



## The Foggara of Moghrar (Algeria): An irrigation system millennium

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This article discusses the topic of foggara of Moghrar. For more than seven centuries, thousands of palm trees are irrigated by this foggaras. On the basis of missions in the oasis of Moghrar during the years 2006, 2009, 2013 and 2015 to understand the functioning of the traditional hydraulic system. The foggara of Moghrar is powered from a water source. Equipped with a gallery of 300 m in length and a single aeration wells, the foggara of Moghrar is used for irrigation of the palm grove. Even with the addition of pumps, the foggara continues to function despite the decrease of water flow.

Received: 20 February 2017  
Accepted: 28 April 2017  
Available online: 30 May 2017

### Keywords:

Foggara  
Moghrar  
Palm grove  
Ksar  
Irrigation

## Introduction

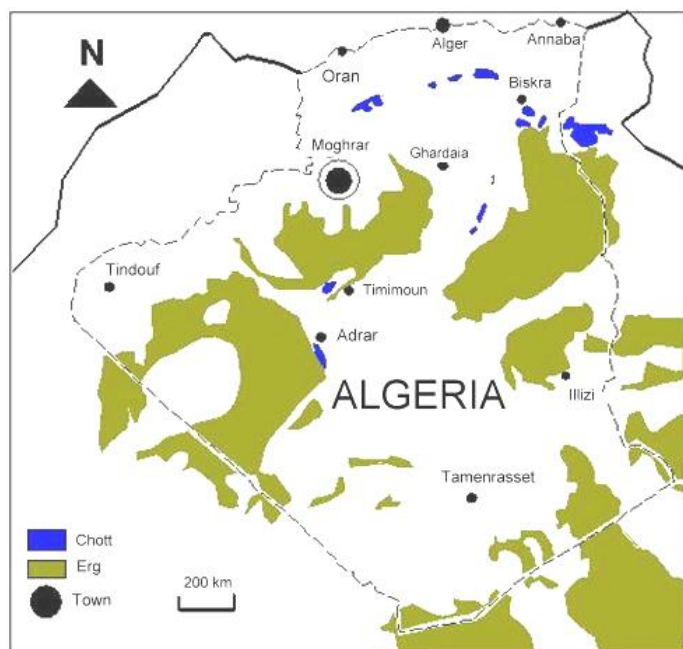
The rarity of rains in the arid and hyper arid regions obliges the local population to seek hidden in the underground waters. Various techniques of water catchments have been used in arid regions of the planet. The ancient technique that has revolutionized the hydraulic is the Qanat. It is an underground gallery, which drains water from tablecloth to the soil surface. It was invented in Iran for more than 3000 years [1-2-3], then it has spread to over 30 countries worldwide [4]. In a recent study, the foggaras was dug in 52 countries of the planet [5]. It was found in 16 Arab countries [6]. In the Algerian Sahara, it has been performed for more than 10 centuries and bears the name of the foggara. Foggaras have been exploited in several regions of the Sahara. They are found at In Salah [7], to Kenadsa [8], to Tamenrasset in the extreme south [9], in Timimoun [10-11-12], in Adrar [13], in the valley Mzab [14]. Considered as the country of foggaras, the Gourara and Touat region has over 700 operating foggaras which capture the waters of the aquifer of Intercalary Continental [15]. The water

divide of the foggara of Touat and Gourara occurs per volume unit and each garden has a basin of water storage (Madjen) [16]. In this paper we study for the first time the foggara of Moghrar which is different from of the foggara of Touat and Gourara.

## Study area and surveys

### 1. Presentation of the study area

Oasis Moghrar is part of the municipality of Moghrar (Sheikh Bouamama), is located 15 km east of the town of Ain Sefra and 600 km south-west of Algiers (Figure 1). The largest palm grove that of Moghrar Tahtani (the lowest) to 40 hectares spread over the two banks of the Oued Moghrar. The palm is made of 14,000 palm trees, fruit trees such as fig, olive, pomegranate, apricot, apple and pear. There are several varieties of dates such as H'mira, Hartan, Feggous and Gharss. Ksar Moghrar is one of the oldest ksours Algeria. It dates from seven to nine centuries. The Jamaat exists today and is responsible for water management.



**Figure 1.** Location of the study area (Remini, 2014)

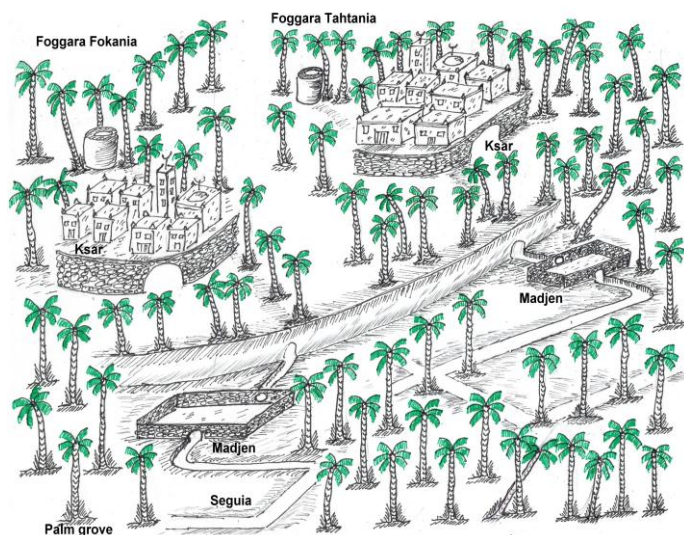
## 2. Missions and investigations

We conducted four missions in the oasis of Moghrar during the years 2006, 2009, 2013 and 2015. During our stays, we conducted the investigations at the foggara and distribution network in the palm grove. Surveys were conducted with local people to understand the functioning of the foggara and sharing mode for parts water. Informations and data were collected from hydraulic services and Agronomy of the region.

## Results and Discussion

At first, the oasis of Moghrar was supplied from two dams located on the Moghrar River; the "El Fougani" dam (Highest) and Tahtani (lowest). Following strong floods drained by the river, the two dams were swept away and destroyed. The two dams were rebuilt several times but without success. After the discovery of water sources in the region, the farmers have built two foggaras locally called "Ain" which capture water sources by a gallery of low slope. At the beginning of its realization, the foggara flows directly into the seguia and irrigation is done by turns. The increased of owners in time meant that farmers had to build a collective Madjen for each foggara. The latter stores it the water of foggara before the distribution in network seguia. The oasis of Moghrar consists (fig 2 and 3):

- Two foggaras
- The Ksar, one of the old Ksar of Algeria.
- The palm grove situated on the Moghrar River.



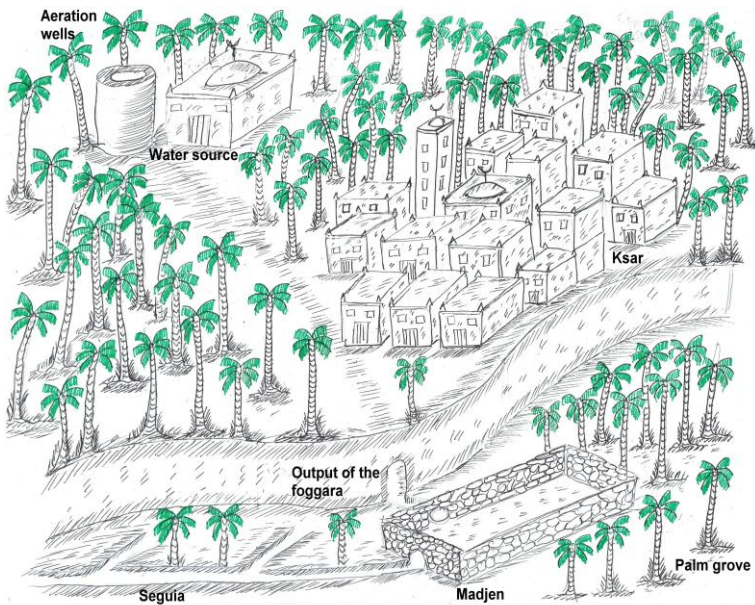
**Fig 2.** Succinct schema of the oasis of Moghrar (Remini, 2014)



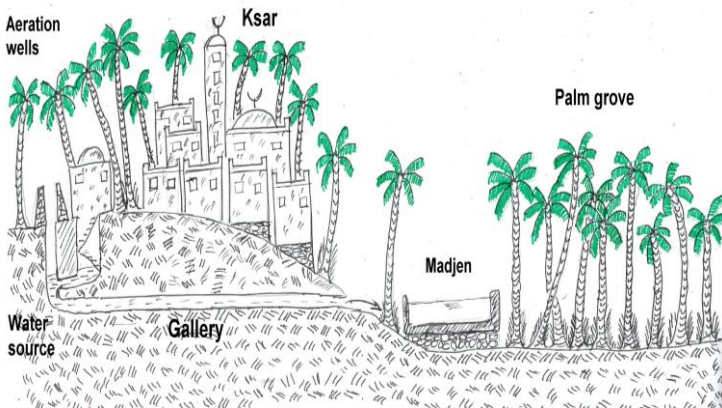
**Fig 3.** The upper part of the palm grove of Moghrar (Remini, 2013).

The foggara of Moghrar is different from classical foggara. It operates a water source which represents the catchment wells. It is equipped with a gallery of 300 m of long slightly inclined and a single aeration wells. It pours permanently in the collective Madjen located in the palm grove (Fig 4 (a and b)). Through an hourly distribution, the water is distributed by turns among the owners. Everyone has their share of water according to its contribution. The water is transported through a network of seguia which distribute the water in the gardens. The classic foggara is a foggara exploited in the regions of Touat and Gourara (South West Algerian). The classic foggara consists of a gallery (which can reach 17 km) and several air shafts (up to 700 wells). The classic foggara operates the waters of the aquifer of the Continental Intercalary.





a) Overview of foggara (Remini, 2014)



b) Longitudinal section of the foggara (Remini, 2014)

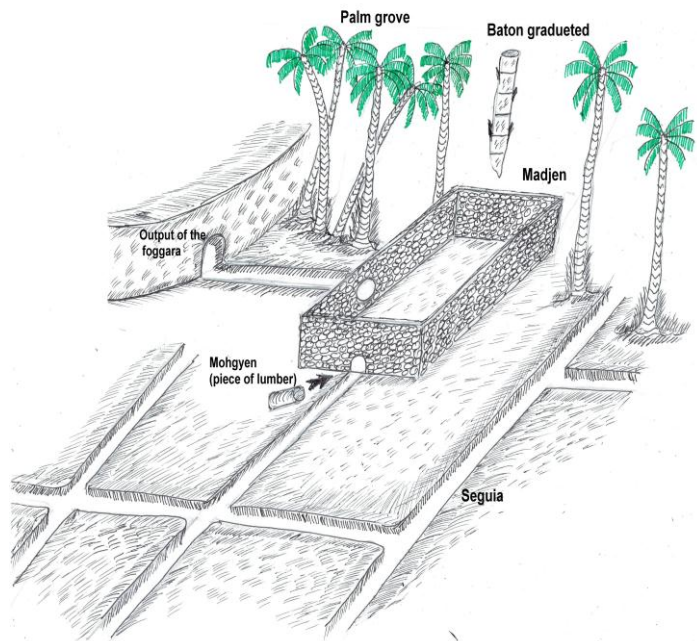
**Fig 4.** Schema synoptic of the foggara of Moghrar (Tahtania)

The Madjen of Moghrar is different from of Touat and Gourara. This is a great reservoir of dimensions of 4 to 6 m of coast and 1 to 1.2 m in height (fig 5). It is fitted with an orifice at the bottom which allows the water from flowing to the seguias. The closure of the orifice is effected with Mohguen (a wooden plug surrounded by a portion of fabric) attached to a rod of about 1.5 m to facilitate the task for the farmer. The scale of the measuring of irrigation share located in the Madjen (fig 6). The distribution network of a classical foggara consists of a set of kasrias (water distributor) (fig 7 and 8), several kilometers

seguias (channels), and several madjens (individual storage basin) (fig9).



**Fig 5.** Collective Madjen of Moghrar foggara (Remini, 2013)



**Fig 6.** Diagram of a collective Madjen with accessories (Remini, 2014)





**Fig 7.** Main kasria of classical foggara in the oasis of Timimoun (Remini, 2009)



**Fig 8.** Secondary kasria of classical foggara in the oasis of Timimoun (Remini, 2009)



**Fig 9.** Individual Madjen of classical foggara in the oasis of Timimoun (Remini, 2009)

The seguia of the palm grove of Moghrar are outside of the gardens (fig 10). They are in the middle of the street or alley next to the palm grove. The objective is to facilitate irrigation rounds between the owners of gardens. When the tower owner (A) comes to an end, the next owner (B) closes the irrigation channel (A) and opens his segua asked without permission. Closing an irrigation channel is done manually by a plug, formed by a piece of wood surrounded by a clay filled tissue. The water distribution is effected by four methods:



**Fig 10.** An irrigation channel in the palm grove of Moghrar (Remini, 2009)

#### ***Method graduated stick***

In the past, the share of each owner irrigation is effected using a stick (palm) graduated by lines (usually stick carries three lines). This stick is placed vertically in the Madjen before irrigation. Each unit is defined by a scale which depends on the effort provided by the owner during the cleaning and maintenance.

#### ***Method "Kadem" (the Pas a healthy person)***

This technique is done on sun days. It starts from daybreak until night. The number of Kadem is proportional to the contribution of the farmer.

### Method Mordjen

At night or when it is raining or there is brown, the method of "Mordjen" are used. The system consists of two copper seals (fig 11). The largest is placed on the ground and filled with water. The second smallest hole and graduated at the bottom. We put it on the free surface of the water of the Great Seal. The time of the capsule filling, that is to say when it is emerged in the water, include a portion of irrigation water.

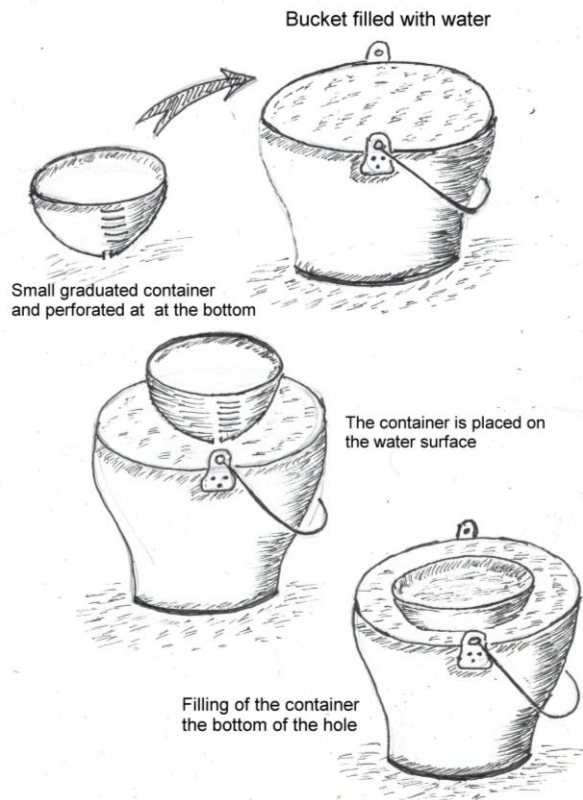


Fig 11. Le Mordjane of Moghrar oasis (Remini, 2014)

### Method El Hadjra

El Hadjra (stone) or Saat Echems (the watch the sun) performed by a flat stone engraved thirty two graduations along a semicircle with a nail in the center of the circle. The time it takes the shadow of the nail between two segments (representing 5 min) represents a share of irrigation water. The number of scale depends on the efforts provided by the farmer (fig 12).

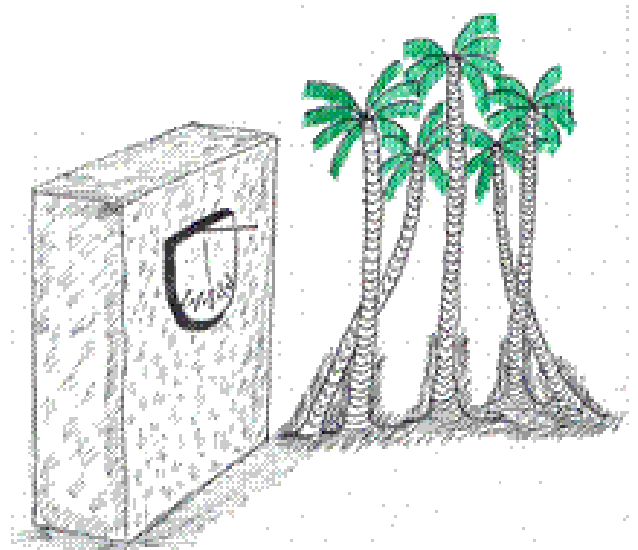


Fig 12. Hadjra of Moghrar oasis (Remini, 2014)

### Conclusion

Today, the foggara of Moghrar continues to function despite the contribution of modern techniques (pumps and wells) in the oasis. The local population still uses these traditional techniques. The foggara of Moghrar is an hourly foggara. The water distribution carries per unit time. Irrigation is carried by turns. The irrigation time is a function of the contribution to the maintenance of each farmer. By cons, classical foggara exploited in the oases of Touat and Gourara is a volumic foggara. The distribution of water is carried per unit volume. Irrigation is carried simultaneously. By collecting the water from a spring, the Moghrar foggara of a length of 300 meters, the water at the finish of the palm grove is stored in a collective basin. The classical foggara captures the water from the aquifer of Intercalary Continental ten kilometers in length. Upon arrival of the palm grove, the water is shared between farmers by the kasria. If today this hydraulic system continues to operate thanks to the local population that continues to protect this heritage.

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