Larhyss Journal, ISSN 1112-3680, n°45, Mars 2021, pp. 183-201

AHBAS N'BOUCHEN: WHEN THE ARTIFICIAL RECHARGE OF WATER TABLE BECOMES A PRIORITY IN THE M'ZAB VALLEY

AHBAS N'BOUCHEN : QUAND LA RECHARGE ARTIFICIELLE DE LA NAPPE PHREATIQUE DEVIENT UNE PRIORITE DANS LA VALLEE DE M'ZAB

REMINI B.

Department of Water Science and Environment, Faculty of Technology, Blida 1 University, Blida 9000, Algeria.

reminib@yahoo.fr

Research Article – Available at http://larhyss.net/ojs/index.php/larhyss/index
Received December 15, 2020, Received in revised form March 13, 2021, Accepted March 15, 2021

ABSTRACT

This article describes the role of the Bouchen dam in the artificial recharge of the water table and the irrigation of the palm grove of the oasis of Ghardaïa. This is how visits to the study site were carried out during the period: 2006-2019. Investigations on the various traditional structures were carried out. It turns out that in all the palm groves of the M'zab valley, the existence of two types of irrigation in the M'zab valley: temporal irrigation which is carried out directly by flood water laden with nutrients. Permanent irrigation which is carried out periodically from animal drawn wells. Ahbas N'Bouchen receives floodwater after the completion of temporary irrigation. The water stored in the Bouchen reservoir infiltrates indirectly through the bottom of the dam and directly through two wells located in the central part of the basin. This technique, applied for more than 5 centuries, has made it possible to satisfy the demand for drinking water from the ksar and the irrigation of the gardens of the Ghardaïa palm grove.

Keywords: Ghardaïa- Ahbas N'Bouchen- Replenishment - Irrigation - Water table - Palm grove.

RESUME

Le présent article décrit le rôle du barrage de Bouchen dans la recharge artificielle de la nappe et l'irrigation de la palmeraie de l'oasis de Ghardaïa. C'est ainsi que des visites sur le site d'étude ont été effectués durant la période : 2006-2019. Des investigations sur les différents ouvrages traditionnels ont été effectuées. Il s'avère que dans toutes les palmeraies de la vallée de M'zab, l'existence de deux types d'irrigation dans la vallée de M'zab : irrigation temporelle qui s'effectue directement par les eaux chargées de crues chargées en éléments nutritifs. L'irrigation permanente qui s'effectue périodiquement à partir des puits à traction animale. Ahbas Bouchen reçoit les eaux de crues après l'achèvement de l'irrigation temporaire. L'eau stockée dans la retenue de Bouchen s'infiltre indirectement à travers le fond du barrage et directement à travers deux puits situés dans la partie centrale de la cuvette. Cette technique appliquée depuis plus de 5 siècles a permis de satisfaire la demande en eau potable du ksar et l'irrigation des jardins de la palmeraie de Ghardaïa.

Mots clés : Ghardaïa- Ahbas Bouchen- Réalimentation –Irrigation – Nappe phréatique- Palmeraie.

INTRODUCTION

In each corner of the vast Sahara desert, the irrigation of the gardens and palm groves is carried out by gravity and the water reaches the lowest point of the palm grove, flowing through a network of open canals (seguia). However, the techniques for extracting water from groundwater depend from one region to another depending on the hydrogeology of the region. This is how in the oases of Touat and Gourara, underground water is taken by draining galleries called foggaras (Remini, 2017). In the Saoura oases, farmers extract groundwater from an average depth of 6 m through outrigger wells called Khottara (Remini and Rezoug, 2017). In the Tiout oasis, the land is irrigated by water from the traditional dam located upstream of the palm grove. The dam is continuously fed by around fifty natural sources (Ait Saadi et al, 2015; Remini, 2019a). In the M'zab valley, which will be the subject of this study, water is taken by the Khottara system which is an animal drawn well (Remini, 2020a; Remini, 2019b). However, the wells in the M'zab valley are closely linked to the recharge of the water table; an original technique used for more than five centuries in the M'zab valley (Remini, 2020). This is the artificial recharge of groundwater. This article discusses one of the places where the groundwater table is recharged in the oasis of Ghardaïa located in the M'zab valley, namely the Bouchen reservoir.

STUDY REGION AND WORK METHODOLOGY

Characteristics of the study area

Ghardaia; capital of the M'zab valley is located 600 km south-west of Algiers (fig. 1 and 2). The oasis of Ghardaïa was born in a rocky region with a hyper arid climate. Today Ghardaïa has become a large metropolis, a wilaya following the division of 1980. An arid to hyper arid climate with temperatures that can reach 47 °C in summer, precipitation practically absent during the year, but rain in the form of showers occur from time to time causing rapid and devastating floods.

Figure 1: A view of part of the M'zab valley (Photo. Remini, 2008)

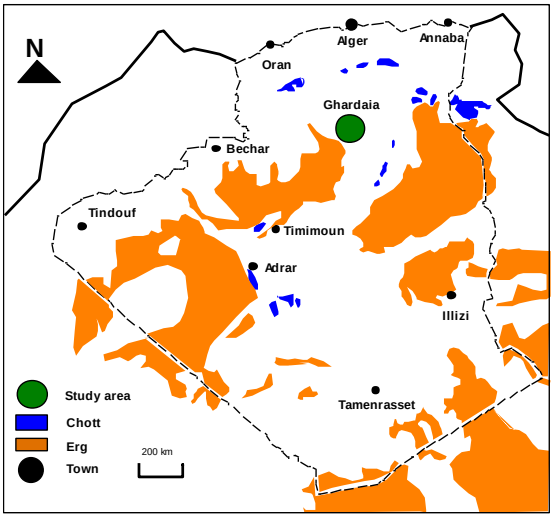


Figure 2: Location of the study region (Remini, 2018)

Methodology of work

During our work missions in the M'zab Valley, we were impressed by the colossal work carried out by the Mozabites over the centuries in the fields of hydraulics and architecture. We were impressed by the Mozabites' hydraulic know-how. With rudimentary means, they were able to build an impressive number of invaluable hydraulic works carried out in the hydraulic field and more particularly the artificial recharge of the water table. This study is based on investigations of various hydraulic structures which have a direct link with the recharge of the water table. Surveys of the local population were carried out to obtain more information on the role of Ahbas Bouchen in the infiltration of flood water into the ground.

RESULTS AND DISCUSSIONS

Artificial groundwater recharge system

Over a hundred Ahbas have been completed in the M'zab hydrographic network. Only Ahbas Bouchen made on the M'zab River upstream of the palm grove of the oasis of Ghardaïa is original and different from other Ahbas. The Bouchen dam with a capacity equal to 1 million m^3 with an average depth of 2 m the first of 10 Ahbas built on the M'zab River (fig. 3 and 4).

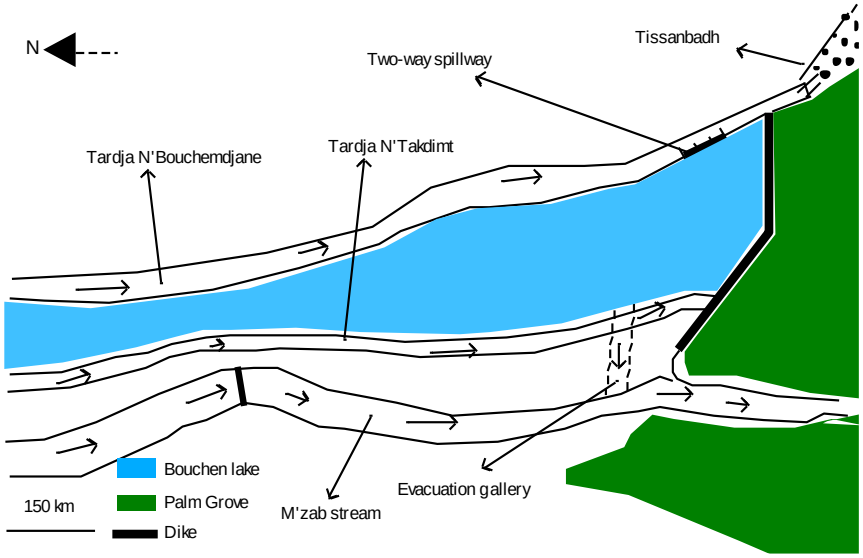


Figure 3: Diagram of the Bouchen dam (Photo. Remini, 2018)

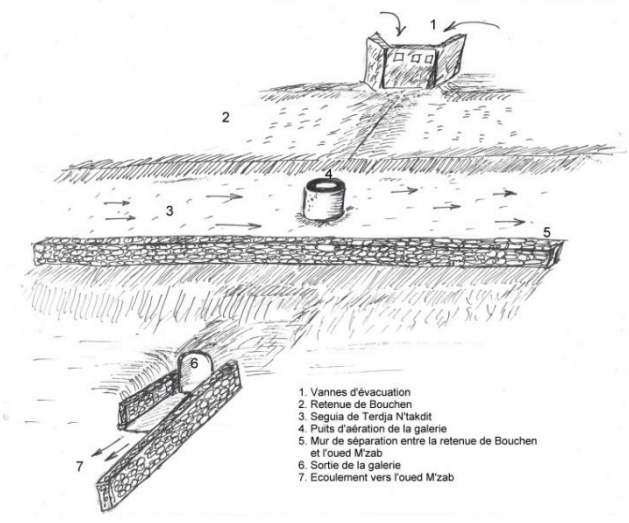
Figure 4: Lake of the Bouchen dam (Photo. Remini, 2008)

Ahbas Bouchen is the first dam to receive flood water from Amlaga; the meeting point of the waters of the wadis of Laadira and Labiod, a distance of 6 km between Amlaga and Ahbas Bouchen. The dam has a dike 3 km long, which is nothing more than a wall built with rock and gypsum mortar (fig. 5).

Figure 5: Ahbas N'Bouchen's wall (photo. Remini, 2012)

Ahbas N'Bouchen is fitted with a metal valve to drain excess water from the reservoir to the M'zab River through a 100 m gallery equipped with an aeration shaft. This drain hole plays the role of safety (fig. 6 (a, b and c)).

a) Drainage gates to the M'zab River (photo. Remini, 2012)



b) Diagram of the Bouchen reservoir drainage system

c) Exit from the tunnel to the M'zab River (Photo. Remini, 2011)

Figure 6: Ahbas N'Bouchen drainage channel

The Bouchen dam is also equipped with a two-way spillway located on the left side of the reservoir (fig. 7 (a and b)). It is a structure that allows water to be evacuated and received from the seguia of Bouchendjen according to irrigation water needs.

a) External face (towards the seguia of Bouchemdjane) (Photo. Remini, 2014)

b) Internal face (towards the Bouchen reservoir) (Photo. Remini, 2013)

Figure 7: Ahbas N'Bouchen two-way spillway

In addition to the basin which is considered as an indirect groundwater recharge basin, Ahabs N'Boucehn is equipped with two wells to directly replenish the water table (fig. 8). The rock-covered well is over 5 centuries old (Fig. 9). On the other hand, the uncovered one was carried out recently for more than 80 years (fig. 10).

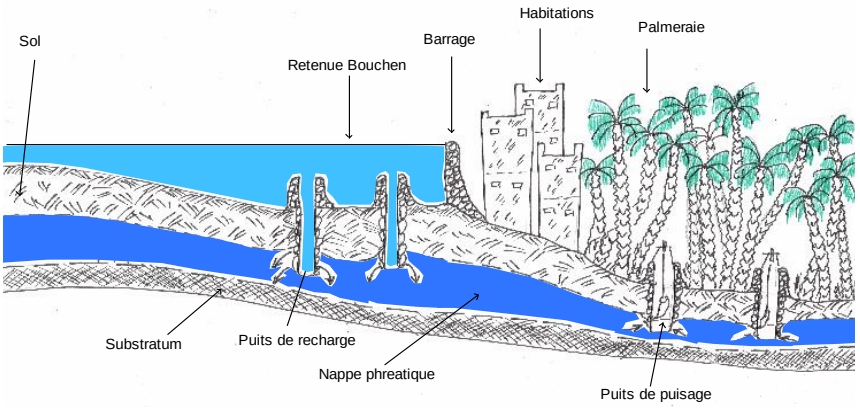


Figure 8: Block diagram of the operation of Ahbas N'Bouchen (Diagram Remini, 2017)

Figure 9: Old well (covered by rocks) for recharge direct from the 5-century-old tablecloth (Photo. Remini, 2018)

Figure 10: New Make-up Well (Not Covered) direct from the 80-year-old tablecloth (Photo. Remini, 2006)

Operation of the artificial groundwater recharge system

The IRS development adopted by the Mozabites in the M'zab valley gives priority to the temporary irrigation (flooding of the gardens) of the upper and lower parts of the eastern palm grove of Ghardaïa to the detriment of the artificial recharge of the water table (

Remini, 2020a). Once the flood arrives in the M'zab River, the first waters are transported by the seguias of Bouchemdjane and Takdimt to reach the eastern palm grove (Remini, 2020b). This type of irrigation by flood water loaded with fine particles is of great importance for oasis agriculture. After this forced flooding of the gardens, the floodwaters go directly to the Bouchen reservoir. This is the operation of the artificial recharge of the water table. The 2 km2 dam lake is used as an infiltration basin and not for storing flood water. The choice of the location for this work is not by chance, but the fruit of exceptional know-how. The water infiltrates and flows slowly to reach the water table (Fig.8). However, to have good recharge efficiency, the dam was equipped with two traditional wells located in the center of the reservoir to directly replenish the water table (fig.9 and 10).

According to our surveys of farmers, once Lake Bouchen is well filled with flood water, the static water table downstream in the eastern part of the palm grove rises to a significant level. Consequently, the water collection wells located in the palm grove will be well filled and can irrigate the gardens and supply domestic needs (Fig. 11). So in this case the amount of infiltrated water can last for twenty years.

Figure 11: Catchment wells in the palm groves of the M'zab valley (Photo. Remini, 2019)

Ahbas N'Bouchen; a sediment storage basin

In addition to its main function, Ahbas N'Bouchen receives tons of fine particles during flood periods. However, the Mozabites considered these materials to be a strategic deposit of great interest for the oases of the M'zab valley. This sludge, which is very rich in organic matter, is intended for soil amendment in palm groves. Indeed, irrigation and strong evaporation cause the formation of a white layer of salts on the surface of the soil. To combat this phenomenon of soil salinization, the periodic replacement of the surface layer of the soil by Ahbas N'Bouchen mud has become an essential process in oases (fig.12).

Figure 12: A well-maintained garden in the oasis of Bounoura (Photo. Remini, 2008)

In the field of construction, the mud stored in the Bouchen dam became among the Mozabites the raw material for the construction of dwellings, ksours and garden walls (fig. 13, 14 and 15). Therefore, this raw material is too much in demand and even coveted by the population. In addition, to these two areas (Agriculture and construction), the cleaning of the Bouchen dam is carried out periodically to facilitate the flood waters to quickly infiltrate the basement and reach the water table. All these operations have been taking place in the M'zab valley for more than 5 years. Unfortunately, that is not the case today.

Figure 13: Bouchen vase; the raw material for the materials construction (Photo. Remini, 2010)

Figure 14: The finished product of Ahbas N'Bouchen's vase ready for construction (Photo. Remini, 2010)

Figure 15: Garden walls built with riprap (foundations) and the upper part (about 3 m) in the ground (Ahbas N'Boucen vase) (Photo. Remini, 2012)

For more than half a century, Algeria has carried out the destruction of a dozen dams using dredging techniques (Remini and Hallouche, 2004). Only the place of discharge of these quantities of mud has not been solved. Unlike the 1970s when the silt was directly discharged into the wadi downstream from the dam. Today, the silt is stored in basins upstream of the dam so that the water from the slurry can return to the dam reservoir. This is the case of the Foum El Gherza dam in Algeria (fig. 16) (Remini et al, 2015; Remini, 2019c). However, such a solution requires a large area of land for the construction of basins (fig. 17). Only a recovery of these millions of tons of mud in the fields of construction, agriculture and pottery will be able to solve the problem of silt deposits at

the bottom of dams (fig. 18) (Labiod et al, 2004; Remini and Kenai, 2000; Remini, 2006; Remini, 2019c).

Figure 16: The Foum El Gherza dam silted up at more than 65% of its initial capacity is in the depletion phase (Photo. Remini, 2016)

Figure 17: Release of silt into a storage basin during dredging of the Foum El Gherza dam (Photo. Remini, 2017)

Figure 18: Storage basin for the silt released by the dredging technique during the clearing of the Foum El Gherza dam (Photo. Remini, 2017)

a) Some pottery products made by the mud from the Foum El Gherza dam (Photo. Remini, 2017)

b) Some construction material products produced by the mud of the Foum El Gherza dam (Photo. Remini, 2017)

Figure 19: Finished silt products from some Algerian dams (Photo. Remini, 2020)

Degradation of Ahbas N'Bouchen

Can we leave today a hydraulic heritage of more than 5 centuries in a very degraded state like that of Ahbas N'Bouchen? Obviously, no. Only the two recharge wells have been rehabilitated today. The N'Bouchen dam lake no longer plays its role as an infiltration basin, since it is filled with more than 2/3 of the total volume of the fine particle basin. Not only has the flood water storage capacity become insufficient to fill the aquifer (1/3 of the total volume remains), but above all these fine particles prevent water from

infiltrating to reach the water table: the permeability decreased following the clogging of the pores by the mud. So the destruction of the N'Bouchen reservoir has now become an inescapable solution, but the place of rejection poses problems. To this end, the local authorities should facilitate access to the population for the use of this mud deposit in soil amendment in gardens and in the construction of houses (fig. 20).

Figure 20: Mud deposit occupying the entire capacity of the Bouchen dam (Photo. Remini, 2018)

DISCUSSION

Can we say that the M'zab valley is the land of artificial groundwater recharge? Indeed, this technique of surface infiltration has been adopted by the Mozabites for more than five centuries. It was their environment that imposed such a hydraulic process. The M'zab Valley, a rocky region with an arid climate where water is scarce. At the time, the only source of water was the water table, which is recharged naturally by the rare floods drained by the wadis of the valley such as the wadis: M'zab, Ntissa, Azioul. Groundwater is drawn through animal-drawn wells called Khottara. However, the development of new palm groves and the enlargement of the ksours as well as the droughts that affected the M'zab valley prompted the Mozabites to invent the system of groundwater recharge.

For five centuries, the Mozabites have understood the relationship between evaporation and infiltration. They understood that it is necessary to accelerate the infiltration into the subsoil at the expense of the evaporation of surface water. The rare floods that hit in dry areas are generally of short duration but with exceptional inflows. It should be remembered that evaporation in arid environments exceeds 2 to 3 meters in height (Remini, 2004). Other authors claim that evaporation can reach a height of 6 to 7 m in hyper arid regions (Rognon, 2000; Boutoutaou et al, 2020). At Lake Chad, annual

evaporation is 4 to 5 m/year according to Bouchrdeau (in Remenieras, 1986). With such an evaporation value, only a small amount of flood water can reach aquifers. So the realization of the water storage basins in places with high permeability can fill the underground reservoirs more quickly. The Bouchen dam was built in a well-studied location (current site) taking into account all the hydrogeological parameters. Such a hydraulic structure reflects the know-how and the oasis genius. Intended to replenish the water table, the Bouchen dam is equipped with a wall with a perimeter equal to ... to collect a volume of water of 1 million m3. The Bouchen reservoir, which acts as an infiltration basin, provides indirect recharge of the aquifer. On the other hand, the two traditional wells which are located in the center of the reservoir provide direct recharging. Filling the Bouchen basin with flood water can meet the demand for domestic water and irrigation of the gardens for a fairly long period. What we can say from this study, in dry environments groundwater recharge by flood water must be done quickly to minimize water loss by evaporation, which is the main handicap of surface water.

Today, we have not taken advantage of our hydraulic history, which is very rich in know-how. We have not been able to take advantage of ancestral hydraulic structures to develop them and adapt them to our time. Today, hydraulics engineers are aware that artificial groundwater recharge is an economical and simple technique to perform. It is enough to find a site favorable to the infiltration of water in the vicinity of a river. Only one artificial groundwater recharge station was built at the start of the 2000s in the willaya de Blida. Unfortunately, the hydraulic structure is stopped (fig. 21).

a) Water intake from the El Harrach River

b) First settling tank

c) Second infiltration basin

Figure 21: Artificial recharge station for the Mitidja aquifer (Photo. Remini, 2008)

Another very interesting experiment on the replenishment of the alluvial water table was carried out by the releases of the Ghrib, Kef Dir and Boukourdane dams during the 1990s. These two experiments have given very encouraging results, more particularly at the Boukourdane dam. Indeed, an operation of the releases of this dam causes a rise in the level in the wells located over a radius of 20 km.

CONCLUSIONS

As we mentioned at the beginning of this paper the M'zab valley represents the cradle of artificial groundwater recharge. In addition, the Ahbas Bouchen site plays an important role in replenishing the Ghardaïa water table and thus allows each flood to increase the static level of the water table. Therefore, the catchment wells will be well filled and thus allow the irrigation of the gardens and the supply of drinking water. On the other hand, the clay particles and silts brought by the floods and deposited at the bottom of the dam are of great interest for the amendment and the fight against soil salinization. In the field of construction of houses, the mud is recovered to reuse it as raw materials in the realization of the walls of buildings. So, the destruction of the N'Bouchen reservoir has now become an unavoidable solution. Today, such a heritage must be rehabilitated and protected.

REFERENCES

AIT SAADI H., REMINI B., FARHI A. (2015). The ksar of Tiout (Algeria): mastery of water management and environmental protection, Larhyss journal, n°24, pp. 243-261.

BOUTOUTAOU D., ZEGGANE H., SAGGAI S. (2020). Evaporation of bodies of water in arid Mediterranean zone: case of Algeria, Larhyss Journal, n°43, pp. 91-101.

REMENIERAS G. (1986). Engineer's hydrology, Editions Eyrolles, Paris, France, 451 p.

REMINI B. (2006). Valuation of silt from dams - some Algerian examples, Larhyss Journal, No 5, pp.75-89.

REMINI B. (2005). Evaporation from dam lakes in arid and semi-arid regions: Algerian examples, Larhyss Journal, No 4, pp.81-89.

LABIOD Z., REMINI B., BELAREDJ M. (2004). Treatment of the mud from the Bouhanifia dam with a view to its recovery, Larhyss Journal, No 3, pp.7-12.

REMINI B., HALLOUCHE W. (2004). Dredging dams. Some Algerian examples, Revue Internationale La Houille Blanche, No 3, pp. 95-100.

REMINI B., KENAI S. (2000). Valuation of the mud from the Oued Lekhel dam for the manufacture of bricks, Revue marocaine de Génie Civil, No 90, pp.36-41.

REMINI B. (2020a). Oued M'zab's IRS Development - Population and Floods, life in harmony- Part 1: Hydraulic structures, Larhyss Journal, No 42, pp. 63-95.

REMINI B. (2020b). Oued M'zab's IRS Development - Population and Floods, life in harmony- Part 2: Design and operation, Larhyss Journal, No 42, pp. 145-166.

REMINI B. (2019c). Algeria: mud at the bottom of the dams, what to do? Larhyss Journal, No 40, pp. 213-247.

REMINI B. (2019b). The oasis of El Guerrara (Algeria): irrigation and groundwater recharge ensured by the floods, Larhyss Journal, No 40, pp. 213-247.

REMINI B. (2019a). Dams in cascade (Tiout oasis, Algeria): a hydraulic heritage to save, Larhyss Journal, No 37, pp. 175-206.

REMINI B. (2017). The foggara of Tadmait: without energy from the water from the subsoil to the surface of the ground, Larhyss Journal, No 32, pp. 301-325.

REMINI B., REZOUG C. (2017). The Saoura khottara: a hydraulic heritage in decline, Larhyss Journal, No 30, pp. 273-296.

REMINI B., BENSAFIA D., MISSOUM M. (2015). Silting of Foum el Gherza Reservoir, GeoScience Engineering, Vol. LXI, No 1. pp. 1-9.

ROGNON P. (2000). Comment développer la recharge artificielle des nappes en régions sèches, Sciences et changements planétaires/Sécheresse, Vol. 11, No 4, pp. 289-296.