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EVALUATION OF MEXA DAM WATER QUALITY IN EL TARF REGION (EXTREME NORTH-EAST ALGERIA)

***Samira GHEID[1], Sofia BAHROUN[2], Amina BENABDALLAH[2], Abdelhak GHEID[3]**

[1] Department of biology, Faculty of Life and Natural Sciences, University of Chadli Bendjedid, El-Tarf, 36000, Algeria. samiragheid@yahoo.fr
[2] BPE Laboratory, Faculty of Life and Natural Sciences, University of Chadli Bendjedid, BP 73, El-Tarf, 36000, Algeria. sofiabahroun@gmail.com , benabdallahamina@hotmail.fr
[3] Water and environment science and technology laboratory, Faculty of Life and Natural Sciences, University of Mohamed-Cherif Messaadia, Souk Ahras, 41000. Algeria. hakgheid@yahoo.fr
*Corresponding author
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Abstract: *The water is a precious natural resource and vital for the living beings, the increasing water demand for irrigation or feeding, have made necessary the construction of a great number of dams that require an excellent physicochemical quality. The objective of our work is to evaluate the seasonal water quality of Mexa dam (Eastern Algeria) during four years 2016, 2017, 2018 and 2019. The present work aims to establish a physicochemical characterization to determine the parameters affecting the water quality, such as temperature, conductivity, turbidity, Hydrometric title, salinity, complete alkalimetric title, calcium, magnesium, bicarbonate, chloride, iron, pH, dry residue (DR), organic matter (OM), nitrate, nitrite, ammonium, biological oxygen demand (BOD_5) and chemical oxygen demand (COD). The results of the water physico-chemical analyses of this dam show that the majority of the obtained values are in conformity with standards, thus the water can directly be used for irrigation. According to NAHR grid, the water quality records of Mexa dam show a medium quality for the majority of the studied parameters. The level of nitrogenous matter (NH_4^+, NO_2^-) in the water is high during 2016 and 2017, this pollution is caused by the oxidation of nitrogenous organic matter.*

Keywords: *Mexa dam, Eastern Algeria, physicochemical parameters, irrigation water, drinking water.*

1. Introduction

Water is a raw resource, partially renewable, like air, it is considered vital to human life. It is one of the main factors in the organization and development of territories [1]. The protection of water resources is one of the most important concerns of any environmental policy [2], it is a strategic global investment that should essentially be managed within the framework of a sustainable development policy [3]. In Algeria, water is an increasingly precious resource, the competition between agriculture, industry and daily population uses accessing to a limited water supplies is already affecting the development efforts of many countries [4]. Important investments have been made in the construction of the dams, especially in the eastern part of the country. Dams offer many benefits to our society, such as the provision of drinking and irrigation water [5]. However, these surface waters are sensitive to all kinds of pollution and are often of bad quality [6]. They may contain significant amounts of natural organic matter such as humic substances, but also other compounds from various pollutant wastes or intensive agricultural practices [7]. These events, able to affect the water quality, require a rigorous control

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of the systems, which is of great interest to ensure the correct performance of these systems. Hence, this work aims to evaluate the quality of Mexa dam water located in El Tarf province (North-East of Algeria), based on the monitoring of physicochemical parameters for both seasons (rainy and dry), during four years (from 2016 till 2019).

2. Materials and Methods

The studied area concerns the Mexa dam, located in the municipality of Bougous near the Algerian-Tunisian border, 8 km from the chief town of El Tarf municipality, and 71 km from Annaba city by the national road N°44 [8].

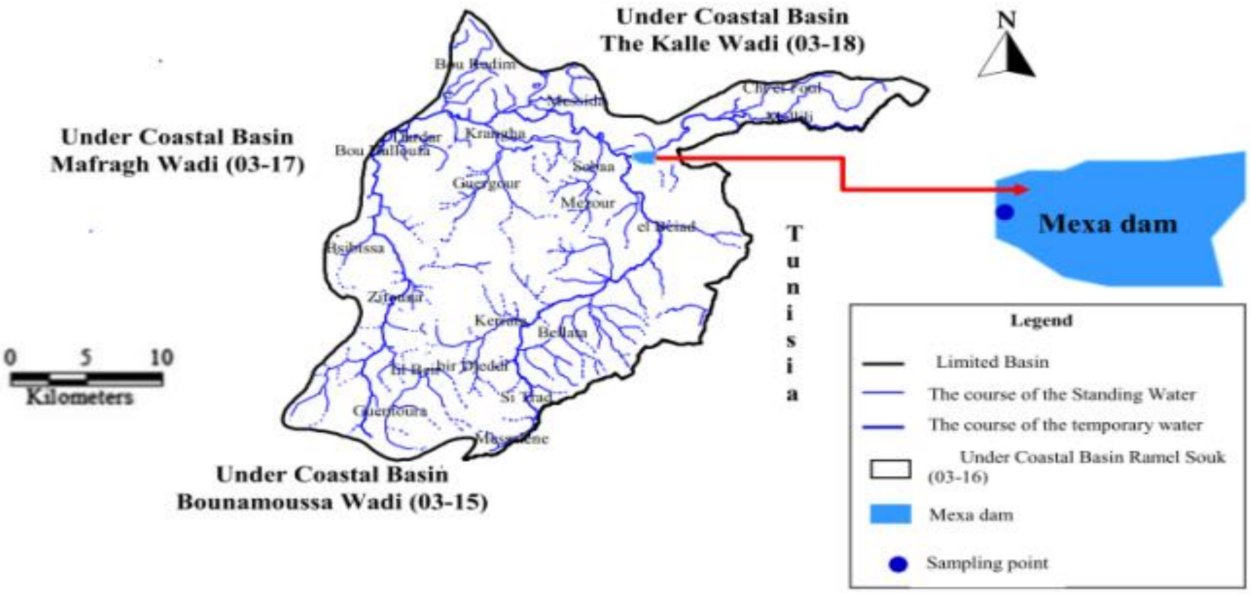

Fig. 1. Geographical location of the Maxa dam [8].

The region has a great agricultural vocation, farming sector provides most of permanent and seasonal jobs [9], it is characterized by a wide variety of cultures (citrus, pear, pomegranate, medlar and quince trees, sorghum, melon, watermelon, and other vegetables) [10]. Industry, *sensu stricto*, is mainly inexistent in the basin, as well as in the whole province [11].

Sampling:

Sampling campaigns of Mexa dam waters were conducted for a period of four years (2016, 2017, 2018, and 2019), by monthly sampling for each year. The survey was conducted on the raw water from the dam site [12-13].

Surface water samples were collected directly with polyethylene bottles, by sampling at a depth of 15-30 cm from the water surface, avoiding edge effects (oxygenation too close to the surface, solid matter suspension too close to the bottom), facing the water current. The samples were kept at a temperature of 4°C. Chemical analyses were conducted in the laboratory where the major elements analyses were performed on the filtered samples [14].

Table 1.
The different methods used for physicochemical parameters

Analysis	Parameters	Methods
In situ analysis (physical parameters)	pH, temperature, electrical conductivity, turbidity and dissolved oxygen	Electro-metric method with combined electrode
In vitro analysis (chemical parameters)	Hydrometric title Full Alkalimetric title Calcium and Magnesium Iron Bicarbonate Chloride Ammonium, Nitrite, Nitrate, Phosphate BOD_5, COD	Volumetric method Volumetric method Flame spectrometer Spectrometric method Volumetric method Mohr method Flame spectrometer [15]. Spectrometric method Measured using an OxiTop IS12

Dam water quality measurement

The study focused on the *in situ* measurement of pH and dissolved oxygen with the determination of other elements in the laboratory (dry residue, OM, BOD_5, COD, PO_4^{3-}, NO_2^-, NH_4^+ and NO_3^-).

The assessment of water quality is based on the comparison of various analyzed chemical elements (often called parameters) to standards or thresholds (Table 2). All the threshold values for the considered parameters constitute a quality grid, through which it would be possible to assign a quality class to the dam water [16-17]. For a better illustration of the different water pollution levels, we have assigned a color to each class according to the grid used by the NAHR (National Agency of Hydraulic Resources):

- The class of good water quality is represented in blue.
- The class of medium water quality is represented in green.
- The class of bad water quality is represented in yellow
- The class of very bad water quality is represented in red.

Table 2.
Water quality grid approved by NAHR (the National Agency of Hydraulic Resources).

Parameters	Unit	Quality Scales			
		Good	Medium	Bad	Very bad
pH		6.5 - 8.5	6.5 - 8.5	8.5 - 9	>9 et <6.5
Dissolved O_2	%	100 - 90	90 - 50	50 - 30	< 30
Ammonium NH_4^+	mg/l	0 - 0.01	0.01 - 0.1	0.1 - 3	> 3
Nitrate NO_3^-	mg/l	< 10	10 - 20	20 - 40	> 40
Nitrite NO_2^-	mg/l	0 - 0.01	0.01 - 0.1	0.1 - 3	> 3
BOD_5	mg/l	< 5	5 - 10	10 - 15	> 15
COD	mg/l	< 20	20 - 40	40 - 50	> 50
PO_4^{-3}	mg/l	0 - 0.01	0.01 - 0.1	0.1 - 3	> 3
OM	mg/l	< 5	5 - 10	10 - 15	> 15
DR	mg/l	300 - 1000	1000 - 1200	1200 - 1600	> 1600

3. Results and Discussion

The temperature: The seasonal temperature changes are represented in figure 2.

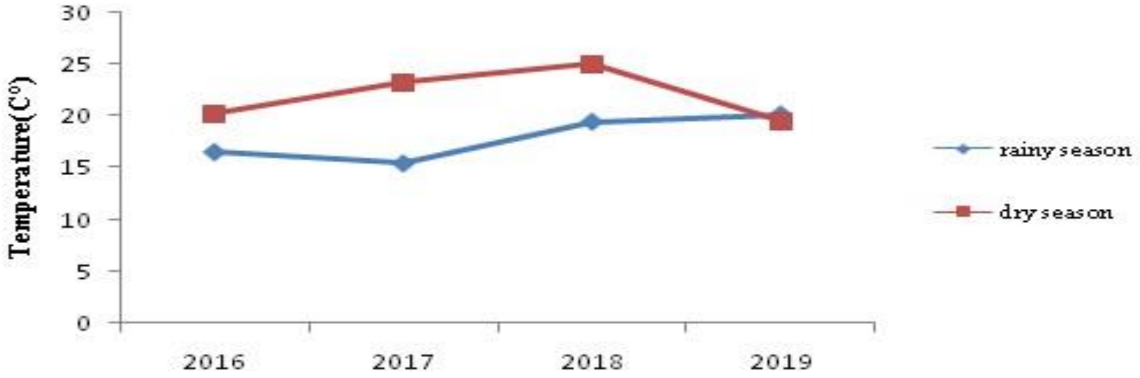

Fig. 2: Seasonal temperature changes

These findings indicate that temperature degrees vary with the seasons, the highest values observed during the dry season and the lowest ones were recorded during the rainy season, which does not exceed the standards of potability during the four years (2016, 2017, 2018 and 2019) [18]. The recorded temperature reached the maximum value in 2018, with an average of 25°C during the dry season and its lowest point in 2017 with an average of 15,46°C, during the rainy season (Fig. 2). According to [8], the water temperature of Mexa dam fluctuated between 10°C, in the rainy season, and 30°C in the dry season, from 2010 to 2012; hence this variation is mainly seasonal. These results are close to those recorded by [6], at the dam of Foum El-Khanga (Souk Ahras, Algeria), and remain lower than those reported by [19], at the Sidi Chahed dam (Morocco). The value of this parameter is generally influenced by the ambient temperature [20]. It obviously varies according to the season, the geological nature and the depth of the water (even superficial or deep water) [21].

The Electrical Conductivity (EC)

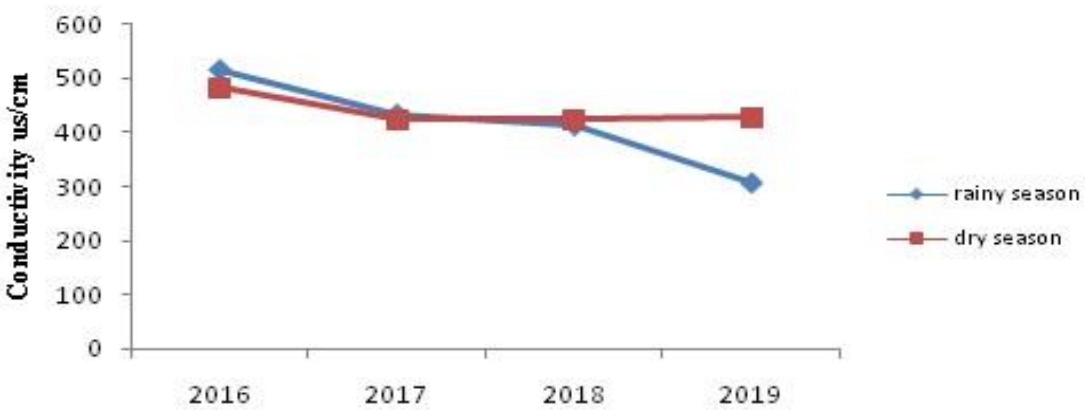

Fig. 3: Seasonal electrical conductivity changes.

According to the results obtained from the raw water conductivity of Mexa dam measured during the period (2016-2017-2018-2019), varied from 308 µs/cm to 515 µs/cm (Fig. 3). We noticed that all the conductivity values recorded during these years are lower than that given by the Algerian standard of potability, fixed at 2800 µS/cm [18]. In addition, the conductivity variation is caused by the presence of ions in the medium, which are mobile in an electric field [15]. This mobility depends on the nature of the dissolved ions and on their concentrations. Usually, electrical conductivity increases with the solution ion concentration and temperature [22]. Our findings are consistent with those obtained by [23], at the Mexa and Cheffia dam, however these values are significantly inferior to those recorded by [6], at the Foum El-Khanga dam (Souk Ahras, Algeria), and by [24], at the Bir M'chergua dam (Tunisia)

The turbidity:

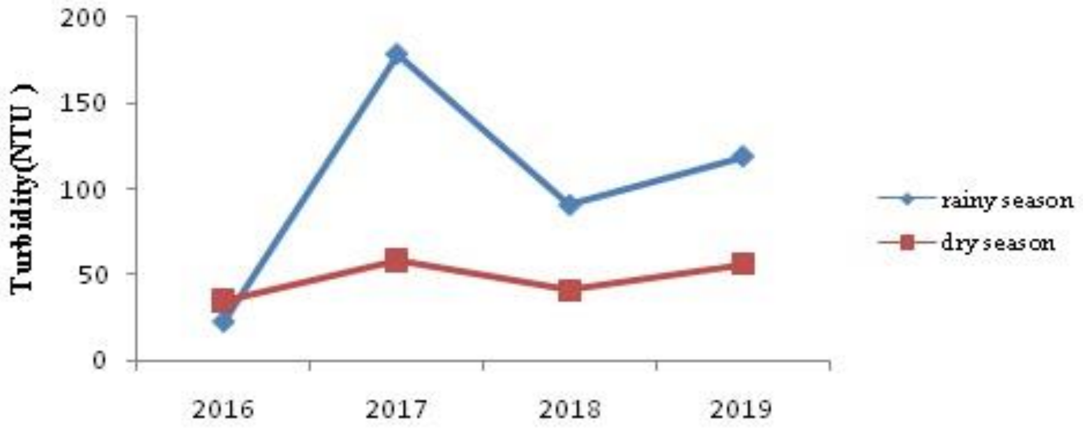

Fig. 4. Seasonal turbidity changes.

These results exceed the Algerian standards with an average of 178.56 NTU (Fig. 4), during the rainy season in 2016, since the studied dam is located in a very densely wooded area with a high vegetation cover, which increases the values of turbidity. In this case, the elevation could be mainly of organic nature, and may therefore induce a significant increase in the chlorine amounts during dam water treatment. The obtained results are comparable to those performed by [25], at the Mexa and Cheffia dams.

During the dry season, turbidity is low compared to the rainy season, where the inflow of runoff increases the turbidity of water [26]. The latter is caused by the presence of suspended matter such as mineral substances (sand, clays or silts), organic matter (decomposed plants, suspended plankton). The evaluation of these matters abundance measures its degree of turbidity [27].

Hydrometric title: HT

The Hydrometric title values of water are expressed in mg/l of $CaCO_3$, the lowest rates are recorded in 2017, during the dry season and in 2018, during the rainy season, in the investigated waters.

This parameter presents a great variation, it decreases in dry period and increases in rainy one, this variation could be related to the lithological nature of the aquifer formation, particularly to its composition in terms of magnesium and calcium [28-

29]. The Hydrometric title of natural water depends on the geological structure of the crossed soils [30].

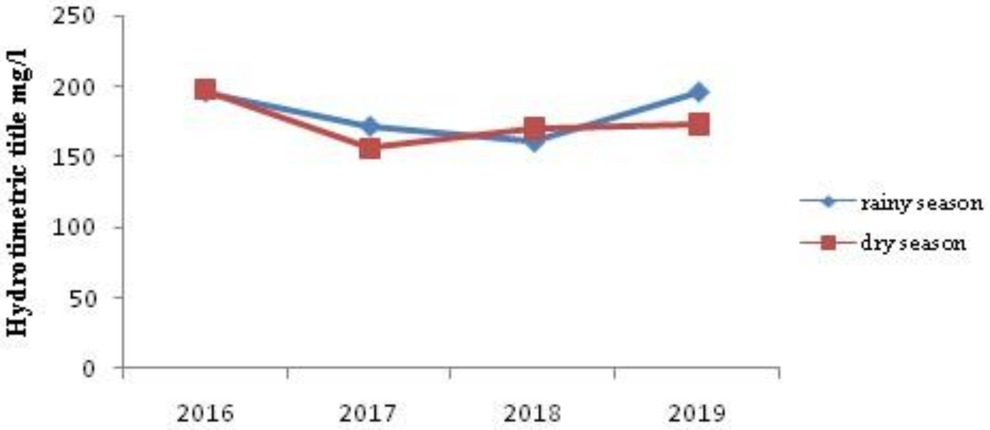

Fig. 5. Seasonal Hydrometric title changes.

Salinity: Salinity measurements revealed values ranging from 0.15% recorded in 2019, to 0.25% in 2016, for the rainy season (Fig. 6). These values are lower than that required by the Algerian standard of 1.5% [18]. This salinity pattern is closely related to the freshwater inflow, and to the low water evaporation which increases the salt concentration in the water. The salinity levels are lower than those of Moroccan lakes, as reported by [31] at Hassan II lake tank, [32] at Hassan Dakhil lake, [33] at Mansour Eddahbi lake tank.

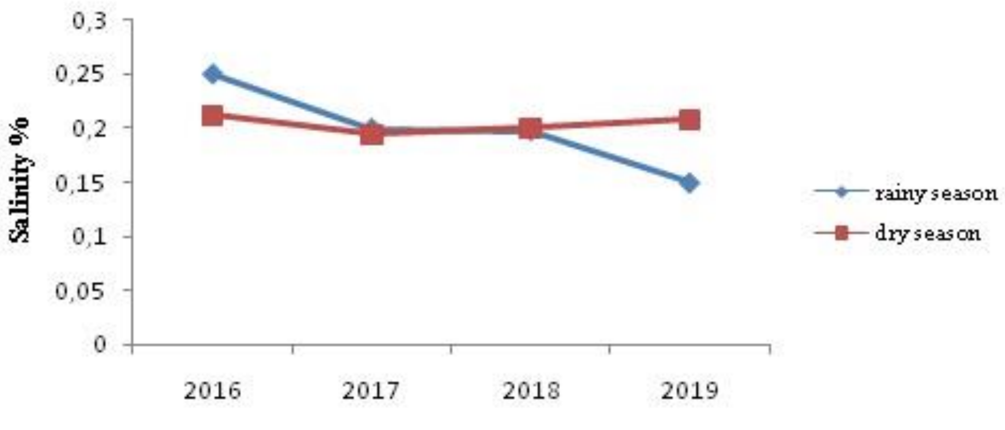

Fig. 6. Seasonal salinity changes.

Complete Alkalimetric Title (CAT): According to the obtained results, the CAT varies between means of 87.98 mg/l registered in rainy period during 2017 and 108.47 mg/l recorded in 2018 in dry period. Therefore the results do not exceed the Algerian standards of 500 mg/l [18]. The CAT findings of our raw water are much higher than those reported by [6] for the waters of the Foum El-Khanga dam, (Souk-Ahras, Algeria).

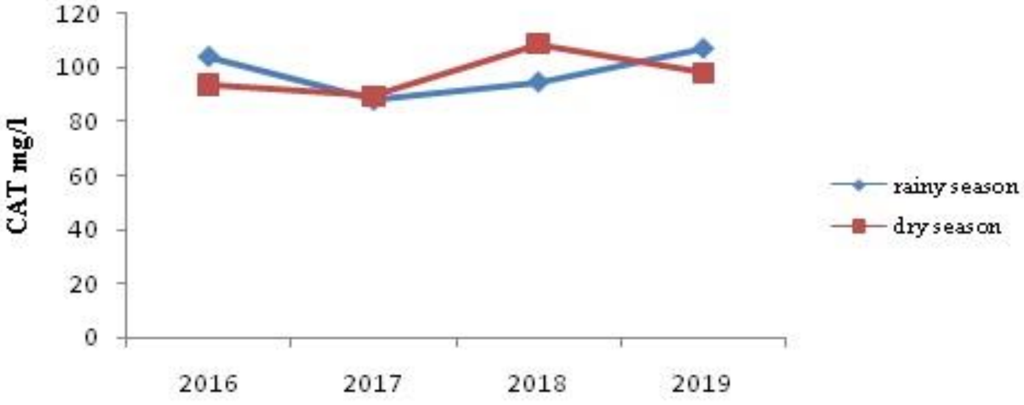

Fig. 7. Seasonal complete alkalimetric variation.

Major elements:

Calcium (Ca^{2+}): The obtained results of calcium content ranged from a minimal mean of 42.48mg/l in the rainy season in 2018 to a maximal mean of 59.95mg/l observed in 2016, for the dry season. The calcium concentration is lower, which means that these waters are less impacted by the dissolution of carbonate and gypsum creations. In contrast to other researches, these concentrations are lower than those reported by [6] at the Foum El-Khanga dam (Algeria) and [23] at Bir M'chergua dam (Tunisia).

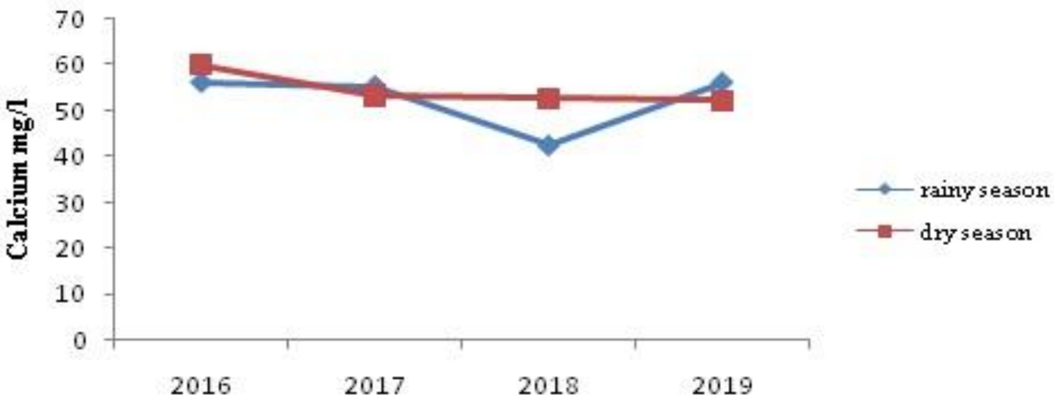

Fig. 8. Seasonal calcium changes.

The magnesium (Mg^{2+}): According to these results, magnesium is the lowest major element in the dam water, among the other studied components. The magnesium contents are generally lower than the norm, they vary between 13.6 mg/l and 5.47 mg/l. These contents turn out to be lower than those found by [6] at Foum El-Khanga dam (Algeria).

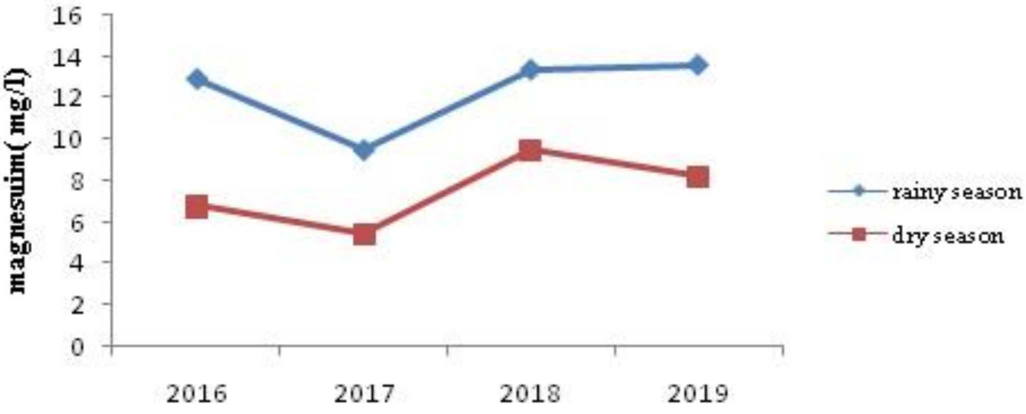

Fig. 9. Seasonal magnesium changes.

Bicarbonates (HCO_3^-): According to Figure 10, the bicarbonate concentrations analysis of the dam waters is about 132.38mg/l recorded in dry period and 92.39mg/l noted in rainy period in 2018.The concentrations show significant variations indicating a heterogeneity of these bicarbonates sources. Similar bicarbonate contents were recorded in 2010 by [8]. Nevertheless, our results still lower than those reported by [24] of Bir M'chergua dam (Tunisia).

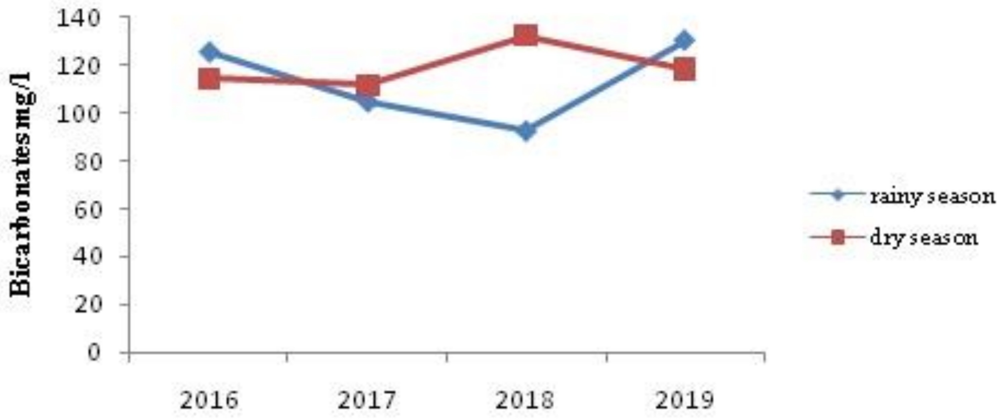

Fig. 10. Seasonal bicarbonates variation.

Chloride (Cl^-): Based on the obtained results (Fig. 11), the chloride concentrations in the dam waters are mostly significant. In dry periods, they vary between 46.14 mg/l (2016) and 38.18mg/l (2017), While in the rainy ones, the fluctuation are between 47.13 mg/l (2016) and 35.45 mg/l (2019). We noticed that the chloride levels in the water of Mexa dam do not exceed the World Health Organization standard (250mg/l). These findings are in agreement with those reported by [31] at the Hassan II dam (Morocco). The origins of the chlorides in the waters are the Numidian clays, marls and clayey marls of Lutetian age [34]. On the other hand, [35] have mentioned that chloride ions, at a concentration higher than 250 mg/l affect the water flavor, which could lead to a water quality deterioration.

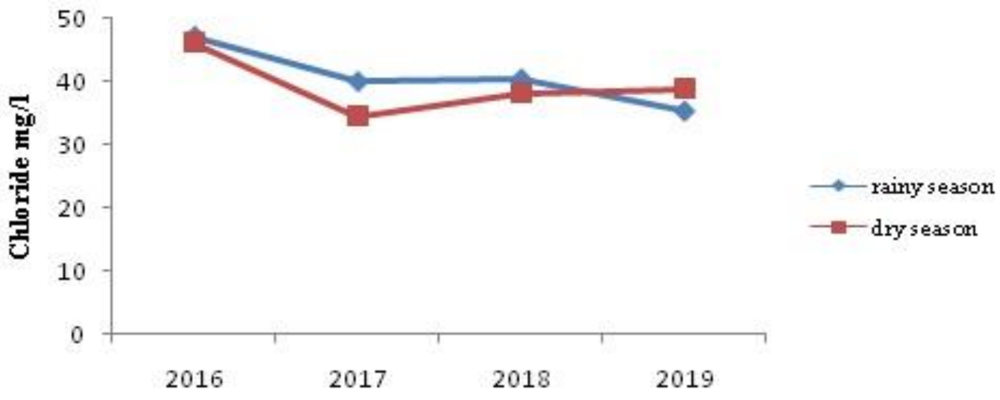

Fig. 11. Seasonal chloride changes.

Total iron Fe^{2+} : The Figure 12 illustrates the concentration changes of iron ions in the Mexa dam waters, these contents are low, they vary between a mean of 0.13mg/l (dry season 2016) to 0.51 mg/l (rainy season 2018). The presence of iron could be due to agricultural soil leaching and the local geological setting (ferromagnesian richness in the sediments) [36].

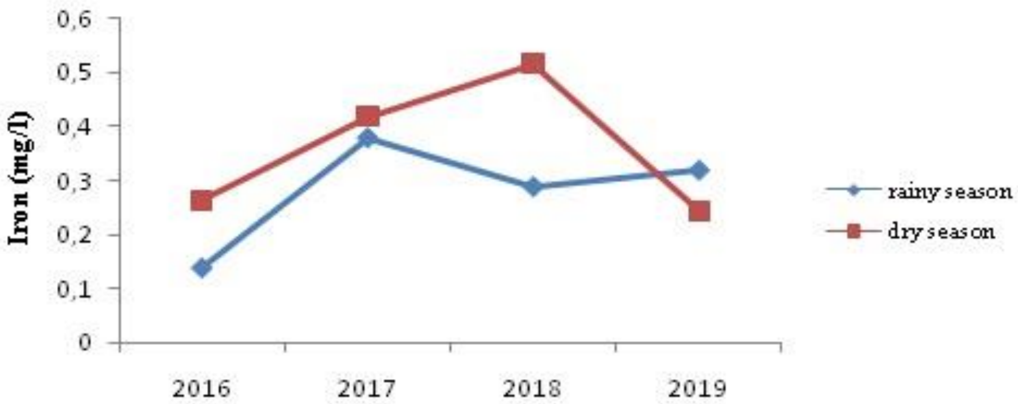

Fig. 12. Seasonal iron changes.

Seasonal changes in the water quality of the dam over four years:

According to the water quality data (Fig. 13), we note that Mexa dam waters are of medium quality for the majority of parameters, the pH of Mexa dam raw water exhibits a range of 7.20 to 8.03, which does not exceed the standard of potability, therefore reflecting a medium quality. These results are consistent with those previously reported in the same study area [23-8] and in the dam of Foum El-Khanga (Souk Ahras, Algeria) [6].

The waters of this dam are charged in NH_4^+ and NO_2^- during 2016 and 2017, this elevation is due to the oxidation of nitrogenous organic matter and the extensive use of fertilizers as well as the inputs of pollutants from urban wastewater discharges and the eutrophication process [37].

The improvement of the water quality of this dam requires treatments, in order to reduce the content of NH_4^+ and NO_2^- [17].

In 2018-2019, we have an improvement of the water dam quality, this could be due to the rainfull period which lead to a high water dam level amongseasons.

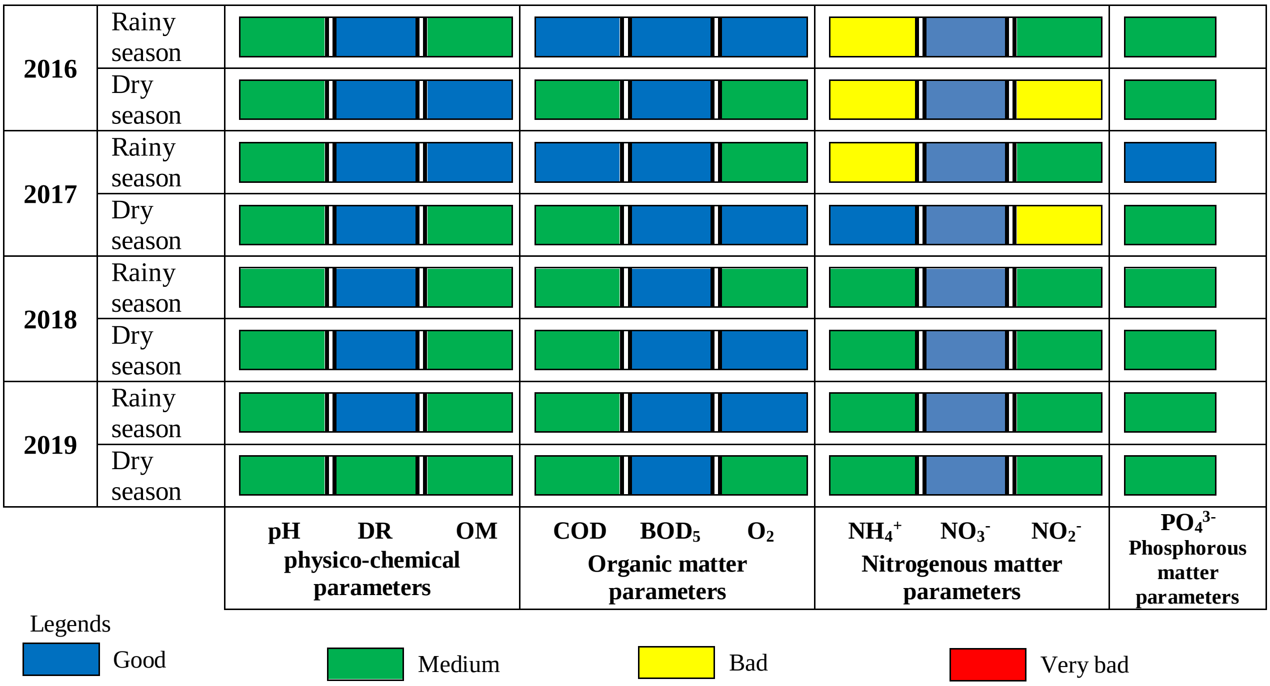

Fig. 13. Seasonal means quality sheet for Mexa dam water (2016-2019).

4. Conclusion

Water quality analyses of the Mexa dam reveal that the water is poorly mineralized, with high values of electrical conductivity (near 515 µS/Cm), calcium (59.95 mg/l), magnesium (13.6 mg/l), bicarbonate (132.38mg/l), chlorides (47.13 mg/l) and iron (0.51 mg/l). The chemical quality parameters are all lower than the WHO potability standards. The Mexa dam water quality records exhibit a medium quality for the majority of the studied parameters. The content of nitrogenous matter (NH_4^+, NO_2^-) in the water is high during 2016 and 2017, this pollution is due to nitrogenous organic matter oxidation.

Therefore, in order to improve water quality and reduce these high levels of nutrients, it is necessary to consider the installation, in upstream, of small pre-treatment stations.

5. Acknowledgement

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