The Hydrological Functioning of the Watershed of Lake Laya- El Hammam, East of Tunisia

Watershed of lake laya

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ABSTRACT

The hydrological rate of flow of the watershed of Lake Laya El Hammam depends on its morphometric and geological features as well as its precipitation.The watershed of Lake Laya El Hammam is part of the coastal watersheds in the central-east of Tunisia. It is the only watershed which is not affected by hydraulic constructions such as dams. Besides, it features a surface area that extends to 204 km2 and a high recorded rainfall. To determine the hydrological rate of flow of the watershed, we had to identify its geological and morphometric characteristics, and gauge the flow of Lake Laya El Hammam. The final results have allowed us to identify: the general aspect of the flow of water in the watershed of Lake Laya El Hammam, the relationship lake/ sheet and the importance of gauging in Eastimating the rate of flow of water during periods marked by lack of rain.

Keywords— *watershed, hydrological rate of flow, Lake of Laya El Hammam, Tunisia*.

I. Introduction

The hydrological functioning of a watershed depends on the morphological characteristics as well as on the precipitation, the relationship lake/sheet and anthropic constructions such as dams, roads, etc. Much research was carried out in the world about this issue [1, 2, 3]. To identify the layers of trickling water, we often use empirical methods [4], a hydrological assessment [5] and gauging in the downstream areas of the lakes. The latter method is very efficient in giving the real measurements of the volume of water. Many techniques and methods are used to measure streams of water such as the volumetric (spillway), chemical (continuous and immediate injections) and electromagnetic methods besides gauging through the use of a float [6].

II. Presentation of the Site

The watershed of Lake Laya El Hammam is located in the East of Tunisa. It is made of ten main streams: Lake Bou Ali, Lake Naguar, Lake El Ghares, Lake El Kharroub, Lake Laya; Lake Mdarej, Lake El Khbir, Lake Guemguem, Lake Ghdir El Ajla and Lake El Hammam.

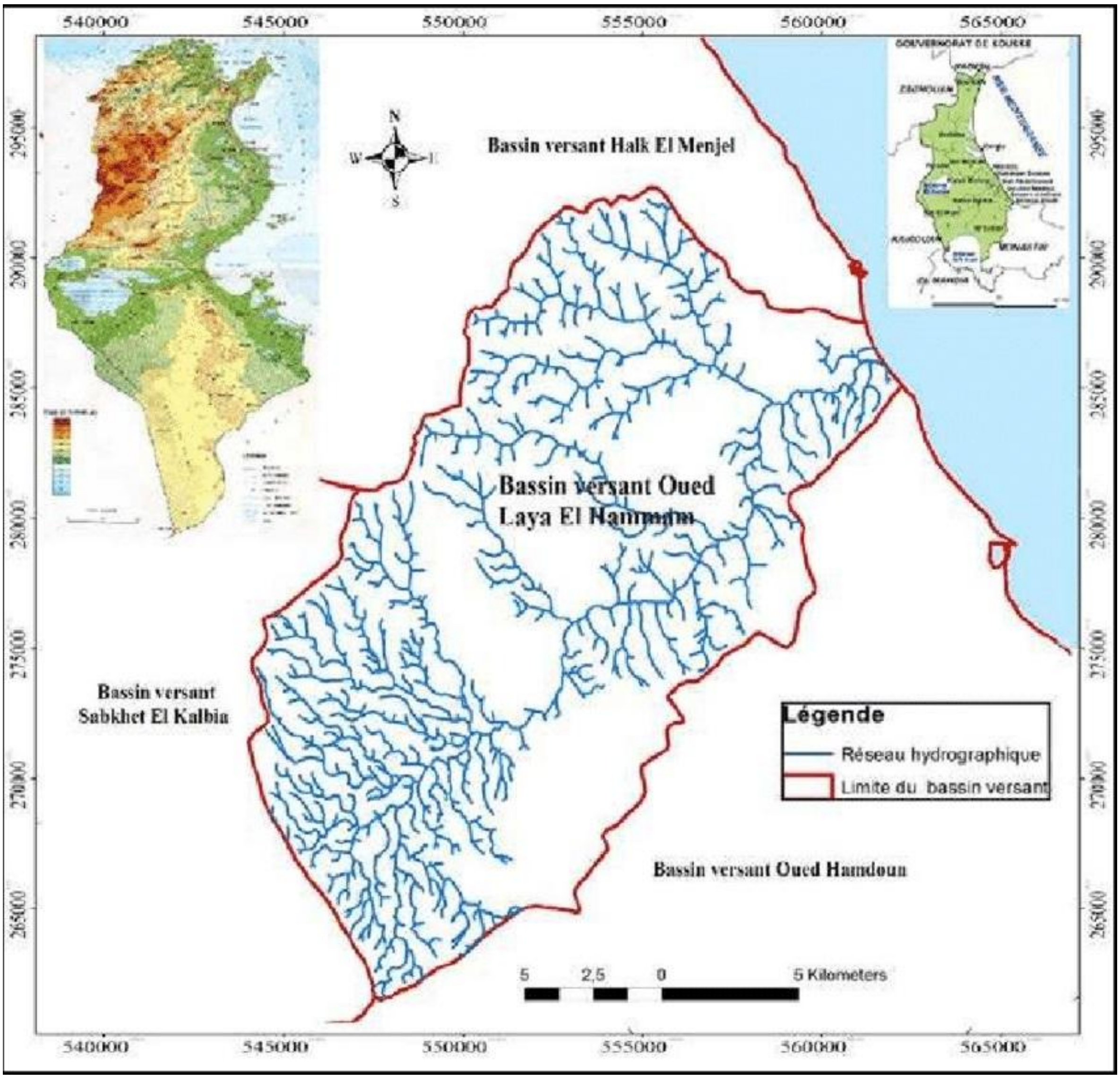

Fig.1. The location and altitudes of the watershed of Lake Laya El Hammam [7].

From a climatological viewpoint, the research zone is Mediterranean. According to the meteorological data provided by Khalâa Station, the average annual precipitation is 350 mm. The maximum monthly temperature in August is 37°C while the lowest one is in January and it reaches 9°C.

From a hydrogeological standpoint, the watershed of Lake Laya El Hammam is made of two geological units:

-The first includes metamorphic rocks (gneiss, limestone) which appear on the mountains surrounding the plain. Some cracks can be noticed here. The streaming of water is important in the rocks that are not fissured or slightly fissured.

-The second one includes sedimentary rocks which essentially appear on the plain:

The lakes beds are made of permeable, alluvial deposits (sand, gravel, pebble …). Rain water infiltrates during heavy showers when the intensity of the rain is greater than the permeability of the earth. Water also flows in the form of streams.

The formation of sandstones and clay can be observed in the northern part of the plain. Sandstones are relatively permeable and could contain water.

The deposits of Miocene separating Lake El Kharroub and Lake Mdarej are impermeable, which means that rain water takes the form of streams.

Detrital deposits are made of gravel, pebble and clay that have continental origins.

III. Equipments and Methods:

The gauging of the rate of flow of Lake Laya El Hammam was done with the help of a float (a piece of wooden square that is 15 cm long and 3 cm high). The station where the gauging of the lake takes place is divided into many sections. The measurement of water speed takes place in each section with the help of a float. The rate of flow at the station is calculated by the sum of the rates of flow recorded in the different sections according to the following formula:

$$Q = \sum_{1}^{n} V_n \times S_n$$

With: Q: Debit in the measurement station,
Vn: Speed of the water in the section n,
Sn: Surface of the water in the section of water n.

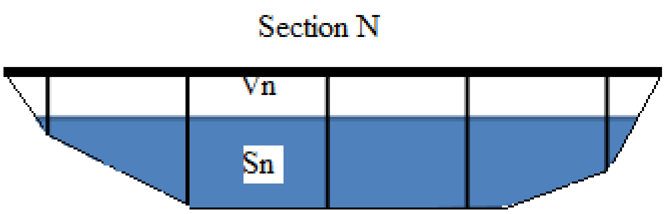

Fig. 2. Schema of the measurement of the rate of flow using a float.

This method of measurement of the water speed on the surface of the lake leads to good results when the water speed is the same on the surface as in depth.

The measurement of the rate of flow was carried out on four stations: one on Lake Naguer, on Lake El Kharroub, another one on Lake Laya and another on Lake El Hammam.

IV. Findings and Discussion

A. *Morphometric Characteristics of the Watershed*

The morphological characteristics play an outstanding role in identifying the importance of streaming. The graphic presentation of the hypsometric curve and the calculation of the morphological characteristics of the watershed are found in figure 3.

The hypsometric curve shows that the altitudes inferior to 100 m represent 23%; these are generally plains with a steep slope. The remaining surface area is made of mountains ranging from average to very steep plains which results in rapid water flow in 77% of the watershed surface.

The calculation of the capacity index of the watershed gave us a value of 2.41 indicating a watershed that has a long shape; this actually reduces the streaming speed of surface water.

According to its morphological characteristics, we can say that the watershed under study presents two streams: a first one in the mountains where the flow of surface water ranges from average to fast, and a second one in the plains where the flow is slow.

B. *Relationship Lake Sheet:*

The Establishment of the piezometric card of the alluvial sheet during the period marked by less water (March 2016) is presented in figure 3.

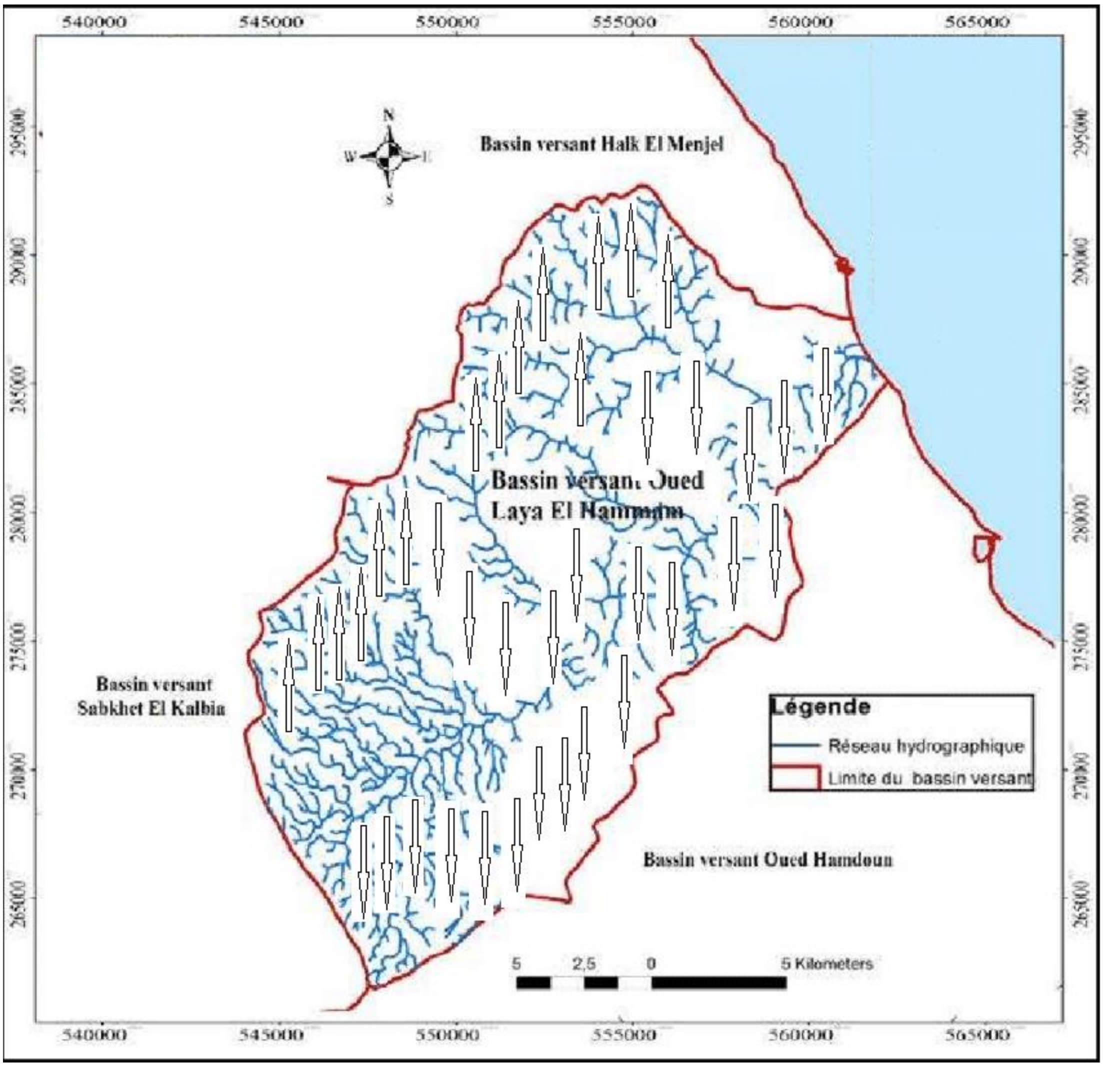

Fig. 3. the piezometric cards of the sheet of Lake Laya El Hammam in March 2016.

This card shows that the curves cut the lakes in a perpendicular way indicating that there is no hydrodynamic exchange between the lake and the sheet. This shows that the water is linked to the precipitation at the uphill part of the lake.

C. Estimation of the Rate of Flow starting from the hydric Report:

The table 1 shows that the flow of water, in March 2016, has reached 450 mm. The infiltration in the plain of Lake Laya El Hammam represents 26.6 % of the rain (CES 2015). The Estimation of the rate of flow of each stream based on the hydrological report shows that the contributions of Lake Laya El Hammam come mainly from the subwatersheds of Lake El Hammam (32%), Lake El Kbir (24%) and Lake Naguer (22.5%).

TABLE I. TABLE 1: THE TEMPERATURE (T) AND THE PRECIPITATION (P) IN ELKALAA STATION [8].

Mois	J	F	M	A	M	J	Jllet	Ao	S	O	N	D
P(mm)	52	48	35	42	26	1	1	1	58	40	74	72
T (C)	13.1	12.4	15.0	17.6	22.5	26	28.5	29.3	26.0	22.9	18.1	11.5

D. Gauging:

The calculation of the rate of flow of Lake Laya El Hammam and its two streams: Lake El Kbir and Lake Naguer present that rate of flow superior to that estimated by the hydric report. This is due to the fact that gauging is instantaneous and to the presence of rain before gauging. The subwatershed of Lake Laya El Hammam often represents the high East rate of flow (77%).

IV. Conclusion

This research shows the importance of the hydrogeological and morphometric characteristics as well as the hydrodynamic exchanges between lake/sheet.

This research allowed us also to show that gauging with the use of a float during periods marked by a shortage of water represents a real rate of flow. However, the Estimation of the rate of flow based on the hydric assessment/report gives an average value of a monthly flow. Yet, it gives a correct proportionality between the rates of flow of the subwatersheds.

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