

# IMPACT DES FUITES D'EAU SUR LES PERTES TOTALES DU BARRAGE DE OUIZERT -ALGERIE IMPACT OF THE WATER LEAKAGES ON THE TOTAL LOSSES OF THE DAM OUIZERT - ALGERIE

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## **Abstract**

*The phenomenon of the water leakages on the level of the dams results of considerable into invaluable water and rare losses and also in very serious threats of the stability of the hydraulic works. Moreover, more the share of the dams are subjected to a loss of capacity due primarily to three phenomena to knowing: water leakages, the silting of reserves and intense evaporation. In Algeria, we listed approximately fifteen dams having losses by water leakages which exceed 1 million m<sup>3</sup> per year for each one, among these dams six have a volume of escape higher than 5 million m<sup>3</sup>. Due to the non existence of a better site and the establishment of the dam Ouizert in an unfavourable site with the storage of water and favorable to the water leakages, this dam is strongly prone to this problem and its loss of capacity is in evolution because of the increase in the water leakages. In spite of the grouting curtain which were carried out along the axis of the dam and which allowed the suppression of the right bank water leakages, the problem of the water losses through left bank of the dam towards the downstream always remains. The dam ouizert is Located at approximately 35 km in the Western – South of the place head of the wilaya of Mascara. It has a total capacity of 100 million m<sup>3</sup>, it is intended to increase the degree of regularization of the Wadi El Hammam for the drinking and industrial water of Oran – Arzew, the irrigation of the perimeter of El Habra located at the North of Mohammadia and to feed the dam Bouhanifia by the lâchers. However, this dam is threatened by the water leakages through the left bank in clear evolution in time. The dam has never reached its maximum level, since the lost volume generally borders the value of 1m<sup>3</sup>/s. We present in this study the assessment of the total water the total losses of the dam Ouizert while trying to show the impact of these water leakages on losses on the level of this dam especially which we considered interannual the volume of the escapes average at 10.42 hm<sup>3</sup>. From where we can conclude that the water leakages are the principal cause in the increase in the total losses of the dam Ouizert beside the accelerated silting of reserve and intense evaporation.*

*Key words: Total losses – Water leakages – Rivets –Dam - Ouizert - Algeria.*

## **Introduction**

The Algerian dams are confronted with three very serious hydraulic problems which are intense evaporation, the excessive silting and the water escapes through banks and foundations especially that our country and more precisely the arid regions are affected by a dry period since approximately twenty years. In addition to the considerable invaluable and rare losses of water that generates the problem of the water escapes, it presents also very serious threats of the stability of the hydraulic works and influences in a remarkable way the increase of the total losses of the dams beside the losses in volume caused by the silting and evaporation. The problem of the water escapes became extensive on the level of the Algerian dams in the course of time owing to the fact that the majority of the dams are exposed to this phenomenon from where the study of the water leakages on the level of the strongly threatened dams proves of great importance, particularly for the dams which are in strategic zones especially for those in arid and semi arid regions where the economic development is closely related to the stored quantities of water. In front of this phenomenon which threatens the dams and causes a big reduction in the water capacities in our reserves, we saw very necessary to make a study of the escapes on the level of the dam of Ouizert which is strongly threatened by this phenomenon and also located in an arid area. For this reason, the water losses are very considerable. Through this study, we are trying to evaluate these losses caused by the three hydraulic problems mentioned before. The dam of Ouizert is located in the south-west of Mascara (a town), it

has a very great economic importance in agricultural and industrial areas since it irrigate 20.000 hectares of the plain of El Habra, to feed the industrial park of Arzew and also the town of Oran by drinking water . Nine months after the startup of the Ouizert dam (03/05/1986) and Thanks the information of the residents located in left bank of the reserve, the direction of the project took note of the phenomenon of water loss probably coming from reserve. Dam of Ouizert has never been completely filled because of the escapes of water which appeared in an adjacent talweg in the left bank. The leak-flow observed to the downstream of the work has been in increase since few years, it became very important and its value can reach approximately  $1\text{m}^3/\text{S}$  . In spite of the grouting curtain which were carried out along the axis of the dam and which allowed the suppression of right the bank water leakages, the problem of the water losses through left bank of the dam towards the downstream remains and we estimated a volume of escapes average interannual of  $10.42\text{hm}^3$  ( photo 1 and 2 ) .

## Data and Methods

### Situation and characteristic of the dam

The dam of Ouizert is located in the North-West of Algeria, at approximately 35 km in the western south of the Chief place of the Wilaya of MASCARA and at 17 km in the south of the locality of Ain Fekan. The studied area belongs to the basin of the wadi El hammam, which extends on a surface of  $14389\text{km}^2$  The site of this stopping is on the wadi of sahouet, to 4 km in North Western – of the village of Ouizert (commune of Taria, wilaya of Mascara - Algeria) . it is established in the Wadi of Sahouet which is the fusion of the Wadis of Taria and Saida. The wadi of sahouet is one of the principal affluents of the wadi el Hammam, on which were built the dams of Bouhanifia and Fergoug . the construction of the stopping in the throats of ouizert created an artificial lake of 10 km length in the valley of the wadi of sahouet , It is a clay dam of 60 m high and a capacity of  $100\text{hm}^3$ , intended to increase the degree of regularization of the Wadi El Hammam,  $12\text{hm}^3$  is intended for the irrigation of 20.000 hectares of the plain of El Habra located in the North of Mohammadia,  $20\text{hm}^3$  is devoted to the food of the industrial park of Arzew and the AEP of Oran.(a filter for the dam Bouhanifia). The annual average contribution of this dam is of about  $45\text{hm}^3/\text{year}$ . The dam Ouizert has as coordinates: X: 250.55 Y: 206.80, Z: 396.00 NGA ( Fig. 1, photo. 1 ) . According to the morphometric study, we found the value of the coefficient of compactness of Gravelius ( $K_c$ ) = 1.49 that means that the catchment area of the wadi sahouet is lengthened what results in the development of linear erosion , we also determined the overall index of slope and the specific difference in level which are one who are respectively ( $I_g = 0.00583$ ,  $D_s = 276.23\text{m}$ ) . According to these values, we can say that our catchment area is with rather strong relief ( Toran ,1970 ) .



Photos 1-2. General sight of the Dam Ouizert. Mascara. Algeria

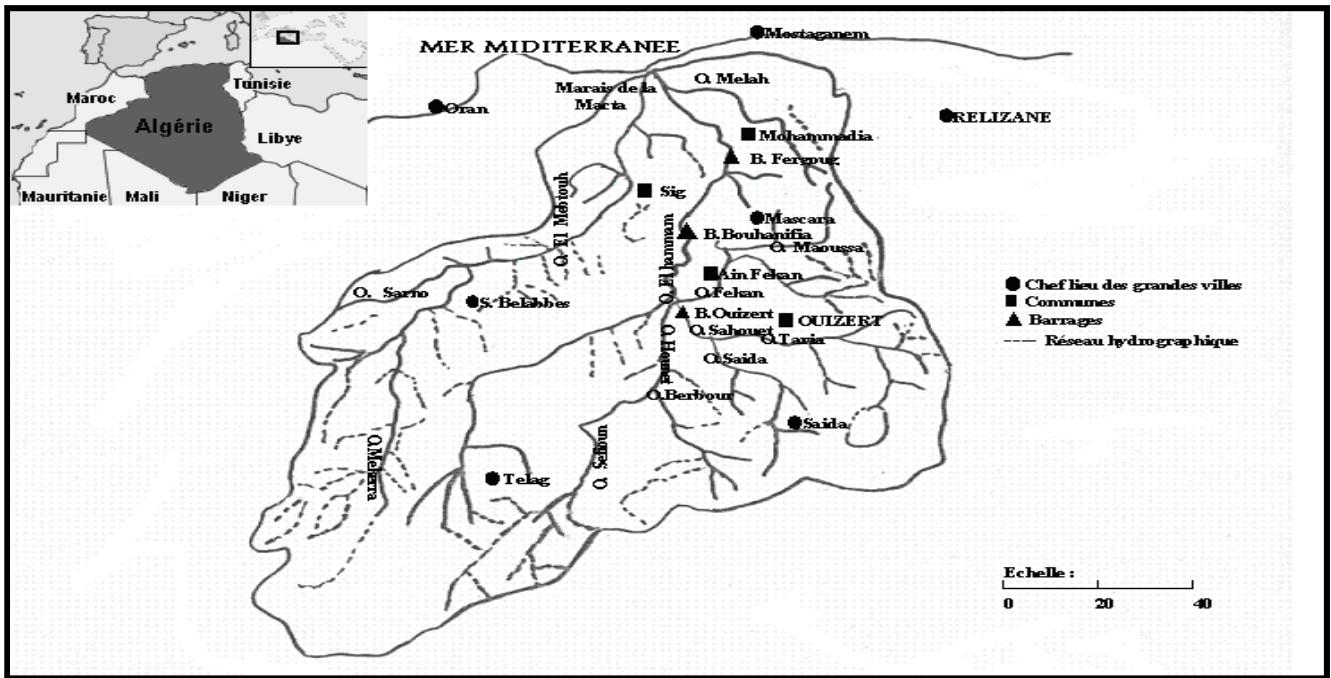


Figure 1. Geographical and hydrographic situation of the dam of ouizert

### Geological data

The Sahouet wadi which occurs at the junction of the Wadis Taria and Saida, crosses mountainous grounds slightly corrugated in general formed of the cretaceous sediments (of secondary origin) covered by places and conglomerates of tertiary origin. The part of the area catchment upstream confluences of the Wadis Saida and Taria is in general made up of limestones, of sandstones and of marls of Jurassic origin (secondary). In the influence of the laying-up basin, the part of the valley of the Sahouet wadi between the site of the stopping and the locality of Ouizert are in general made up of sandstones and marls of cretaceous origin. On the surface, deposits of conglomerates occupy a significant surface and extension on left bank directly upstream from the site of the stopping. These deposits are partly visible and partly covered with thin layers of colluviums or fall of slope. The cretaceous sediments, which form the bed-rock in place, extend in the North East- South East direction and are slightly tilted towards the South East . The deposits of conglomerates, which occupy a large surface on left bank, extend above the cretacic sediments. The Sahouet wadi which runs in general in the East-West direction formed in certain parts of its course, the more or less large meanders and the slopes of rather asymmetrical valley. It appears obvious that the general direction and the local directions of the course of the wadi as well as the formation of its valley are due to a significant and combined action various factors, namely: The geological composition of the ground, various resistances met, the general position and slopes of the rock complexes, as well as the direction of the degraded zones. On the other hand , it is to be stressed that the formation of the relief of the valley of the Sahouet wadi was certainly influenced by the actions of the atmospheric agents( Toran , 1970 ).

### Extract on the Lithology of banks and the site of the dam

The restricted zone of the stopping consists of two geological formations, namely:

- Cretacic sediments .
- deposits of conglomerates (continental miocene)
- colluviaux and alluvial deposits.

The cretacic sediments constitute the bed rock'n'roll and are of various types of sandstones, marly sandstones, sandy marls, marls and grés-limestones rocks . To this complex of various sediments belong also bluish limestones in benches. Frequent changes of facies give to this complex characteristics of a flyshs. The major part of measurements showed that the dip of the layers evolves/moves of 5° to 10°( National Agency of t he Dams Algiers, 2000).

### **Right Bank**

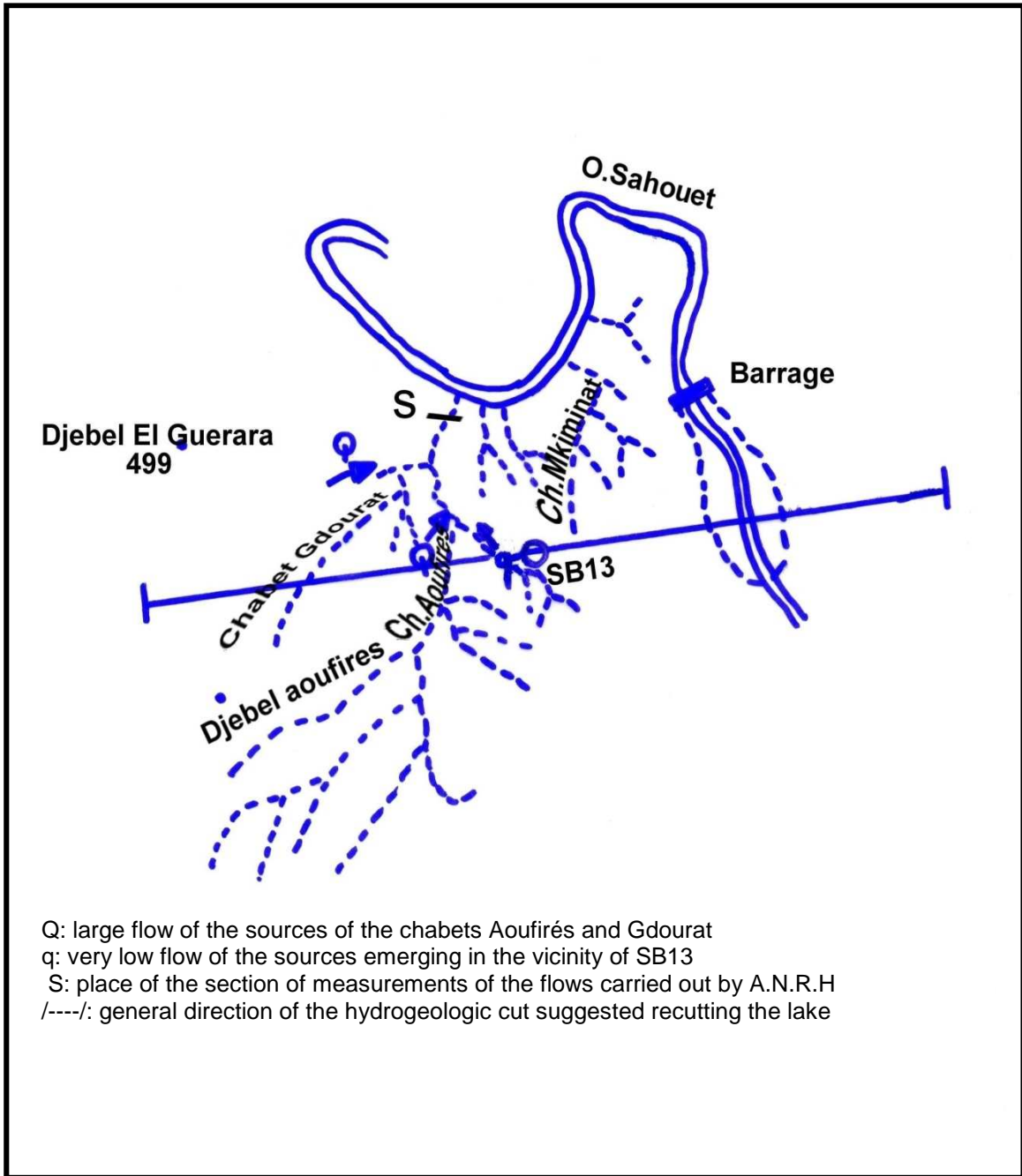
The rock complex on right bank was dislocated and lowered. It is supposed that the depression of the rock block occurred along two lines of break roughly parallel during the wadi. It is not the case of left bank. In the dam, the only permeable levels by except the conglomerates protected by the veil under the work, are consisted the sandstones limestones of the layer "j" and the sandstones of the level "G". Regarding to the sandstones limestones, the dip upstream makes that they are level with the downstream of the dam at a very high coast, approximately 5 m with the lower part of the level of the collar. Moreover the distance between the zone of infiltration and the sector of possible resurgences is approximately 150 m what gives a very weak gradient –taking into account the small load and which these grounds are not permeable. It does not have there to wait on this side of perceptible filtrations; moreover, if they would occur at the time of a zone of cracks, and that one would consider it useful to clog it, works of injection would not pose any problem starting from the works which will equip the collar. For the sandstones of the layer "G", in consequence of a sedimentary discordance, they finish in bevel against the preceding layer, not reappearing with the downstream.

### **Left bank**

On cliffs of left bank downstream from the profile of the dam are visible significant and interesting discontinuities (slits and faults) whose directions of extension are of little meadows parallel and perpendicular during the wadi. The deposits of conglomerates extend in discordance with the top from the flyshs. They are clastic and coarse, consist of rollers and materials with coarse grains in an sablo-argillaceous or carbonated binder. By places the conglomerates are enough degraded and deteriorated. The sandstones of the layer "G" and the conglomerates are level with the reserve with approximately 20 and 40 m respectively with the lower part of the coast of the peak of the dam. The section ranging between 20 and 40 m, i.e. most of the sandstones is covered by formations of slope relatively not very permeable. However, the problem of filtrations as well by skirting of the veil as towards the chabet of Mkiminat deeply notched in the sandstones. The gradient is relatively strong especially towards the chabet Mkiminat in the vicinity of the collar and where it is necessary to envisage cracks of direction East West which will increase certainly the low permeability of the affected materials. Thus probable filtrations are starting from left bank and they will turn over to the Sahouat wadi. To cure this problem, the concerned services produced a grouting curtain along the axis of the dam and which allowed the suppression of water leakages in the right bank, but unfortunately the problem of the water losses through left bank of the dam towards the downstream always remains. The cracks in the rock mass are numerous, they are marked in the hard grésolimestones rocks than in the marls and the conglomerates. Certain directions of cracking of the conglomerates coincide with those of the bedrock.

### **Vegetable cover**

Vegetable cover is practically non-existent on the marly zones and generally not very dense on the slopes. The current forest cover of the basin is in continuous degradation following the anthropic action and the recent fires. The dominant species are especially the oak, the thujas and the pine of Alep. One also finds, a rich arboriculture, practically all along the wadi and in the valley (Remini, 2004).



**Figure 2.** General situation of the surface of study (extracted increased topographic chart:1/50.000 )

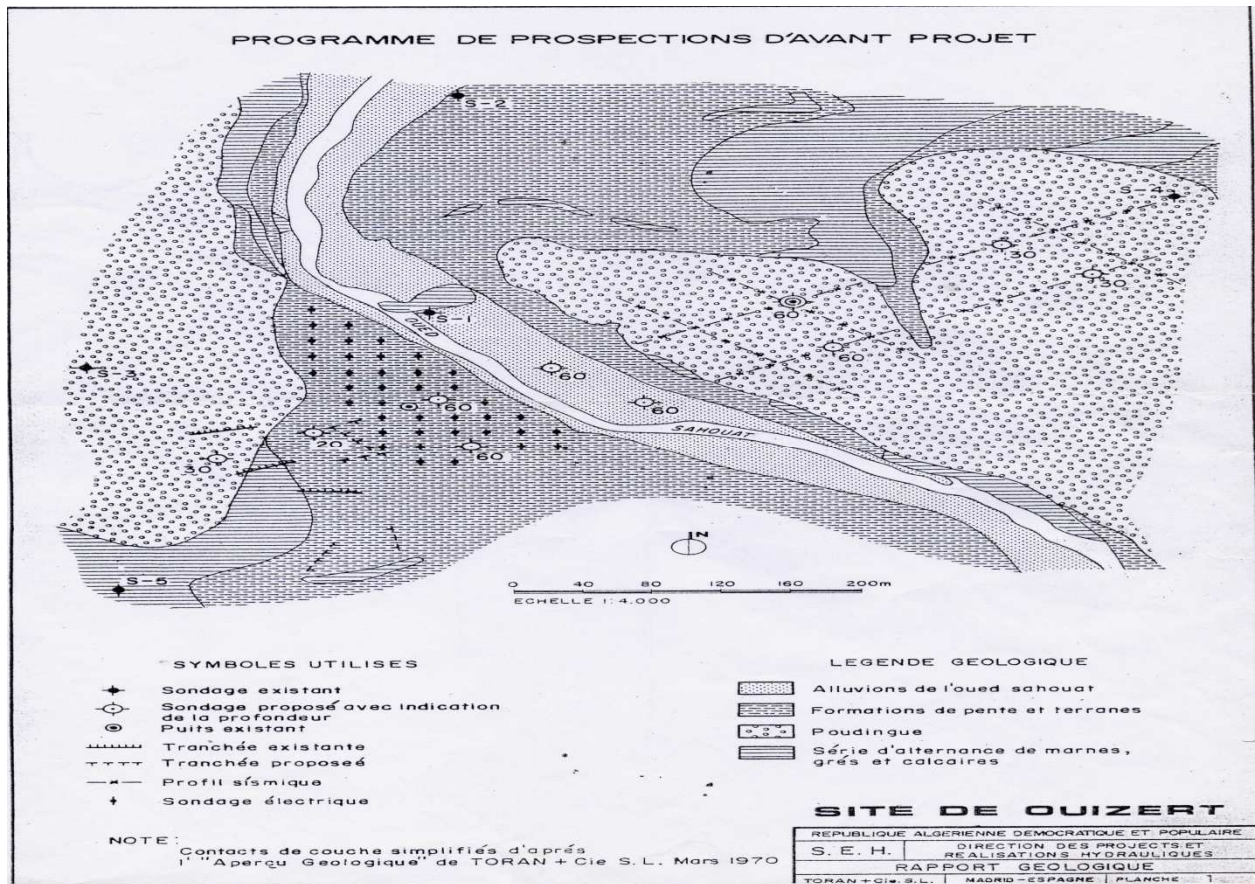




**Photo 3.** Water leakages the level of left bank Beside piezometer SB13. Dam Ouizert ( q )



**Photo 4.** Place of meeting held on the three water leakages on the level left bank. Dam ouizert (S)



**Figure 3.** Geological data – Dam of ouizert





## Data used

We used the operating data of the dam of ouizert (precipitation, contributions, leakages of water, Evaporation, losses by percolation, Envasement, totality of the losses) provided by the services of the National Agency of dams (ANB) during the period (1986/2002)( National Agency of the Dams Algiers, 1986-2002).

## Data processing and discussions of results

### Climatic data

The catchment area of the dam Ouizert confronts a semi Tellian Atlas arid climate. The mode is characterized by a clear opposition between dry and wet season. The annual variations are between 100 mm and 400 mm (Fig. 5 ), with very strong intensities in winter and spring. Average annual pluviometry is 242,47 with a minimum of 102.6 mm and a maximum of 497.4 mm.

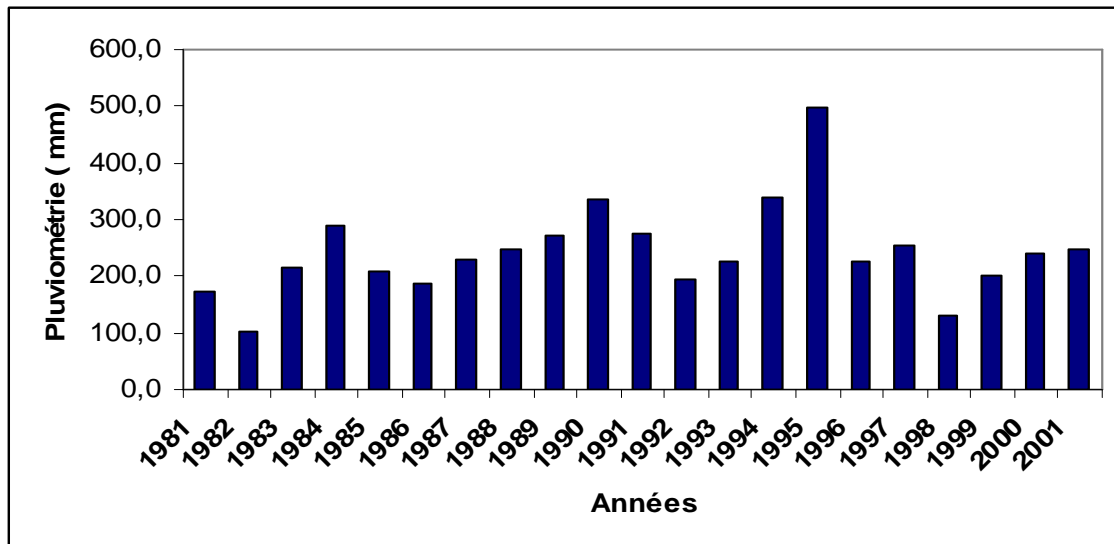


Figure 5. Catchment area of the dam Ouizert  
Annual pluviometry (period 1981-2001)

### Hydrological data

#### Liquid contributions

The annual average contributions of this stopping were evaluated in the studies of preparatory project detailed of the dam Ouizert (1970) to 84 hm<sup>3</sup>/year, because of the dryness and of the clear reduction in precipitations in this area during this last decade, the annual average contribution during the period (1987/2002) is estimated at 22.36 hm<sup>3</sup> ( Fig. 6 ).

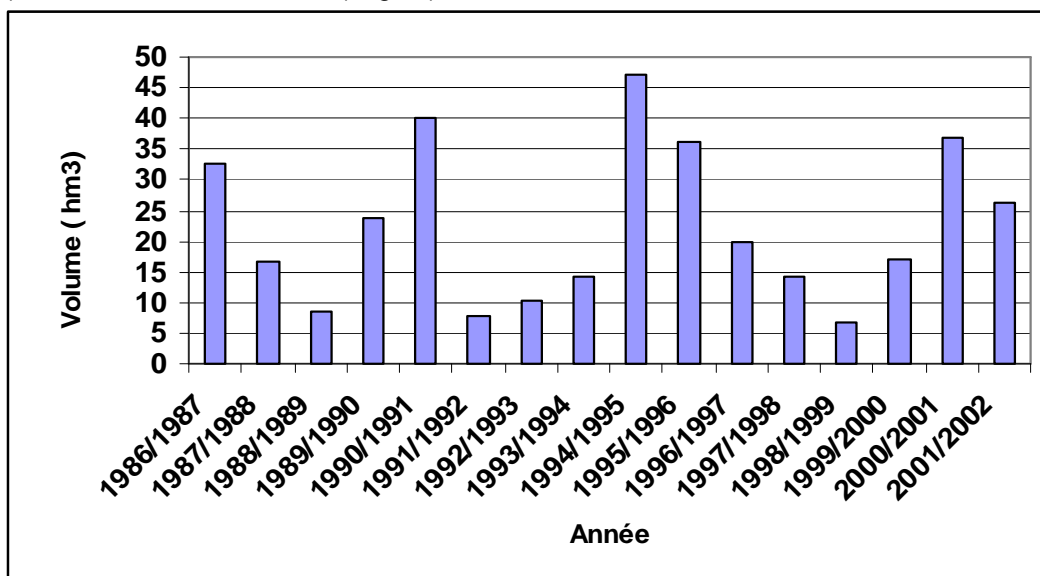
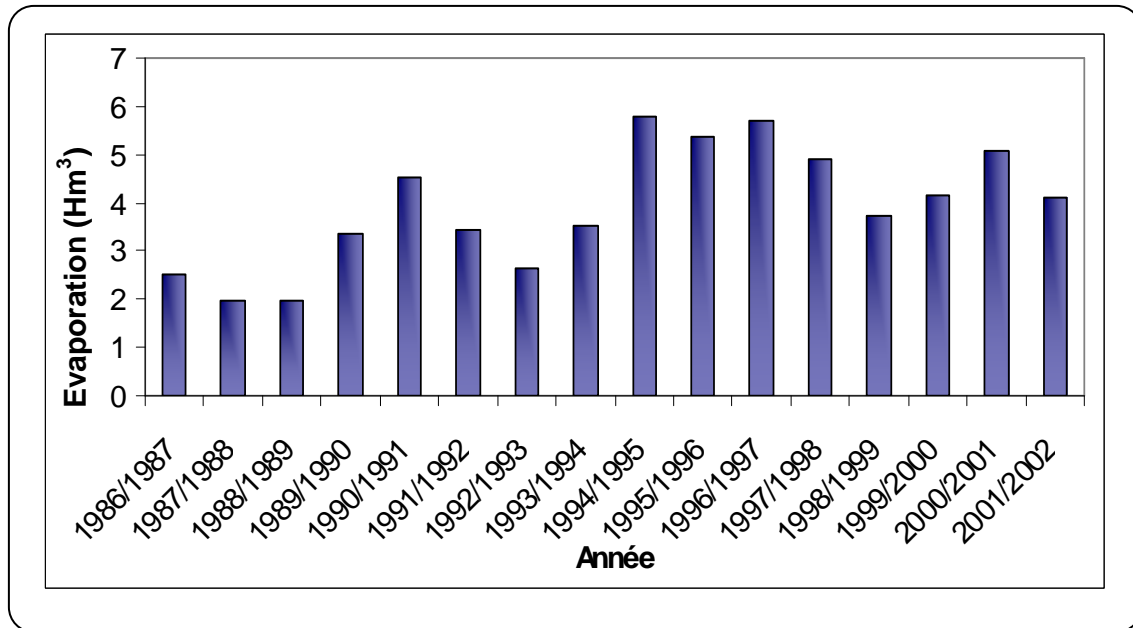


Figure 6. Annual variations of the contributions liquidate Dam Ouizert



### Losses evaporation at the reserve

The data of the losses evaporation (1986-2002) were provided to us by the hydraulic services of the National Agency Of the Algiers-Dams. In figure 7, we present the variations of evaporation according to time (they were measured directly using the weather station of ouizert in situ) .

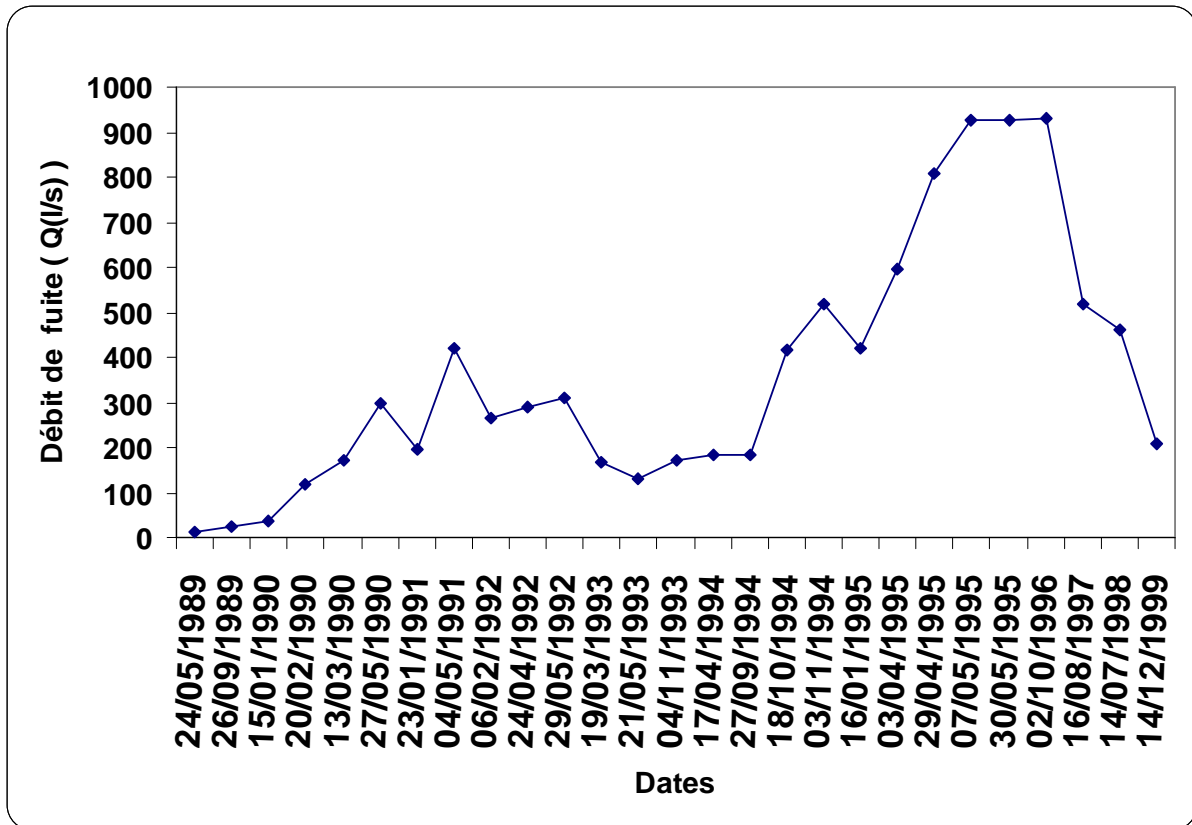


**Figure 7.** Histogram of variation of the losses evaporation in time –Dam Ouizert

In figure 7, it is noticed that the losses by évaporation vary from 2 hm<sup>3</sup> with 6 hm<sup>3</sup> per annum, the annual average value being equal to 4 hm<sup>3</sup>.

### Water leakages on the level of the dam of Ouizert

In figure 8 , We present measurements of the leak-flows at the level of left bank of the dam of ouizert carried out by the services of the National Agency of the Hydrous Resources of Oran ( National Agency of the Dams Algiers, 1989-1999) .

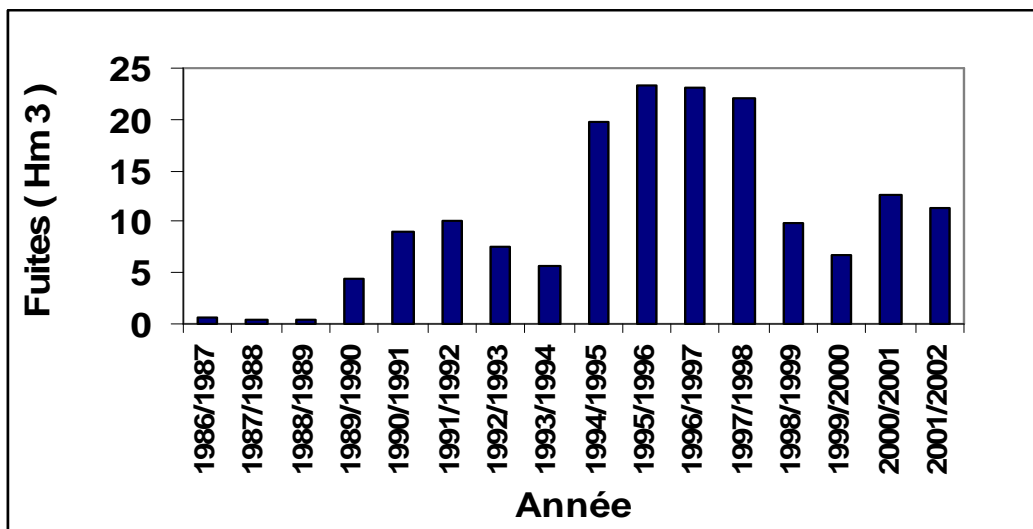


**Figure 8.** Variation in the time of the leak-flow –Dam of Ouizert - Algeria

In figure 8 , We notice that the leak-flow is in increase, these values were weak during the first years of the startup of the dam Ouizert (24/05/89 → 11.6 L/S) to increase with a significant value of 419 L/S on 04/05/91, then to decrease slightly (for example on 21/05/93 one records a value of 131 L/S), then one notices an increase (ex: on 03/11/94 → 520 L/S) to reach very significant maximum values (07/05/95 → 926 L/S, 30/05/95 → 926 L/S, 02/10/96 → 930 L/S). The leak-flow 930 L/S on 02/10/96 reflects well the importance of the values of the water leakages recorded in the dam of Ouizert ( Benfetta, 2007).

#### Variation of the volume of the escapes during years

In figure 9, we present the variation of the volume of the escapes during the years (1986-2002):

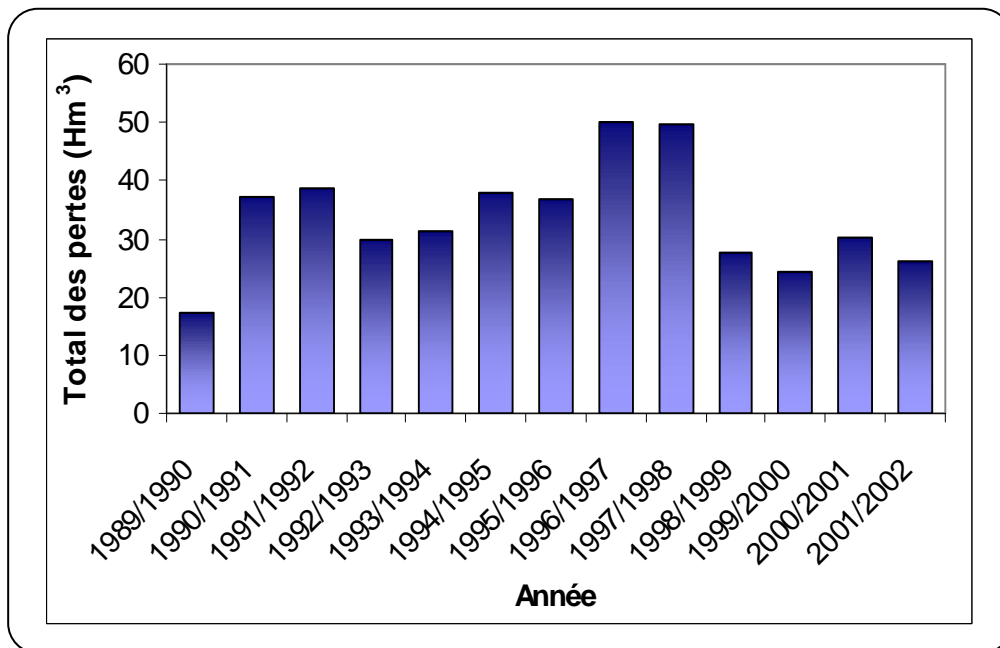


**Figure 9.** Variation of the volume of the escapes in time

In figure 9, one notices that the volume of the escapes is significant , the water leakages vary from 0.365 hm<sup>3</sup> with 23.34 hm<sup>3</sup> per annum, the annual average value being equal to 10.42 hm<sup>3</sup>.

### The total Analyze of losses in the dam of Ouizert

The data of the total losses of the dam of ouizert (1989 -2002) were provided to us by the hydraulic services of the National Agency of the Algiers –dams (Remini, 2003 )

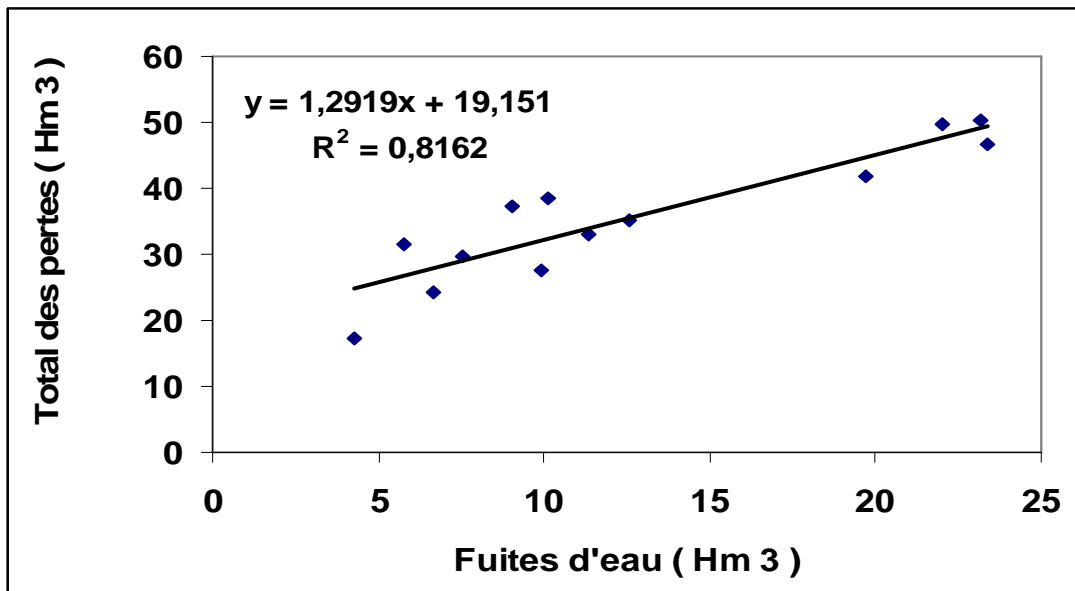


**Figure 10.** Histogram of variation of the totality of the losses in time –Dam of Ouizert

In figure 10, we notice that the total water losses are considerable and in evolution, this increase in the total losses is due to the increase in the escapes. For example, during year 1996/1997, we recorded a volume of very high total loss of 50.226 hm<sup>3</sup> which corresponded to a very significant volume of escape of 23.135 hm<sup>3</sup>. the annual average value being of 33.61 hm<sup>3</sup>.

### Evolution of the total losses according to the water leakages through time

In figure 11 , we present the evolution of the total losses according to the water leakages through time ( Remini, 2003):



**Figure 11.** evolution of the losses total be according to the water leakages.

According to the curves of regression of figure 11, one notices that the total losses are narrowly correlated with the volume of the water leakages ( $R^2 = 0.81 \rightarrow$ strong correlation). The figure 14 confirms that the totality of the losses varies primarily according to the water leakages. Higher the water leakages are more significant the total losses are.

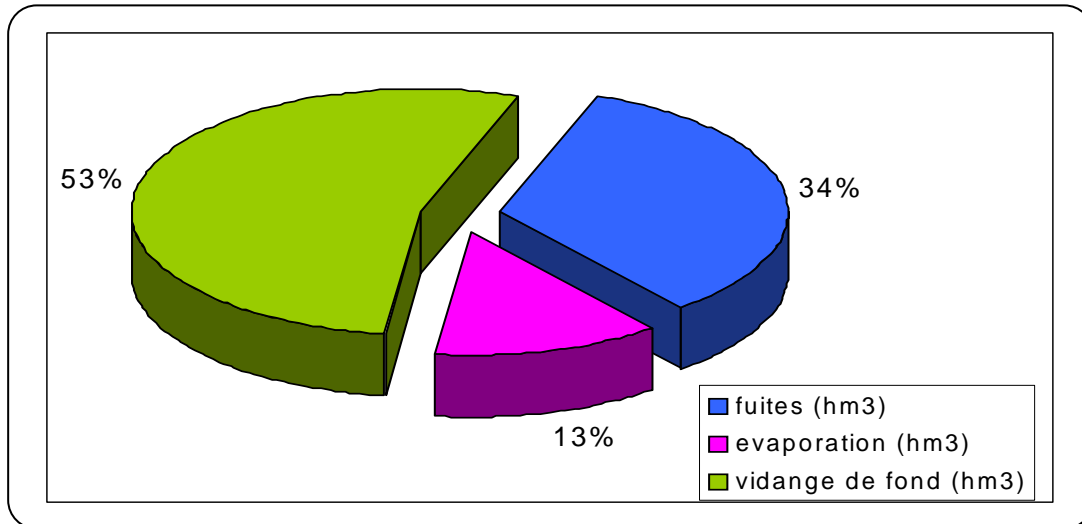


### Representation of the water leakages by sectors

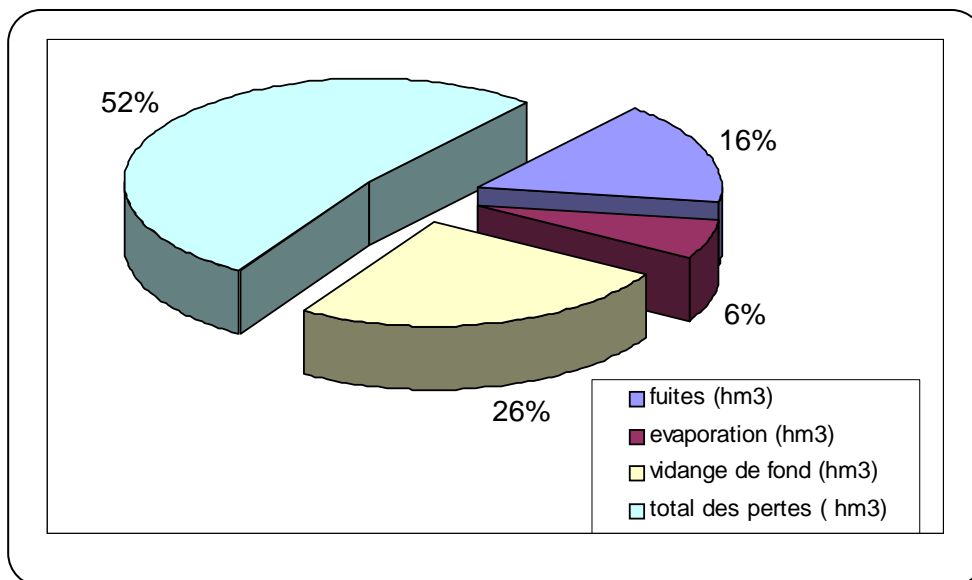
In table 1, we roughly present the annual average values of the various losses of the dam Ouizert :

**Table 1.** Various losses of the dam Ouizert ( Benfetta, 2007).

escapes (hm3)	Losses by evaporation (hm3)	basic draining (hm3)	total of the losses (hm3)
10,42	3,92	16,55	33,61



**Figure 12.** Representation of the water leakages by sectors compared to the losses basic evaporation and draining



**Figure 13.** Representation of the water leakages by sectors and expressed as a percentage of the total losses

The representations of the water leakages by percentage illustrate well the importance of the escapes on the level of the dam Ouizert and their impact on the total losses of the dam, indeed, these figures show well that the losses by water leakages are considerable, they present significant percentages varying between 30 and approximately 59% total losses of the dam Ouizert and an annual average percentage of 10.42% of the total capacity of the dam ( Benfetta, 2007).

### Silting of the Reserve of the dam Ouizert

In this part , We expose the results of the countryside carried out on the dam Ouizert realized from the 2<sup>nd</sup> of June to the 22<sup>nd</sup> , 2004. The results of the work carried out on the ground and their treatment will make it possible to follow the evolution of the level of the silting of reserve and to manage in a rational way and specifies the capacity of reserve. The bathymetry of a surface of 172 5 ha was carried out in 3 days from the 5<sup>th</sup> of June to the 8<sup>th</sup>, 2004. The terrestrial topographical survey of a surface of 615.3 ha was carried out in 15 days from the 5<sup>th</sup> of June to the 21<sup>st</sup>, 2004. Thus The total surface raised 787.8 ha is distributed between approximately 78% in terrestrial survey and 21 % in bathymetric lifting. The principal result obtained is the estimate of the capacity and the surface in the highest waters (PHE) and to normal Reserve (RN). They are as follows ( Remini, 2004):

The current surface of the stopping to normal reserve (448.00 m) is 663.14 ha

The current surface of the stopping with the PHE (449.00 m) is of 728.33ha.

The current capacity of the stopping to normal reserve (448.00 m) is of 93.91 hm<sup>3</sup>.

The current capacity of the stopping with the PHE (449.00 m) is of 106.43 hm<sup>3</sup>.

From 1986 (date of its introduction) at 2000, the tank of Ouizert is envasé by 7.4 million m<sup>3</sup> (under normal Retenue). In 2000, the volume accounts for approximately 8% of the initial capacity (1986), this rate is close to that observed with the dam Bouhanifia between 1986 and 2000 (9%). The lifespan of the tank can be estimated at approximately 180 years.

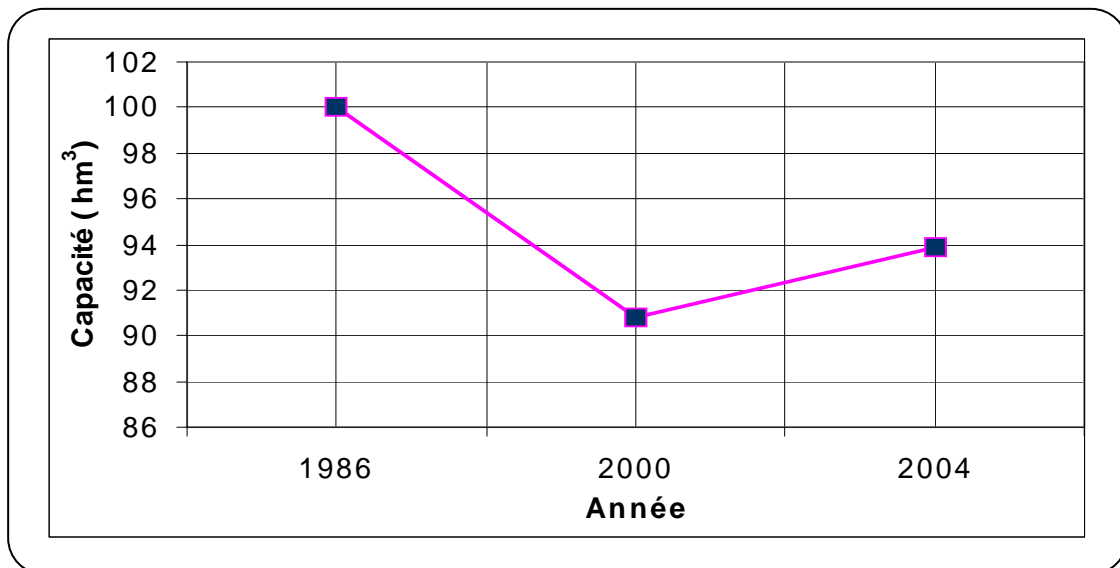
**Table 2:** Dam Ouizert – State of the silting .

Year	V(RN) (M <sup>3</sup> )	Silting		Duration of life (years)
		Period	Annual	
1986	98 250 000	0	0	199
2000	90 831 100	7 418 900	494 593	184

**Source:** the National Agency of the Dams – Algiers .

### The capacity loss of the dam Ouizert

We present in figure 14 the loss of capacity according to the age of the dam of ouizert:



**Figure 14.** Loss of capacity according to the age of the dam

Since the year of setting in water of the dam in 1986, its reduced capacity at summer of 6.09 Hm<sup>3</sup> what corresponds to a percentage of loss of 6.09 %. Either an annual average value of loss in capacity between 1986 and 2004 of about 338300 m<sup>3</sup> / a year.

### Estimated volume losses of the dam Ouizert

The total capacity of reserve includes following volumes:

- useful volume: Quantity of water for the needs for food of the drinking water agglomerations and industry.
- Infiltrated volume: It corresponds to the section lost by infiltration.
- Evaporated volume: It is the water section lost by evaporation.
- Dead volume: Slice envasée reserve.

If one takes as reference the data of the year 2000 , we can estimate the losses in volume in 2000 as follows : (without taking into account the losses by basic draining)

$$PV = VM+VI+VE$$

PV : losses in volume

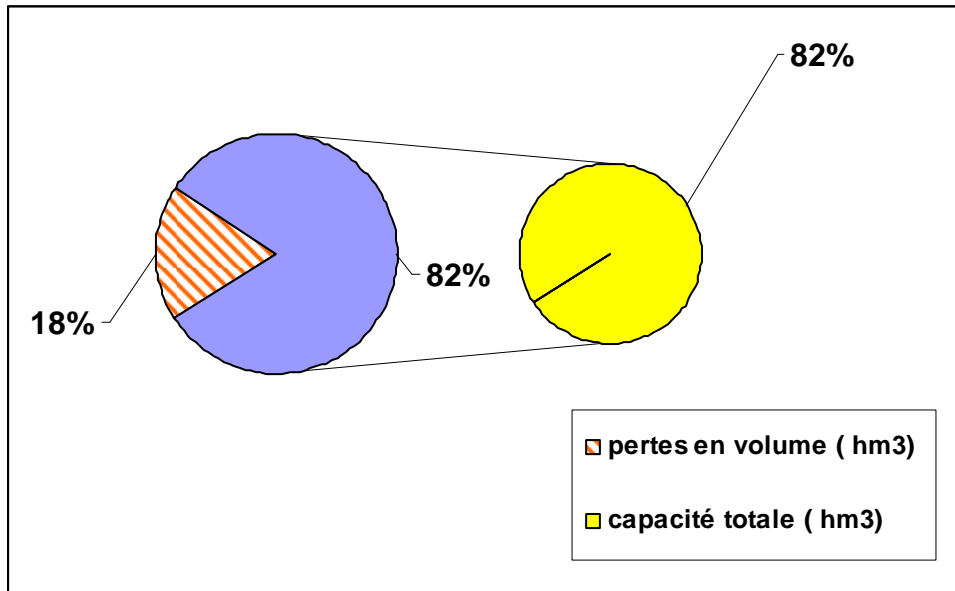
VM : Dead volume = 7.41 hm<sup>3</sup> in 2000

VI : Infiltrated volume/year (water leakage): 10.42 hm<sup>3</sup>

VE : Evaporated volume/year: 4 hm<sup>3</sup>

From where, the losses in volume are estimated at 21.83 hm<sup>3</sup> .

On figure 15, we present the volume losses in percentage compared to the total capacity:



**Figure 15.** Presentation of the volume losses by sectors compared to the total capacity

In figure 15, we notice that the losses in volume are considerable and present a significant percentage of 18 % of the total capacity of the stopping what means that each year the dam losses a volume of approximately 22 hm<sup>3</sup> on average ( Benfetta, 2007).

According to these estimates, we can conclude that the reserve of the dam Ouizert confronts a loss of capacity due primarily to three phenomena (Remini, 2004 ):

- ◆ Very high water leakages on the level of left bank
- ◆ An accelerated silting
- ◆ A strong evaporation

Therefore, we notice that the water leakages and the silting present the factors more most significant which generate considerable losses and reduce the capacity of the dam Ouizert in a remarkable way. Thus, it proves very necessary to fight against these hydraulic problems in order to reduce until acceptable volumes of losses of this dam.

## Conclusion

The reserve of the dam Ouizert confronts a loss of capacity due to the accelerated silting, intense evaporation and especially to the very high water leakages which generate considerable losses.

- The dam Ouizert is established in a site consisted of a complex rock fissured enough and faulted, which is particularly noticed on types of harder rocks: limestones, sandstones , grésolimestones rocks. This cracking is much marked on the marly rocks. The local cracks are also visible on the deposits of conglomerates but to a lesser extent.

- On the right bank, the rock complex was dislocated and lowered. it is supposed that the depression of the rock block occurred along two approximately parallel lines of break during the wadi. The water leakages are not very probable starting from right bank then that the faults observed are practically parallel to the direction of the layers and consequently to the axis of the dam .

- On the cliffs of the left bank downstream from the dam are visible important and interesting discontinuities (slits and faults) whose directions of extension are about parallel and perpendicular during the wadi. These discontinuities support the water losses starting from reserve.

In front of these conditions, we note that our stopping is threatened by the problem of the escapes especially that the flow of the escapes is in increase during times because of the deterioration of



unquestionable zones of the grouting curtain caused in its turn is by hydraulic erosion or chemical corrosion.

According to the analysis of the results obtained, we can conclude that the water leakages appear on the level of left bank to the downstream of the stopping and are supported by the presence of the cracks of directions to little meadows parallel and perpendicular during the wadi and also by the gradient which is relatively strong, whereas side of right bank, one notices the absence of the water losses due to the direction of the cracks which is parallel to the axis of the dam, with the weak gradient and to the veil of injection existing along the axis of the dam which the suppression of the escapes allowed the level of right bank.

In addition to the considerable losses generated by the water leakages estimated at an interannual average volume of 10.42 hm<sup>3</sup>, we add the losses in volume caused by the silting, evaporation, 4 hm<sup>3</sup> of evaporated volume and 7.41 hm<sup>3</sup> of volume died in 2000 is a total loss of volume of 21.81 hm<sup>3</sup> (22 % of the total capacity of the dam).

Therefore, we notice that the volume of the escapes presents a high percentage of the total losses of the dam Ouizert, followed by the losses in volume of the silting and then losses evaporation. So it is necessary to regulate the problem of the escapes initially in order to reduce until acceptable volumes the losses especially by percolation through the left edge of reserve that this phenomenon if it persists will present in the future of the threats on the stability of the work.

Secondly, it is necessary to pass to the means of fight against the silting and evaporation to increase the storage capacity of the stopping and also to avoid the considerable damage with the environment and a setting in danger of the economy of the project ( Benfetta, 2007).

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