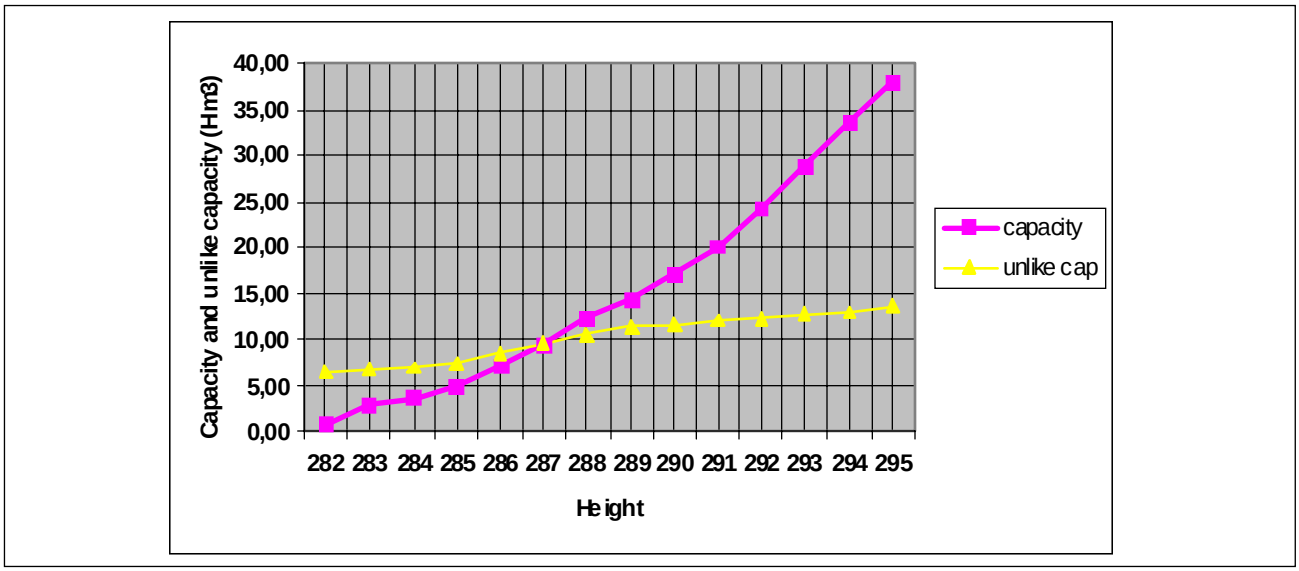

Figure 2a. Evolution of capacity and their gap between 1985-2003.

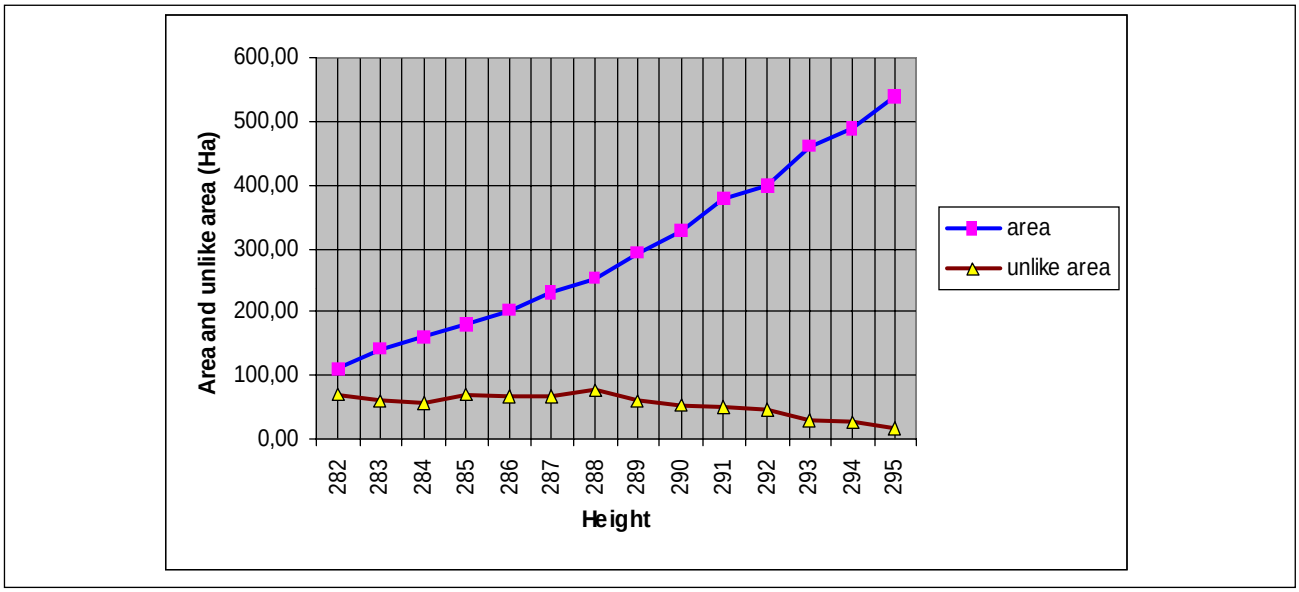

Figure 2b. Evolution of the area and their gap between 1985-2003.

For the heights where the gaps are highest, interpretation is difficult to make a distinction as a result of silting (Achite, 2006) of the effect of the configuration of the shoreline between the periods of 1985 and 2003.

The evolution of the loss of capacity of the dam analyzed from 1973 is as follows in the RN (see Table 2).

Compared to the year 1973 which corresponds to the year for which we have the first surveys, the loss in capacity is on the order of 513000 m3/yr. In addition, different coasts minimum recorded on the shell as a whole rose from 259.10 m in 1985 to 275.22 m in 2003.

Table 2. The evolution of the loss of capacity of the dam.

Periods	1948 -1973	1973 -1985	1985 -2003	Total
Loss of the ability (hm3)	/	1922	13459	15381
Average Annual Loss (hm3)	/	0,160	0,748	0,513

CONCLUSION

This paper presents the results of the study on the Bouhanifia dam (wilaya of Mascara) from September 9-26, 2003. The results of the work done on the ground as well as in the office have enabled the monitoring of the level of silting of the dam and efficient management of its capacity.

In order to achieve this, the grouping L.S.M. was conducted from 12 to 26 September 2003 (13.5 days) concerning land surveying an area of 559.4 ha. The bathymetric survey of an area of 101.6 ha was conducted from 12 to 14 September 2003 (2.5 days).

Table 3 shows the estimation of capacity and the area to the PHE and the RN.

Table 3. Estimation of capacity and the area to the PHE and the RN.

	Surface current dam (Ha)	**Current dam** (Hm3)
Withholding normal (295m)	517,98	38,11
PHE (300m)	662,79	67,80

The overall area clearance, which required the determination of 20500 points, is 661 ha divided between about 85% in ground surveying and 15% in bathymetric survey. Table 3 shows the main results obtained for estimating the capacity of the area and the PHE and the RN.

The loss in capacity of the dam since 1973, the year for which we have the first survey, is estimated at 15381 hm^3, equivalent to 28.75% of its capacity in 1973. This corresponds to an average annual loss of 513000 m^3/year that aggravates the already alarming situation regarding the water shortage in Algeria (Hadef and Hadef, 2001). Thus, we propose a variety of upstream remedies to apply to the river system to combat the phenomenon of water erosion (Labiod et al., 2004):

- reforestation,
- soil conservation measures, development of traditional farming,
- correction gullies (mechanical and biological),
- correction of banks (biological),
- pastoral management.

It is reported that a special program to combat erosion has been launched by the forest service where an area of 1.5 million hectares will be treated by 2010 at a rate of 6700 ha per year.

For the silting up of dams, several mechanisms have been put in place to combat this phenomenon (Remini and Halbouche, 2006):

- Direct scour methods using a scour outlet,
- Dam releases that mobilize sediment, and
- Dredging.

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