Larhyss Journal, ISSN 1112-3680, n°26, Juin 2016, pp. 167-181

THE WATER SUPPLY OF OASIS BY ALBIAN FOGGARA: AN IRRIGATION SYSTEM IN DEGRADATION

REMINI B.[1], ACHOUR B.[2]

[1] Department of Water Sciences, Blida University, Blida 9000, Algeria,
[2] Department of Hydraulic, Biskra University, Biskra 7000, Algeria,

reminib@yahoo.fr

ABSTRACT

This paper discusses a type of foggara most common in the Algerian Sahara. This is the Albian foggara. Currently, 820 foggaras a total length exceeding 2000 km and exploit the Intercalary Continental aquifer on the periphery of the Tadmait plate; real water tower of foggaras. The distribution of water from the Albian foggaras between farmers obeys the volumetric method. The gardens are irrigated at the same time; we talk about irrigation in parallel. For cons, the Moroccan khettara obeys the temporary method, the gardens are irrigated turn after turn, and we speak of a linear irrigation. For the Albian foggara, the kasria (comb diverter) is considered as the boundary between the upstream (extraction) and downstream (distribution). The kasria is considered as the essential element of social organization. The investigations that we conducted in the oases of Touat and Gourara in 2007, 2008, 2010, 2013, 2014 and 2015 have shown that cultural heritage is increasingly abandoned because of technical problems and socioeconomic.

Keywords: Foggara - Albian – Intercalary Continental – Aquifer – Sahara Algerian

NOMENCLATURE

Ksar: City of farmers

Kasria: Flow Splitter

Madjen: Basin of Water Storage

Guemoun: Garden

Touiza: Feast

Seguia: Canal

INTRODUCTION

In hyper-arid regions of the Sahara as the Touat and Gourara, or the precipitation below 15 mm/year. It is therefore the water of aquifers that constitute the water resources of the oases of Touat and Gourara. For acquire of the groundwater, the farmers have developed of hydraulic techniques called the foggaras. The foggara is a universal technique, which exists in over of 35 countries in the world (Hofman, 2007; Abdin, 2006). It is known by different names: the qanat in Iran, the khettara in Morocco, the falj in Sultanate of Oman, the kriga in Tunisia and kariz in Afghanistan. Although if there are still doubts about its origin, several authors showed the north west of the plate Iranian as the place of his birth for more than 3000 years (Hussain et al, 2008; Kazemi, 2004; Wulf, 1968). The foggara which has similarities with the Iranian qanat, the Moroccan khettara and the falaj of Oman has been improved and adapted to local conditions of regions of Touat and Gourara. Through to the ingenious and competence of the farmer, the foggara has been an extraordinary development in particular in the distribution network. For this, the farmers were largely inspired by the observation of their natural environment. They used the topography and hydrogeology to their advantage without damaging the environment. By working hard, they could fertilize them any arid environment and contribute to the development of agro-ecosystem.

In this study we examine the particularities and the characteristics of the Albian foggara which was excavated in the oases of Touat and Gourara at the periphery of Tadmait plate for over 10 centuries.

STUDY AREA AND DATA USED

Our investigation focuses on the Albian foggara located in the oases of Touat and Gourara about 1000 km at southwest of Algiers (fig.1). Three missions were carried out in these oases in 2007, 2008, 2010, 2013, 2014 and 2015. Surveys were conducted among the villagers for information on the originality of the foggara. To better exploit our results, we used the data from the last

inventory of foggaras conducted by the National Agency of Water Resources between 1998 and 2001.

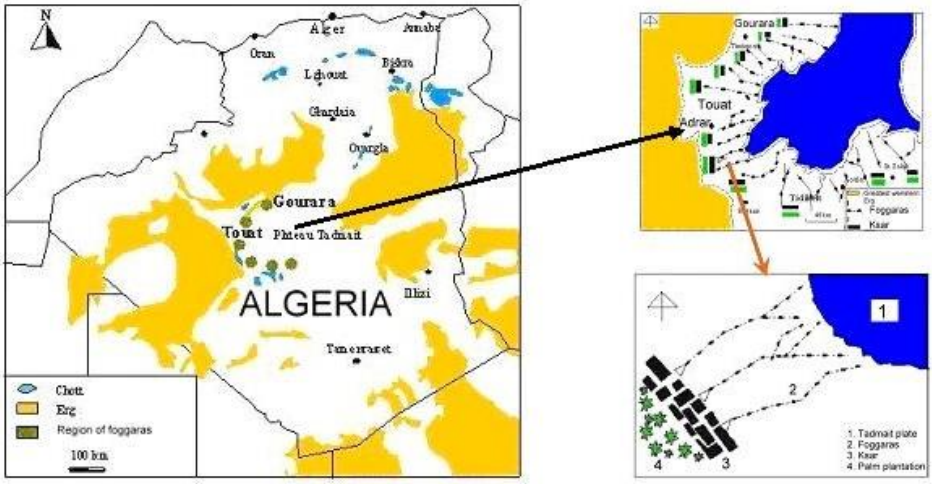
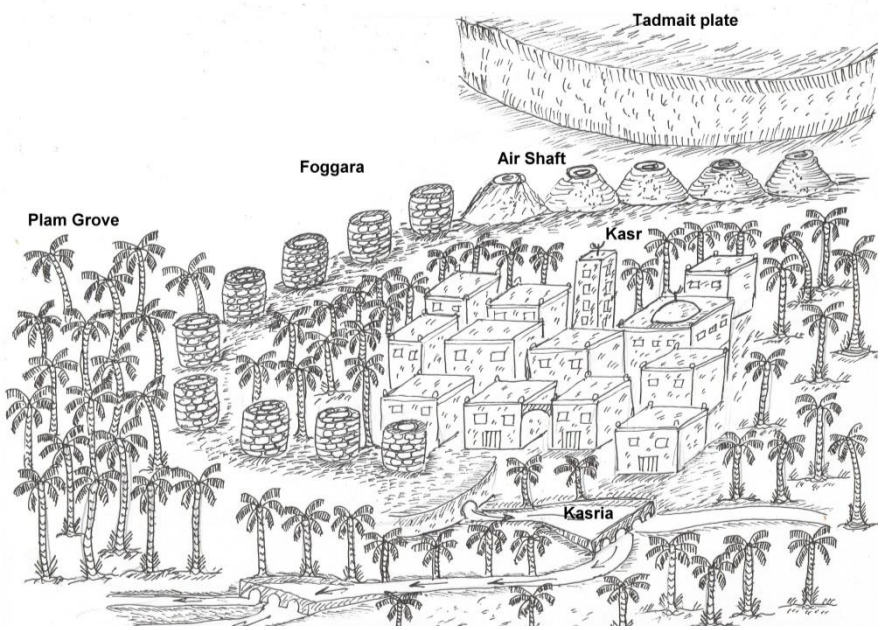


Figure 1 : Location of the zone of the Albian foggaras (Authors, 2015)

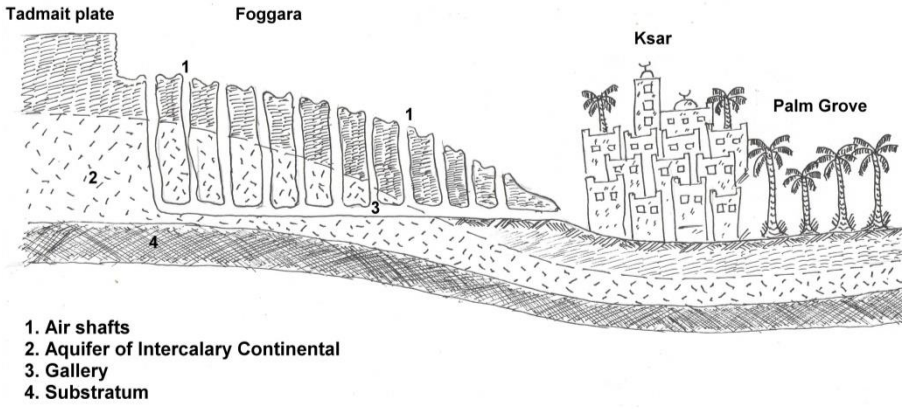
RESULTS AND DISCUSSION

The originality of the Albian foggara

The Albian foggara is a lightly sloping gallery equipped of a variety of air shafts; it drains the water of the Intercalary Continental aquifer to the gardens. The air shafts have an average depth of 14 m, an average diameter of 90 cm and an average distance of 13 m between two wells (fig. 2, 3, 4).



a) General view



b) longitudinal section

Figure 2 : Simplified diagram of a foggara Albian (Remini, 2016)

Figure 3 : Gallery of Albian foggara (Remini, 2007)

Figure 4 : Air Shaft of Albian foggara (Remini, 2007)

The Albian foggara is the most prevalent in the oases of Touat and Gourara. Of the 903 foggaras inventoried by the National Agency of Water Resources between 1998 and 2001, there are about 820 Albian foggaras in operation in the regions of Touat and Gourara foggaras, who's the discharge is around 2.8 m^3/s for a total length of 2000 km. These foggaras were dug into the sandstone layers of the Intercalary Continental which enter the upper part of the groundwater located on the periphery of the Tadmait plate (the water tower of foggaras) to ensure a gravity flow to the gardens. (fig .1). Unlike the Moroccan khettara or the Iranian qanat which exploiting the groundwater, the Albian foggara collects the water of the Intercalary Continental aquifer (Albian) (fig. 5). For this reason

we chose the name the "Albian foggara". This tablecloth belongs to Aquifer System of Septentrional Sahara (ASSS), which designates the superposition of two major deep aquifers; this is an Intercalary Continental aquifer (which is the broadest and the most profound) and the Terminal Complex aquifer. The ASSS covers an area of over of 1 million km^2, which 700000 km^2 are found in Algeria, 80000 km^2 and 250000 km^2 are found in Tunisia and in Libya (Larbi, 2003; Abdous et al, 2005). The principle of capture and drainage of the Albian foggara presents a similarity with that of the khettara or the qanat: it is based on an underground tunnel equipped with several ventilation shafts whose number varies from one to foggara another. For cons, the distribution of water is different, that of the Albian foggara is based on the volumetric method. The irrigation of gardens occurs at the same time. We speak of irrigation in parallel. Contrary to the Moroccan khettara, the distribution of the water is subject to temporary method. In this case, the irrigation is done turn by turn (Nuba) that is to say, garden after garden. We are talking of irrigation in series. The kasria (comb distributor) is the centrepiece of the volumetric method. At the arrival of water at the surface, it will be distributed in an equitable manner among the owners according to their contribution.

However, for problems of tunnel collapse and depletion of groundwater, the number of Albian foggaras is decreasing each year. The collapse of the galleries is generally caused by the raw, the expansion of towns and the vehicular traffic. The floods of 2004 that affected the region caused the collapse of several sections of the gallery, as the case of the Amokrane foggara which was drained. El Meghier foggara, the greatest of Timimoun captures the water from the Intercalary Continental aquifer. With a length of 11 km, contains 600 ventilation shafts, the flow has attained a value of 50 l/s during the sixties. More than 200 families lived from this foggara which irrigates a daily palm plantation of area of 80 hectares (Remini and Achour, 2008). Today, because of the collapse of the galleries, its flow does not exceed 3l/s. Without the heavy exploitation of water Intercalary Continental aquifer for thirty years, the depletion of several foggaras was reported throughout the oases from Touat and Gourara (fig. 5). Today, the ASSS is operated by around 8800 of water points, boreholes, sources and foggaras distributed between the 3 countries (Algeria: 6600, Tunisia: 1200 and Libya: 11000). Given a total flow operated equal at 2.2 billion of m^3 per year: 1.33 billion of m^3 in Algeria, 0.55 billion m^3 in Tunisia and 0.33 billion of m^3 in Libya (Abdous, 2005 and Remini, 2007). This high consumption of water by 3 countries caused a significant decrease in the level of the groundwater and therefore the reduction of flow of foggaras in the time.

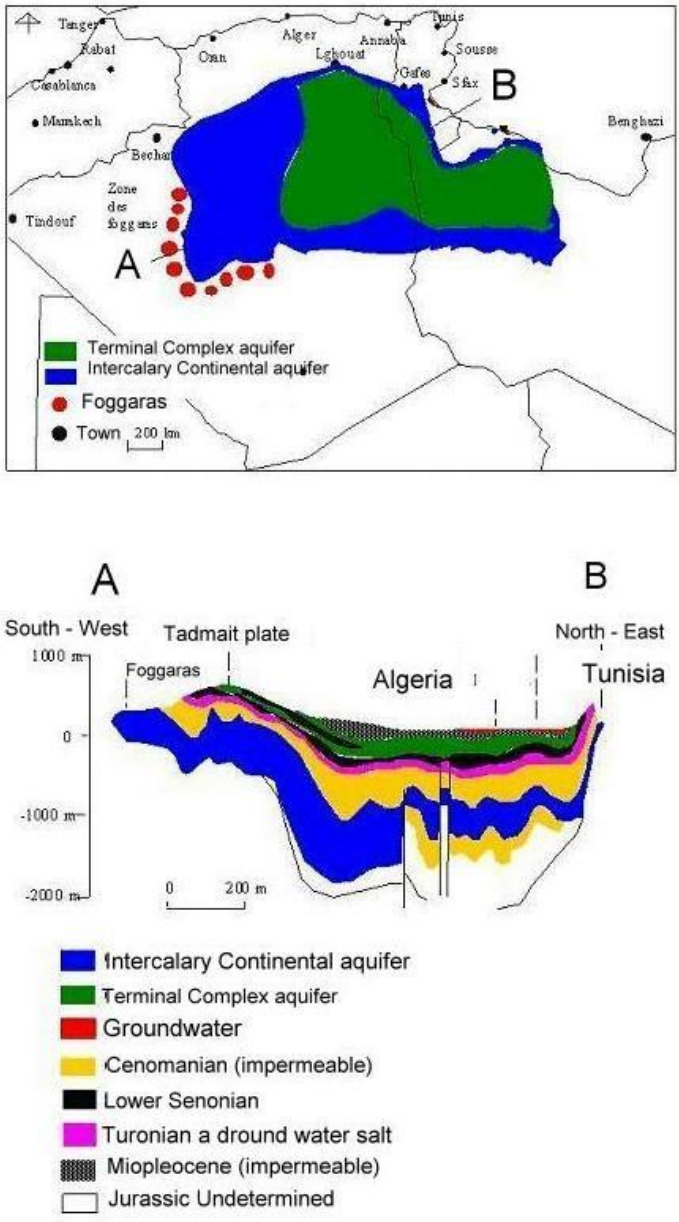


Figure 5 : Intercalary Continental aquifer: the source of Albian foggaras (source UNESCO in 1972 Castany, 1985 as amended by the authors)

The foggara irrigates the palm and feeds Ksar

The rarity of water in a hyper arid region such as of Touat and Gourara allowed the farmer of know better the value of water. To controlling the distribution of water between the families, the farmer has adopted during the centuries a rigorous discipline to control of water. Each receives its part of water according of its contribution. The foggara with the slope of the gallery, the water arrives at the palm plantation which will be divided between the owners through kasria (fig. 6). Then seguias in the transport of water to madjens or it will be stored and then irrigate the guemouns (fig. 7). Offering diversity of fruits and vegetables allowing food self-sufficiency and for the population of the Ksar and even make winnings to families by selling a portion of their crop in the souk. The economy of the farmers depends directly on cultures of cultures f land of the palm plantation.

Figure 6 : Kasria of Albian foggara (Remini, 2007)

Figure 7 : Madjen of Albian foggara (Remini, 2014)

We have shown in figure 8, the flow of each foggara of oases of Touat and Gourara in function of the area of cultivable land. It is interesting to note that there is a good correlation between the both parameters: Speed - area. The same result was obtained by the figure 9, which confirms the relationship between the flow, the length of the foggara and the area irrigated gardens. This good correlation is synonym of good management of water in the gardens; there was no deficit or surplus of water. Each garden received exactly its part of water. Even of small gardens not exceeding the area of 9 m^2 are irrigated by a stream of water transported by very small channels (tertiary canals).

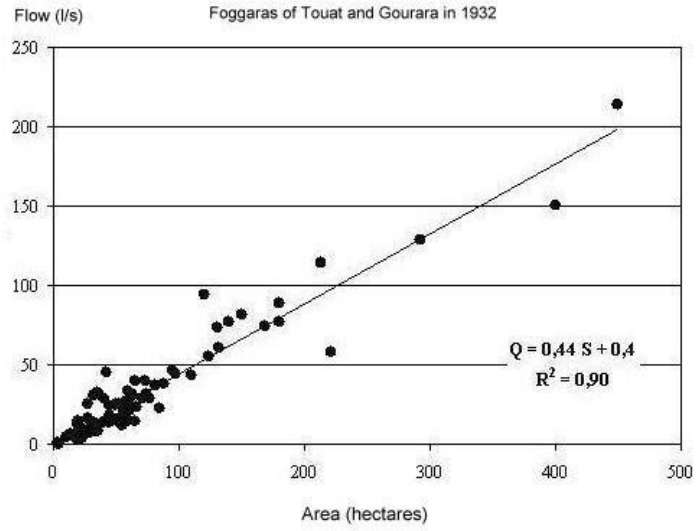


Figure 8 : Relationship between the discharge and the area Irrigated (source of data: Arrus, 1985)

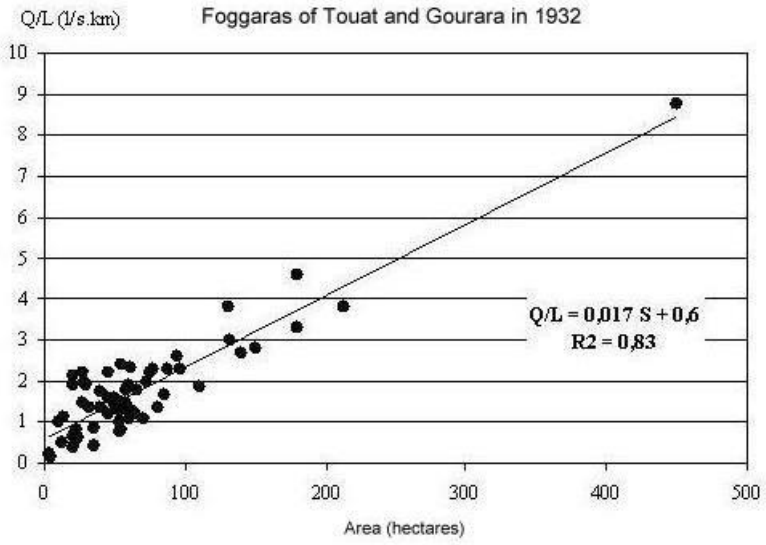


Figure 9 : Relationship between the discharges, the length of the foggara and area irrigated (source of data: Arrus, 1985)

The priority of the foggara is to supply drinking water to the population of the ksar. The realization of ksar is always makes upstream of the palm plantation on the flow of water. The main kasria installed in the center of the ksar. In this case, the seguias through the streets of ksar. In several sites the ksar, the seguias openings are equipped by the openings of same size of a bucket of water allowing the population to feed of the water from the foggara. The foggara is the main element of the determination of the area of the ksar. In effect, it does not there was a shortage of water in the ksar. The size of ksar and more precisely the number of families is related to the supply of water of the foggara. Ksar was realized on the flow of water upstream of the palm plantation. Ksar a populated means that water of the foggara is abundant. Ksar a less inhabited means that the flow of the foggara is quite low. In an oasis of Aghlad (Timimoun), the flow of the foggara significantly decreased because to sand encroachment, there were only three families in the ksar in 2005. So the foggara has a directly an impact on the accommodation capacity of ksar and area of cultivable land in the palm plantation

The foggara affects the environment

The foggara is the veritable creator of a microclimate in the oasis. Effectively, thanks to the ramified network of thousands of miles of seguias and a hundred of madjens, a microclimate is created in the palm grove. Freshness is released continuously following the disengagement of high levels of humidity. There was deference in temperature of 5 to 10 degrees between outside and inside the palm plantation. This freshness attracts a multitude of migratory birds. This is the foggara that protects and preserves the ecosystem and the environment of the oasis. Despite a continuous flowing of water, the foggara exploits moderately the groundwater and has never exceeded the critical threshold. Unlike the drilling which exploits massively the reserves of ground water?

Degradation of the Albian foggara

Today this hydraulic heritage is threatened to disappearing in the short-term for a reasons technique and socio economic. The galloping demography and the requirements of development have caused the expansion of towns of Adrar and Timimoun characterized by the multiplication of roads and the realization of homes above the galleries foggaras. The situation has caused to collapses and

landslides of galleries. For remedy this technical problem, of operations of pardons have been initiated by public services in recent years, but it remains as a temporary solution until a socioeconomic solution not found. The foggara is increasingly abandoned to the detriment of modern techniques such as drilling. The farmer is more and more demanding and requires the comfort and ease of acquiring the water with an important quantity and without efforts. This situation generated a strong fall of the level of the tablecloth. One hundred of farmers and owners of foggaras which we interviewed during our missions revealed that 80% of the population of different ages does unconcerned about the very poor shape of the foggara. Moreover, we found the foggaras and gardens completely abandoned by their owners, others are in very poor condition and not maintained and their owners come only every autumn harvest dates (fig. 10, 11 and 12).

Figure 10 : Albian foggara abandoned (Nouh et Remini, 2010)

Figure 11 : Kasria of Albian foggara destroyed (Nouh et Remini, 2010)

Figure 12 : Palm grove abandoned (Remini, 2015)

CONCLUSION

Our study reveals that the Albian foggara presents some characteristics of it. The Intercalary Continental aquifer is the main source of the Albian foggara, who's the Tadmait plate is the real water tower. The irrigation by this type of foggara is irrigation in parallel. The kasria represents the centerpiece of the distribution of water. It distributes the water according to the contribution of each owner. The counting of data of the last inventory conducted between 1998 and 2001 by the National Agency of Water Resources, there are about 820 of the Albian foggaras in exploitation. In 2011, this number will be revised downwards. Today, this foggara has difficulties of management and maintenance by reason of the collapse of the galleries and the lowering of the ground water. Although the water services are currently responsible for the rehabilitation of certain foggaras, this solution remains temporary because the real problems are socio-economic. Despite these attempts at rehabilitation are to encourage and generalize about all foggaras, this hydraulic national heritage has not again attracted the interest necessary to its preservation and safeguard.

BIBLIOGRAPHY

ABDIN S., 2006. Qanats single groundwater management tool has an arid region: The Case of Bam region in Iran. International symposium sustainability, Alicante (Spain), Junary, 24-27.

ABDOUS B., BESBES M., FEZZANI C., LATRECH D., MAMOU A., 2005 : North-Western Sahara Aquifer System (SASS). Joint management of a transboundary basin. International Symposium on Groundwater Resources in the Sahara (CIRESS, Ouargla, December, 12 -13.

ARRUS R., 1985. Water in Algeria, Ed. Office of University Publications Algeria.

CASTANY G., 1985. Principles and practices of hydrogeology, University Edition Dunod.

CRISTINI A., LANGLAIS C., 2004. The qanat sensing device ancestral H2O, 46, March, page 10.

HASSAN I., 1988. Traditional methods of extraction of groundwater in the Algerian Sahara. Science and Technical Review, 6, 20-24.

HOFMAN A., 2007: The traditional management of water qanat in Iran is compatible with the concept of IWRM. Technical Summary, February, Engref (Montpellier, France), 17 pages.

KAZEMI GA., 2004. Temporal change in The Physical Properties and Chemical Composition Of The municipal water supply of rood Shah, northeastern Iran. Hydrogeology Journal, 12, 723 -734.

KOBORI I., 1982. Case studies of oases in foggara The Algerian Sahara and Syria. University of Tokyo, Report 2, 45 p

LARBES A., 2003. The North Western Sahara Aquifer System. International Symposium, El Oued, 19-20 May

REMINI B., ACHOUR B., 2008: Towards the disappearance of one of the largest foggaras of Algeria: El Meghier foggara . "Revue Secheresse", 19 (3), 1-6.