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Scaling of the potable water network of the Touggourt city (Algeria)

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ABSTRACT

With rainfall not exceeding 100 mm/y, the Touggourt region is supplied by the groundwater from the Intercalary Continental aquifer. The needs of irrigation and potable water are met by deep drillings that capture the water of the Intercalary Continental aquifer. It is a fossil water whose temperature is source around 60°C and a mineralization exceeding 2 g/L, which has led to the formation of tartar deposits in the supply network of potable water. The investigations conducted in 2004, 2005, 2007, 2009, and 2010 in the Oued Righ valley reveal the seriousness of the phenomenon of scaling and the consequences on the distribution of water in the Touggourt city.

Keywords: Touggourt; Network; Potable water; Scaling; Intercalary continental aquifer

1. Introduction

The region of Touggourt is rich with groundwater. Thus, the irrigation and potable water are carried through deep drilling that draw from the Intercalary Continental aquifer 1,500 m of depth. Such groundwater quality is affected by water recharge from a number of mineral elements related with the nature of the ground. The water for consumption should not contain a number of minerals; its total mineralization, salinity or solids should not exceed 2 g/L [1]. The water of Touggourt is characterized by a temperature around 60°C at the source and mineralization of water exceeds 2 g/L, which promotes the formation of deposits in tarts carried in the network.

This study describes the problem of scaling of the potable water supply network to the city of Touggourt and technical and economic consequences such as the occurrence of tartar deposit in pipes. The only solution of this problem is periodic replacement of sections of conduits with new conduits.

2. Study area and field missions

The Touggourt city is part of the Oued Righ valley, located 600 km southeast of Algiers and 160 km north of Ouargla (Fig. 1). Palm is the main crop in the region, including the Deglet Nour. Four missions were conducted in 2004, 2005, 2007, 2009, and 2010 in the Oued Righ valley and especially the Touggourt city to understand the phenomenon of scaling of the supply lines.

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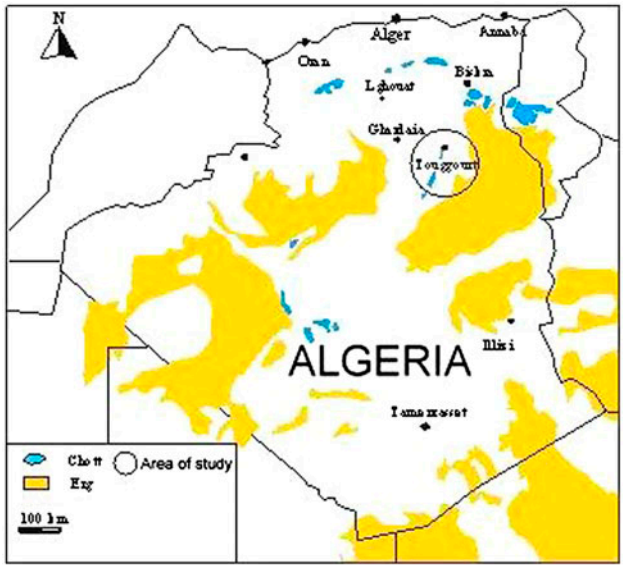

Fig. 1. Location of study area.

3. Results and discussion

3.1. Water resources in Touggourt region

For Touggourt, most of water resources come from the Intercalary Continental aquifer, one of the greatest reservoirs of fossil water in the world which extends throughout the Northern Sahara (Fig. 2(a) and (b)). On an area of 600,000 km^2 and containing 60 trillion m^3 of water, this volume is the equivalent 12,000 times the capacity of our existing dams [3]. According to the experts, this volume is theoretical and could in reality be much lower. These waters are not renewable at a rate corresponding to the needs. The turnover time of the Albian groundwater is estimated at 70,000 years.

The basin of Intercalary Continental is constituted by different permeable formations of Saharan basement filled with water during rainy periods of the Quaternary. It contains an amount of water corresponding to a fictitious continuous discharge of 1,000 m^3/s (theoretical) for twentieth centuries [4–6]. The basin of Intercalary Continental was defined between 1940 and 1960 [7]. To the west, the basin is bounded by the Sulcus of Saoura and Messaoud rivers, to the north by South Atlasian flexure and south by an outcrop passed through Adrar, In Salah, and Bordj Omar Driss. To the east, the aquifer extends into southern part of Tunisia and northern part of Libya.

These aquifers of the Intercalary Continental and the Terminal Complex as the North Western Sahara Aquifer System (SASS) which designates the superposition of these two deep aquifers (Figs. 2(a) and (b)). It covers an area of over 1 million km^2, divided between three countries (Algeria 700,000 km^2, Tunisia 80,000 km^2, and Libya 250,000 km^2). Since early 80s, the SASS is operated through the proliferation of deep wells, exploited today around 2.2 billion m^3 divided among the three countries—Algeria 1.33 million m^3, Tunisia 0.55 million m^3, and Libya 0.33 million m^3 [8,9].

The results of various simulations carried out by the ANRH (National Agency of Water Resources) taking into account certain assumptions about levels of

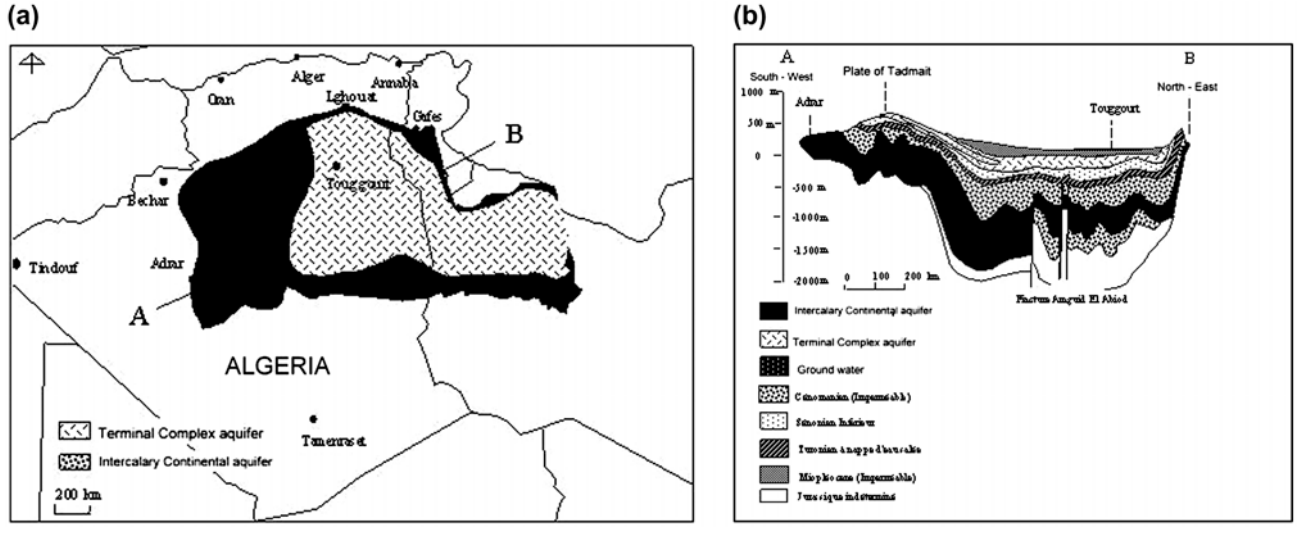

Fig. 2. Aquifers of the intercalary continental and terminal complex (a) general framework of the two aquifers and (b) schematic of the two aquifers (UNESCO 1972 in [2]).

Table 1
Results of chemical analysis of water drilling (Sources: National Agency of Water Resources, [10])

Elements	Drilling F1 ANRH	Sidi Mahdi II [10]	Drilling F2 ANRH	Sidi Mahdi III [10]	Drilling F3 ANRH	Ain Sahara [10]	Standards of the OMS
Ca^{++} (mg/l)	236	168	233	160	247	162	200
Mg^{++} (mg/l)	91	121	90	126	106	128	150
Na^{+} (mg/l)	243	309	287	288	295	294	200
K^{+} (mg/l)	30	44	37	44	38	43	–
Cl^{-} (mg/l)	472	538	516	535	438	527	500
SO_4^{-} (mg/l)	753	660	688	650	913	672	400
HCO_3^{-} (mg/l)	126	134	126	131	131	134	–
TH (°F)	96	92	95	92	106	92	50
pH	8.2	7.35	8.25	7.40	8.2	7.50	6.5–8.5

drawdown and sampling locations have shown that it can take about 5 billion m^3/y, divided between Terminal Complex aquifer (40%) and Intercalary Continental aquifer (60%). The utilization of water resources of the Sahara is currently estimated by ANRH about 28%, representing 1.4 billion m^3 per year of total volume exploitable (5 billion m^3).

3.2. Scaling of the network of Touggourt city water supply

Irrigation and potable water supply in the region of Touggourt are carried out from three deep (1,600–1,800 km) artesian wells that exploit the Intercalary Continental aquifer whose total operating flow varies between 80 and 150 L/s at a total pressure between 20 and 30 bar. The water temperature at the exit of drilling varies between 50 and 65°C, which makes it inconvenient to use, especially in summer, by cons in cold weather, the population of Touggourt is eased and does not use water heaters. The mineralization of the water varies between 1 and 2 g/L of dry residue and can reach 5 g/L. The analyses performed by the National Agency of Water Resources on water samples from three drilling are shown in Table 1.

The water in the region of Touggourt has a salty taste, less potable and high hardness due to the presence of salts of calcium and magnesium. It is manifested in difficulty in cooking vegetables and production of foam with soap. Megdoud [11] confirms very bad chemical quality (magnesium sulfate content is above the prescribed standards of quality) of water from the Albian aquifer particularly in its central part (Ghardaia, Ouargla, Touggourt, El Oued) (Table 2).

Table 2
Water quality from the Albian aquifer of the central portion [11]

Designation	RS 105°C (mg/L)	$CaCO_3$ (mg/L)	Mg^{2+} (mg/L)	SO_4^{2-} (mg/L)
Average	1,731–2,142	900–1,100	125–162	619–843
Quality limit	2,000	500	150	400

Although abundant, water Touggourt has a very high content of lime scale. It constitutes the major preoccupation of the local authorities and mobilizing a large budget every year. The evolution in time of deposit of limestone in the network of water supply is dramatic, resulting in an annual decrease of about 35 mm diameter, an average annual decrease in 10% of initial diameter (Fig. 3). Pipes, valves, and elbows were completely closed after only seven years of service (Fig. 4).

The phenomenon of scaling has resulted in an increase in pressure drop exceeding 2 m in certain places. This deprives the use in several quarters in the consumption of potable water. Scaling causes disruption of the flow regime in the pipe network. The latter determined by the Reynolds number has an effect on the calculation of losses. The deposit of scale complicates the evaluation of water hammer. The dimension-

Fig. 3. Decrease the diameter of the pipe (photo 2010).

Fig. 4. Clogging of the valves by scaling (photo 2005).

Fig. 5. Renovation of water mains in the Touggourt city (photo 2010).

Fig. 6. A sample of tartar deposited in the conduct of the network of Touggourt (photo 2010).

ing of anti-Bélier becomes hazardous, since there is currently no study on behavior of conduct or scaled time of appearance of the shock wave. On average, every seven years the hydraulic services renovate the network of potable water for the Touggourt city (Fig. 5). Three types of scale are formed: sulfate and silicate deposits that are very hard and stick to the walls; the carbonate deposit of tartar that is most experienced in the Touggourt network (Fig. 6).

4. Conclusion

The population of the Touggourt city consumes the water of Intercalary Continental aquifer. After softening station and cooling, the water reaches the taps of consumers at a high temperature. Scale deposits are standing in the pipes of the network, thereby reducing its diameter over time, and therefore, the pressure drop increases. Thus, each year, the pipe diameter decreases by 35 mm, which poses problems of reduced pressure in several locations on the network. The renovation of the network of the Touggourt city water supply occurs on average every seven years.

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