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Assessment Report of Physico-Chemical and Bacteriological Quality of Two Water Sources in the Souarekh Region of El Kala North-East, Algeria and Its Suitability For Irrigation

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Abstract**:** *The good quality of source water for the consumption by humans and other living organisms is an important element for public health. This study was conducted at __ during __ to evaluate two water sources in the region of Souarekh in the wilaya of El Tarf (Ain Siglèb and Ain Siporex) for the various physical parameters (T°, pH, EC, Salinity, TDS and Turbidity), chemical (CAT, Ca+2, Mg+2, Na+, K+, Cl- and Cl2) and pollution indicators (PO4-3, NH4+, NO3-, NO2-, BOD5 and COD). For the bacteriological analyses, the presence or absence of total and faecal coliforms, sulfuto-reducing clostridia, faecal streptococci, Salmonella, E. coli and Cholera Vibrio were determined. The results indicated that most of the physico-chemical parameters of Ain Siglèb and Ain Siporex are situated within or at the margin compared to the admissible limits of the Algerian and World Health Organization (WHO) standards for drinking water and irrigation water. Microbiologically, the results showed that the water sources studied undergo significant contamination by total coliforms, faecal coliforms, streptococci and clostridium in Ain Siglèb compared to that of Ain Siporex. In recent years, much research has focused on the study of groundwater and the quality of surface water resources. This work adds to other works and deals with the physico-chemistry and the bacteriological quality of spring water taken from the sub-basin in the region of El Tarf. These, mainly agricultural region is located in the northeast of Algeria. The surface waters studied are of good quality for agriculture and suitable for the irrigation of most crops, but attention must be paid to leaching, which is difficult in soils with low permeability, and to drainage. These need special attention due to extreme climate change and increased pollution.*

Keywords: *Ain Siglèb, Ain Siporex, bacteriology, physico-chemical parameters, water quality*

1. Introduction

Water is a natural resource around which life is maintained and developed, and also an essential element in human life and activity. It is a major component of the mineral and organic world. It participates in all daily activities, especially domestic, industrial and agricultural, which makes it a receptor element exposed to all types of pollution. It is also considered a potential carrier of many diseases [1].

Ordinary potable water is water with physical, chemical, microbiological and organoleptic qualities according to standards that make it acceptable for human consumption [2]. Water is essential to life but it is also responsible for the death of millions of human beings in the third world because of its pollution by chemical and microbiological products that make it unfit for consumption [2]. Water intended for human consumption must have a certain number of physical qualities: clarity, absence of color, odor, abnormal flavor, and microbiological, that is to say absence of pathogenic germs and any pollutant dangerous to the health of those who consume it [2].

Currently, water quality is under great pressure from population growth and industrial activity. Deterioration of the quality of water resources is as great a threat as the quantitative disequilibrium [3]. Anthropogenic activities are the most cause of problems pollution in water resources. Contamination of surface waters by pathogens is a pollution problem that goes back a long way [2].

In Algeria, water is an increasingly precious resource. The competition between agriculture, industry and the EPA for access to limited water supplies is already putting a strain on the country's development efforts [4]. For several decades, in Algeria, animal, agricultural, industrial and domestic dejections have contributed, more and more to rivers and groundwater pollution than elsewhere.

The wilaya of El Tarf is recognized at the regional and even national level by its diversity of these sources. But, the problem is that the majority of these sources are not usable because of poor management. Those in charge in this field continue to make drillings while the source waters run away on the surface or are rejected in the rivers or are used for washing cars. In addition to that, they are not protected against polluting agents.

In this context, the objective of this study is to evaluate for the first time the quality of raw water of two sources (Ain Siglèb and Ain Siporex) located in the region of Souarekh (El Tarf) by the determination of its physicochemical and bacteriological characteristics.

2. Material and Methods

2.1. Description of the Study Area

The study focuses on the territory of Oum Teboul. The latter is a village located in the commune of Souarekh (Ain Siglèb and Ain Siporex), in the Wilaya of El Tarf, Algeria; it is located 10 km west of the Tunisian border [5]. Located in the extreme northeast of Algeria, with a coastline of 09km, inhabited by about 22,000 people (Fig. 1).

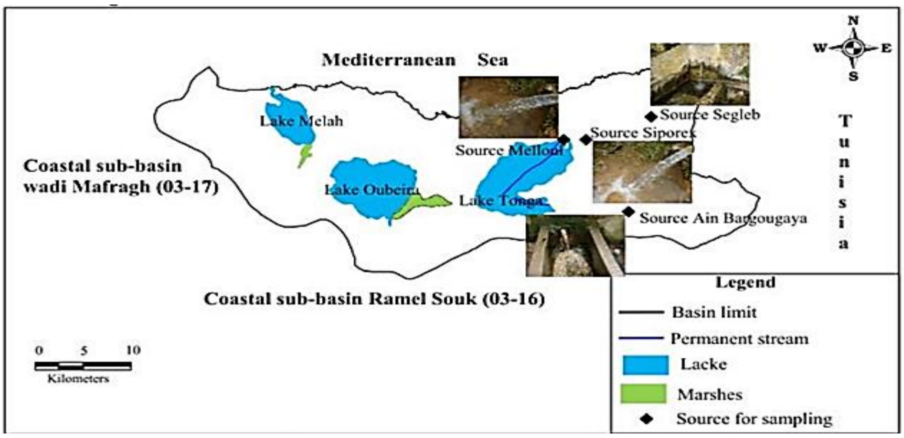

Fig. 1. Localisation of the study area (Bahroun, 2021).

2.2. Inventory of sampling sources with Names and Coordinates

Siporex : Coordinates (degree minute); 36°53.576′N08°33.017′E / Altitude (m); 29

Segleb : Coordinates (degree minute); 36°53.576′N08°33.017′E / Altitude (m); 120

2.3. Sampling and Choice of Sampling Sites

In the framework of the physicochemical and bacteriological quality analysis of drinking water of some natural sources of Souarekh commune and considering the important number of sources in the area, two sites were chosen: Sources of Ain Sigléb and Ain Siporex. The sampling sites were chosen according to their exposition to the different pollutants. The sampling was carried out in situ, in winter period of 2020 extended over three months at a rate of one sampling per site, in two different sites.

2.4. Physico-Chemical Analysis of Water

This study included 20 physico-chemical parameters for each sample at both sites. Physico-chemical parameters such as temperature (T°), hydrogen potential (pH), electrical conductivity (EC), salinity, total dissolved solids (TDS) and turbidity, were measured in situ using a multi-parameter field instrument (type Hanna Hi 8519N). The monitoring of physico-chemical parameters is carried out in the laboratory according to the technique of Rodier and *al.,* (2009) and the standards of AFNOR, 1997. These parameters are: Total alkalimetric titre (TAC), calcium (Ca^{+2}), magnesium (Mg^{+2}), potassium (K^{+}), sodium (Na^{+}), chloride (Cl^{-}), total chlorine (Cl_2), ammonium (NH_4^{+}), nitrate (NO_3^{-}), nitrite (NO_2^{-}), orthophosphate (PO_4^{-3}), Biological Oxygen Demand (BOD_5 and COD).

The parameters were determined using standard methods. Various instruments or methods used for physico-chemical analyses are presented in Table I.

In our study, water geochemical facies characterization was retained and used by the Piper diagram. (Fig. 2). The determination of water suitability for irrigation is based on the combination of the SAR and Wilcox diagram (Fig. 3). The evaluation of the organic pollution index is evaluated by the index (OPI) (Table II).

2.5. Bacteriological Study

During this study we carried out a systematic enumeration of pollution indicator germs; *Total germs (total flora or revivable germs), Coliforms (total coliforms), Faecal coliforms (FC), Faecal streptococci (FS) and Clostridium sulfito-reducers (CSR).*

This study is focused on the enumeration of: total germs at 22°C and 37°C, total coliforms and faecal coliforms, faecal streptococci, bacteria of the genus *Salmonella* and anaerobic sulfite-reducing bacteria according to the technique described by [6].

2.6. Water Suitability for Irrigation

The most used classification of irrigation waters is the one of the American salinity laboratory (USDA) developed by Richards in 1954, based on the combination of the SAR "Sodium Absorption Ratio" with the electrical conductivity in the form of a class diagram (Wilcox diagram).

The SAR is given by the formula; $\boldsymbol{SAR = \frac{Na}{\sqrt{Ca+Mg/2}}}$

2.7. Evaluation of the organic pollution index (OPI)

For evaluation of organic pollution, we used the Organic Pollution Index [7]. The OPI calculation principle is based on measurements of ammonium, BOD_5, nitrite and orthophosphate and to distribute the values of the polluting elements in 05 classes (Table II). The corresponding class number for each parameter is then determined from the values obtained in the study (Table II).

3. Results and Discussion

3.1. Physico-Chemical Characteristics of the Water

The results of physicochemical characteristics of water of Ain Sigleb and Ain Siporex areillustrated in Table I.

- **Temperature**

The water temperature plays a significant role in the intensity of the latter's sensation. It represents the most appreciated factor for a water destined for human consumption, say Gregorio and Pierre-Marie (2007) [8]. The temperature of natural water depends on a series of factors, such as: geographical location, season, depth (shallow surface), color and volume of water, industrial and domestic discharges [9]. The water temperature measurements reach a minimum of 14.3°C in both sites represented in Figure 02. The latter is in agreement with the values granted by the Algerian standards (JORA, 2011). These values don't show large variations from one source to another. The temperature fluctuations are related to the local climatic conditions and more particularly to the air temperature and the phenomena of water evaporation. These characteristics are, as Bahroun (2021) [10] pointed out, very much related to the shallow depth of the water mass.

- **Potential of Hydrogen (pH)**

The pH determines the acidity or alkalinity of a water by measuring the concentration of H^+ ions, it varies on a scale of 0 to 14. The latter depends on the origin of water, the geological nature of the substrate and the watershed crossed [10-11].

In the case of the study area, the pH values do not show significant variations, with a minimum of 7.06 for Ain Siporex source and a maximum of 8.08 for the case of Ain Siglèb source, which indicates a minor alkalinity of the environment. These are in agreement with the results established by Saidi (2013) [12] on waters sources in the region of Saida and also with the work of Hazzab (2011) [13], Sekiou and Kellil (2014) [14] and Jatoi (2018) [15]. This situation is favorable for intense microbial proliferation. The parameter was within the permissible limit (6.5-8.5) (JORA, 2012), so the water quality can be considered safe for domestic and agricultural uses.

- **Electrical conductivity (EC)**

Conductivity is due to the presence of ions in the environment, which are mobile in an electric field. It depends on the nature of these dissolved ions and their concentrations [16]. The results obtained in the study area show that the electrical conductivity of water varies between 381 and 476 µS/cm (Table I); the maximum value of 476 µS/cm isrecorded in the Ain Siglèb source. The latter represents lower values compared to the work of Sekiou and Kellil (2014) [14] on bottled source water in Algeria. Water conductivity is slightly higher at Ain Siglèb compared to Ain Siporex during wet weather. The high conductivity values reflect a continuous external input of mineral salts along the source. EC levels were within acceptable limits set by Algeria and the World Health Organization.

- **Salinity**

The salinity is proportional to the conductivity. It depends on temperature; concentration and type of ions present [17]. Its variation followed the same pattern (Table I). These salinity rates are probably due either to the nature of the geological layers of the water table, or to the presence of undesirable mineral elements resulting from exogenous pollution [18].

- **Total Dissolved Solids (TDS)**

Total dissolved solids have considered as an important factor for water taste and plant growth [18-19]. All of our analyses show TDS level below the allowed limits 1200 mg/L (WHO Standard), ranging from 183.1 to 200 mg/LL (Table I). The variation in overall mineralization was identical to that of conductivity.

- **Turbidity**

Turbidity of water is an important parameter, which influences the light penetration inside the water and consequently affects aquatic life [20-22]. During the present study, the maximum turbidity was recorded at Ain Siglèb (1.6 NTU) and the minimum at Ain Siporex (0.45 NTU), which is below the standard admissible limits set by Algeria and the World Health Organization. The parameters were within the admissible limits, therefore the water quality can be considered safe for domestic and agricultural needs.

- **Alkalimetric Titre (AT) and Complete Alkalimetric Titre (CAT)**

Our results show that the complete alkalimetric titre for the stations of Ain Siglèb and Ain Siporex is 13.1 and 5.8f° respectively. These are in accordance with the Algerian standards of potability which are set at 125f° **(**Table I). According to these results, we distinguish a low presence of bicarbonates which would be related to the existence of free alkalis and carbonates in the water, approved by Zeddouri (2003).

- **Total Chlorine (Cl_2)**

The chlorine present in the water combines with the bacteria to leave only free chlorine for further disinfection (Bengoumi and *al.,* 2013). The values noted by Colorimetry (DIN ISO 7393 G4-2) method are; 0.86 mg/L at Ain Siglèb and 0.18 mg/L at Ain Siporex. These values are not exceeding the standards recommended for free chlorine by the WHO (0.4 and 1.2 mg/L). Thus, according to our results, the majority of the values recorded are within the quality standards for human drinking water.

- **Chloride (Cl^-)**

According to Ayad and Kahoul (2017) [23]; the extremely varied chloride contents of water are mainly related to the nature of the terrain crossed [16].

The results presented in Table I show that the average chloride content varies between 22 and 35 mg/L. These values are in agreement with the Algerian standard (JORA, 2011) which set 500 mg/L as the maximum value which means that the water quality in the study area is excellent in both sources. Similar results were found in the studies conducted by Oyelude and Ahen- korah (2012) [24].

- **Cations Concentration (Ca^{2+}, Mg^{2+}, Na^+ and K^+)**

The average concentration of calcium (Ca^{2+}) in our samples varies between 150 and 240mg/L (Table I) and its content varies essentially according to the nature of the terrain traversed [11]. The results obtained in the source of Ain Siglèb are higher than those of the Algerian standards (JORA, 2011) which sets a maximum value of 200 mg/L.

Magnesium (Mg^{2+}) is an essential element for growth (50% in bones) and for the production of certain hormones [25]. The measurements of our samples gave a magnesium concentration varying between 40.8 and 55.2 mg/LL (Table I). These values are in agreement with the Algerian standard (JORA, 2011) which set a maximum value of 150 mg/L. Similar results were found by Sekiou and Kellil (2014) [14], however another study by Hazzab (2011) [13] revealed that the magnesium concentration varies between 5 and 400 mg/L.

Magnesium is highly valued by bacterial cells, which absorb it from the external environment and concentrate it in specific resource vacuoles [26].

Sodium (Na^+) is a vital element that participates in essential functions. It is necessary to provide an adult and child organism with 2000 and 200mg/day respectively, which is confirmed by Potelon and Zysman (1998) [25]. The results obtained vary between 26 (Ain Siglèb) and 33 mg/L (Ain Siporex) (Figure 2), and are in agreement with the Algerian standard (JORA, 2011). On the other hand our results represent higher values than those elaborated by Oyelude and Ahenkorah (2012) [24], Sekiou and Kellil (2014) [24] and Saidi and *al.*, (2013) [12].

According to Ayad and Kahoul (2017) [23], potassium (K+) plays an essential role in humans including the transmission of nerve impulses. The results obtained vary proportionally between 1.2 and 2.3 mg/L (Table 01 and Figure 02). This allows us to say that our water is in the Algerian standard **(**JORA, 2011). Our results are close to the results found by Sekiou and Kellil (2014) [24], however our results are lower than the results obtained by Hazzab (2011) [13].

- **Ammonium (NH_4^+)**

Ammonium has no appreciable effect on consumer health, but its presence in water is a confirmed indicator of pollution [27]. Ammonium in water usually reflects an incomplete degradation process of organic matter. It comes from the reaction of minerals containing iron with nitrates [27].

The results obtained do not show a significant difference between the two sites and vary between 0.03 and 0.15 mg/L (Table I) and are below the maximum limit of 0.5 mg/L set by the Algerian standard (JORA, 2011). These data are in agreement with the work of (Dembele, 2005) [27].

- **Nitrate (NO_3^-)**

Sources of nitrates in water (especially groundwater) include decomposing animal and plant matter, agricultural fertilizers, manure, domestic wastewater, and geological formations containing soluble nitrogen compounds declare (Kahoul and Touhami, 2014) [23]. Nitrate pollution comes from urban and industrial discharges but also from agricultural discharges through soil leaching during rainfall events [28]. In the presence of phosphorus, nitrates promote the phenomenon of eutrophication. These products are generally brought by wastewater following excessive use of nitrogen fertilizers in agriculture [29]. According to Table I; all the results obtained vary between 7 and 20 mg/L are in accordance with Algerian standards (JORA, 2011). Our results are lower than those found by Sekiou and Kellil (2014) [14] and Jatoi and *al.*, (2018) [15] who set maximum values of 30 and 21 mg/L respectively. Therefore, the studied waters are not subject to a risk of nitrate pollution despite this difference between the two sites.

- **Nitrite (NO_2^-)**

High nitrite levels correspond to the reduction of nitrate to nitrite by sulfite-reducing anaerobes. They can also be related to the bacterial oxidation of ammonia [30].

According to Table I and Figure 02; the results obtained are negligible and vary between 0.002 and 0.008 mg/L. These values are lower than the Algerian standards (JORA, 2011) and which set 0.1mg/L as a maximum value. The concentrations obtained are comparable to those reported by Sekiou and Kellil (2014) [14]. On the other hand, the results obtained by Saidi and *al.*, 2013 shows values of 0.14 mg/L for the Sidi Maamar source. The presence of nitrite in water in significant quantities degrades water quality and could affect human health. The toxicity related to nitrite is very significant because of their oxidizing power.

- **Orthophosphate (PO_4^{-3})**

Phosphates degrade the organoleptic qualities of water (odor, flavor, turbidity, color) confirmed by Dembele (2005). The increase in phosphorus flows in surface waters results from the intensification of demographic pressure and agricultural activities in the watersheds. The presence of the latter in surface waters leads to a massive development of algae is considered as a factor triggering the phenomenon of eutrophication [31-32] and [24]. The results obtained vary between 0.01 and 0.05 mg/L (Table I). The recorded orthophosphate (PO_4^{3-}) concentrations are very low, and conform to the Algerian standard (JORA, 2011) and which sets a maximum value of 0.5 mg/L.

4. Biological Oxygen Demand (BOD_5)

The values noted are 0.6mg/L O_2 at Ain Siglèb and 2.4 mg/L O_2 at Ain Siporex. Our results show minimal values in both sites, which means the low presence of organic matter. According to WHO and JORA (2011) standards, they are classified as good quality.

5. Chemical Oxygen Demand (COD)

The values noted are: 32 mg/L O_2 at Ain Siglèb and 60 mg/L O_2 at Ain Siporex. The comparison of the concentrations with the standard of potability shows that the water of these sources is classified between a fair to poor quality respectively. This can be explained by the presence of discharges of agricultural activities and urban discharges around the two sources.

6. Report COD/ BOD_5

The calculated values are presented as follows; Ain Siglèb = 53.33 and Ain siporex = 25. The latter places these waters in non-biodegradability. However, this organic pollution probably comes from discharges of vegetable or animal household waste, animal or vegetable waste, excrements or animal excrements. All this generates chemical pollution which penetrates in the ground and then in the underground or surface water [33].

Geochemical Facies

The representation of the concentrations of major elements on the Piper diagram, shows that the sampled waters are generally of the hyper chloride calcic facies. It can be seen that calcium cations characterize all the points represented on the triangle of cations, thus giving indications on the origin of the water. The chloride anions characterize the totality of the points represented on the triangle of the anions, giving indications on the origin of the water (Fig. 2).

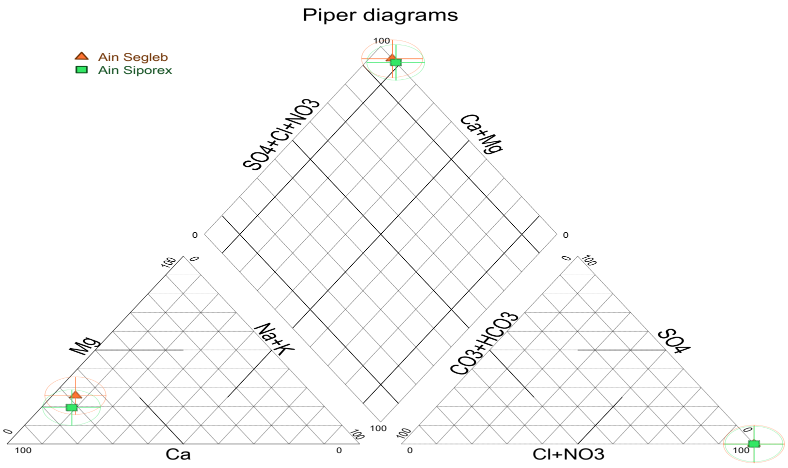

Fig. 2. Representation of the chemical facies according to Piper diagram (Source: own study).

7. Water suitability for irrigation

After plotting the two water stations on the Wilcox diagram (Fig. 3), according to the electrical conductivity and SAR value, the waters of two sources (Ain Siglèb and Ain Siporex) belong to the C2S1 class: characterize waters of good quality and can be used without special control for irrigation of plants moderately tolerant to salts and on soils with good permeability (Fig. 3).

TABLE I Interpretation of physico-chemical analyses results

Results of physico-chemical analysis			Methods
Parameters	Ain Sigleb / S1	Ain Siporex / S2	
Temperature (T°)	14.3° C	14.3° C	Thermometer
Hydrogen potential (pH)	8.08	7.06	Potentiometry/pH probe
Electrical Conductivity (EC)	476 µS/cm	381 µS/cm	Conductometry
Total Dissolved Solids (TDS)	200 mg/L	183.1 mg/L	TDS-meter
Turbidity	1.6 NTU	0.45 NTU	Turbidometer
Biological Oxygen Demand (BOD_5)	0.6 mg/L O_2	2.4 mg/L O_2	DIN EN 1899-1
Biological Oxygen Demand (COD)	32 mg/L O_2	60 mg/L O_2	DIN ISO 15705
Complete Alkalimetric Titre (CAT)	13.1 F°	5.8 F°	Titimetry
Hydrometric Title (HT)	420 mg/L	310 mg/L	Titimetry
Calcium (Ca^{2++})	240 mg/L	150 mg/L	EDTA titrometry
Magnesium (Mg^{2++})	55.2 mg/L	40.8 mg/L	EDTA titrometry
Potassium (K^+)	1.2 mg/L	2.3 mg/L	Spectrophotometry
Sodium (Na^+)	26 mg/L	33 mg/L	Spectrophotometry
Chloride (CL^-)	35 mg/L	22 mg/L	Mercury nitrated titrometry
Total chloride (Cl_2)	0.86 mg/L	0.18 mg/L	Colorimetry. DIN ISO 7393 G4-2
Ammonium ion (NH_4^+)	0.15 mg/L	0.03 mg/L	Spectrophotometry
Nitrate (NO_3^-)	20 mg/L	7 mg/L	Spectrophotometry
Nitrite (NO_2^-)	0.008 mg/L	0.02 mg/L	Spectrophotometry
Orthophosphate (PO_4^-)	0.05	0.01	Spectrophotometry

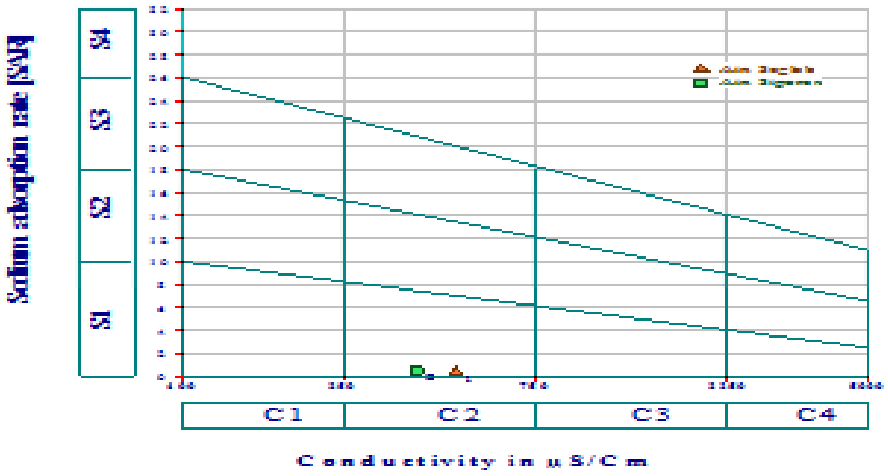

Fig. 3. Classification of irrigation water according to the Wilcox . Diagram (Source: own study).

8. Evaluation of the Organic Pollution Index (OPI)

Our results give a value of 4.25, which classifies our waters in the low organic pollution category. The values of this index are explained by the very low values of ammonium, nitrite and phosphate.

TABLE II. Grid of organic pollution index classes OPI and degrees of pollution (Leclercq, 2001).

Parameters Classes	NH_4^+ (mg/LL)	BOD_5 ($mg\text{-}O_2/L$)	PO_4^{3-} (µg/L)	NO_2^- (µg /L)	Average of classes (OPI)	Level of organic pollution
5	<0,1	<2	<15	<5	4,6-5,0	Nothing Pollution
4	0,1-0,9	2,1-5	16-75	6 – 10	4,0-4,5	Low Pollution
3	1-2,4	5,1-10	76-250	11 – 50	3,0-3,9	Moderate Pollution
2	2,5-6	10,1-15	251-900	51 - 150	2,0-2,9	Strong Pollution Forte
1	>6	>15	>900	>150	1,0-1,9	**Very strong pollution**

OPI : Average of the class numbers of the 04 parameters.

9. Bacteriological Analysis of Source Water

The results obtained are presented below (Fig. 4).

9.1. Search for total germs and sulphite-reducing clostridium

Total and Faecal Coliforms

Our results confirm a total presence of total and faecal coliforms in Ain Siglèb, on the other hand the water of the source of Ain Siporex confirms a total absence of total and faecal coliforms (Total germs; Ain Siglèb= 1473CFU/100 ml and Ain Siporex= 80CFU/100 ml). The results obtained are comparable to those reported by Singla and *al.*, (2014) [32] in India and Nitin Joseph and *al.*, (2018) [34] and Saidi and *al.*, (2013) [12]. This contamination is due to free airborne germs that are in direct contact with unprotected sources. The high concentrations of total coliforms, faecal coliforms and faecal streptococci suggest the possible existence of the wastewater discharge upstream of these two points. According to Hébert and Légaré (2000) [35].

Faecal Streptococci

The regulation of our country (JORA, 2011) excludes imperatively the presence of faecal Streptococci in 100ml. This is also the case with our water where the total presence of faecal streptococci was found in the source water of Ain Siglèb and the total absence in the source water of Ain Siporex. The discharge of wastewater from several residential units into the source may also be an important source of streptococci in the water that participate in the contamination of this site.

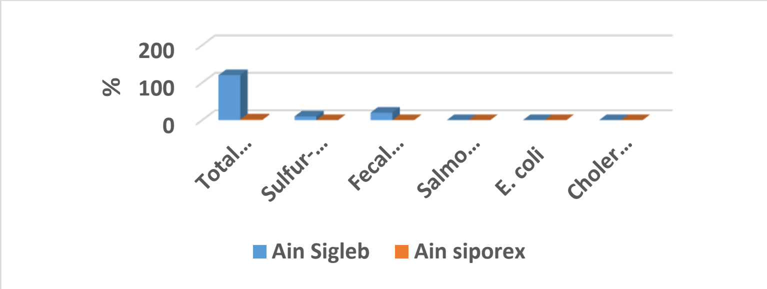

Fig. 4. Results recapitulation of the bacteriological analyses.

Enumeration of Total Germs and Clostridium Sulfito RéducteursTotal germs

The results seen exceed the threshold of 20germs/ml set by the Algerian regulation (JORA, 2011). The contamination of these waters by total germs could be due to the poor protection of the sources, the ignorance of the elementary rules of hygiene, which is confirmed by Ayad and Kahoul (2017) (Table III and Fig. 4) [23].

Table III. Results of the enumeration of total germs and *Clostridium- Sulfito Reducans*

Station	Total Germs	Clostridium
Ain Sigleb	1473 CFU/100 mL	10
Ain Siporex	18 CFU/100 mL	0
Standard (Germes/Ml)	20 CFU/100 mL	0

10. Conclusion

At the end of this study, the results of the physico-chemical parameters found show that all the values are in conformity with the Algerian standards of potability and show that the source waters of the region of Souarekh can be considered as admissible and does not present any danger for human consumption. The waters of two sources are fresh waters and of good chemical quality. From a bacteriological viewpoint, the sources studied present very high concentrations of total coliforms, faecal coliforms and streptococci, which undoubtedly constitutes a threat for the users of these sources. The source water of Ain Siporex is free of pathogens and of good physico-chemical quality compared to the source water of Ain Siglèb. Nevertheless, a permanent monitoring of the water quality is necessary especially during the summer period when risks of contamination are frequent and also to monitor and control the use of fertilizers and pesticides in order to minimize or prevent the migration of excesses to the groundwater.

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