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Characterization of Scaling Power of Tiznit Region Waters

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Abstract

The phenomenon of scaling is particularly observed in the regions of Morocco which exploit groundwater. The region of Tiznit uses these waters, partly, for its domestic and industrial needs. The major problem of the use of this water is, besides its medium quality, the clogging of the pipes. The aim of this work is to study the phenomenon of water scaling in Tiznit region using the means of thermodynamic and kinetic analyses. The physicochemical analysis of this region's waters shows that their contents of calcium and magnesium are very high. The hydrometric title is situated between 18˚F and 64˚F. The alkalinity varies from 22˚F to 82˚F. The classification of waters of this region for assessing the risk of clogging, according to their hardness, shows that 80% of these waters are hard waters. The kinetic characterization of scaling power of drinking water in this region was conducted using the method LCGE which also proved the scaling character of these waters.

Keywords

Scaling Power, Calcium Carbonate, Clogging, LCGE, Tiznit

1. Introduction

The water resources of the city of Tiznit and the neighboring rural communes are very limited. The exhaustion of water requirements of this area is made from the dam of Youssef Ibn Tachfine located on one of the arms of Oued Massa, from Reggada source located in the platform of Ouled Jerrar, and from Talaint wells, distanced respectively of 32.8 km, 20 km and 24 km away from the city of Tiznit. The exploitation of the Reggada source water began in 1996. Two thirds of this water is used to supply hundreds of small villages surrounding Tiznit with drinking water. The waters of Youssef Ibn Tachfine dam and Talaint wells are mainly intended for the feeding of Tiznit city. During the water flow, the phenomenon

of scaling in the pipelines transporting these waters is observed mainly under the effect of a degasification of the water and the very low solubility limit of calcium carbonate. Thus, we are interested in this work to study this phenomenon of scaling, which is a priority in our research works, and in finding an adequate solution to eradicate this problem [1] [2].

To take account of the variation, according to the seasons of the physicochemical water quality of the Tiznit region, we have followed up the quality of these waters during one year (from August 2014 to July 2015) from several sampling points. A classification of these waters has been done, at first, for the thermodynamic evaluation of chemical clogging of pipeline of these waters. We have then, in a second, selected five representative samples of the water of this region for the kinetic characterization of the scaling power of these waters by the method of controlled degassing "LCGE".

2. Experimental Techniques

The kinetic characterization of the scaling power of drinking water of Tiznit region was studied by means of the method LCGE [2] [3] [4] [5]. This method aims at provoking the precipitation of the calcium carbonate by a degassing (displacement of the calco-carbonic balance in the sense of the formation of the calcium carbonate) of the studied water. The statement of the pH values and the concentration of Ca^{2+} ion in the course of time, consequently, allow making a description of the kinetics of precipitation according to the following reaction:

$$Ca^{2+} + 2HCO_3^- \longrightarrow CaCO_{3(S)} + CO_{2(g)} + H_2O. \quad (1)$$

The statement of the pH values and the concentration of Ca^{2+} ion in the course of time, consequently, allow making a description of the kinetics of precipitation.

The physicochemical characterization of the studied waters was carried out using standardized methods:

- The ions calcium, magnesium and hydrogen carbonates were determined by the volumetric method.
- The chloride and sulfate ions were respectively determined by Mohr's method and the gravimetric method.
- The ions NH_4^+ were determined by colorimetry.
- The NO_3^- ions were determined by measuring UV/visible spectrophotometry.
- The atomic absorption was used for the determination of concentrations of ions Na^+ and K^+.

3. Results and Discussion

3.1. Physico-Chemical Characterization of Waters of Tiznit Region

In order to reflect the variation of the physicochemical water quality of Tiznit region, according to the seasons, at the consumer level, we carried out a monitoring of quality of these waters during one year (from August 2014 to July 2015). The

measured physical and chemical parameters are shown in Table 1. It is about the pH, temperature (T), the dry residue (DR), conductivity (σ), the total hardness (TH) and the total alkalinity (TAC).

We first note that the values obtained for the different parameters are in accordance with the Moroccan standard for the quality of drinking water [6].

The total hardness fluctuates between a maximum value of 64˚F (640 mg/L of $CaCO_3$) and a minimum value of 18˚F (180 mg/L of $CaCO_3$). The total alkalinity varies between 82˚F and 22˚F. Four samples of the studied waters were selected for the characterization of scaling power. They are from Reggada source (Water R), Talaint well (Water T), Youssef Ibn Tachfine dam (water D), and the water reservoir (Water (R + D + T)) where water of the Reggada source mixes with that of Youssef Ibn Tachfine dam and that of Talaint well. The results of the physicochemical analysis of these waters are reported in Table 2 and Table 3.

The examination of physicochemical analysis results show that, except for water of Youssef Ibn Tachfinedam, the contents of calcium and magnesium of these different waters are very high and consequently they are very hard [7].

The concentrations of the hydrogen carbonate ions of these waters are also very important in causing the precipitation of calcium carbonate, highly dissoluble salt, which is responsible for the most common problems of scaling [8] [9]. Consequently, the scaling potential of these waters will be very high because the reaction of precipitation of the calcium carbonate is directly related to the contents of calcium and hydrogen carbonates [10] [11] [12].

Table 1. Minimum and maximum values of the measured parameters.

	TH (˚F)	TAC (˚F)	T (˚C)	pH	DR (mg/L)	σ (µS/cm)
Minimum values	18	22	15.5	7.10	336	450
maximum values	64	82	23.1	7.95	1310	1457

Table 2. Physical parameters for different samples of drinking water of the Tiznit region.

	pH	Temperature (˚C)	Conductivity (µS/cm)
Water R	7.10	21.3	878
Water T	6.90	20.9	1457
Water D	7.50	21.4	472
Water (R + D + T)	7.50	23.1	1002

Table 3. Chemical parameters for different samples of drinking water of the Tiznit region.

	TH (˚F)	TAC (˚F)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	NH_4^{+} (mg/L)	Cl^{-} (mg/L)	NO_3^{-} (mg/L)	SO_4^{2-} (mg/L)
Water R	46.44	81	99.40	52.59	40	1.81	0.03	95.85	1.78	10.72
Water T	62.60	67	151.82	60.12	103.42	2.59	0.00	333.70	4.69	31.67
Water D	18.20	24	47.13	15.65	18	0.80	0.01	46.15	0.11	-
Water (R + D + T)	52.66	67	109.25	45.64	48.46	2.18	0.00	223.65	2.31	21.84

3.2. Kinetic Study of Scaling Power

For the kinetic study of the scaling power of selected waters, we adopted the "LCGE" method to determine the pH and the time of germination (pHg and Tg) of calcium carbonate. Figure 1 and Figure 2 show successively the evolution of pH and TCa according to time at 25˚C obtained by the "LCGE" method for the water samples selected.

At the beginning of degassing, the pH continues to increase. During this increase of the pH, no evolution of the Ca^{2+} concentration is noticeable. This metastability state ceases abruptly at the time Tg which we define as the practical time of germination and manifested on the pH that accuses a fall. The beginning of

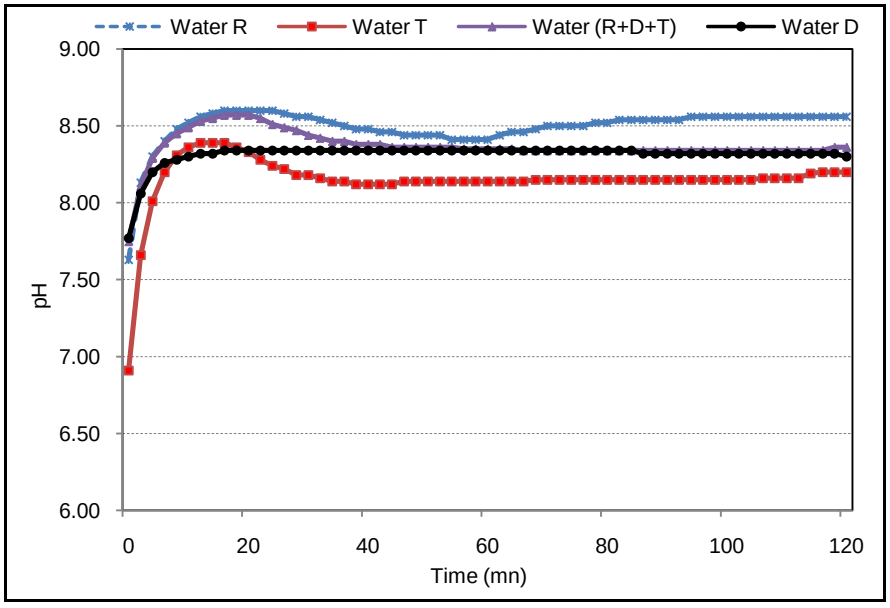

Figure 1. Curves of pH according to the time of water of the Tiznit region.

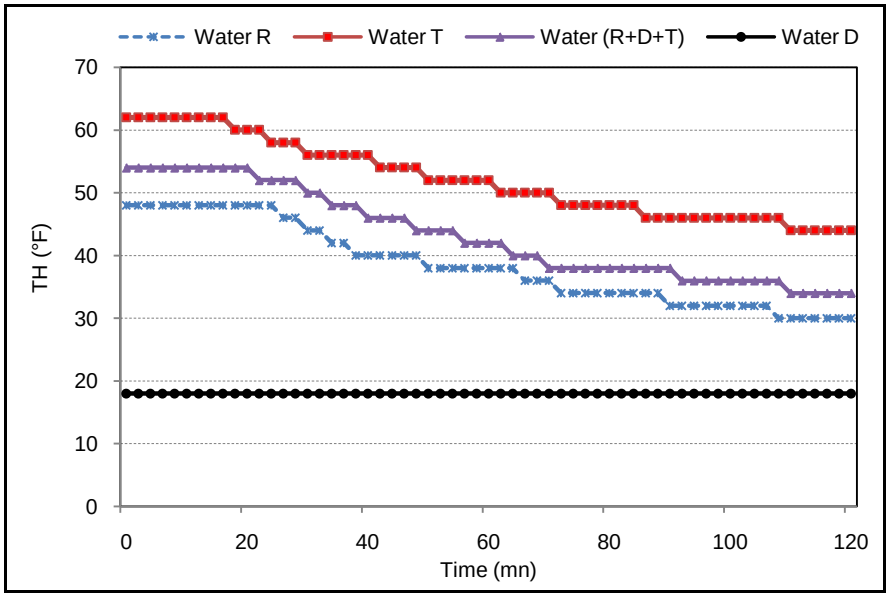

Figure 2. Curves of TCa according to the time of the waters of the Tiznit region.

Table 4. Time of germination (Tg) and pH of germination (pHg) of drinking waters of Tiznit area.

	Water R	Water T	Water (R + D + T)	Water D
pHg	8.58	8.36	8.55	-
Tg (mn)	26	18	22	-

precipitation is also accused by a decrease of the concentration calcium ion (**Figure 2**). This fall of pH can be related to the proton release when the precipitation of calcium carbonate begins according to the following reaction:

$$Ca^{2+} + HCO_3^- \longrightarrow CaCO_{3(S)} + H^+. \quad (2)$$

This mechanism of formation of $CaCO_3$ from HCO_3^- and of Ca^{2+} was advanced by Roques *et al.* [4]. This decrease in pH continues up to the time t which depends on the quality of the studied water and beyond which it starts to rise slowly. At this time t, the rate of precipitation, according to the last reaction, has slowed sufficiently and the degassing speed becomes higher than the release rate of proton H^+.

At the time Tg we define the pHg as the pH of practical germination. The values of these parameters deduced from curves "LCGE" are given in **Table 4**. It should be noted that the scaling power of the waters of Tiznit region follows the sequence:

Water T > Water (R + D + T) > Water R.

The experimental results obtained by the method "LCGE" after 2 hours for water of Youssef Ibn Tachfine dam show no fall in pH or TCa according to time and, consequently, there is no precipitation of calcium carbonate.

4. Conclusion

The physico-chemical quality of drinking waters of Tiznit region varies with the seasons. The total hardness fluctuates between 18˚F and 64˚F. The total alkalinity ranges from 22˚F to 82˚F. The characterization of the scaling power of the waters of this region was studied by means of the LCGE method and led to conclude that, except for the water of Youssef Ibn Tachfinedam, all other waters are scaling water.

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