ALJEST

Study of the reliability of "Chekfa" in water distribution in the "foggara" system: a case of Adrar region, Algeria

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ABSTRACT/RESUME

Abstract: This work describes the reliability of the instrument of water flow measurement chekfa, and the role of the latter in the durability of the foggara system in Adrar region, South of Algeria. As the establishment of foggaras is essentially a collective task, no one can be proclaimed the owner of foggara. Therefore, it is considered as a common property. This system of the co-ownership poses the problem of water distribution. Captured water is distributed by a traditional measurement method done by an expert person, kial el ma. The objective of this study was to examine the reliability of traditional methods of water flow measurement in comparison with the current hydraulic methods of flow gauging and measurement. The experimental results, undoubtedly, showed the conformity between habba flow and the corresponding flows measured by the habba fractions. Hence, the methodologies of measurement adopted by the autochthon people were checked against those of the current hydraulic system (flowmeter), the amount of water given to each of the owners of the foggara is recorded in a register called Zemam. The values obtained could be reproduced entirely and precisely through the saved values in Zemam (register of kial el ma).

I. Introduction

In Algerian Sahara, life is sustained thanks to non-renewable groundwater reserves. All the cities are thus found near natural out crops of the main aquifer, Intercalary Continental (IC). In spite of the desert medium, agriculture is considered as a principal activity of the inhabitants [5]. Oases are irrigated by a traditional method thanks to water supply by an extraordinary system called *foggara* (also referred to as *qanat* in Iran and other names in other countries) [2]. This system ensures water arrival to the cultivations by gravitating flow from a source often very far away from the oases [1], crossing underground galleries until storage reservoir or *madjen* established in the oasis.

There are different opinions on the origins of the foggara system. Historical reports or archaeological investigations have shown that the *qanat* system was introduced in our study area by the Arabs between the ninth and tenth century to ensure both potable water supply and sufficient water for irrigation purposes. There were more than 2000 qanat systems in Adrar region, with 3000 km of total length.

Centuries ago, autochthon people of Sahara managed in the establishment of the foggara system to ensure their lives. The issue in water co-propriety was its distribution between farmers. To resolve this problem, an expert, *kial el ma*, used a copper plate [3] known as *chekfa* (Fig.1) for distributing water. *Chekfa* contains many orifices with different diameters. *Habba*, a reference orifice, constitutes

the principal unit of measurement [3]. *Habba* and all other orifices are made by *kial el ma*-who does not have any idea about geometry and mathematics skills-.Hence, the object of our study was to investigate the reliability of the measuring instrument, *chekfa*, used to distribute water by *kial el ma* and to check whether the gauging method using the traditional flow meter corresponds to the expected flow using mathematic formula.
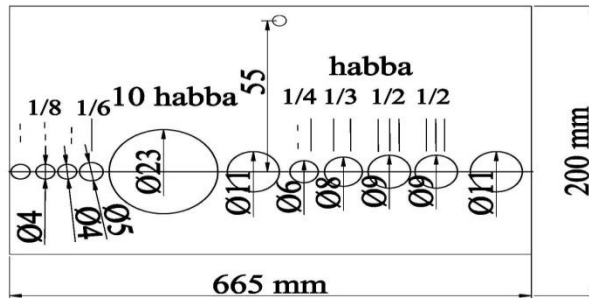

Figure 1.Form of flow measurement instrument chekfa (Ø is a diameter of the holes in mm and :; || symbols sculpted on the plate).

II. Materials and methods

II.1. The study area

Adrar region, located approximately 1,500 km southwest of Algiers (Fig.2); [10], covers an area of 525,270 km^2 which represents 1/5 of national territory. This region is defined by latitude 0°30' W to 0°30' E and longitude 26°30' N to 28°00 N with an altitude of 280m above MSL [6]. Its natural boundaries are the Greatest Western Erg to the North, the Erg Echech to the West, the Tanezrouft Sahara to the South, and the Tademaït plateau to the East [8]. Touat and Gourara is a hyper arid region, with precipitations below 15 mm/year.

Figure 2.Location of the study area (source: www.carte-algerie.com).

II.2. Construction and exploitation of foggara system in Adrar region

Historical documents record that the foggara system is found in different regions and has many appellations: *Qanat* in Iran; *Ain* in Saudi Arabia; *Falaj* in the United Arab Emirates and Oman; *Kanerjin* in China; *Khettara* in Morocco and foggara in Algeria. As a result of the widespread of this system, it is difficult to know its origin [2]. Two main theories on the origin of foggara system in area study have been offered [4]: (1) The population have invented the qanat system to practice agriculture in the region. Our investigation has led us to say that the beginning of digging is done from downstream to upstream (alluvial aquifers) of the groundwater table (fig.3). The vertical shafts (wells) are installed to provide light and aeration of the gallery system; the distance between the wells is estimated at about 3 to 6 m (2) The second theory asserts that the foggara system was introduced in Toaut region from Iran by Arabe expansion to north Africa in the tenth century.
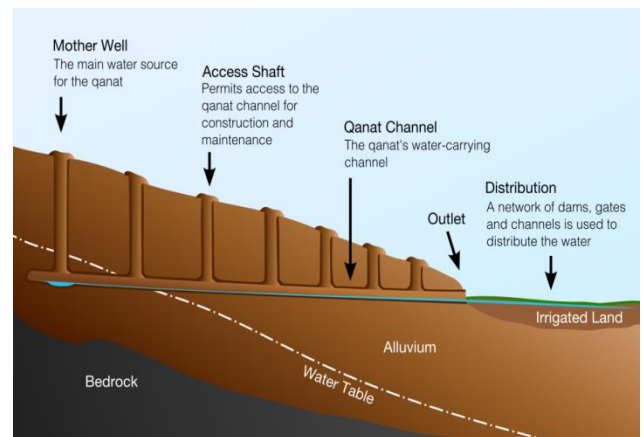

Figure 3.The general schema for a foggara system (source: www.pinterest.fr)

II.3. Partage of water in the foggara system

As the establishment of foggaras is essentially a collective task [7], no one can be proclaimed the owner of foggara. Therefore, it is considered as a common property. This mode of the co-ownership poses the problem of water distribution [11]. The way the water is distributed is as original as the way it is collected. Once established, *kial el ma*, who has inherited this job from his ancestors, measures the initial flow of the foggara with *chekfa* (fig.3and 4).

In laboratory, we elaborated a system similar to that of foggara to study various parameters related to water flow. Our system was made up of water source with low flow, canal, water basin and gauging plate (*chekfa*) [12].

We have used a *chekfa,* which was kindly provided by the head of foggara association of Tamentit region. The experiment proceeded as follows: *chekfa,* with already blocked orifices, was first

placed just at the exit of the canal to bar the incoming flow and to form a small basin (fig 4). Once the water level in the basin reaches overflow, several holes were unblocked until the equilibrium had been established; in other words, the amount of water that comes into the *chekfa* from the canal, and the amount of water the goes out through orifices that we opened gradually are considered to be the same amount only if the water level in the basin stays stationary. This equilibrium can be known through indicators engraved on the *chekfa* plate [12]. The number of holes was then counted to know the water flow entering. Finally, measures were recorded in a note book (zemam) by using the local symbols ($||$, $+$, $\vdots$, $\overset{\bullet\bullet}{\rule{8mm}{0.3mm}}$, $+$, $\bullet$, $|||$, $|$) which are used by the local inhabitants.

Figure 4.*Operation of measurement using chekfa (photography Benziada, 2006).*

III. Results and discussion

Results of water flow are summarized in the table 1.

Table1. *Values of water flow for each orifice of chekfa.*

Characteristic of *chekfa* (Tamentit). Height of overflow (H=40mm) Diameter of the *habba*(D_{habba}=8 mm)				
Fraction	Diameter (mm)	local symbols	Flow	
			Local unit	ml/s
habba	8	none	24 *kirate*	33
1/2 *habba*	6	$|||$	12 *kirate*	19
1/3 *habba*	5	$||$	8 *kirate*	11
1/4 *habba*	4	$\downarrow$	5 *kirate*	8
1/6 *habba*	3	$|$	4 *kirate*	5

Subsequently, the values obtained in the experiment can be justified by the law of Torricelli, taking into account the absolute ignorance of the geometrical knowledge and the relation between the flow and surface of the opening.

$$Q_{habba} = m * S_{habba} * \sqrt{2gh_{overflow}} \quad (1)$$

Where Q_{habba} is the flow to run out through the opening corresponding to the *habba* in the *chekfa* plate (ml/s), S_{habba} is a section of the *habba* opening (m²), $h_{overflow}$ is the hydraulic head above the opening(m), *m* is the coefficient of contraction depending on the shape of the opening. In our case *m*=0.62 [9].

$$Q_{\frac{1}{2}habba} = m * S_{\frac{1}{2}habba} * \sqrt{2gh_{overflow}} \quad (2)$$

To determine the diameter which corresponds to the flow of ½ *habba*, we use the equation 2, where$Q_{\frac{1}{2}habba}$are replaced now by their values, obtained in experiments during the gauging of the flow of Tamentit foggara (Table 1). After the numeric application, we found that the diameter calculated for the 1/2, 1/3, 1/4 and 1/6 of the *habba* are 6mm5 mm, 4 mm and 3mm respectively.

IV. Conclusion

In Touat, the measurement is made by means of a copper board pierced with holes. This copper board is called *chekfa.* The measuring unit of water is the *habba.* It is the quantity of water which runs out through a hole of a given dimension during 24 hours. The specialist charged to make the *chekfa* and to carry out measurements is called *kial el ma.* He is the holder of foggara register. He is assigned by the assembly of the water owners "*djemaa*". The *kial elma* occupies a significant place in the social hierarchy.

The plate of traditional measurement *chekfa* was studied by a reproduction of the characteristics specific to dimensions of the openings, in conformity with the studied prototypes.

The experimental results initially showed undoubtedly conformity between the flows of *habba* and the fractions of *chekfa's habba* considered *(Chekfa* of Tamentit). In the second time, the methodologies of measurement adopted by the autochthon people were checked and validated with those of the current system.

From these encouraging results, it was checked that the exact restitution of the entry flows of the foggara (that of Tamentit region), could be reproduced entirely and precisely through *Zemam* (register of *kial el ma*).These last records in writing the whole history of the flow-water evolution of the gallery of the foggara studied (taking as flow of *habba* equal to 119.18 l/h), and thus to give the whole of the split flows of the foggara.

V. References

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