

# SILTING OF FOU M EL GHERZA RESERVOIR

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## Abstract

The Fom El Gherza Reservoir fails to satisfy the irrigation of 300,000 palms of Sidi Okba and Seriana due to advanced siltation. Based on data from bathymetric surveys conducted by the National Agency for Dams, the siltation rate was estimated at 0.9 million m<sup>3</sup>/year. With a total capacity of 47 million of m<sup>3</sup>, the Fom El Gherza dam is silted up with more than 65 million m<sup>3</sup>. In this case, the life of the dam will not exceed 11 years of operation. The total silting of the reservoir will occur in 2023. Desilting the dam proves an emergency to save the palms of Seriana and Sidi Okba.

**Keywords:** Dam, Fom El Gherza, Siltation, Current density, Desilting.

## 1 INTRODUCTION

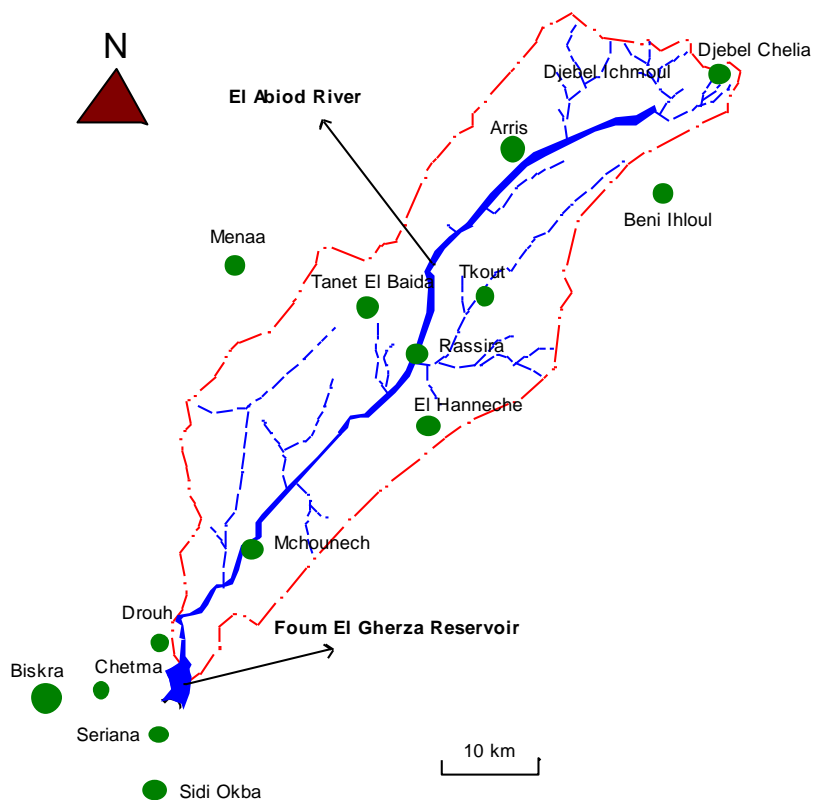
The phenomenon of erosion in Algeria is spectacular. The specific erosion in 30 studied catchments varies between 30 and 3350 t/km<sup>2</sup>/year (Mekerta, 1993). According to Demmak (1982), the erosion rate can reach 4000 t/km<sup>2</sup>/year in the chain of coastal Dahra. By against, it reaches 62 t/km<sup>2</sup>/year in the Seine River basin, and 1500 t/km<sup>2</sup>/year in the basin of the Durance River (France). It exceeds 2500 t/km<sup>2</sup>/year in several basins in China and the island of Java in India (Mechin, 1980). Values of the specific erosion rates exceeding 4500 t/km<sup>2</sup>/year were evaluated in the catchment area of Wadi Agrioum (Remini et al, 2009a, 2009b). About 180 million tons of soil is eroded annually in the catchment areas of northern Algeria (Demmak, 1980). This number has never been updated; it can be revised upwards given the degradation of our catchments in recent years. This situation has a negative effect on dam reservoirs. In fact, each year, silt in a volume of 45 million of m<sup>3</sup> is deposited in 70 major Algerian dams (Remini, 2011). In 2030, the loss of storage capacity of the studied reservoirs may reach 43% of their initial capacities (Ben Mammou and Louati, 2007). The Fom El Gherza dam does not escape this phenomenon. It is classified among the most silted dams in Algeria. It's a barrage of great economic importance for the region of Zibans. Reaching the age of 63 years, the Fom El Gherza dam is intended to irrigate palm groves of the downstream area of the dam. However, given its accelerated siltation, the dam cannot satisfy irrigation needs in the short and medium terms. The study of the evolution of siltation and evaluation of the life of the Fom El Gherza dam proves a necessity.

## 2 SITUATION AND CHARACTERISTICS OF STUDY AREA

### 2.1 Catchment of Fom El Gherza dam

The catchment area of El Abiod Wadi is located in the southern slope of the eastern part of Saharan Atlas. With a length of 85 km, El Abiod Wadi rises in the Massif des Aures (the mountains of Chélia). Covering an area of 1300 km<sup>2</sup> in a perimeter of 205 km, the catchment has an elongated shape (Fig. 1). The catchment area of El Abiod Wadi is a semi-arid region (northern part). It is composed of a naked part without vegetation, and then forests with dominance of Aleppo pine occupy much of it.

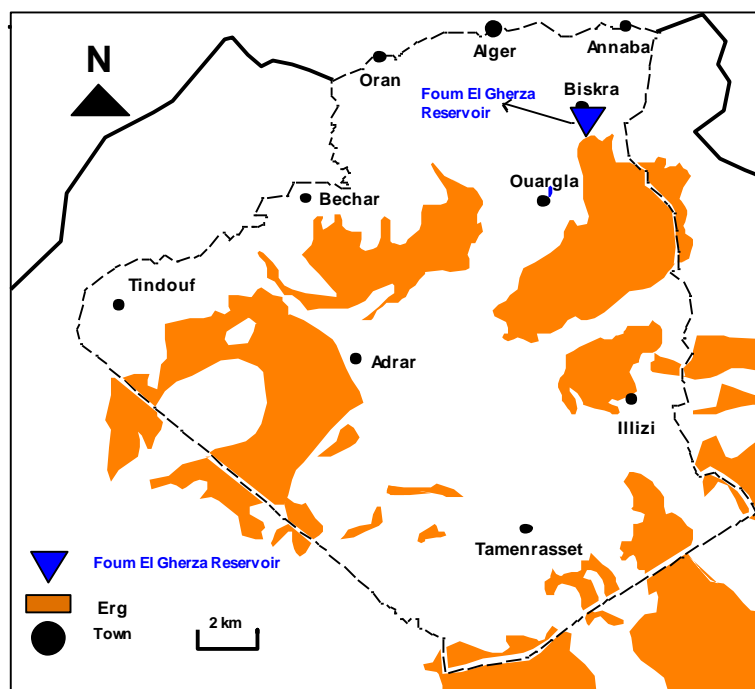
There are also reserved cereal and tree parts. El Abiod River floods are sudden and dangerous. For example, in October 10, 1966 a flood occurred on the river whose peak discharge reached the value of 1980 m<sup>3</sup>/s. During the month of March 2004, the peak discharge was estimated at 1000 m<sup>3</sup>/s. At the Fom El Gherza Reservoir the worst flooding took place in March 30, 2004, the water level has exceeded the rating of 202, which corresponds to a nape of 3.65 m, a maximum evacuated discharge of 570 m<sup>3</sup>/s.



**Fig. 1** Catchment boundaries of El Abiod River

## 2.2 Situation of Fom El Gherza Reservoir

The Fom El Gherza Reservoir is located 18 km east of the city of Biskra and about 600 km southeast of Algiers (Fig. 2). It allows the irrigation of palms of Sidi Okba in the southwest of Seriana in the north and Thoudra. This is an arch dam with an initial capacity of 47 million of m<sup>3</sup> (Fig. 3).



**Fig. 2** Location of Fom El Gherza dam



**Fig. 3 Overview of Foum El Gherza dam (Remini, 2004)**

### **2.3 Field investigation and data used**

The Foum El Gherza Reservoir is intended to irrigate over 300,000 palms of Sidi Okba, Seriana and Thoudra oases. However, the dam is threatened by rapid siltation. The floods of the El Abiod River bring sediments in concentrations exceeding 100g/l. This causes the formation of density currents that drain sediment up to the base of the dam. In order to dredge the dam during the year 2015, we wanted to study the evolution of silting in the dam. For this purpose, nine historical bathymetric surveys collected at the National Agency of Dams (NAD) were used. These are surveys conducted in 1950, 1952, 1957, 1967, 1975, 1986, 1993, 2001 and 2004.

## **3 RESULTS AND DISCUSSIONS**

### **3.1 Erosion and undercutting of banks**

The erosion of the catchment of El Abiod Wadi recorded high values. The annual evaluation of the specific erosion rates exceeded 1500 t/km<sup>2</sup>/year during the year 1976. The average specific erosion rate approaches the value of 300 t/km<sup>2</sup>/year. Undermining the banks of El Abiod Wadi is very important, except that we have not been able to quantify this phenomenon. However, we have located more than 20 outbreaks of bank erosion along the River of El Abiod (Fig. 4).



**Fig. 4 Sapping of banks of El Abiod Wadi upstream the dam (Remini, 2004)**

### 3.2 Sediment transport in El Abiod River

Sediment transport in El Abiod Wadi is very important, especially in times of flood. The amount of soil eroded in the watershed and the banks of the river are drained by the river to the dam. Concentrations of fine particles have been registered at the entrance of the reservoir. With a slope of the wadi bed greater than 1 per thousand, the bed load is very significant in the river wadi of El Abiod.

### 3.3 Density currents in Fom El Gherza Reservoir

The arrival of flood waters brings to the Fom El Gherza Reservoir charged fine particles causing the formation of density current that propagates down to the foot of the dam (Remini, 2008). Generally, it happens during spring (March and April) when density currents emerge at the entrance of the reservoir (Fig. 5 and 6).

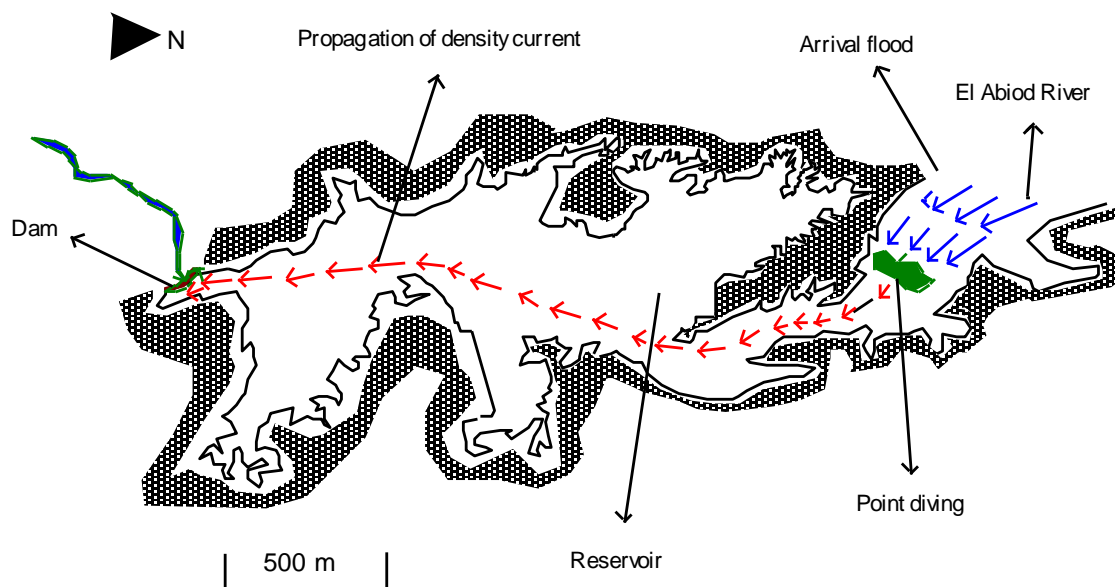


Fig.5 Path of current density of Fom El Gherza Reservoir

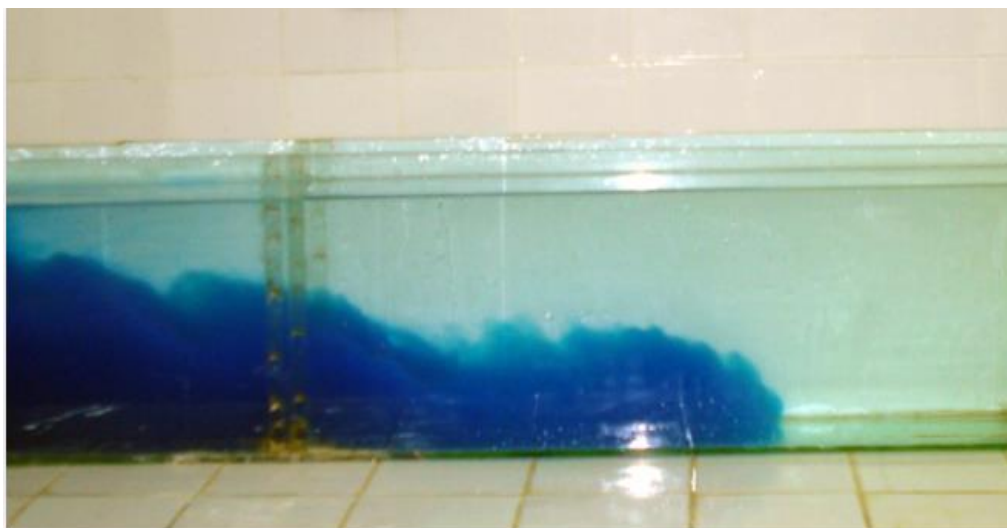
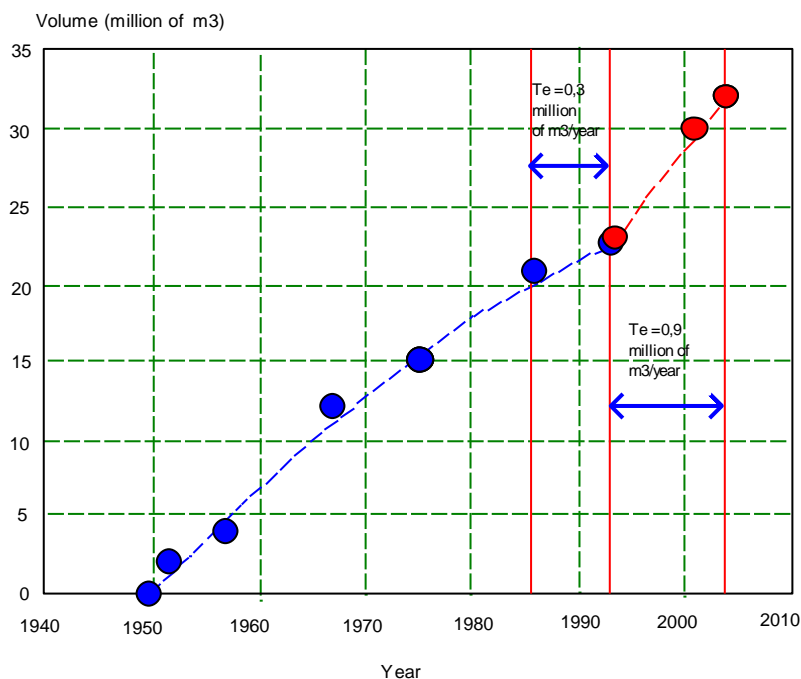


Fig. 6 Propagation of density current in channel

### 3.4 Silting of Fom El Gherza Reservoir

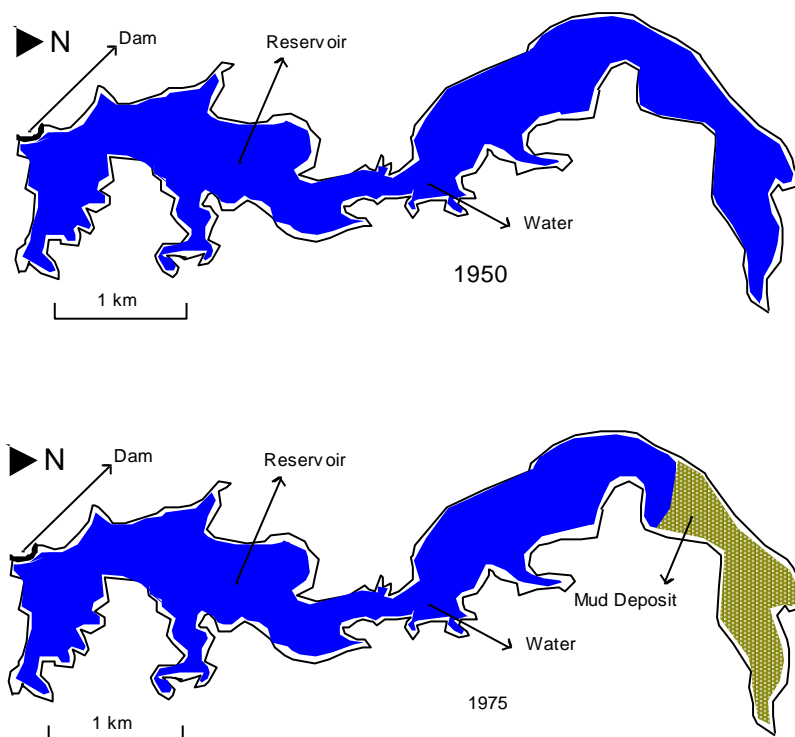
The dam is located in a Saharan region. Streams are characterized by torrents, speed and violence of the floods. The rivers carry a large amount of solid materials from bare slopes as density currents. Arriving at the foot of the dam, the density currents settle those solid particles to the bottom of the dam. Muddy deposits accumulate annually in the reservoir. Bathymetric surveys were established in 1950, 1952, 1957, 1967, 1975, 1986, 1993, 2001 and 2004 in order to monitor regularly the roof of the vase and discount curves of

height/capacity. From 1950 to 2004, silt in a quantity of 32 million of  $m^3$  was deposited in the reservoir, causing the siltation of 68% which represents an annual average siltation rate of 0.6 million  $m^3/s$ . Fig. 7 shows the temporal evolution of the silting of Foum El Gherza Reservoir. The sedimentation rate increased from 0.3 million of  $m^3/s$  in the 1986-1993 period to 0.9 million  $m^3/year$  in the 1993-2004 period.

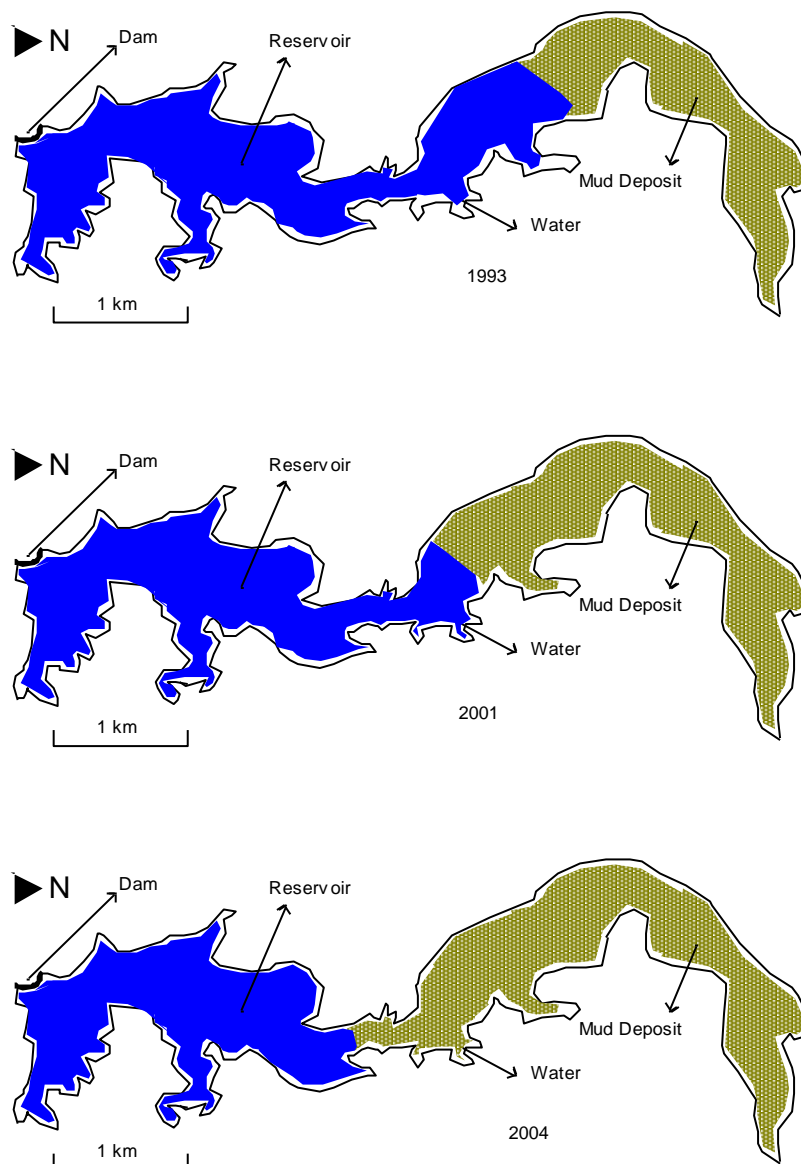


**Fig. 7 Evolution of silting of Foum El Gherza Reservoir**

Taking into account the temporal evolution of the silting of the Foum El Gherza Reservoir, we represent in Fig. 8 the evolution over time of the capacity of the dam and the lake area of the dam. It is noted that in 2004 the capacity of the dam is 15 million of  $m^3$ .







**Fig. 8 Temporal evolution of Foum El Gherza Reservoir capacity**

### 3.5 Technical means to fight against silting of Foum El Gherza Reservoir

The most widely used medium to fight against this phenomenon consists in the evacuation of current density by opening the bottom valve. This technique helped evacuate about 0.5 million  $\text{m}^3$  in the year 1989/1990. But due to the rapid siltation, this valve was blocked after 7 years (1982-1989) of operation. From 1990 until 1993, an amount of 0.1 million of  $\text{m}^3$  of silt was evacuated. In addition to this process, several techniques were used at the catchment to minimize the rate of erosion. For example, there may be mentioned the reforestation of catchment and the treatment of ravines by the construction of weirs. Despite those technical means of control, the state of dam siltation deteriorated, which obliged the hydraulic services to carry out the desilting of the dam by dredging (Fig. 9). A volume of 4 million  $\text{m}^3$  was evacuated during 21 months (Fig. 10 and Fig. 11). The operation was launched in March 2005.



**Fig. 9 Dredging Foum El Gherza Reservoir (National Agency for Dams)**



**Fig. 10 Rejection of vase (Remini, 2006)**



**Fig. 11 Vase of Foum El Gherza dam (Remini, 2006)**

### **3.6 Calculation of dam lifetime**

In 2006, the volume of silt deposited at the bottom of the reservoir is around 35 million  $m^3$ . In 2008, the volume of mud was 31 million of  $m^3$ , since 4 million  $m^3$  of silt have been removed. From 2006 to 2012, a vase in an estimated volume of 3.6 million of  $m^3$  was introduced in the reservoir by various floods. So in 2004, the volume of mud is around 35 million of  $m^3$ . In regard to the sedimentation rate of 0.9 million  $m^3$ /year, the lifetime is 11 years. The dam will cut off in 2023 if the provisions of desilting will not be taken as soon as possible.

## **4 CONCLUSION**

As mentioned at the beginning of this study, the erosion in the catchment of the El Abiod Wadi is very worrying due to its very poor shape. In 1993 its values exceeded  $600 t/km^2/year$  as evaluated. Floods recorded on the El Abiod River, which occur during the months of March, April, May and June, are extremely violent and sudden draining high concentrations of fine particles. Values exceeding  $100 g/l$  were measured at the entrance to the Foug El Gherza Reservoir during the years 2004 and 2006. A significant quantity of sediment comes from watershed erosion and from the undermining of banks of the River of El Abiod. Such concentration automatically generates the formation of density currents at the entrance of the reservoir which propagate over a distance of 6.5 miles below the clear waters of the reservoir to reach the foot of the dam. Closing the bottom valve during floods caused its closure in 1986. Successive deposits of sediment at the bottom of the reservoir caused accelerated silting the dam. Thus during the period 1993-2004, the sedimentation rate increased from 0.3 to 0.9 millions of  $m^3/year$  for unknown reasons. The desilting of the reservoir of more than 4 million  $m^3$  of silt during the period of 21 months has not solved the problem. We estimated the lifetime of the Foug El Gherza Reservoir to 11 years, and that is to say the dam will have shut off by 2023 if the technical measures are not taken promptly.



**REFERENCES**

- [1] Ben Mamou A. and Louati M.H., 2007. Temporal evolution of the silting of dams in Tunisia. *Journal of Water Science*, vol. 20, n° 2, 2007, p. 201-210.
- [2] Mekerta B., 1993. Study of the sedimentation of reservoirs, mechanical properties of fine-grained soils. *Communication First National Congress of Large Dams*. Algiers, 24 and 25 May, pp. 1-9.
- [3] Demmak A., 1982. Contribution to the study of erosion and sediment transport in Algeria Septentrionale. *These Doctor Engineer*, University of Pierre and Marie Curie, Paris XI.
- [4] Mechin Y., 1980. General introductory report on desilting reservoirs. *International seminar on desilting reservoirs*. Tunis, 1, 2, 3 and 4 July, 5p.
- [5] Remini B. et Bensafia D., 2012. The impact of climate changes on the acceleration of reservoir siltation in arid regions the Algerian case study. *Elixir International journal Bio. Diver.* 44 . 7074-7076.
- [6] Remini B., Hallouche W., et Achour B., 2009. Algeria: more than a century of desilting dams. Book entitled *State of water resources in the Maghreb in 2009*, published by UNESCO Office in Rabat, pp. 123-142.
- [7] Remini B., Leduc C. et Hallouche W., 2009. Evolution of large dams in arid regions: some Algerian examples. "Sécheresse" journal, n°20, vol.1, pp.1-8.
- [8] Remini B., 2011. Racking turbidity currents: a way to reduce siltation. Case of the dam Wadi Fodda. *National Seminar hydraulic*. Chlef, 23 and 24 November.