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HEALTH ISSUES RELATED TO THE QUALITY OF DRINKING WATER FROM TWO URBAN SPRINGS, MAZOUTA AND SIDI-LAHCEN, IN THE WILAYA OF TLEMCEN (NORTHWESTERN ALGERIA)

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ABSTRACT

The research analysed water from the Mazouta and Sidi-Lahcen springs in the city of Tlemcen to determine their level of pollution and estimate their possibly of harmful effects on consumer health. The physico-chemical and bacteriological analyses carried out have made it possible to classify these waters as calcium bicarbonate waters, carrying pathogenic germs such as coliforms and *Escherichia coli* that could trigger gastric diseases, hepatitis or typhoid. Contamination is caused not only by sewage in view of the degradation of the supply channels, but also by chemical fertilizers. Considerable levels of nitrate and potassium have been recorded in Mazouta and Sidi-Lahcen waters, respectively.

KEY WORDS : Waters, Mazouta, Sidi-Lahcen, Disease, Pollution, Germs

INTRODUCTION

Global heating is causing changes to the Earth's climate, and concerns about clean water availability are increasing worldwide. For its part, Algeria struggles to find appropriate supplies of drinking water and has to face the triple challenge of drought, pollution, and surging needs resulting from the growth of its population (Bouzid, 2014).

In this country, the overall consumer demand for drinking water has increased fourfold over the past 40 years. In response to this situation, Algerian consumers are trying to diversify their supplies, such as water from non-conventional natural springs, whose quality is guaranteed by the Nb. 05-12 Law published in the Official Gazette of the Algerian Republic (JORA, 2005).

Algeria is already experiencing an increase in droughts and therefore a worsening of desertification, soil salinization, surface water pollution and consequently the progressive degradation of its water resources. Paradoxically, floods occur more and more frequently in both the northern and southern parts of the country, especially in Spring and Autumn (Nichane and Khelil, 2015).

An inventory of potential pollution sources in the Tlemcen urban area (Fellah *et al.*, 2013), revealed the presence of several polluting spots affecting groundwater resources such as uncontrolled discharges into the natural environment and irrigation with non-conventional waters.

Contamination of these unconventional waters is the main cause of diseases such as gastroenteritis, viral hepatitis, typhoid, etc.). The rate of waterborne diseases remains high in western wilayas, particularly in Tlemcen, Mascara, Ain-Témouchent and Oran.

Although cholera and polio have been eradicated, typhoid fever epidemics remain a public health problem, mainly because the water and sanitation networks are obsolescent; tuberculosis has increased in recent years (Maalem, 2016).

Consequently, water control is a challenge for Algeria's future. A balance must be struck between, satisfying water demands for all without conflicts of use (Belaribi *et al.,* 2014).

Our study contributes to evaluating the physico-chemical and bacteriological quality of the two most commonly used springs:"Mazouta" and "Sidi-Lahcen". Owing to their degraded state it is likely that these waters are contaminated to some extent, so they need careful analyses in order to assess their drinkability.

MATERIALS AND METHODS

Presentation of the study area

Located northwest of western Algeria (Fig. 1), the landscape of Tlemcen wilaya consists of a large variety of coastal foothills, plains and plateaus, mountains and steppes. It is bounded to the North-East by the wilaya of Ain-Témouchent; to the East by the wilaya of Sidi Bel Abbès; to the West by the Algerian-Moroccan border and to the South by the wilaya of Naama (Abdelbaki and Touaibia, 2014). The city of Tlemcen is the capital of the wilaya, located at 34°53'24'' North and 1°19'12'' West, at an altitude of 842 m.

The Tlemcen wilaya covers an area of 9,061 km²; it is characterized by the presence of the Tlemcen mountains, occupying more than a third of the territory, with an average altitude of 1,200m; the steppe zone extends to the borders of Naâma wilaya (Bensaoula *et al.,* 2012; Abdelbaki *et al.,* 2012). Drinking water supply to the Tlemcen Urban Group (GUT) consists of three kinds of resources: underground (17 boreholes and three springs), surface (two dams: Mefrouche and Sikkak) and the Souk Tleta desalination plant (Allal *et al.,* 2012).

The springs of Mazouta (34°52'47.286'' North 00117'37.494'' West; altitude1,210 m) and SidiLahcen (34°53'12.796'' North 001°18'15.300'' West; altitude1,770 m) are located in very popular districts of the Tlemcen wilaya (Fig. 2).

Sampling and analysis

Water withdrawal from these two locations is frequent during Spring, Summer and Autumn. But

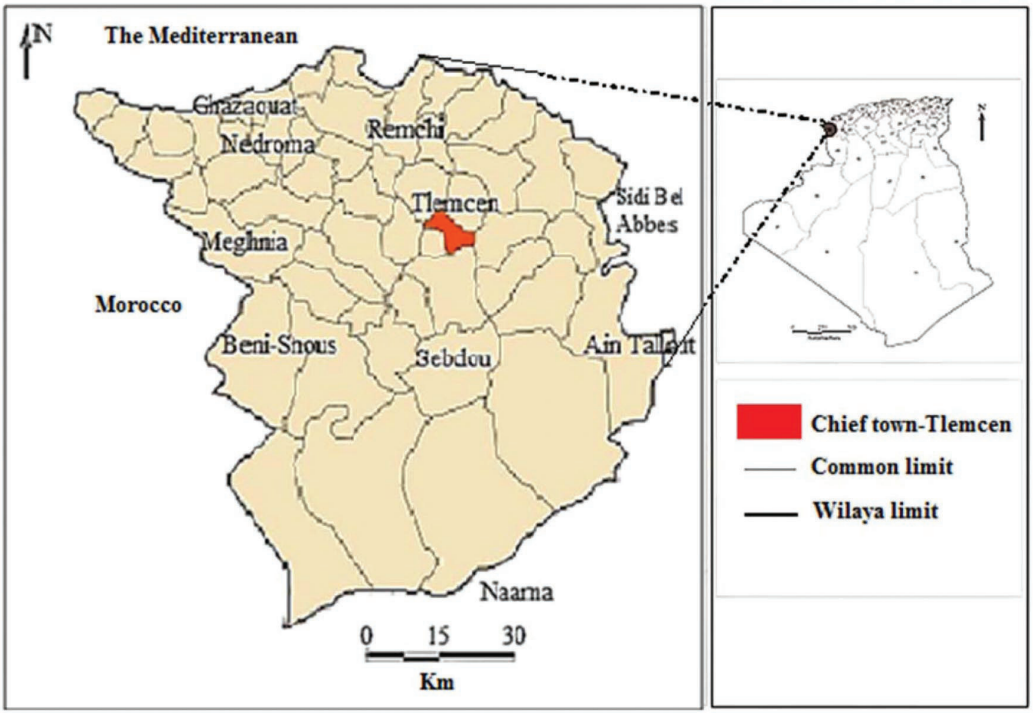

Fig. 1. Geographical location of the city of Tlemcen (study area).

Fig. 2. Location of the Mazouta and Sidi-Lahcen springs in the city of Tlemcen.

the most critical period is Spring, when recurrent power cuts result in restrictions in domestic water.

Water samples collected in sterile glass vials according to the WHO protocol (WHO, 2011) were subjected to the following analyses.

- The physico-chemical analyses consisted in determining the following parameters: Organoleptics, colour, flavour, pH, conductivity, mineral salts, total hardness, chloride, nitrate and nitrite;
- Bacteriological analyses targeted in particular: Enumeration of bacteria and total germs by the agar incorporation method; coliforms, faecal *Streptococci*, as well as *Echerichia coli* by the miniaturized liquid sowing method (MPN); sulphite-reducing *Clostridium* by the solid medium incorporation method.
- Statistical analysis: The study of the typology of water pollution at the stations studied was based on a Principal Component Analysis (PCA). The results of this analysis were obtained with the STATISTICA version 7 software.

RESULTS AND DISCUSSION

Physico-chemical parameters

pH

The measurements made show a pH value of 6.5 for both springs. These values stand at the lower limit of WHO standards (WHO, 2011). This slightly acidic pH does not present any health risk. Waters with lower pH would tend to be corrosive to plumbing and could dissolve metals such as lead, cadmium, zinc, and copper. The pH values depend on the origins of the water and on the geological layers through which it percolates (Ehsan *et al.*, 2013).

Electrical conductivity at 20°C

Conductivity is one of the parameters used to determine the overall quality of water (New-Brunswick, 2016). We measured stable values between 1,869 and 1,870ms/cm, which is significantly higher than the WHO standards, which are limited to 1,000ms/cm at 20°C. High conductivity reflects either abnormal pH or high mineral salt content (WikiWater, 2016). This parameter increases with the amounts of dissolved minerals (ions), and may indicate the presence of other contaminants; e.g., TDS of 1,044 mg/L and 757 mg/L for Mazouta and SidiLahcen spring, respectively.

Turbidity

It is a key parameter in water quality. Turbidity can be caused by the presence of clay, mud or inorganic materials (Oudot, 2007). The measurements made for this parameter are 1.18 NFU for the Mazouta spring and 1.77 NFU for the Sidi-Lahcen spring. These figures reveal high turbidity in both cases,

with Mazouta predominating. The international standards for this framework vary from country to country and are not defined by WHO. By referring to the French maximum standards of 1 NFU, these waters are qualified as cloudy; they might harm human health, and lead to the formation of kidney stones.

The dry residue and mineralization

The dry residue expresses the mass of minerals collected after evaporation of 1 L of water heated at 180°C, in particular calcium, magnesium and sodium (Daine and Duperrin, 2007). The measurements show a rate of 1,214.85 mg/L for Mazouta and 890.5 mg/L for Sidi-Lahcen. Calcium is strongly present in both springs, with a predominance of the Mazouta spring with 146 mg/L. Strong mineralization is reported in both waters with 1,417.72 mg/L in Mazouta and 1,039.21mg/L in Sidi-Lahcen, mainly owing to the leaching of metamorphic carbonate formations (Bougherira *et al.,* 2017).

Nitrates

The chemical composition reveals a strong dominance of nitrate elements and bicarbonates in the Mazouta water. This makes it unfit for consumption by pregnant women and babies. These parameters could be caused by agricultural fertilizer contamination (Bougherira *et al.,* 2017). Agrochemicals such as pesticides and their residues are likely to cause growth retardation, early puberty, premature birth, infertility, early menopause (Delmont and Mouton, 2016).

The levels of the remaining components, including ammonium, potassium, sodium, nitrites, sulphate, chloride and magnesium meet WHO standards.

Bacteriological analyses

Bacteriological analysis is a way to check the condition of the urban water network. Gastroenteritis is the main public health problem associated with microbial quality of drinking water. Microbiological safety is assessed by detecting microbial indicators of faecal pollution. These are organisms that are present in large numbers in human or animal faeces (Verhille, 2013).

In our study, the following microbial indicators were monitored in order to assess drinking water safety: Total germs (GT), total coliforms (TC), *Streptococci* (Sq), *Escherichia coli* (*E. coli*) and sulphite-reducing *Clostridium* (CSR).

Total coliforms are present in both springs, with a value of 4 g/mL of sample, far exceeding the standards (0 g/mL). Coliform bacteria exist in the faeces usually found in the intestines of living beings but can also grow in certain natural environments (soil, vegetation). The presence of this type of germs may also indicate a deterioration in water quality owing to the distribution system (biofilm formation, soil infiltration) (Verhille, 2013; CEAEQ, 2015). When total coliforms are detected in drinking water, a search for *Escherichia coli* and *Enterococci* is initiated (Verhille, 2013).

The results shown in Fig. 3 illustrate a strong presence of total germs in both sources, with Mazouta predominating. These germs, also called revivable aerobic germs, have no direct health effects, but are indicators of possible bacteriological contamination. The European standard limits them to 10g/10mL of sample (CEAEQ, 2015). We assume that their presence in large numbers is probably a sign of quality water degradation by the ruptures of the sewer pipes, since the source is located in the middle of an urban environment, near the railways. This information remains to be confirmed by other future work.

The presence of these coliforms, living in the

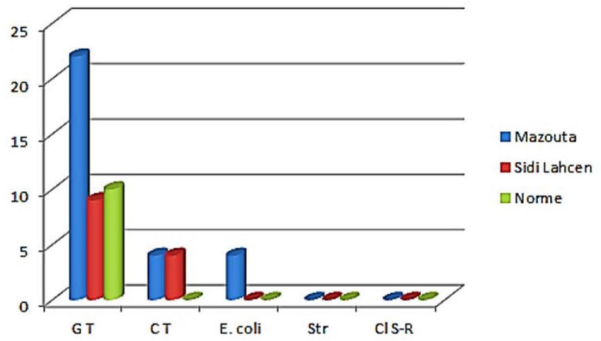

Fig. 3. Graphical representation of bacteriological analyses. Total germs (GT), total coliforms (TC), *Escherichia coli (E. coli), Streptococci* (Stq), and sulphite-reducing *Clostridium* (Cl S-R).

intestines of animals and humans, is a good test for faecal contamination of water (Verhille, 2013). The undeniable presence of *E. coli* in Mazouta Water springs confirms the occurrence of recent faecal contamination and indicates the potential presence of enteric pathogens. This faecal contamination is probably the result of the deterioration of the water distribution channels with those of the sewers, following the indefinite vibrations caused by the

passage of trains located just at the level of the Mazouta source. This theory is a vision that remains to be confirmed. Young children, the elderly, and people with weakened immune systems may endure more severe symptoms. In extreme cases, some pathogens can infect lungs, the skin, eyes, the nervous system, kidneys, or the liver, and effects can be more severe, chronic, or even fatal (Verhille, 2013). This situation is the concrete explanation of the waterborne diseases recorded in the wilaya of Tlemcen, such as typhoid fever in 2017, which is recognized as a typical disease of the region (Khaled, 2016); in addition, 558 cases of pulmonary and extra-pulmonary tuberculosis were reported across the wilaya of Tlemcen during the year 2018, reported by Dr Hassaine-Brixi, coordinating doctor in charge of the tuberculosis control programme in the wilaya (APS, 2019). Currently, like many other countries, Algeria is facing a new type of tuberculosis that attacks not only the lungs but also other organs of the human body (Tattevin *et al.,* 2012). It's probably infiltration of surface wastewater - i.e. contaminated water carrying a high potential for infection - into water points.

In Algeria, the annual number of declared cases of extra-pulmonary tuberculosis stands at more than 15,400. This number is increasing and only concerns people screened. The objective of the specialists is to implement the recommendations of the World Health Organization to eradicate tuberculosis, in all its forms, by 2030. WHO has implemented a new programme to control this disease. It will be enforced soon in Algeria (Soufi, 2019).

Statistical processing of data

A main component analysis (PCA) was carried out, whose matrix is the cross-reference of all the variables selected, physico-chemical and biological analyses of the stations studied (S1: Spring of Mazouta, S2: Spring of Sidi-Lahcen and S3: WHO Standards). This statistical analysis makes it possible to identify three groups of stations (Fig. 4). In terms of factors, the F1 axis that provides the most information in the PCA (70.15% inertia) compared to the F2 axis (29.85%), pits the Gr1 group against the two groups Gr2 and Gr3.

On the basis of this factorial segregation on the F1 axis, facies related to pollution are opposed: less polluted towards the positive side (Gr1 group) and more polluted towards the negative side (Gr2 and Gr3 groups).

- Group Gr1: is represented by station S1 (control station) correlated with the following parameters: ammonium, chloride, nitrite and pH. It is a plant characterized by drinking water which is free of pathogens and whose elements strictly comply with standards;
- The Gr2 group: is given by station S2 (spring of Sidi-Lahcen) strongly correlated with the following parameters: sodium, calcium and total coliforms. It is water with an acceptable mineralization rate but which is carrying pathogenic germs. This group has a high concentration of potassium, which is harmful to people afflicted with diabetes, renal failure, heart failure and hypertension (NOVA SCOTIA, 2014);
- Group Gr3: mainly concerns station S3 (spring of Mazouta) strongly correlated with the following variables: nitrates, calcium, *Escherichia coli* and total germs. This provides totally non-potable water, with a high level of nitrates that play an important role in the natural nitrogen cycle. Evidently, this water is contaminated with agricultural fertilizers. Therefore, this water is strictly not recommended for human consumption without prior drinking water treatment.

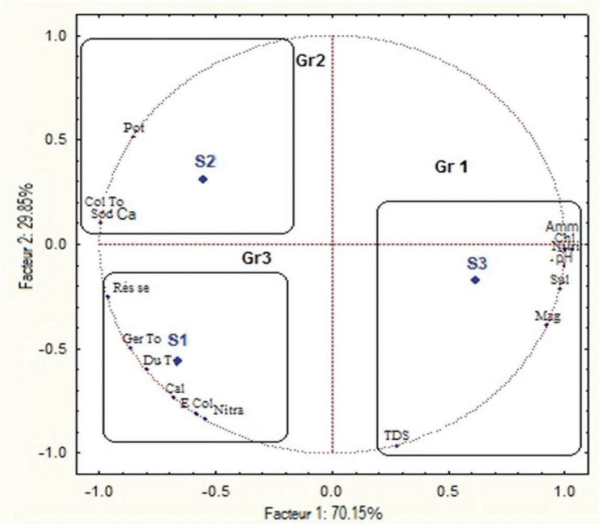

Fig. 4. Graphical representation of the PCA (correlation circle, map 1-2). S1: Mazouta spring; S2: Sidi-Lahcen spring; S3: WHO standards.

CONCLUSION

The wilaya of Tlemcen is known for its rich spring water, particularly the Mazouta and Sidi-Lahcen springs, located in the city of Tlemcen. The study demonstrated the level of pollution of these two springs and their harmfulness to human health.

Physico-chemical and bacteriological analyses revealed the presence of nitrates, nitrites, limestone, magnesium and pathogens.

The results of the analyses carried out made it possible to classify these waters as calcium bicarbonate waters, carrying pathogenic germs, especially total germs, total coliforms. The spring of Mazouta also contains the *Escherichia coli* germ. We found that both springs were contaminated by sewers in view of the degradation of the supply channels; and by chemical fertilizers, because of the presence of high levels of nitrate in Mazouta water and of potassium in Sidi-Lahcen water. It is therefore water that triggers gastric diseases, even hepatitis and typhoid. The activating parameter for the degradation of feeder channels is probably the repeated ground vibrations caused by the nearby railway traffic. This situation should draw the attention of the competent authorities and encourage them to take the necessary measures to repair the pipes and install treatment filters. Otherwise, these waters should be redirected for agricultural use.

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Disclosure statement

No potential conict of interest was reported by the authors.

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