Prevention of the scaling in water distribution systems

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1 Introduction

Tunisian waters have a relatively high mineralization. Thus, 30% of the surface water and 80% of the groundwater have hardness greater than 30 °F. Therefore, the problem of scaling is acute in the industrial and agricultural sectors [1, 2]. Operating systems and distribution of drinking water have not escaped this problem whose manifestations can be dramatic in some cases [3].

The work developed on scaling distribution conduit drinking water [4-7] show that the most affected circuits are fed by groundwater. It has been shown that the origin of this problem is an imbalance in the system after a calco-carbon intensive degassing of dissolved CO_2. This parameter is often neglected over the mineralogical composition of water by farmers.
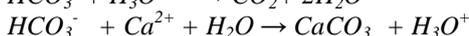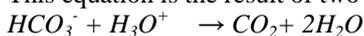
2 Description of calco-carbonic system

Among the various components of natural water, some are likely to react with each other in a system known as the calco-carbonic system "CO_2-H_2O-$CaCO_3$" [8]. This three-phase system consists of a gas phase (CO_2), a liquid phase and a solid phase ($CaCO_3$). The exchange of CO_2 between the liquid phase and the gas phase can be the main engine of scaling. The study of this system requires knowledge of all the balances that are established at the interfaces and in the liquid phase. Ω is defined as the supersaturation ratio of the product ion activity (Ca^{2+}) (CO_3^{2-}) and the solubility product of calcium carbonate. This coefficient expresses the difference between the thermodynamic equilibrium of calcium carbonate and the concentration.

Precipitation of calcium carbonate is in tanks, pipes and water meters, whatever the nature of the materials. The following photos illustrate this phenomenon. The equation for the precipitation reaction of the calcium carbonate is represented as follow:

$$Ca^{2+} + 2HCO_3^- \leftrightarrows CaCO_{3\,(sd)} + CO_{2\,(gaz)} + H_2O$$
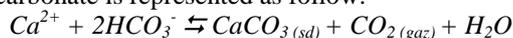
This equation is the result of two successive reactions:

$$HCO_3^- + H_3O^+ \rightarrow CO_2 + 2H_2O$$
$$HCO_3^- + Ca^{2+} + H_2O \rightarrow CaCO_3 + H_3O^+$$

The first reaction is the release of CO_2 which is accompanied by a consumption of H_3O^+, where the increase the pH. The second reaction is the precipitation of carbonate that is done with decreasing pH. This degassing causes an increase in the pH and consequently increases the saturation until the onset of precipitation. Therefore, monitoring the change of pH values can detect this phenomenon and control it.

3 Study of a real calcified circuit

3.1 Circuit diagnosis

The diagnosis of calcified circuit shows that the causes of scaling are many and varied. But in the most cases, the release of dissolved CO_2 causes the precipitation of $CaCO_3$. The contact with air causes a material exchange that occurs between the water and the atmosphere, as carbon dioxide content is lower in the air ($pCO_2 = 3.10^{-4}$ atm) than that of water ($pCO_2 \sim 10^{-1}$ atm) at the output of the drill.

In drinkable water circuits, degassing takes place in tarpaulins water tanks and wind loads. We present the diagnosis of a distribution of drinking water for a length of about 12 km that contains several glances of venting.

Photo 1. Photo of circuit breeze load of drinking water.

pH measurements along the circuit (Figure 1) shows that the water comes out of the borehole at a pH equal to 7.48 and increases to 8.02, then it decreases.
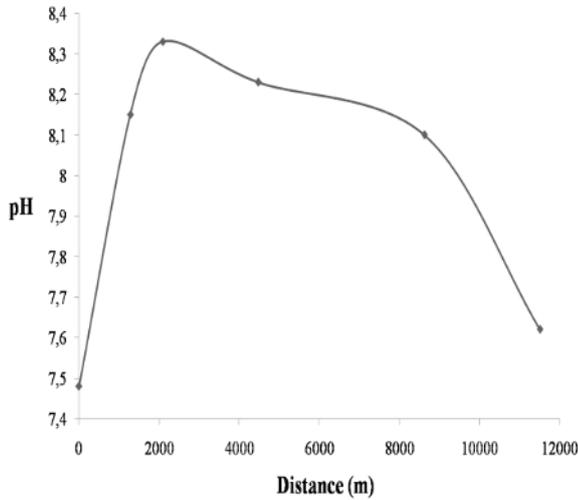

Figure 1. pH of the water as a function of the distance.

The examination of the circuit also shows that the precipitation of calcium carbonate engages from a distance of approximately 2000 meters where supersaturation is at its maximum. (Figure 2).
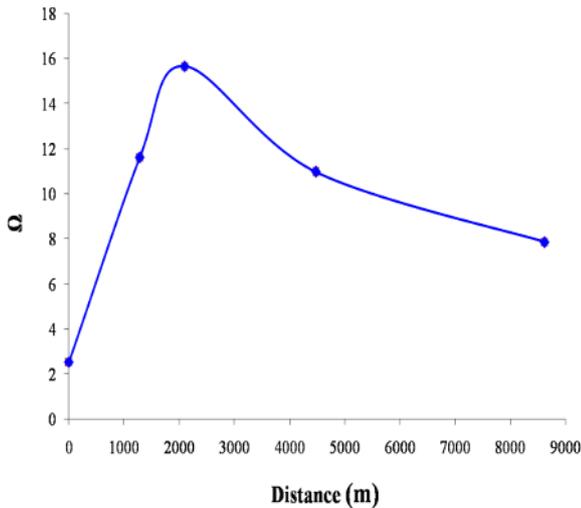

Figure 2. The supersaturation of the water as a function of the distance.

3.2 Reduction of CO_2 emission

To overcome this situation we need to reduce the release of CO_2 in the various circuits, particularly tank breezes loads and water tanks. To limit their lease of CO_2, we propose two major interventions:

-The first is to drown all water in let sat tarpaulins and glances of venting (Photos 3).
- The second in cover in gall these circuits in order to keep the CO_2 confined.

Photo 2. Photo of potable water tank and water charge breeze before intervention.

After the first operation we observe a decrease in the pH of the water throughout the circuit. This decrease is also greater after covering tarpaulins and glances of venting.

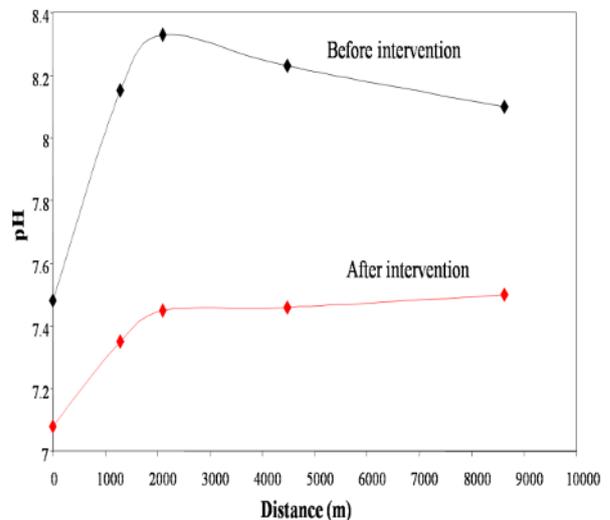**Photo 3.** Photo of potable water tank and water glances of venting after intervention.

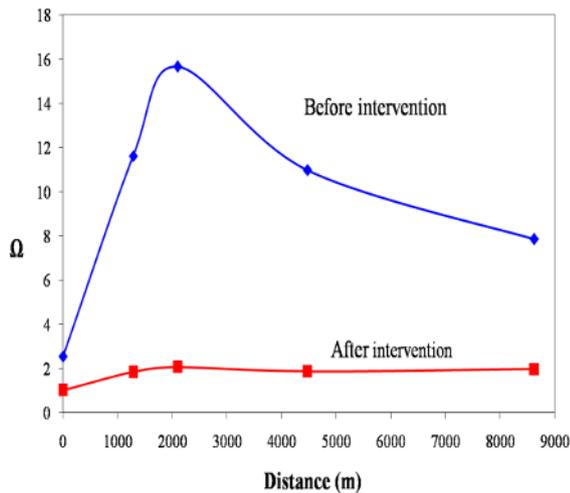**Figure 3.** pH according to the distance before and after intervention.

Figure 4. Saturation function of the distance before and after intervention.

This figure clearly shows that after the limited air/water contact, the pH stabilized at values well below the pH of precipitation.

This result is confirmed by the values of the supersaturation of calcium carbonate in water. After intervention, the saturation is maintained throughout the circuit.

4 Conclusion

This study shows that the control of CO_2 can limit the scaling of distribution channels. This method is easy to implement and does not use any chemicals compound. So it is an environmentally friendly way.

Acknowledgment

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