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ANALYTICAL STUDY OF THE WATER QUALITY FOR THE DRINKING WATER NETWORKS IN BECHAR CITY

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Abstract
The study carried out involves an evaluation of the physico-chemical parameters of drinking water networks in Bechar city (Algeria). In this work we have characterized the quality of drinking water, investigated the main sources of water pollution and proposed solutions to this problem. Today, the water consumer in Bechar city enjoys an aftertaste in drinking water, despite its treatment upstream of the dam. The installation of the dam began in October in 968, the drinking water supply system of the town of Bechar was carried out between 1978 and 1980, and the dam was inaugurated in May 1981. This work was initiated to better understand the quality of drinking water. The quality of drinking water must be checked upstream (sources of water) until downstream (consumer), it can also be degraded during its storage and passage through the distribution of drinking water networks. Contamination can come from the network itself. The results found show that almost all of the parameters analyzed comply with both national and international drinking water regulations. To this end, we have concluded that the supply of drinking water to the city of Bechar is subject to several constraints such as the degradation of drinking water supply networks and the aging of reservoirs.

Keywords: dam, distribution network, drinking water, physicochemical analysis, reservoir, storage, water treatment.

1. INTRODUCTION

Province of Bechar, located in the south-west of Algeria, is characterized by an arid climate with a Saharan tendency (Nasri et al., 2018). The supply of drinking water of Bechar city comes mainly from the DjorfTorba (80%), and secondarily from the Turonian aquifer of Ouakda (20%), with flows, respectively of 358,72 1/s and 97 1/s (Nasri et al., 2018). The dam provides two to four times the volume exploited from Ouakda, to reach 80%. For this reason, we are interested in this research on the quality of surface water (Djorf-Torba dam) to consumers.
Currently, these rivers receive urban and industrial discharges loaded with chemical and organic elements, often toxic, which make necessary a better knowledge on the existing water resources especially, the evolution of the water quality of the dam, and the vulnerability of the resource to a potential factor (Kabour et al., 2015). It is therefore necessary to know and to follow the evolution of the water quality of this resource.

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This work was initiated to better understand the evolution of raw, decanted and treated water quality at the Dam and the various treatment plants, using the Water Quality Index (WQI). In order to complement the previous studies, then to identify the various factors that are at the origin of this problem related to the natural environment and to all the processes of anthropogenic origin.

2. MATERIALS AND METHODS

II. 1. Description of study area

In the south-west of Algeria, the Djorf-Torba dam represents a majestic hydrotechnical structure. It ranks fourth in Algeria, with an estimated capacity of 360 hm3. It was carried out during the period from 1965 to 1969 at the most appropriate site in the wilaya of Béchar (60 km west of the capital) (Kabour et al., 2015). The town of Bechar (Figure 1) is located between the 27°N and 32°N parallels and the 0°W and 5°W meridians. The area is approximately 164,881 km2. This region has a reported population of approximately 339,795 in 2020 (DPAT, 2020).

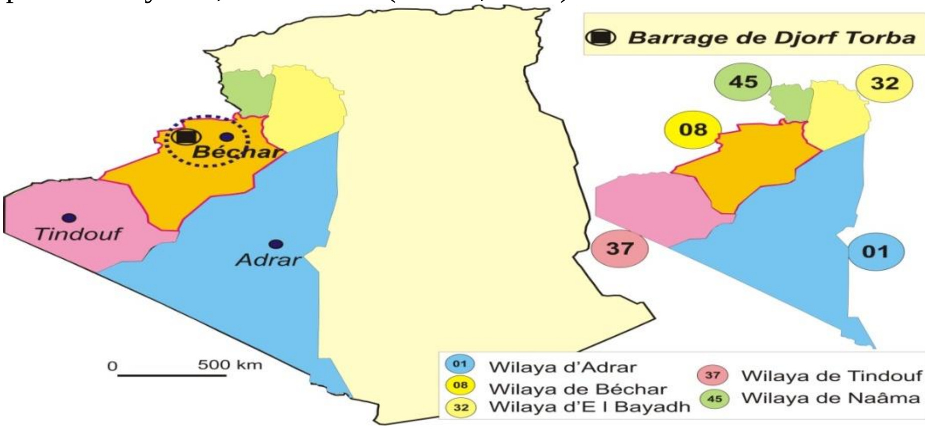

Figure 1. Location map of the study area

II.2. Climatological Aspect

The study area has a desert-like climate with low precipitation (mean 55 mm/year) and an average annual temperature of 20.5°C, with low air humidity (ANRH, 2008).

II.3. Geological aspect

In a broader view, the Djorf-Torba site enclaves itself in the southern part of the Cretaceous basin of Bechar, formed by a wide range of terrains ranging from Precambrian to current (Figure 2). The Paleozoic, predominantly carboniferous lands are found in the southern part of the map and make up the djebels of Bechar, Horreït and Antar. These lands belong to the old Saharan platform deformed during the Hercynian. The secondary and tertiary fields occupy the northern part and correspond to the alpine domain. Turonian limestones circumscribe the morpho-structural limits of the Cretaceous basin of Bechar (Nasri et al., 2018).

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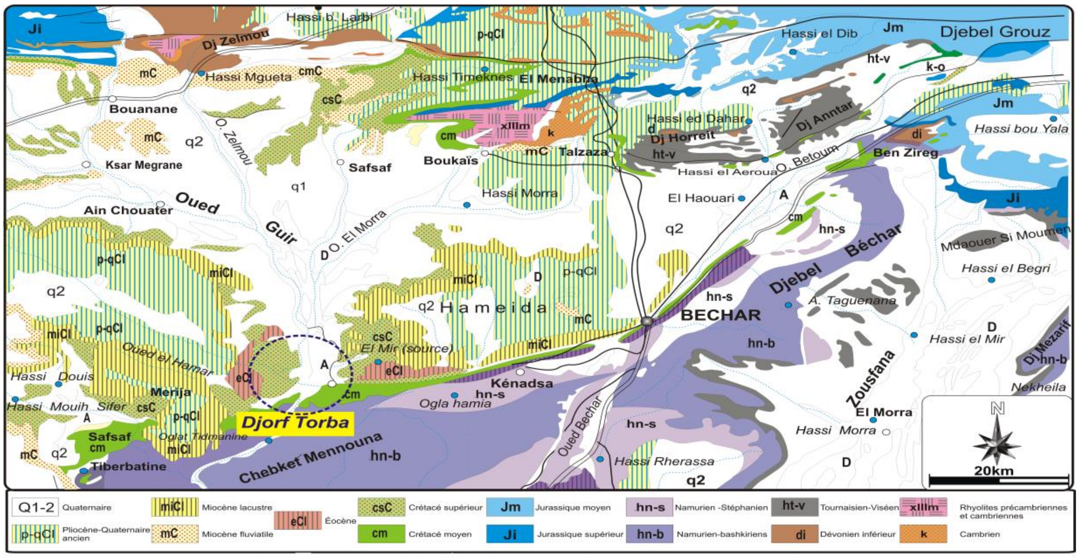

Figure 2. Geological map of the study area **(Nasri et al., 2018)**

II.4. Quantitative Aspect

The water resources in the Béchar region are limited and do not meet the needs of the capital of the wilaya of bechar especially with the increase of its population, and the development of the industrial and agricultural sectors. Several projects have been carried out to feed the town of Béchar from the region's aquifers, as in the case of Turonian and Quaternary tablecloths of Ouakda, the transfer from the Jurassic of Mougheul, and recently the transfer project of Oued Ennamous (Nasri et al., 2018).

II. 5. Qualitative aspect

Today, the city of Bechar has an aftertaste in the quality of drinking water, despite the presence of a treatment plant upstream of the dam because of various factors.

Currently, these rivers receive urban and industrial discharges loaded with chemical and organic elements, often toxic, which makes necessary a better knowledge on the existing water resources especially, the evolution of the water quality of the dam, and the vulnerability of the resource to a potential factor (Nasri et al., 2018) is therefore necessary to know and to follow the evolution of the water quality of this resource.

III. Sampling and Analytical Methods

The present study, consists of a monitoring of the water quality from the source (Djorf-Torba dam) to the consumer, using the database of water analyses carried out by the water quality monitoring laboratory of the Bechar ADE. In order to better identify variations and fluctuations in water quality, monitoring according to national and international standards is carried out at three levels:

1. Main Intake (Djorf-Torba Dam)
2. Reservoirs that directly feed the population (R: 2X2000; R: 2X3000; R: 3X250)
3. Consumer taps: four different neighbourhoods (BecharDjadide, Dabdabdaba, Hai Elbadre and City Centre)

The analytical techniques used are those described by (Rodier et al., 2009). The water samples were then transported to the laboratory in a 4°C cooler for analysis within 24 hours of collection.

Secondly, the analyses are carried out on 10 parameters according to standard analysis methods. Temperature, pH and conductivity were measured on site using a coupled pH meter of a thermometer

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and a conductivity meter type WTW 315i SET after calibration of these devices. Total dissolved salts (TDS) were determined after evaporation at 180°C, according to method NF T 90-029, described by the water analysis, chlorides are determined by the AFNOR NF EN ISO 15682 method, sulphates are determined by the method NFT 90-009, nitrates and ammoniacal nitrogen by NFT 90-012. These parameters were measured using the Perkin Elmer Lambda 25 visible UV spectrophotometer according to the method described by (Rodier et al., 2009 cited by Hanon et al., 2011). Carbonates and bicarbonates are determined by acidimetry according to method NF T90-036, calcium and magnesium (TH) have been determined by titrimetric methods according to standard NF T90-016 and NF T90-003, trace elements are determined by method NFT90-119. And are measured by Visible UV spectrophotometry according to reference (Rodier et al., 2009).

3. RESULTS AND DISCUSSIONS

IV. 1. Organoleptic parameters

The organoleptic quality of the water is due in particular to plankton, algae mounted by rivers. It is the most complex quality problem to understand and control.

Tastes and smells can be generated on three levels: The dam, the reservoir and the distribution of drinking water network. The main materials that can give the water an unpleasant flavor iron, manganese and chlorine. This flavor develops with increasing temperature.

The solutions are of the same type as those recommended for microbiological parameters.

IV.2. Physico-chemical parameters

Monitoring the evolution of water quality at three levels (the Djorf-Torba dam, the reservoirs that directly feed the population and the taps of the consumer) and compare them to national and international standards of potability, which is an essential step in preserving this resource.

Temperature

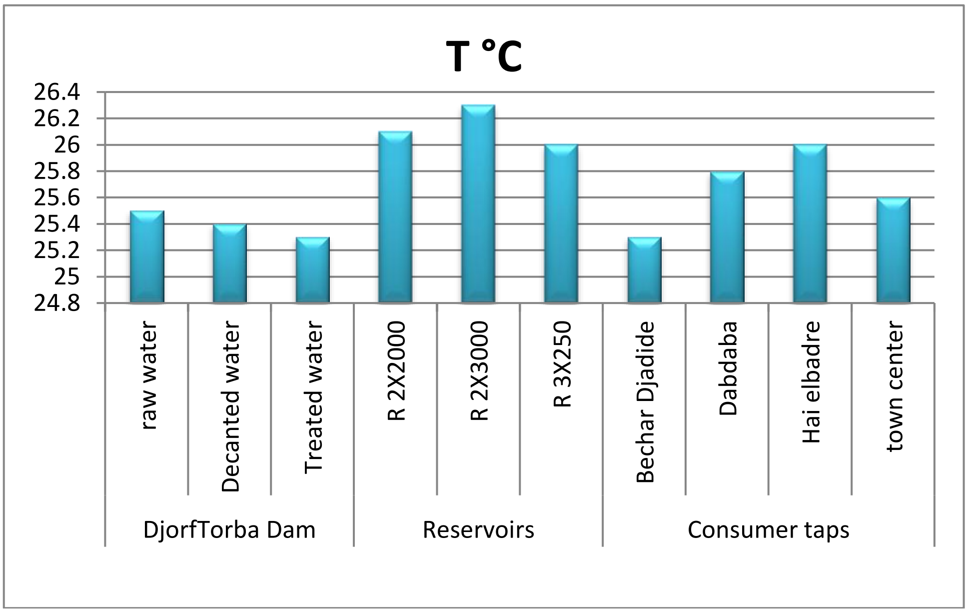

Figure 3. Variation in water temperature of the town of Bechar

Water temperature is an important factor in the aquatic environment as it governs all physical, chemical, and biological reactions. In relation to the water potability standards set by the

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WHO(WHO, 2000) water is: excellent when the temperature varies between 20 and 22°C; fair when the temperature fluctuates between 22 and 25°C; The results of the temperature measurements (Figure 3) show that these values are variable and range from 25.3°C to 25.5°C for the waters of the DjorfTorba Dam, and from 26°C to 26.3°C for the waters of the reservoir to 25.3°C and 26°C for Consumer Taps. The majority do not comply with Algerian standards <25 (MRE, 2014) and WHO recommendations. These values are above 25°C, which could mean that compared to these standards, the waters analyzed are poor. These values were obtained from May onwards, which means that this increase is due to ambient temperature.

Hydrogen potential (pH)

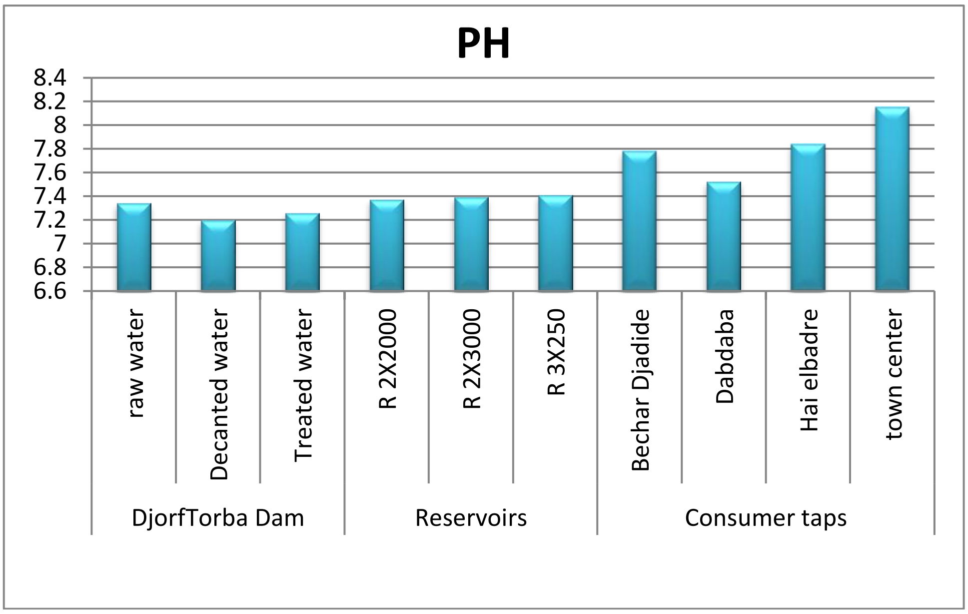

Figure 4. Variation in pH of the waters of the town of Bechar

Water pH is a parameter that determines the acidity or alkalinity of a water by the concentration of H+ ions. The acidity of the water in itself poses no problem for the health of the consumer. However, acidic water distributed through a pipeline system can indirectly pose a health threat to the ill-informed or unwise consumer (Hanon et al., 2011). The pH values of the water points studied (Figure 4) vary between 7.20 and 7.34 for the waters of the Djorf-Torba dam and between 7.37 and 7.41 for the waters of the reservoirs and between 7.15 and 7.84 for the waters of the consumer's taps, with a generally alkaline character. These results are well in line with the WHO recommendations (7 to 8.5) (WHO, 2000) and the Algerian standard (6.5 to 8.5) (MRE, 2014).

Conductivity (EC)

The conductivity of water makes it possible to evaluate quickly, but approximately the total mineralization of in situ water by an approximation equal to the product of electrical conductivity at 25°C by a coefficient between 0.55 and 0.95.

The classification of water according to conductivity is as follows:

Conductivity of 0.05pS/cm: demineralised water; Conductivity of 10 to 80 pS/cm: rainwater; Conductivity of 80 to 100 pS/cm: lightly mineralized water; Conductivity of 300 to 500 pS/cm:

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moderately mineralized water; Conductivity of 1000 to 3000 pS/cm: saline water; Conductivity greater than 3000 pS/cm: seawater (Rodier et al., 2009).

The waters analysed (Figure 5) show that the conductivity of the waters of the Djorf-Torba Dam varies between 1002 pS/cm and 1005 pS/cm, and between 962 and 1014 us/cm for the waters of the tanks, and between 649 and 1903 for the consumer's water. These results also show that all the analyzed waters have an EC in conformity with the Algerian standards (2800 ps/cm). The values of electrical conductivity are between 1000 and 3000 pS/cm and are therefore according to this classification, saline water. This increase depends on the decrease of the dam volume in this period and the increase of the temperature.

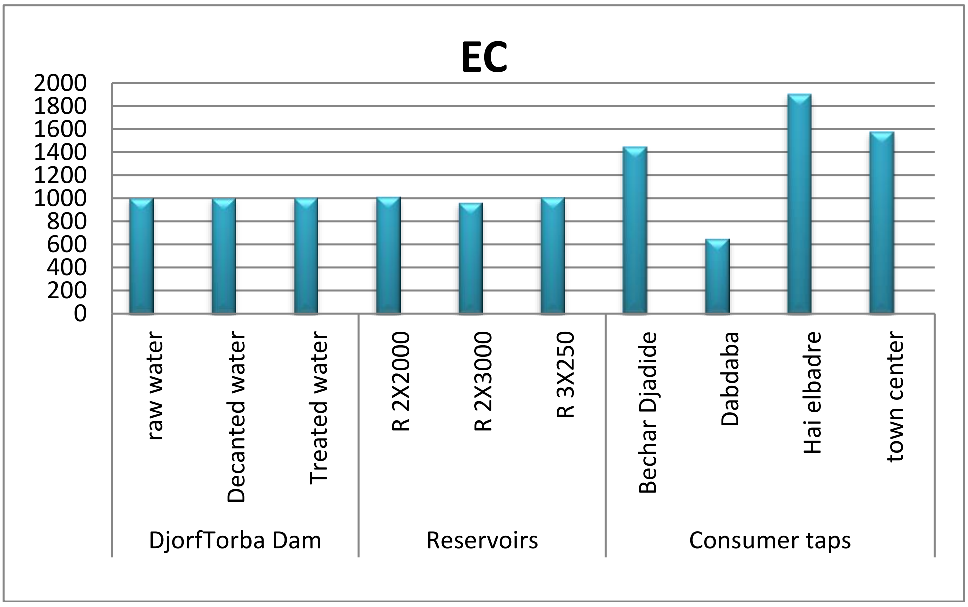

Figure 5. Variation of electrical conductivity of the waters of the city of Bechar

Total dissolved salts (TDS)

TDS is the amount of dissolved salts and organic matter in water obtained by drying water at 110-180°C for 24 hours,

According to a WHO publication, the appetite of drinking water has been assessed by groups of tasters in relation to its TDS level as excellent, less than 300 mg/1; good, between 300 and 600 mg/1; fair, between 600 and 900 mg/1; poor, between 900 and 1200 mg/1; and unacceptable, greater than 1200 mg/1. Water with extremely low concentrations of TDS may also be unacceptable because of its flat and tasteless taste.

The results of the analyses obtained (Figure 6) show that the TDS values for the waters of the Djorf-Torba Dam are around 492 and 493 mg/1 and between 472 and 478 mg/1 for the reservoir waters and between 475 and 478 mg/1 for the tap waters of the consumer. These results also show that 100% of the waters analysed have a lower mineralization than Algerian standards (1500 mg/1) and according to WHO recommendations. The TDS values, between 300 and 600 mg/1, conform to the potability standards.

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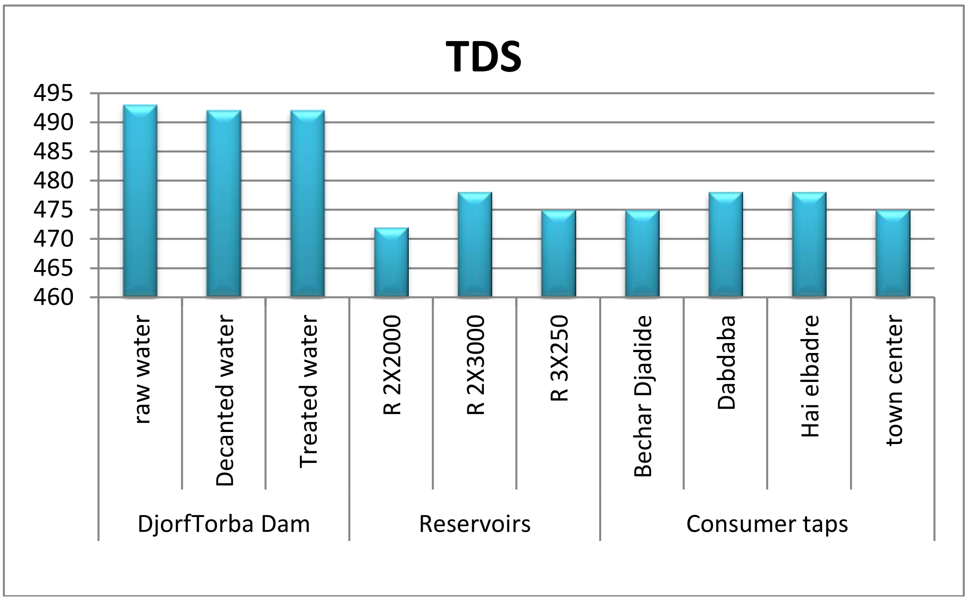

Figure 6. Variation of TDS in the waters of the town of Bechar

Total hardness (TH)

The total hardness obtained by the addition of calcium and magnesium levels expressed in French degrees (°f). The results of the water analyses carried out during this period (Figure 7) indicate a high hardness that sometimes exceeds 30°f in general; it varies between 38°f and 28.5°f for the waters of the Djorf-Torba Dam and between 30 and 30.1°F for reservoir and consumer tap water. The samples analyzed show that these waters are hard to very hard. This is due to the dissolution of the limestone formations with the increase in temperature. This high hardness would have no impact on the health of the consumer.

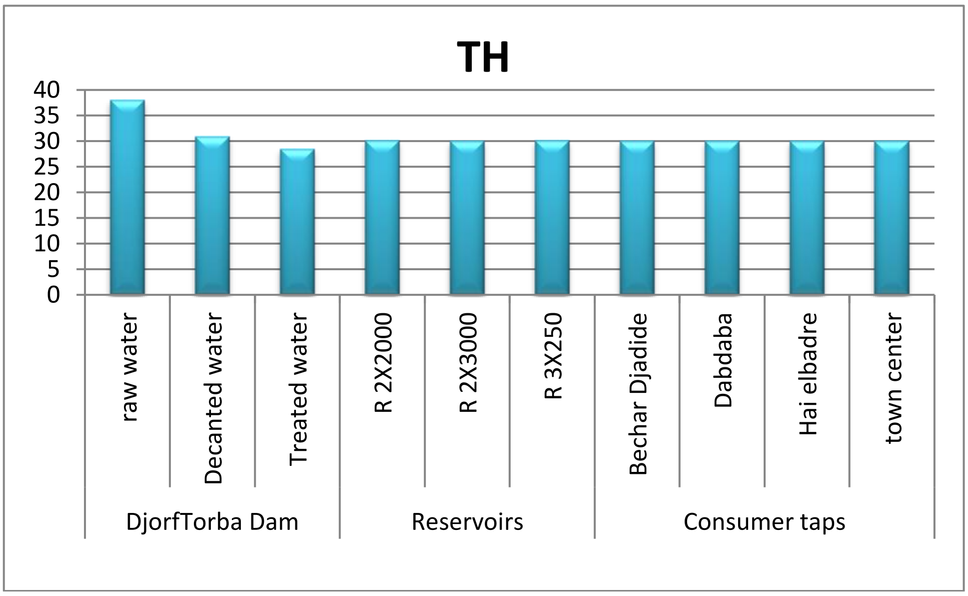

Figure 7. Variation of TH in the waters of the city of Bechar

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The sulphate content

The presence of sulphates is generally due to the dissolution of gypsum formations (CaSCL, $2H_2O$) and anhydrite ($CaSO_4$), they can also come from the oxidation of pyrite (FeS_2). Sulphate levels in the waters of the Bechar region (Figure 8) vary between 64.35 and 81.06 mg/1 for the DjorfTorba Dam, and between 55.58 and 69.7 mg/1 for the reservoir waters and between 58 and 58.26 mg/1 for the tap waters of the consumer. In general, 100% of the water tested has values in accordance with Algerian (200 to 400 mg/1) and WHO (250mg/l) standards.

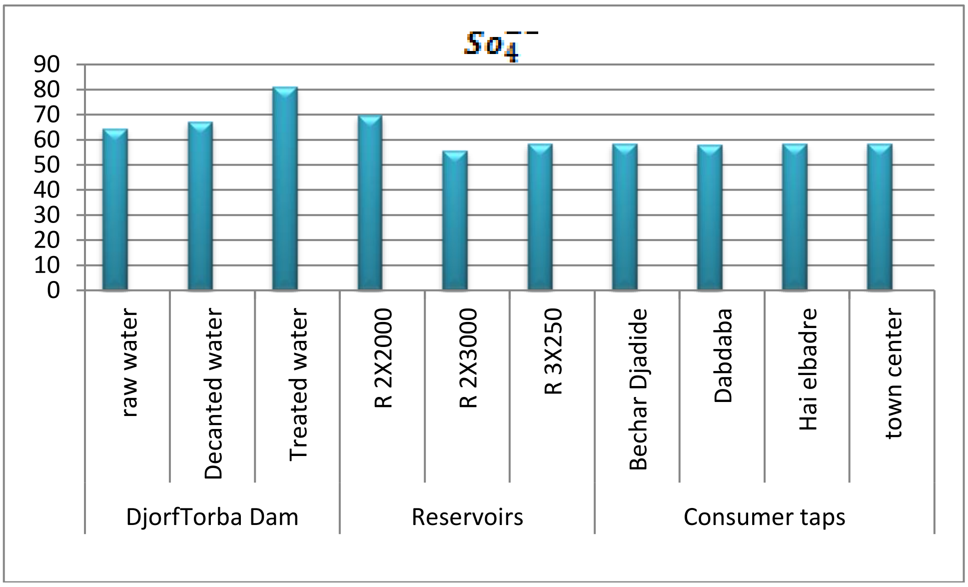

Figure 8. Variation of SO_4 of the waters of the city of Bechar

The chloride content

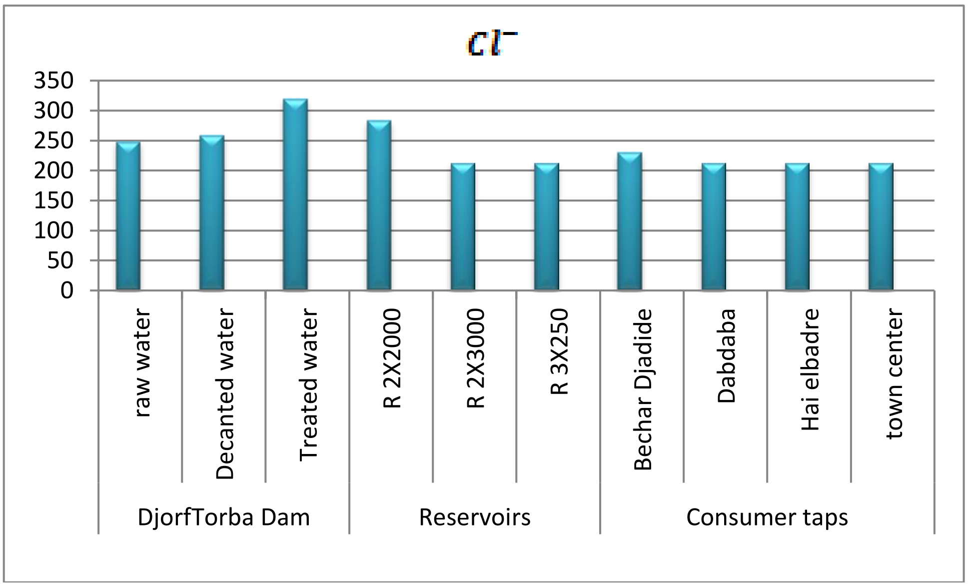

Figure 9. Variation de Cl^- des eaux de la ville de Bechar

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The natural chloride concentrations in surface waters depend on the chemical composition of the bedrock, the climate and the areas crossed by these waters. It results from the dissolution of natural salts such as sylvite (KC1) and Ehalite (NaCl). Chloride levels (Figure 9) range from 248.15 to 319.05 for the Djorf-Torba Dam and 212.7 to 283.6 for the reservoir and 212.7 to 230.42 mg/1 for the consumer's tap water. These values show normal amounts of chlorides are in accordance with Algerian and WHO standards. Some studies (Weinberg et al., 2011) have shown that even in the case of excessive amounts in drinking water, chlorides would not have adverse effects on the health of the consumer.

The nitrate content

Nitrates are one of the main causes of water quality degradation. They mainly come from agricultural pollution, domestic waste water, fertilisation by chemical or organic nitrogen fertilisers and intensive animal husbandry (animal waste). Nitrates themselves pose no particular health hazard; it is their transformation into nitrite in the stomach that can be toxic.
The waters analysed (Figure 10) have very low nitrate levels and do not exceed 10 mg/1, they vary between 0.06 and 0.75 mg/1, for the different types of water: the waters of the Djorf-Torba Dam, the waters of the reservoirs and the waters of the taps of the consumer.

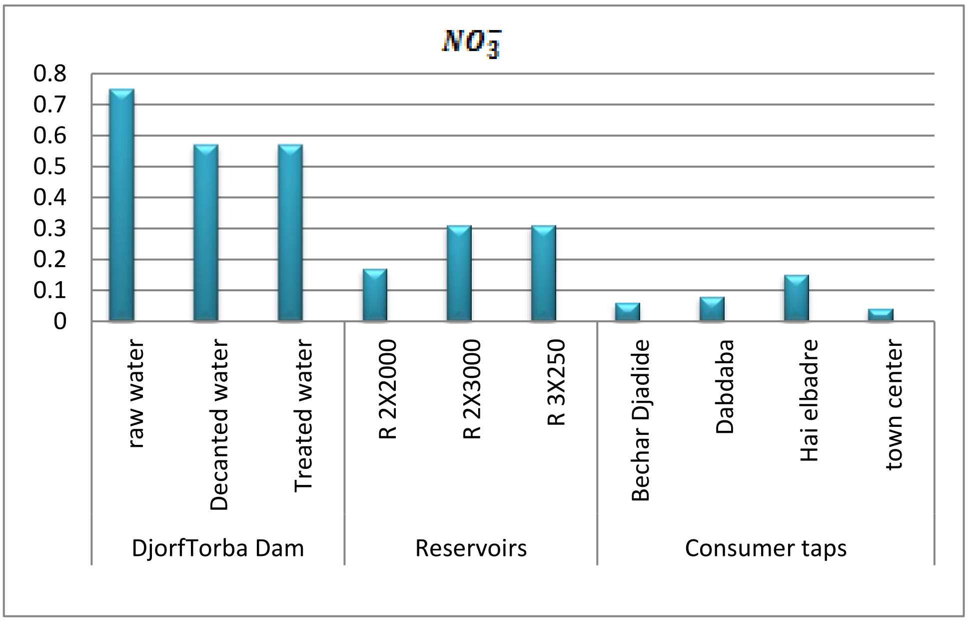

Figure 10. Variation of NO_3^- in bechar city waters

Calcium

Calcium is generally the dominant element of drinking water and its content varies mainly according to the nature of the terrain crossed (limestone or gypsum).
Adverse effects that are primarily organoleptic or aesthetic in nature resulting from the presence of calcium in drinking water can be attributed to its contribution to hardness (AWWA, 1990). The calcium levels in the waters analysed in the city of Bechar (Figure 11) are all below the maximum permissible concentration of 200 mg/1, as set out in Algerian standards (MRE, 2014), and that of the WHO for drinking water.

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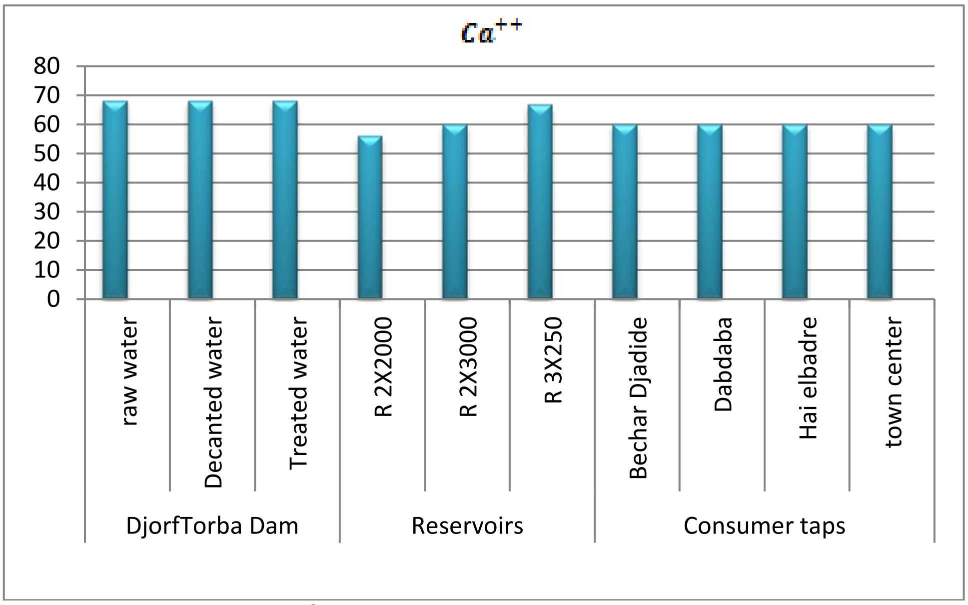

Figure 11. Ca^{2+} variation of the waters of the city of Bechar

The ammonium content

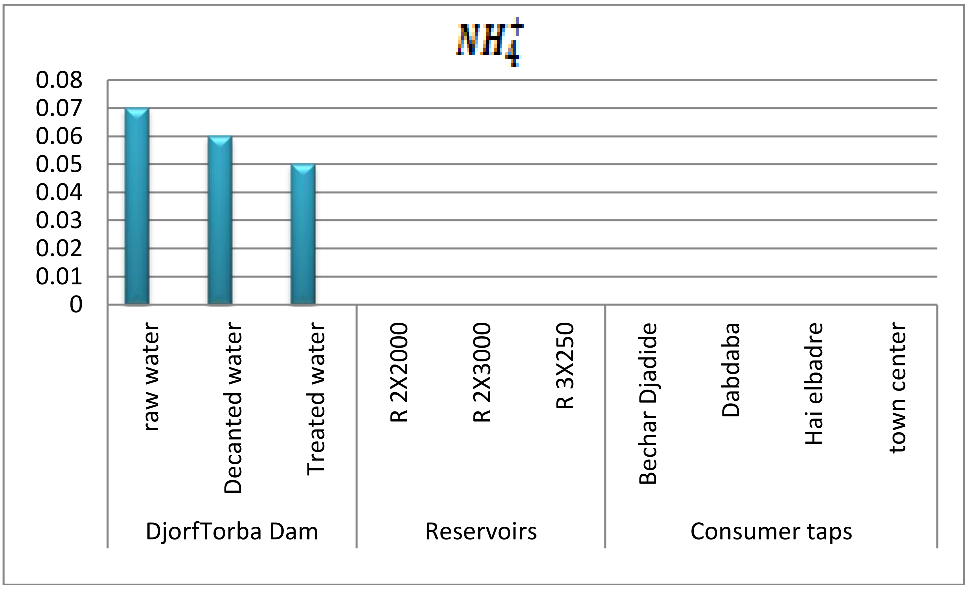

Figure 12. Variation of NH_4^+ in the waters of the town of Bechar

The presence of ammonium in water explains the existence of an incomplete degradation process of organic matter. It comes from the reaction of minerals containing iron with nitrates. It is therefore an excellent indicator of water pollution from agricultural, domestic and industrial organic waste.
The water samples from the town of Bechar (Figure 12) show that the ammonia nitrogen content varies between zero and 0.07 mg/1. In general, the results show values comply with Algerian (0.05 to 0.5mg/l) and WHO (0 mg/1) standards and show that there is treatment efficiency at the dam treatment plant.

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Trace metal elements

The metal trace elements (MTE) of the surface waters of the Djorf-Torba Dam of the Bechar region measured in the samples are limited to only two (Fe^{2+}) and (Mn^{2+}). The state of surface water pollution by trace metal elements was demonstrated by comparing the mean values of MTE with Algerian standards (MRE, 2014) and the World Health Organization's guiding values (WHO, 2011) for drinking water.

In the waters of Bechar city (Figure 13), iron levels range from 0.03 to 0.09 mg/1 for the waters of the DjorfTorba Dam and from 0 to 0.03 mg/1 for the reservoir waters and 0 for the tap waters of consumers. These results show values in accordance with Algerian (0.3mg/l) (MRE, 2014) and WHO (0.1 mg/1) standards (WHO, 2011) .

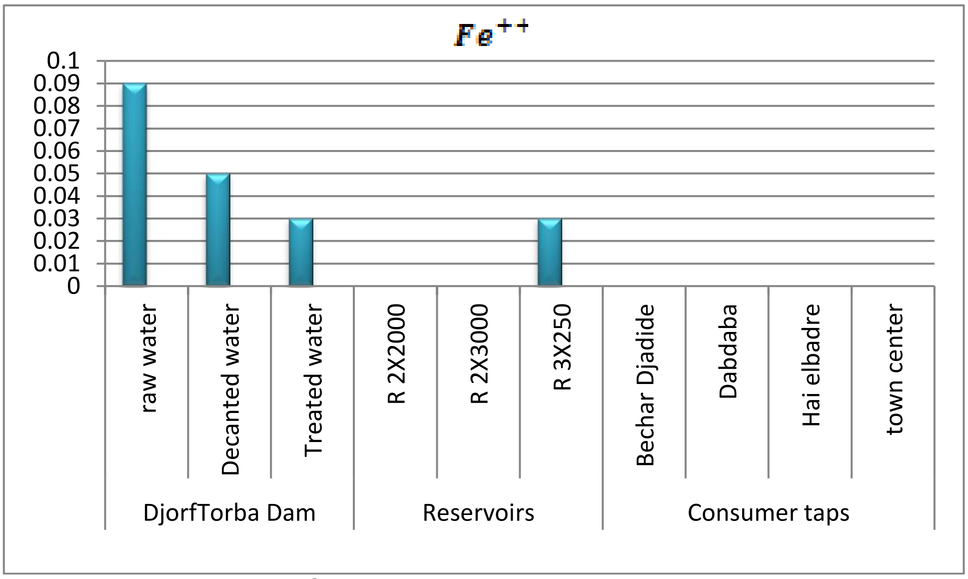

Figure 13. Fe^{2+} variation of the waters of the city of bechar

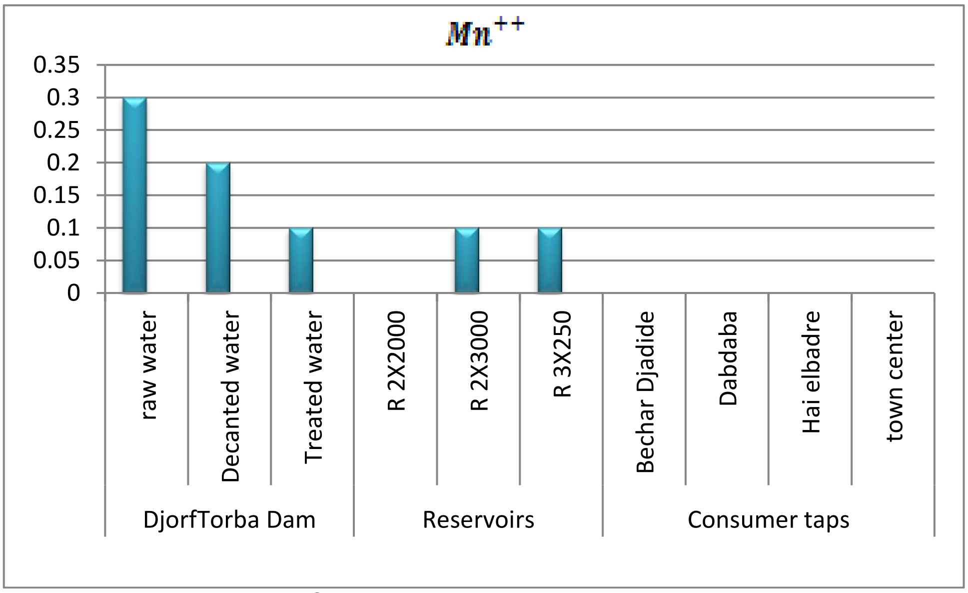

Figure 14. Mn^{2+} variation of the waters of the city of Bechar

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For manganese levels (Figure 14) vary between 0.1 and 0.3 mg/1 in the waters of the Djorf-Torba Dam, and between 0 and 0.1 in the reservoir waters, and 0 in the tap waters of consumers. The results conform to Algerian standards and reveal a slight exceedance of WHO standards, for the waters of the Djorf-Torba Dam, in the waters of reservoirs (MRE, 2014) (WHO, 2011). These values would have as the dissolution of the geological formations of the region, especially the rocks carbonates, oxides and silicates.

IV.3. Bacteriological parameters

The results of bacteriological analyses of drinking water from the city of Bechar are reported in Table 1:

Table 1. Bacteriological test results for the City of Bechar

Bacteriological settings	DjorfTorba Dam			reservoirs			Consumer taps			
	raw water	clarified water	treated water	***R 2X2000***	***R 2X3000***	***R 3X250***	BecharDjadide	***Dabdaba***	Hai elbadre	city centre
CSR	0	0	0	0	0	0	0	0	0	0
Total coliforms	0	0	0	0	0	0	0	0	0	0
Faecal coliforms	0	0	0	0	0	0	0	0	0	0
Escherichia coli	0	0	0	0	0	0	0	0	0	0
Faecal streptococci	0	0			0	0	0	0	0	0

The water of Bechar city has no germs. It’s clean water from a bacteriological point of view.

V. Water Quality Index

The Water Quality Index is a water classification criterion based on the comparison of water quality parameters with drinking water quality standards. It is used to summarize a number of data into a single number that represents a water quality level (Abbasi et al., 2012; Zamiche et al., 2018). This technique is used in this work to determine the impact of natural and anthropogenic factors on the water quality of the city of Bechar. To calculate the Water Quality Index, several steps are taken (Magesh et Al., 2013; Acharya et Al., 2018), a weight is assigned to each quality parameter based on its ratio of importance in overall water quality and its health effects, which is 2 to 5 (Çner et al., 2017)). A maximum value of 5 was assigned to nitrate (NO_3), a value of 4 for total dissolved TDS salts and pH, a value of 3 for iron (Fe^{2+}) and manganese (Mn^{2+}), and TAC, and a minimum weight of 2 for other parameters such as TH, SOf", Cl~, and NH. LQS values assigned to parameters are given in Table 2.

In a second step a relative weight (Wi) is calculated according to Formula 1, and the values obtained are given in the following table:

$$W_i = \frac{w_i}{\sum_{i=1}^{n} wi} \qquad (1)$$

With:

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Wi: is the relative weight;
wi: Weight assigned to each parameter;
n; the number of parameters.

Table 2. Relative weights of physico-chemical parameters

Parameters	Standards WHO	weight	relative weight m
pH	6,5-8,5	4	0.133
TDS	1000	4	0.133
TH	300	2	0.066
TAC	200	3	0.1
$S0_4$	200	2	0.066
CL	250	2	0.066
$N0_3$	50	5	1.66
NH_4	0.5	2	0.066
Fe	0.3	3	0.1
Mn	0.5	3	0.1
		$\sum w_i = 30$	2.484

Then, another factor called (quality rating scale $\boldsymbol{q_i}$) for each parameter is calculated by dividing the concentration of the element by its standard and multiplying the result by 100 according to the following equation 2.

$$q_i = \left(\frac{c_i}{s_i}\right) \times 100 \qquad (2)$$

With $\boldsymbol{q_i}$is the quality rating, $\boldsymbol{C_i}$is the concentration of each chemical parameter in each water sample in mg/1, and $\boldsymbol{S_i}$ is the Algerian water quality standard.
Finally, and for a final step before proceeding to the water quality index calculation, another Sl_i factor is calculated for each chemical parameter according to Equation 3, which is then used to determine the water quality index according to the following equations (Logeshkumaran et Al., 2015):

$$Sl_i = W_i \times q_i \qquad (3)$$

$$IQE\ (WQI) = \Sigma\ Sl_i \qquad (4)$$

With: Sl_i is a sub-index of the parameterized Iemme analyzed water quality. Then, the water quality under study will be determined according to the classification grid given in the following table.

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Table 3. Quality Classes by Water Quality Index IQE

settings		DjorfTorba Dam			reservoirs			Consumer taps			
		Raw water	Settled water	Treated water	*R 2X2000*	*R 2X3000*	*R 3X250*	*Bechar Djadide*	*Dabdaba*	*Hai elbadre*	City centre
PH	***Sli***	11.48	11.27	11.36	11.53	11.56	11.59	12.17	11,77	12.27	12.75
TDS	***Sli***	6.56	6.54	6.54	6.28	6.36	6.32	6.32	6.36	6.36	6.32
TH	***Sli***	0.84	0.68	0.63	0.66	0.66	0.66	0.66	0.66	0.66	0.66
TAC	***Sli***	0.58	0.55	0.55	1	0.75	0.75	0.55	0.55	0.55	0.55
$S0_4$	***Sli***	2.12	2.22	2.67	2.3	1.83	1.92	1.92	1.91	1.92	1.92
Cl	***Sli***	6.55	6.83	8.42	7.49	5.62	5.62	6.08	5.62	5.62	5.62
$N0_3$	***Sli***	2.49	1.89	1.89	0.56	1.03	1.03	0.2	0.27	0.5	0.13
NH_4	***Sli***	0.92	0.79	0.66	0	0	0	0	0	0	0
Fe	***Sli***	3	1.66	1	0	0	1	0	0	0	0
Mn	***Sli***	6	4	2	2	2	2	0	0	0	0
Fe	***Sli***	3	1.66	1	0	0	1	0	0	0	0
ISli= IQE		39.62	35.64	35.72	31.82	29.81	30.89	27.9	25.23	27.88	27.95

4. CONCLUSIONS

At the end of this study, which focused mainly on the assessment of the quality of the drinking water of the city of Bechar, it emerges that the all the parameters analysed comply with both national and international potability regulations.

The results obtained on the physical level have shown that the pH of these waters meets the standards, their degree of mineralization is average and their temperature is high because it is the ambient temperature of the region in May. From a chemical point of view, these waters are also within the norm in so far as their hardness is relatively high but without risk to the health of the consumer, their normal levels of calcium and chloride, and especially their levels of nitrates, which are known to cause adverse health effects, are very low in relation to the maximum permissible value.

Finally, the bacteriological results show that the drinking water of the city of Bechar is healthy and no germs are present.

The water quality index calculation shows that all waters are of excellent quality.

In conclusion, the waters of the city of Bechar can be considered good to consume so well on the disinfection operations (chlorination and others) are well performed. It would be desirable to carry out this type of studies on a regular basis based on physical and chemical evaluation, but we take into account the rehabilitation of EPA networks and reservoirs to solve the problems of organoleptic quality (tastes and smells).

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