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Quality control of raw and potable groundwater from the Gharb Aquifer, Mechraa Belksiri- Morocco

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ABSTRACT

Groundwater is formed by infiltration water and is free of pollution. However, it can be contaminated by the drawing technique, the proximity of latrines or other sources of pollution, the lack of protection. It can be loaded by the elements; brackish water (NaCl), hard water (Ca2 +) or Ferruginous (fe2+).

The main purpose of our study is the monitoring of quality parameters during the physicochemical treatment for the removal of iron and manganese from the groundwater of the Gharb aquifer by the Mechraa Belksiri station.

The results of the analyses carried out on the groundwater of the city of Mechraa BelKsiri show that they present exceedances compared to the limits set by the Moroccan standard. We highlight these exceptions for iron which exceeds 0,4 mg/l and manganese which exceeds the standard 0,1 mg/l up to 0,5 mg/l.

Even if the presence of iron and manganese in drinking water does not constitute a public health problem, the WHO prescribes, as a guideline value, an iron concentration equal to 0,3 mg/l, and 0,1 mg/l for manganese. These waters require treatments in order to make them of good quality and suitable for human consumption in order to avoid potential problems related to their presence. There are currently two conventional processes to eliminate them: biological processes and physicochemical processes.

Keywords: Groundwaters, Gharb, Physicochemistry, Potabilization, Kenitra, Morocco.

INTRODUCTION

Water is a renewable resource as evidenced by the well-known water cycle: evaporation, condensation, precipitation and runoff, then new evaporation and repetition of the cycle (Kirzner, 2001). From this perspective, the quantities of water should not be depleted.

However, we realize today that drinking water is not inexhaustible. The acceleration of population growth gives rise to a dizzying increase in drinking water consumption. In addition, they produce more and more agricultural and industrial waste that contribute to polluting water in a sometime irreversible way, especially in the absence of a wastewater treatment system, as is the case in several developing regions. It is therefore not because water stocks are disappearing that the issue of water becomes problematic, it is mainly because the polluting activities of humans, in the absence of sanitation networks, poison the water and in addition the resource is unevenly distributed geographically.

All living organisms contain water. In humans, water is the main component of the body. The body of an adult contains up to 70% water. Blood, for its part, contains 82% water, while some fruits, vegetables and marine animals are made up of 95% water (Roland, 2000). Water is essential for all living organisms since it contributes to the proper functioning of the body by facilitating blood circulation and respiration, transporting nutrients to cells and promoting the elimination of waste and toxins.

Drinking water is free of pathogenic germs (bacteria, viruses) and parasitic organisms and does not cause any health risks according to the World Health Organization (WHO, 1984). Its potability characteristics meet standards established either at the national or international level.

Water resources are becoming increasingly limited, fragile, threatened, not always of good quality and very irregular in time and space. Water is currently subject to constraints from climatic hazards and strong anthropogenic pressure. Morocco is particularly vulnerable to climate change, particularly in terms of its water resources, because of their scarcity, vulnerability, abnormal climate changes, their degree of severity and low adaptability.

The water issue is currently going through a difficult gestation. For this reason, studies in this area are already underway and require prolonged monitoring while respecting the imposed laws. The work of the hydrology services and basin agencies must be made available to the scientific community in order to validate them and take other paths, thus accelerating the process of sustainable development.

Our present work consists of the evaluation of the physicochemical quality, as well as the dosage of iron and manganese in the groundwater of the Gharb aquifer and finally a descriptive experimental study of the stages of treatment and potabilization of these waters in the Mechraa Belksiri station.

STUDY ENVIRONMENT

GEOGRAPHICAL AND SOCIO-ECONOMIC FRAMEWORK OF THE STUDY AREA

The study area is the Cercle of Mechraâ Bel Ksiri, which is part of the province of Sidi Kacem and includes six rural communes of Nouirate, Sidi Al Kamel, Rmila Sefsaf, Al Haouafate and Dar Laâslouji (Figure 1). It benefits from a privileged geographical location and considerable water and soil resources that have favored remarkable agricultural and agro-industrial development; with 16% of the national irrigation potential.

Bordered by the Oued Sebou near an irrigated area, the town of Mechraâ Bel Ksiri extends over an area of approximately 8 km2 (800 ha), it is located in the heart of the Gharb region at the crossroads between the North and the Saiss in the eastern corner of the latter.

CLIMATE

The climate of Mechraa Belksiri is continental, characterized by a dry period from April to October and a relatively humid period from November to March, with often irregular rainfall resulting in an annual average varying from 300 to 565 mm of rain on average per year. In summer, a hot and dry season, the area is influenced by West-East winds with certain periods of Chergui, particularly in July and August, while in winter, a cold and rainy season, with modal values in December (98 mm), November (90 mm) and January (82 mm). The average temperatures of Mechraâ BelKsiri vary from 28 to 30°C in summer and between 15 and 26°C in winter (McNeely et al., 1979). According to Emberger's classification (1952), Mechraâ BelKsiri has a coefficient which is equal to 59,66 and thus belongs to the upper semi-arid bioclimatic level.

POPULATION

The population of Mechraa BelKsiri is divided into urban and rural. The urban population consists mainly of a population looking for work from different regions of the country and this is due to the importance of the economic activity which has agro-industrial characteristics that the Circle contains. The rural population on the outskirts of the city of Mechraa BelKsiri is mainly composed of Gharb in the North of Sebou, which is also divided into two groups Beni Sefiane and Beni Malek. Beni Hessen in the South of Sebou which includes Wlad Mokhtar and Wlad Moussa.

Thus, the geographical, historical, economic and human context has made Mechraâ BelKsiri one of the most homogeneous and functional cities in the Kingdom, which has thus become a point of passage and concentration. The region has very diversified economic potential that contributes remarkably to its socio-economic development. These assets include agriculture, industry and tourism (ORMVAG, 2002).

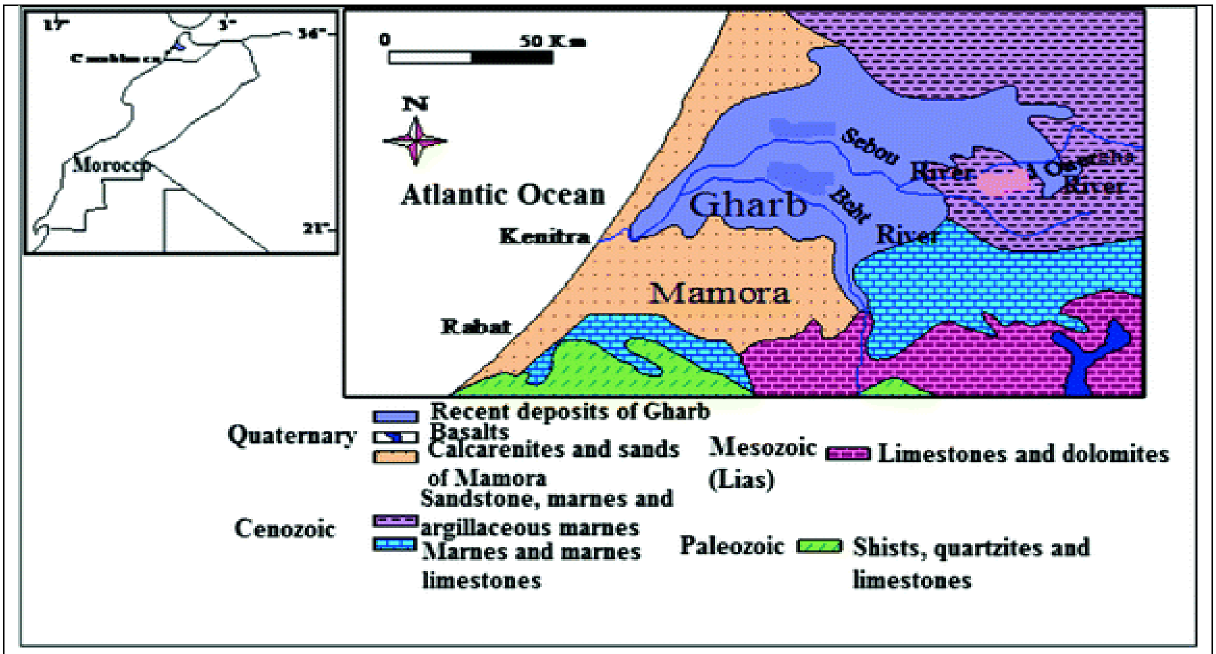


Figure 1: Gharb Aquifer.

TECHNIUES OF ANALYSES

SAMPLING TECHNIQUE

Taking a water sample is a very delicate operation to which the greatest care must be taken, it conditions the analytical result and the interpretation that will be given. The sample must be homogeneous, representative, and obtained without modifying the physicochemical characteristics. The analyses and sampling are done in the water treatment plant intended for human consumption which is located 6 km from the city of Mechraa BelKsiri.

The raw water comes from drilling on the groundwater of the Gharb aquifer and is stored in a 500 m3 tank. For treatment, the water passes through the station and is then taken up by three groups of electric pumps, each supplying a treatment line. A flow meter and a control valve are used to control and adjust the flow rate of each line.

Upstream of each line, air is injected into the water. The diffusion and mixing of the air throughout the liquid vein is carried out using a mixer equipped with baffles. The water thus aerated is admitted to the lower part of an oxidation tower and passes from bottom to top through a contact mass of volcanic origin (Pozzolan).

The excess air is evacuated at the top of the tower by an automatic purger. At the outlet of the oxidation tower, potassium permanganate in solution is injected into the water.

The injection is carried out using three dosing pumps, a fourth pump intended as a backup is connected to the network.

PHYSICO-CHEMICAL SAMPLING

We took a total of 50 samples including one sample for raw water from the Gharb aquifer and another for water treated by the treatment plant, every week for a month. Sampling for physicochemistry does not pose any particular problem. Plastic bottles are sufficient and the volume of the sample is one liter for a complete analysis. The sample can be kept for a few days but it was preferred to perform the dosage of chemical elements as soon as possible because elements such as nitrates can undergo changes during storage.

PHYSICO-CHEMICAL MEASUREMENTS IN THE LABORATORY

Physico-chemical analyses focus on the natural composition of water, its balances and the impurities that can contaminate it. Physico-chemical analyses are used to control the quality of water intended for human consumption.

To perform the physicochemical analyses, the following devices were used (**Figure 2**).

+Conductivity meter Inolab WTW series 720

+ pH meter Inolab WTW series 720

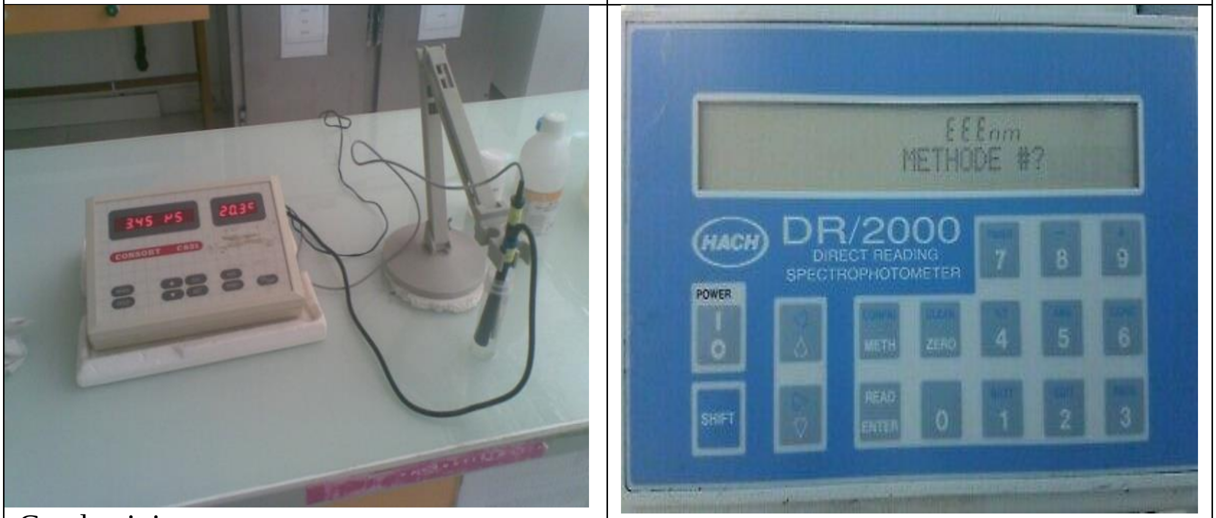
+ Spectrophotometer HACH DR/2000 (Programmable)

+ Turbidimeter 2100N HACH

+ GFL 5-seater oxidizability device.

pHmeter

Turbidimeter



Conductivimeter

Spectrophotometer

Figure 2 : Equipment for physicochemical water analysis.

TEMPERATURE

Water temperature is a comfort parameter for users, it also allows to correct the analysis parameters whose values are related to the Temperature. Moreover, by highlighting contrasts in the Temperature of water on a medium, it is possible to obtain information on the origin and flow of the water (McNeely et al., 1979).

The temperature is measured by a thermometer on site at the time of sample collection, the result is read when thermal equilibrium is established. It is expressed in degrees Celsius (°C).

HYDROGEN POTENTIAL (pH)

Hydrogen potential is one of the most important parameters in the physicochemistry of water. It controls several types of acid-base reactions, such as the measurement of $CO2$ and alkalinity.

pH also governs the chemical forms in which metals are found in water as well as the transition from one form to another (Rodier, 1996).

This parameter allows us to know if the water is corrosive or encrusting, pH measures the concentration of H+ ions in the water, it varies between 0 and 14.

The pH changes according to the temperature and is measured using colored indicators, or better, using a pH meter.

The electrode is rinsed with distilled water and wiped with a disposable tissue. The electrode is immersed in the solution to be measured to a minimum depth of four centimeters. The electrode is rinsed with distilled water and dried with a clean tissue to take the next measurement.

TURBIDITY

Turbidity is the reduction in the transparency of a liquid due to the presence of fine undissolved matter such as clays, silts, silica grains, organic matter, etc. It is immediately understood that there is a certain relationship between the concentration of suspended solids and the turbidity of water. Turbidity is measured precisely using a turbidimeter that works on the principle of nephelometry.

Turbidity measurement, the unit of which is: Nephelometric Turbidity Unit (NTU), must be done quickly after the sample is taken, otherwise the sample can be kept in the dark for a maximum of 24 hours.

Turbidity measurements are valuable indicators of water quality (Table 1). High turbidity measurements or fluctuation in measurements may indicate inadequate water treatment or a water quality problem (Le Chevallier et al., 1981).

Table 1: Common turbidity classes (Le Chevallier et al., 1981).

Turbidity (NTU)	Water class
NTU < 5	Clear water
5 < NTU < 30	Slightly Cloudy water
NTU < 50	Cloudy Water

CONDUCTIVITY

Conductivity measures the ability of water to conduct current between two electrodes. Most of the dissolved matter in water is in the form of electrically charged ions. Measuring conductivity therefore allows us to assess the quantity of salts dissolved in the water.

Conductivity is also one of the ways to validate physicochemical analyses of water; the value measured in the field must be comparable to that measured in the laboratory.

Conductivity is the inverse of resistivity, which is the resistance of a column of water, between two electrodes, with a section of 1 cm^2 and a length of 1 cm. It is expressed in (Siemens/cm) or (µSiemens/cm) (McNeely et al., 1979) (Table 2).

Table 2: Relationship between mineralization and conductivity according to regulations.

Conductivity	**Mineralization**
0-100 µS/cm	Very low mineralization
100-200 µS/cm	Low mineralization
200-333 µS/cm	Medium accentuated mineralization
333-666 µS/cm	Accentuated mineralization
666-1000 µS/cm	Significant mineralization
1000 µS/cm	High mineralization

THE COMPLETE ALKALIMETRIC TITRE (TAC)

Alkalimetric titer: Corresponds to the neutralization of all the hydroxide ions OH- and the transformation of half of the carbonate ions into hydrogen carbonates by a strong acid (HCL).

$TA = [OH^-] + 1/2[CO_3^{2-}]$

The dosage reaction is: **$CO_3^{2-} + H^+ \longrightarrow HCO_3^-$**

The complete alkalimetric titer (TAC): corresponds (Table 3) to the neutralization of all the hydroxide, carbonate and hydrogen carbonate ions by a strong acid (HCL).

$TAC = [OH^-] + [CO_3^{2-}] + [HCO_3^-]$

The dosage reaction is: **$HCO_3^- + H^+ \longrightarrow H_2CO_3$**

TA and TAC are generally expressed in French degrees (°F).

***TA measurement**

Generally TA = 0 for soft water, $7 < pH < 8,5$.

***TAC measurement**

If pH < 4,3; the solution is immediately red or orange: TAC = TA

If pH > 4,3; the solution is yellow: TAC is determined in the same way as TA.

1°F = 3,4 mg/l of OH- (hydroxide)

1°F = 6,0 mg/l $CO_3{}^{2-}$ (carbonate)

1°F = 12,2 mg/l of HCO_3^- (bicarbonate)

In an Erlenmeyer flask containing 100 ml of the sample, add 2 drops of helianthine, a yellow color is produced. The mixture is titrated with hydrochloric acid (N/10), until the helianthine turns orange-yellow. Let V (ml), necessary for the change.

Hence: **TAC = V (ml) x 4°F**; With V (ml) total volume of titrant poured

Table 3: Values of OH-, CO3, HCO3 ions as a function of TA and TAC.

Ions	**OH^-**	**CO_3^{2-}**	**HCO_3^-**
TA= 0	0	0	12,5TAC
TA < TAC/2	0	12TA	12,2(TAC-2TA)
TA = TAC/2	0	6TAC	0
TA> TAC/2	3,4(2TA-TAC)	12(TAC-TA)	0
TA = TAC	3,4 TAC	0	0

In the absence of orthophosphates, it can theoretically exist in non-pure waters carbon dioxide and three elements measured by the TA and TAC titers: HCO3, CO3, and OH.

Indeed, water cannot contain more than two of these elements in significant quantities, because one reacts with the other, thus pure waters can be presented according to the following compositions (Table 4):

Table 4: TA and TAC values as a function of pH

Constitution	**pH**	**TA**	**TAC**	**Remarks**
CO_3^{2-} alone	4,5	0	0	TAC =0
CO_2 with HCO_3^-	3,5 à 8,3	0	>0	HCO_3^- =TAC
HCO_3^- with CO_3^{2-}	>8,3	>0	>0	TA<TAC; CO^{2-}=2TA HCO_3^-=TAC-2TA
CO_3^{2-} alone	>8,3	>0	>0	TAC=2TA
CO_3^{2-} with OH^-	>8,3	>0	>0	TA>TAC/2 ; CO_3^{2-}=2(TAC-TA) ; OH^-= 2TA-TAC
OH^- alone	>9	>0	>0	OH^-=TA-TAC

HYDROMETRIC TITLE (TH)

The hardness of water represents the concentration of dissolved calcium or magnesium salts (Table 5). These bodies are hydrogen carbonates or sulfates to which chlorides must sometimes be added. There are several types of hardness:

+Temporary hardness: due to calcium and magnesium hydrogen carbonates.

+Permanent hardness: due to calcium and magnesium sulfates, and sometimes chlorides.

+Total hardness: equal to the sum of the two previous ones.

It is expressed in melliequivalent meq/l or in French degrees (°F).

Dosage by complexometric solution (or hydrotimetric solution). Add 5 ml of the buffer solution to 100 ml of water to be analyzed, then just a small amount of the erichrome black indicator, then titrate with the 0.02M complexon III solution.

EDTA (Ethylene-Diamine-tetra-Acetic) has the property of combining with calcium and then magnesium ions to form soluble compounds, chelates. The end of the dosage is detected by the blue color of the colored indicator (Net Indicator), being purple as long as the magnesium ions remain in the free state in solution.

Expressions of the results

TH = 1000*C*V1/V2

C: concentration in mol/l of the complexon solution III

V1: Volume of complexon III

V2: volume of sample to be assayed.

For C2 = 0,02 and V2 = 100 ml we have: **TH = V*0.4 in (meq/l)**

With V: Volume of the complex solution III

Table 5: Classification of water according to its hardness value.

Water Hardness	Concentration
Very Soft	0 - 1,4 meq/L
Soft	1,4 - 2,8 meq/L
Medium Soft	2,8 - 4,4 meq/L
Quite Hard	4,4 - 6,4 meq/L
Hard	6,4 - 8,4 meq/L
Very Hard	More than 8,4 meq/L

CALCIUM HARDNESS

Calcium is the main compound of hardness, it is present in a large number of minerals mainly limestone and gypsum.

All groundwater and surface spring waters contain, depending on the rock with which they have been in contact, calcium salts in solution. They generally represent a considerable part of the hydrotimetric title, and its titration is done by complexometry.

To 100 ml of water to be analyzed, add 5 ml of the sodium hydroxide solution (NaOH), an indicator spatula tip (Calcone) and titrate using EDTA until the change from pink to royal blue.

The concentration of Ca2+ is given by the following relationship:

[Ca2+] = Tb x 0,4 (meq/l)

[Ca2+] = Tb x 8 (mg/l)

With Tb = Burette drop in ml

MAGNESIAN HARDNESS

Magnesium is one of the most widespread elements in nature. It constitutes approximately 2,1% of the earth's crust. It is an essential element for growth. It acts as a plastic element in bone and as a dynamic element in enzymatic and hormonal systems. Magnesium is a significant element in water hardness. From a concentration of 100 mg/l and for sensitive subjects, magnesium gives an unpleasant taste to drinking water (RODIER, 1996).

$[Mg^{2+}] = TH – [Ca^{2+}]$ (meq/l)

$[Mg^{2+}] = TH – [Ca^{2+}]$ (mg/l)

OXIDABILITY BY POTASSIUM PERMANGANATE (KMNO4)

Oxidability or the permanganate index of water corresponds to the quantity of oxygen expressed in mg/l given up by the permanganate ion MnO4- and consumed by the oxidizable materials contained in a liter of water under the conditions defined by this standard.

The water to be analyzed is heated to 100°C in a boiling water bath in the presence of a known quantity of KMnO4 N/100 and in an acid medium for a given period.

Part of the permanganate is reduced by the oxidizable materials in the sample and the excess permanganate is determined by adding an excess of sodium oxalate solution, followed by titration of the excess oxalate with permanganate.

In a round flask, add 2 ml of concentrated sulfuric acid to 100 ml of the sample to fix the water. Then 10 ml of KMnO4 (N/100). Finally, place the flask in a water bath at 100 ° C for 13 min.

Then remove the flask and add 1 ml of sodium oxalate solution (N/10).

After complete discoloration of the sample, titrate it back with $KMnO_4$ until a persistent pink color appears.

Result expression: **Oxidizability = (Tb1-Tb2) * 0,8 mgO2 / l**

Note the volume of $KMnO_4$ added, i.e. Tb of each bottle (blank and water analyzed)

Tb1: Tb of burette of the blank sample.

Tb2: Tb of burette of water to be analyzed.

IRON

Iron (Fe) is the fourth most important element found in the Earth's crust. Mobile iron present in water oxidizes, is thus found in a less mobile form and precipitates as ferric iron. The concentration of iron in surface water is generally less than 0,5 mg/L. The growth cycle of water algae influences the concentration of iron in surface water (McNeely et al., 1979).

The presence of iron in groundwater has multiple origins. Iron, in the form of pyrite (FeS_2), is commonly associated with sedimentary rocks deposited in a reducing environment (marls, clays) and metamorphic rocks. Present in reduced form (Fe^{2+}), iron is oxidized by oxygen in the air and precipitates in ferric form when water is pumped $Fe^{2+} \longrightarrow Fe^{3+} + 1e^-$

The drilling slabs or wells are then colored brown/rust and people sometimes lose interest in the resource because using water loaded with iron for washing colors the laundry and, consumed directly or as an infusion, can have a strong taste.

The Kit method is often used in the station laboratory, it is not very precise, but it can detect the presence of iron in raw water, based on the reaction of iron (II) with the ferrospectral in thioglycolate buffer with the formation of a purple colored complex.

The iron concentration is read by placing the color plate in the slot on the lower right edge of the base until the sample with added reagent matches the color obtained in the blank test.

MANGANESE

Manganese is a metallic element found in many types of rocks and frequently in water. It is an essential element, in small amounts, for all living organisms. Manganese can accumulate and clog pipes or fittings, and come off as black flakes or sediments, giving the water an unpleasant appearance and taste (Manitoba,1987).

The presence of manganese in water is troublesome because it can give the water a blackish color, cause hydroxide deposits, and give it an unpleasant metallic taste.

The manganese removal treatment is done by oxidation to form a precipitate of manganese oxide or hydroxide that is separated from the water by filtration (demanganization of water).

The kit method is also used to determine the manganese load of water based on visual comparisons during the blank test. This method gives approximate results.

AMMONIUM

The ammonium ion, NH4+, is the reduced form of nitrogen. It mainly comes from the decomposition of natural proteins contained in phytoplankton and microorganisms. It can also come from the supply of treated urban effluents, industrial or agricultural waste. It is found in natural waters at concentrations that can vary from 0.1 to more than 10 mg/l.

Preparation of the standard range:

A stock solution of 100 mg/l of NH4+ is prepared from a mass m of NH4 CL and a daughter solution at 2 mg/l from which the following range is prepared:

100 ml of each standard is prepared. NH4+ in mg/l (0,00; 0,1; 0,5 and 1).

To 25 ml of each standard, add 1 ml of sodium citrate, 1 ml of phenol (reagent A) and 1 ml of cyanide dichlorides (reagent B) then let the color develop for at least 4 hours in the dark and pass to the spectrophotometer at λ = 630 nm, the calibration curve is already drawn from a commercial solution of known concentration (**Figure 3**).

The samples are treated in the same way as the standards, their concentrations are extrapolated from the curve.

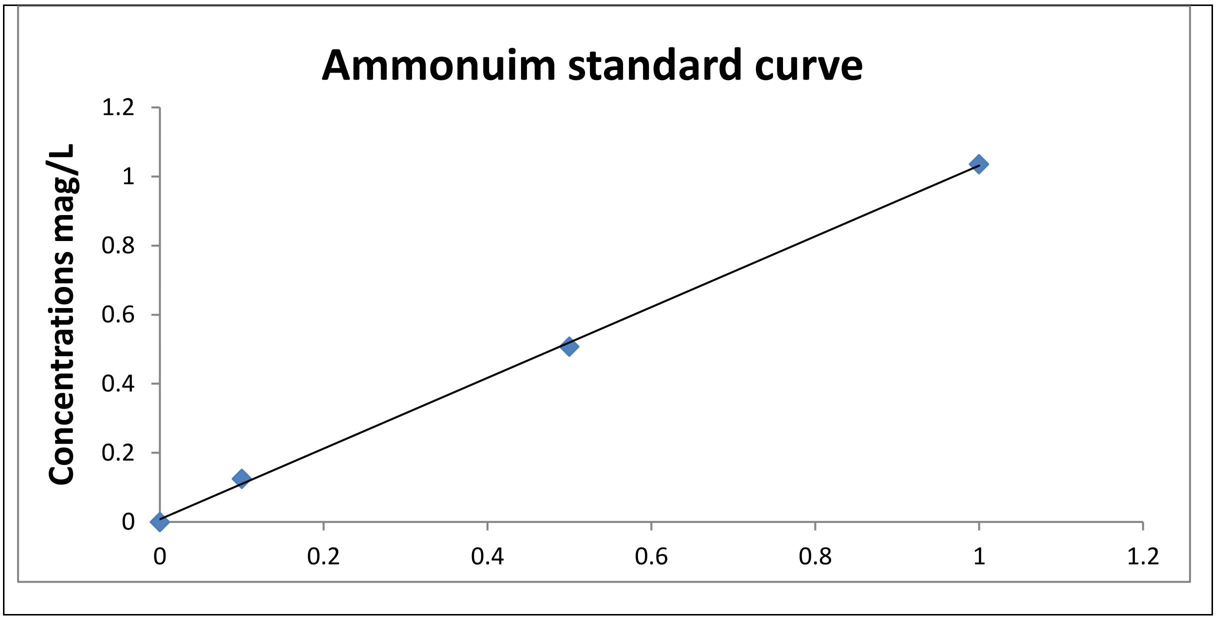


Figure 3: Calibration curve of ammonium.

NITRITES NO2-

Nitrite (NO2-) is present in its natural state. It is composed of nitrogen (N) and oxygen (O).

Nitrogen and nitrogen compounds, such as nitrite, occur naturally in air, soil, water and plants (Sanderson et al., 1997).

Under certain conditions, when there is insufficient oxygen, nitrate (NO3-) can be converted to nitrite. Consequently, many sources of nitrate can also be sources of nitrite.

Unstable nitrites are only maintained when the environment is not sufficiently oxidized; their presence indicates a critical state of organic pollution. Nitrites are the result of two processes:

- Incomplete oxidation of ammoniacal nitrogen (incomplete nitrification)
- Reduction of nitrates under the influence of a denitrifying action.

If the sample contains less than 1 mg/l of NO2-, 50 ml of the sample is placed in a 250 ml graduated flask; If the sample contains more than 1 mg/l of NO2- introduce an aliquot of the sample into a 250 ml graduated flask and fill to the mark with distilled water.

In the presence of sulfanilic acid, N (N-Naphthyl 1) diamine 1,2-ethane dichloride, or NED, forms a pink complex with nitrite ions whose intensity is proportional to the quantity of nitrites.

In a 250 ml tank containing water to be treated, add 1 ml of sulfanilamide and 1 ml of NED and homogenize the solution, wait at least 30 min and not more than 2 hours and measure the absorbance on the spectrophotometer at a wavelength of 540 nm. The calibration curve is already drawn from a commercial solution of known concentration (**Figure 4**).

Each standard solution is then passed through the column, the first 25 ml are discarded and the nitrites are determined on 25 ml of the remaining fraction. To this collected solution, 1 ml of sulfanilamide is added and the solution is left to stand for 2 to 8 minutes, then 1 ml of NED is added. The colour is allowed to develop for at least 30 minutes and at most 2 hours, after which the absorbance of each solution is measured at 540 nm. In addition, the calibration curve is already drawn from a commercial solution of known concentration. The same procedure is carried out for the samples.

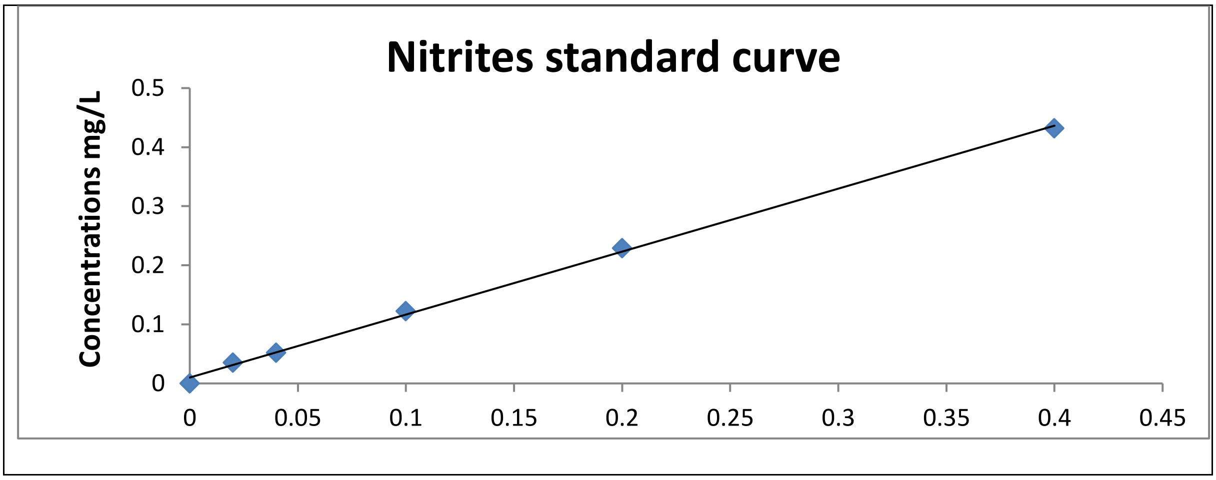


Figure 4: Calibration curve of nitrite.

NITRATES NO3-

Nitrates are almost quantitatively reduced to nitrites on a column containing amalgamated cadmium (Cd). The nitrates produced form a diazo compound with sulfanilamide, which, when coupled with N-(1-naphthylo) ethylenediamine, gives a characteristic coloration whose intensity is proportional to the amount of nitrate. It is preferable to use unfixed samples stored at 4 °C. If the fixed samples are analyzed, the pH is adjusted to 7 with sodium hydroxide before the assay. The reactions involved are:

$$Cd \longrightarrow Cd^{2+} + 2\ e^-$$

$$NO3^- + 2H^+ + 2\ e^- \longrightarrow NO_2^- + H2O$$

$$Cd + 2H^+ + NO3^- \longrightarrow NO_2^- + H2O + Cd^{2+}$$

Vegetables and cold cuts are the main source of nitrates in our diet, before water. Nitrates are an undesirable substance in large quantities but not toxic. The quality limit is set at 50 mg/l. Once ingested, nitrates can be transformed into nitrites and cause toxicological problems.

Nitrites react with the blood and prevent the transport of oxygen (like carbon monoxide): adults have defenses that quickly restore the situation, but this is not the case for infants and the elderly. Nitrates can also produce carcinogenic substances.

Preparation of the column

Weigh 60 g of cadmium and wash with hydrochloric acid HCl (2N) then with distilled water several times. Then add 200 ml of 2% CuSO4 to the cadmium and leave it in contact for 5 to 10 minutes until the blue color disappears. This solution is poured and 200 ml of CuSO4 are added again and left in contact until a brown suspension develops on the Cd grains. Rinse with distilled water several times (at least 10 times).

At the bottom of the column, a piece of glass wool is introduced and then the Cd is introduced using distilled water so that there are no air bubbles. The column is filled with 400 ml of diluted buffer solution.

Using dilutions, a series of standard solutions are prepared in 50 ml flasks with the concentrations indicated in the following table 6:

Table 6: Standard nitrate solutions

Flasks	1	2	3	4	5
Concentration mg/l	0,00	0.05	0,1	0,2	0,5

In each flask 1,25 ml of concentrated buffer solution is added. Each standard solution is then passed through the column, the first 25 ml are discarded and the nitrites are determined on 25 ml of the remaining fraction. To this collected solution, 1 ml of sulfanilamide is added and the solution is left to stand for 2 to 8 minutes, then 1 ml of NED is added. The colour is allowed to develop for at least 30 minutes and at most 2 hours, after which the absorbance of each solution is measured at 540 nm. In addition, the calibration curve is already drawn from a commercial solution of known concentration (**Figure 5**). The same procedure is carried out for the samples.

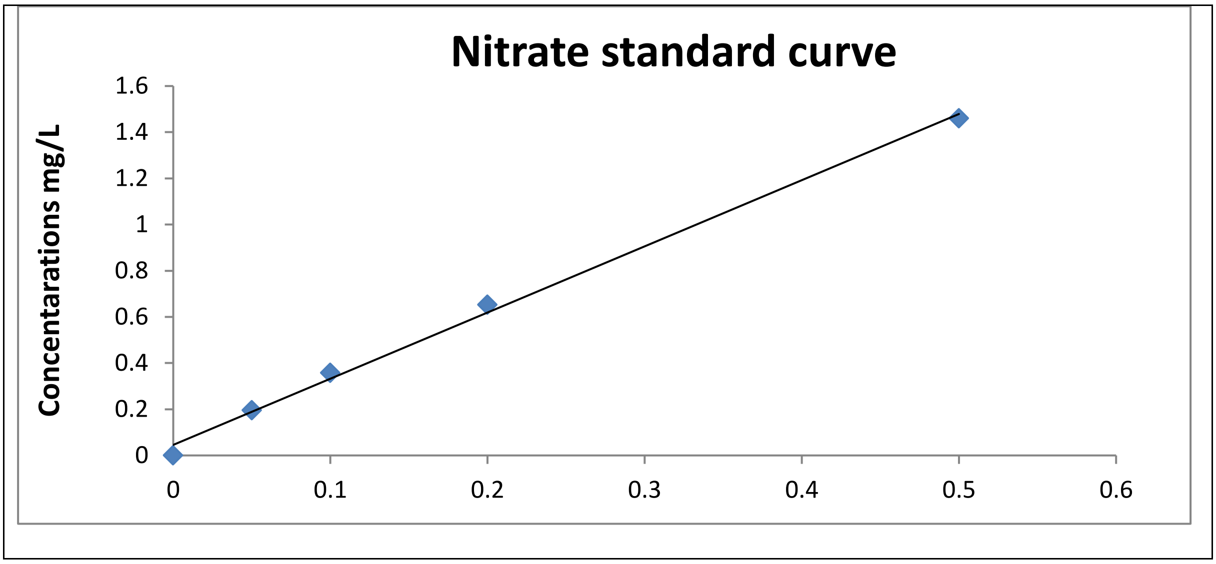


Figure 5: Nitrate calibration curve.

SULFATES SO_4^{2-}

Sulphate (SO42-) is composed of sulphur (S) and oxygen (O). This element occurs naturally in soil and rock. In groundwater, most sulphates come from the dissolution of minerals such as gypsum and anhydrite. Artificial sources include industrial discharges and fossil fuel deposits.

They are found in the form of magnesium sulphates and in calcium form in hard water. At high concentrations, they can cause gastrointestinal disorders (especially in children). They can also give the water an unpleasant taste (TARDAT, 1992).

Place 100ml of water to be analyzed (or a smaller volume that is extended to 100ml, if the sulphate concentration exceeds 80mg/l) in a 250ml Erlenmeyer flask. Add exactly 5 ml of reagent to the hydrochloric acid, stir. While continuing to stir, add a full spatula (about 0.5 g) of barium chloride crystals. Start the stopwatch at the same time. Stir for exactly 1 minute at constant speed. Immediately measure the turbidity, the amount of turbidity formed is proportional to the sulfate concentration. The calibration curve is already drawn from a commercial solution of known concentration (**Figure 6**).

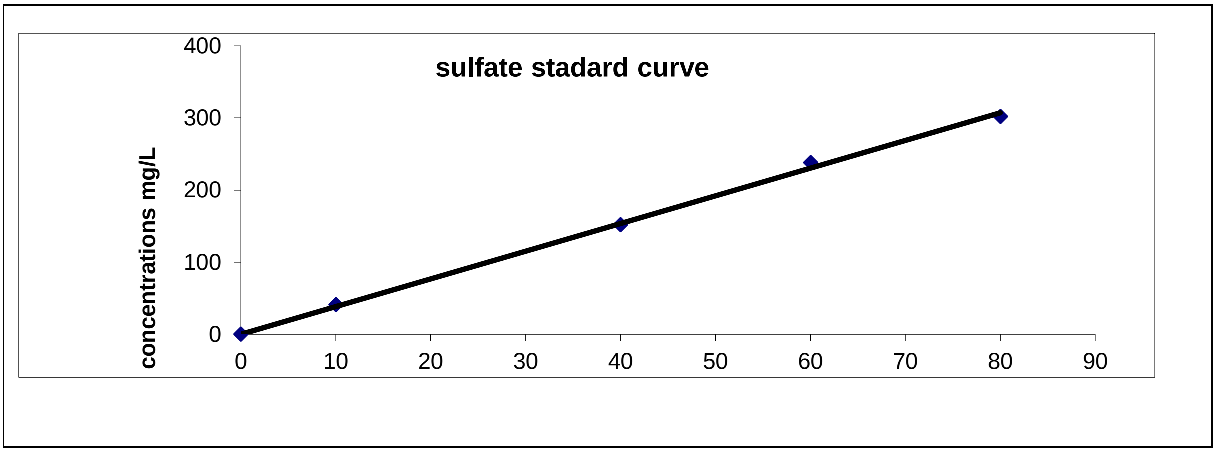


Figure 6: Sulfate calibration curve.

CHLORIDES Cl-

The chloride (Cl-) content of water is extremely varied and mainly linked to the nature of the terrain crossed. Thus, unpolluted running water often has a chloride content generally lower than 25 mg/L, but in some regions, crossing saliferous marls can lead to exceptional contents of 1000 mg/L.

The disadvantage of chlorides is the unpleasant taste that it imparts to water from 250 mg/L, especially when it comes to sodium chlorides. However, the presence of other ions in the water can influence the taste in combination with chlorides, so for an equivalent quantity of chlorides, the taste can be less marked in the presence of Calcium and Magnesium. They are also likely to cause corrosion in pipes and tanks, particularly for stainless steel elements, for which the risks increase from 50 mg/L (McNeely et al., 1979).

The WHO recommends a guide value of 250 mg/L for the chloride content in water intended for human consumption (drinking water). This is for taste considerations of the risks of corrosion of pipes and tanks; the directives of the Council of the European Communities indicate a guide level of 25 mg/L. French regulations set a limit value of 200 mg/L.

This is a volumetric dosage in an acid medium (HNO3) using a mercuric nitrate solution, in the presence of a pH indicator. In an Erlenmeyer flask, 100 ml of water to be analyzed, 7 drops of pH indicator are introduced, then nitric acid (HNO3 N/3) is added drop by drop until a yellow color is obtained, 3 drops of excess are added, titrated with the mercuric nitrate solution (HgNO3 N/10) until the first violet tint appears, persistently formed.

The chloride concentration is given by the following relationship:

[Cl-] = Tb * 35,5 mg/l (Tb: Burette drop).

RESULTS OF PHYSICO-CHEMICAL PARAMETERS

The results obtained from the analyses carried out are illustrated in table 6. Water temperature is an important factor in the aquatic environment because it governs almost all physical, chemical and biological reactions (CHAPMAN and KIMSTACH, 1996). Certainly, any sudden variation in this parameter causes a disturbance in the balance of the aquatic ecosystem. In our study, we noted that the temperature of the raw water remains almost constant. There is a slight increase in the temperature value for treated water compared to raw water, this can be explained by the reactions that the water undergoes during treatment.

pH measures the concentration of H+ protons contained in water, and therefore the acidity or alkalinity of the water on a logarithmic scale from 0 to 14. This parameter influences most chemical and biological mechanisms in water. Usually, pH values are between 6 and 8.5 in natural waters (CHAPMAN and KIMSTACH, 1996). It decreases in the presence of high organic matter contents and increases during low water periods, when evaporation is significant (MEYBECK et al., 1996).

Table 6: Temperature of raw and purified water.

Samples	**Raw Water (°C)**	**Treated Water (°C)**
1	22,1	22,6
2	22	22,7
3	22	22,1
4	21,9	22,1
5	22	22,2
6	21,9	22,1
7	22	22,1
8	21,9	21,8
9	21,8	21,9
10	21,9	22,3
Min	21,8	21,8
Max	22,1	22,7
Mean	21,95	22,19
standard deviation	0,0849	0,2806

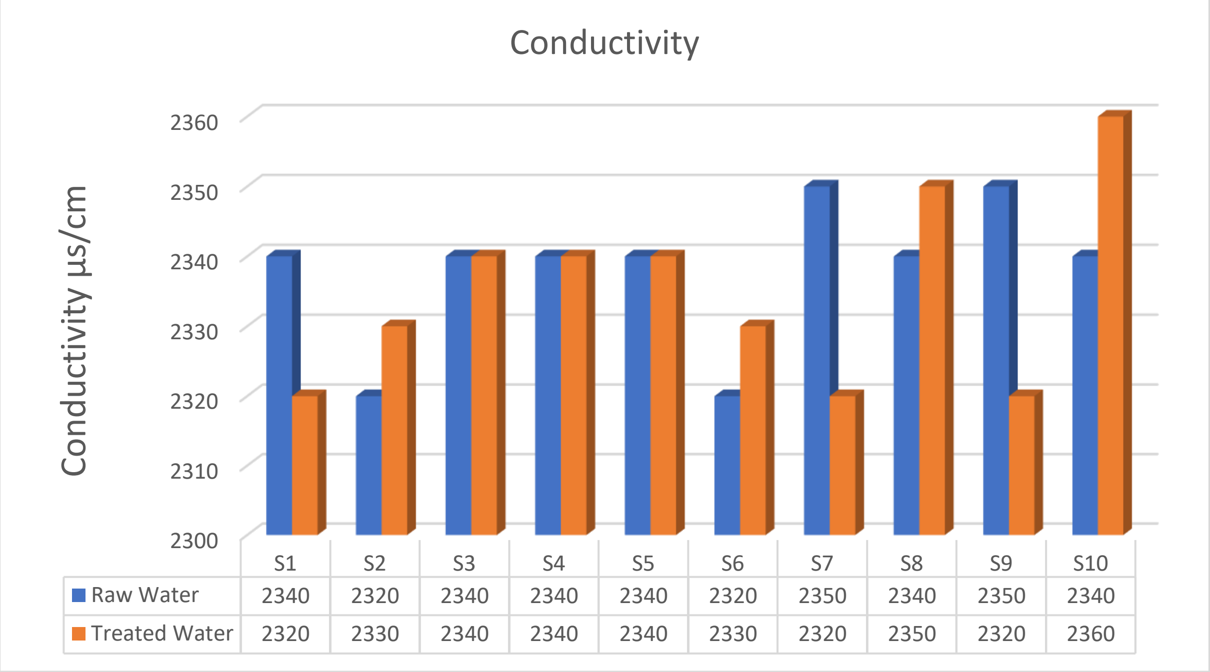
The pH values of the waters of the Gharb de Mechraa BelKsiri aquifer of raw water vary from 7,02 to 7,4. While the pH of the treated water varies from 7 to 7,26.

The values obtained are close to neutrality, so referring to Moroccan standards (pH between 6,5 and 8,5) for drinking water, 100% of the water analyzed is compatible with human consumption and does not require pH correction. Turbidity varies during the study from 3,65 to 1,2 NTU for raw water and from 0,13 to 0,45 NTU for treated water. The normal rate is set at 5 NTU according to Moroccan potability standards.

For drinking water, turbidity can occur naturally and be caused by suspended matter such as mud, clay, very fine organic and inorganic matter, as well as microorganisms. According to this survey, we note that 100% of the water has low turbidity levels and complies with Moroccan standards.

Electrical conductivity refers to the ability of water to conduct a current. During our study, conductivity values vary between 2320 and 2350 µs/cm for raw water and 2320 to 2360 µs/cm for treated water. The maximum admissible value (MAV) is set at 2700 µs/cm according to Moroccan standards of potability. According to this study, it can be seen that these values always remain stable and lower than the maximum admissible value (**Figure 7**).

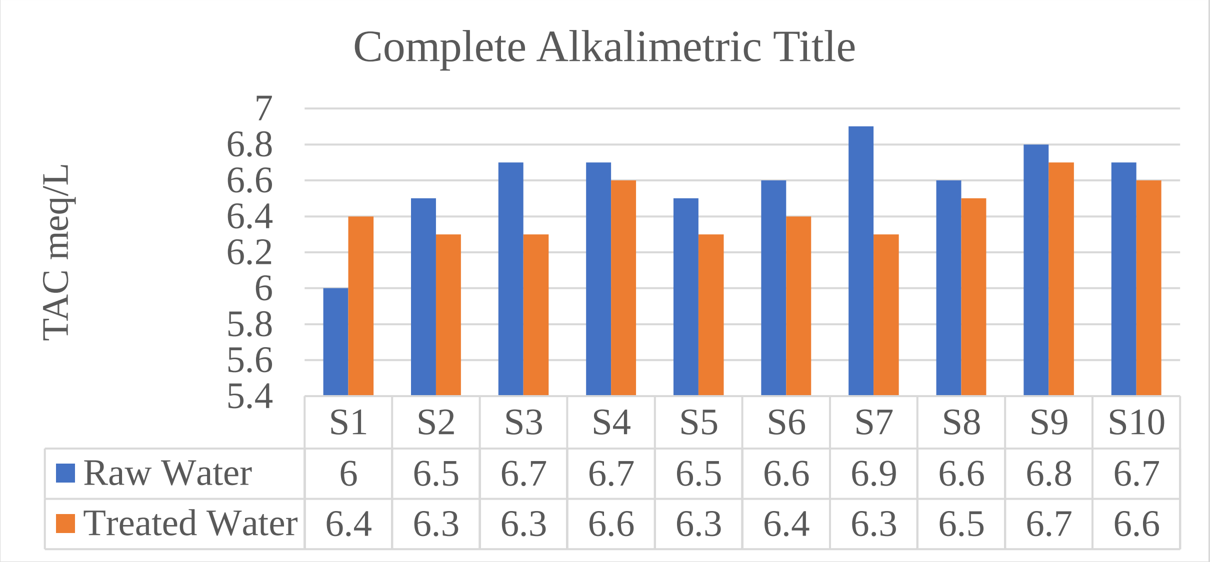
The high content of this parameter is explained by the high content of chloride ions (Cl-), and the high mineralization due to the contact of these groundwaters with rock formations. It is also noted that the values of raw water generally coincide with those of treated water, so we can say that treatment by oxidation followed by filtration does not influence conductivity.



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
■ Raw Water	2340	2320	2340	2340	2340	2320	2350	2340	2350	2340
■ Treated Water	2320	2330	2340	2340	2340	2330	2320	2350	2320	2360

Figure 7: Variation of conductivity as a function of raw water and treated water sampling.

The total alkalimetric titer of water varies during the study from 6 meq/l to 6,9 meq/l for raw water and from 6,3 meq/l to 6,7 meq/l for treated water. The TAC is an indicator factor of the presence of carbonate, bicarbonate and hydroxide ions. The values obtained are generally stable, and based on pH values which are always lower than 8,3 (TA=0), then the TAC values only represent the bicarbonate concentrations (**Figure 8**).



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
■ Raw Water	6	6.5	6.7	6.7	6.5	6.6	6.9	6.6	6.8	6.7
■ Treated Water	6.4	6.3	6.3	6.6	6.3	6.4	6.3	6.5	6.7	6.6

Figure 8: Variation in the TAC of raw and treated water from the Gharb aquifer.

The Hydrotimetric Title (TH) represents the content of alkaline earth metal salts (calcium, magnesium, strontium and barium salts) in water. Since strontium and barium are often present in water in trace amounts, the total hardness is reduced to its concentration in calcium and magnesium ions.

During our study, the TH values range from 10,56 to 11,88 meq/l for raw water and from 10,09 to 11,04 meq/l for treated water. According to these results, we can see that the values obtained are greater than 8,5, so the waters of the Gharb aquifer are very hard waters, thus this can be explained by the contact of groundwater with rock formations containing bivalent metals (Mg2+, Ca2+, etc.) responsible for this hardness (**Figure 9**).

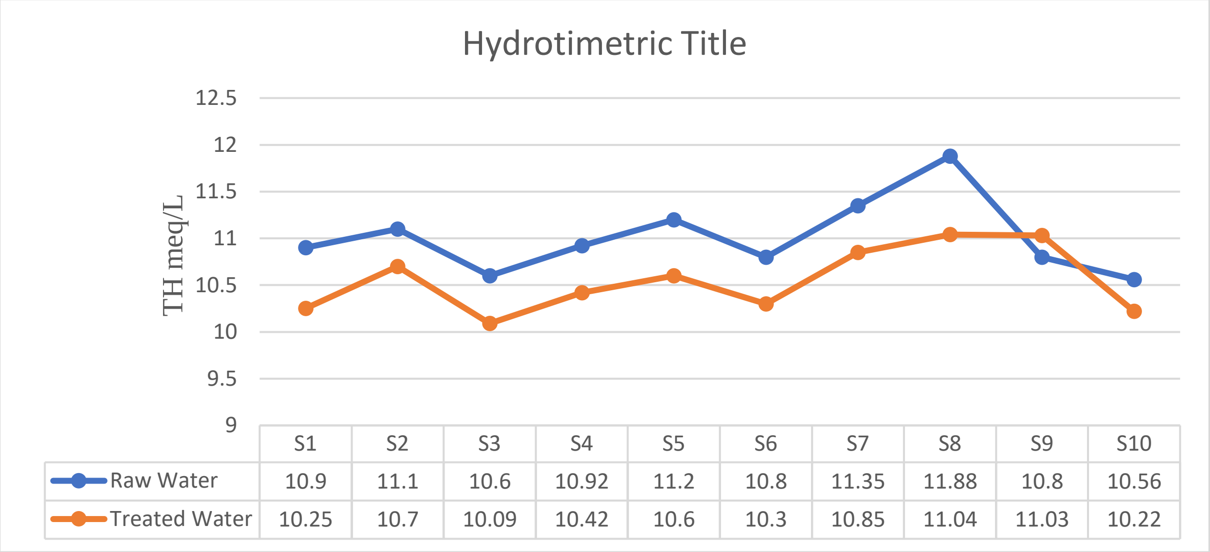


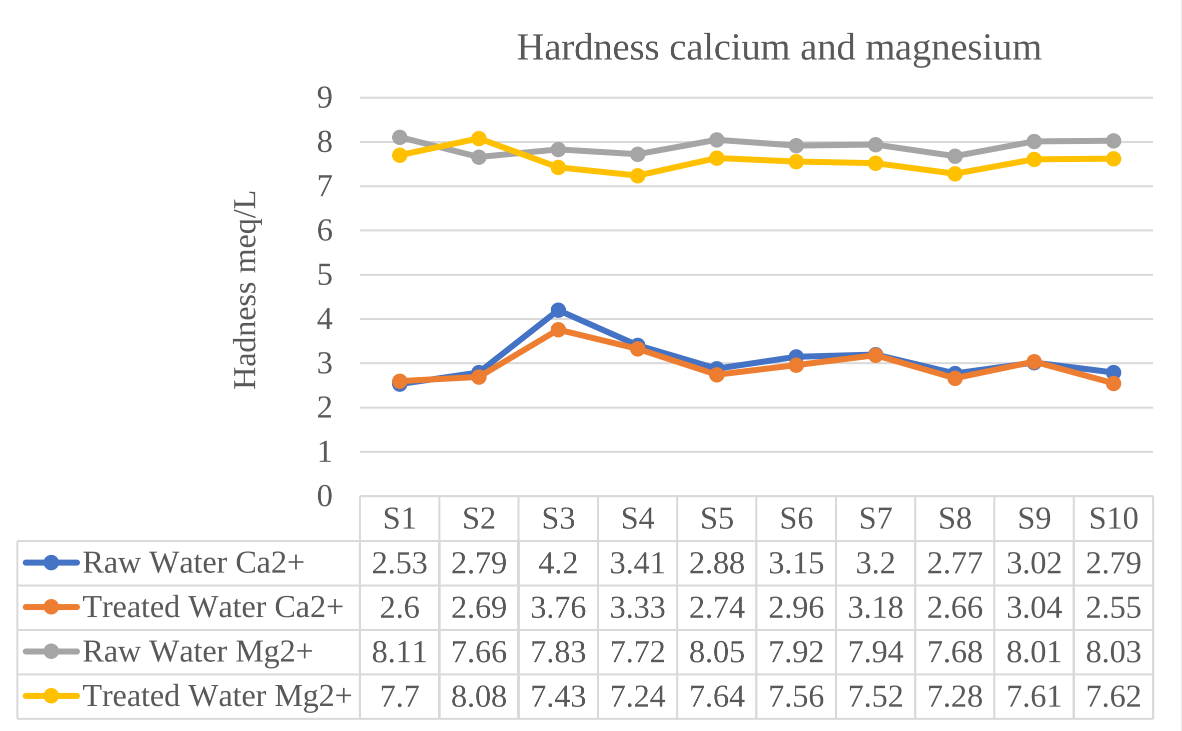
Figure 9: Variation of TH of raw and treated water.

During our study, calcium hardness values ranged from 7,66 to 8,11 meq/l for raw water and from 7,24 to 8,08 meq/l for treated water. This high Ca2+ content can explain the high total hardness (TH).

During our study, the magnesium hardness values varied from 2,53 to 4,2 meq/l for raw water, and from 2,55 to 3,76 meq/l for treated water. This high concentration of Mg2+ can also justify the high total hardness (TH) (**Figure 10**).

The oxidizability by dissolved KMnO4 varies during the study from 0,95 to 1,2 mg/l of O2 for raw water and from 0,61 to 0,72 mg/l of O2 for treated water. The normal rate is set at 2 mg/l of O2 according to Moroccan standards of potability.

These contents are generally stable and in accordance with Moroccan standards of potability, and this means that these waters are characterized by the absence of any organic and mineral pollution, because a high content of organic matter should always lead to suspicion of microbial contamination.

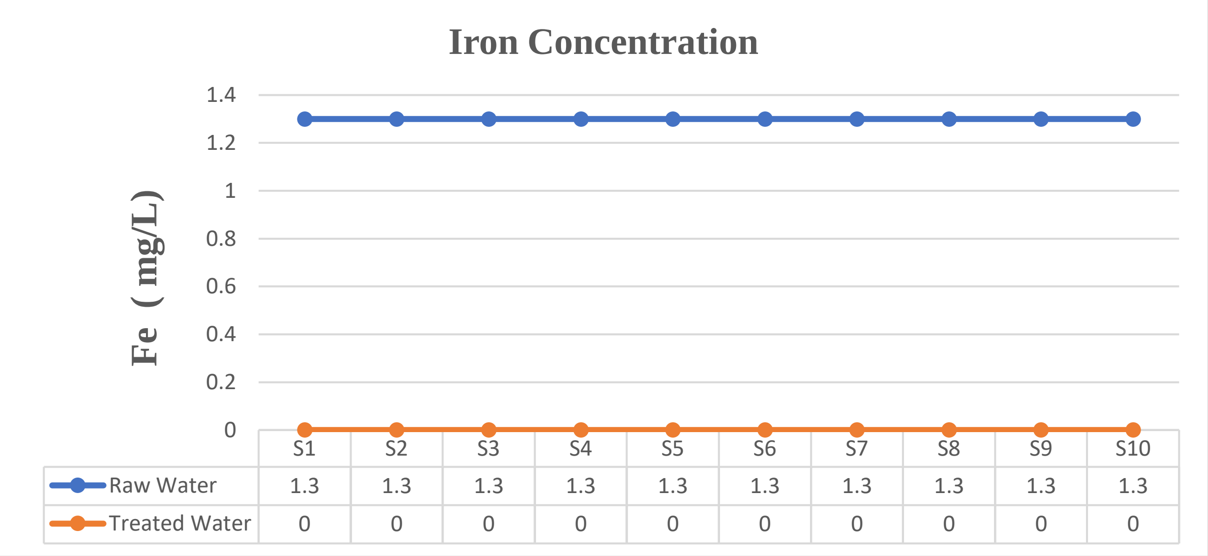


	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Raw Water Ca2+	2.53	2.79	4.2	3.41	2.88	3.15	3.2	2.77	3.02	2.79
Treated Water Ca2+	2.6	2.69	3.76	3.33	2.74	2.96	3.18	2.66	3.04	2.55
Raw Water Mg2+	8.11	7.66	7.83	7.72	8.05	7.92	7.94	7.68	8.01	8.03
Treated Water Mg2+	7.7	8.08	7.43	7.24	7.64	7.56	7.52	7.28	7.61	7.62

Figure 10: Variation in calcium or magnesium hardness depending on the samples of raw and treated water.

The iron concentration is 1,3 mg/l for raw water and 0 mg/l for treated water. Its normal rate is set at 0,3 mg/l according to Moroccan standards of potability (**Figure 11**).

The iron levels in the waters of the Gharb aquifer exceed the standards at the level of raw water, however the treated water always reaches the zero value and this is considered as a witness to the efficiency of the deferitization - demanganese station of Mechraa BelKsiri. The iron removal efficiency is 100%.

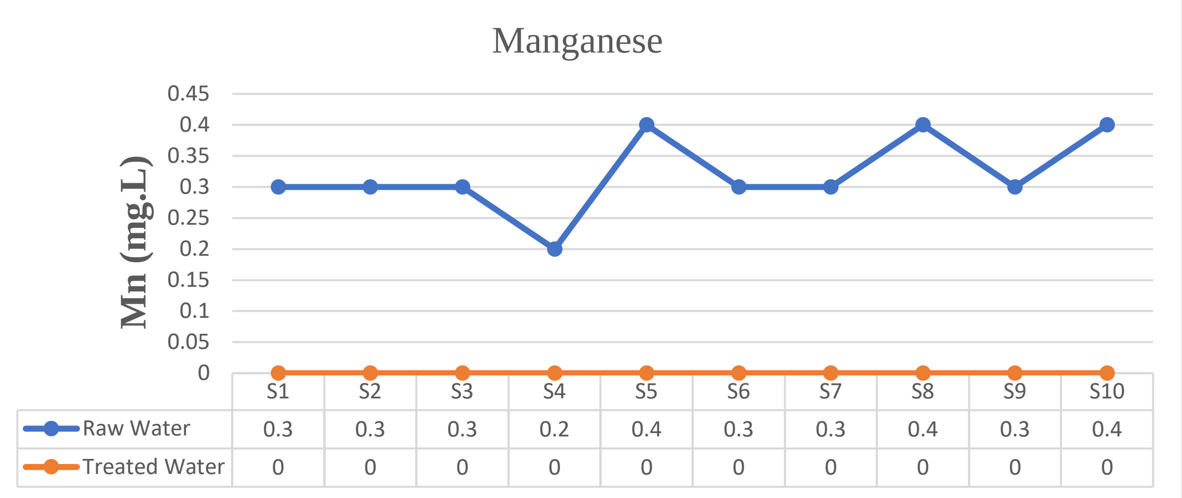


	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Raw Water	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Treated Water	0	0	0	0	0	0	0	0	0	0

Figure 11: Variation of iron concentration depending on raw and treated water.

The manganese concentration varies during our study from 0,2 to 0,4 mg/l for raw water, and is zero for treated water. The normal rate is set at 0,1 mg/l according to Moroccan standards of potability (**Figure 12**).

Manganese concentrations exceed the standards at the level of raw water of the Gharb aquifer, however the treated water always reaches the zero value and this is considered as a witness to the efficiency of the Machraa BelKsiri demanganese treatment plant. The manganese removal efficiency is 100%.



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Raw Water	0.3	0.3	0.3	0.2	0.4	0.3	0.3	0.4	0.3	0.4
Treated Water	0	0	0	0	0	0	0	0	0	0

Figure 12: Variation in manganese concentration depending on raw and treated water.

Ammonium is the product of the final reduction of nitrogenous organic substances and inorganic matter in water and soil. It also comes from the excretion of living organisms and the reduction and biodegradation of waste, without neglecting the contributions of domestic, industrial and agricultural origin. This element exists in small proportions of less than 0,1 mg/l of ammoniacal nitrogen in natural waters. In surface waters, it comes from nitrogenous organic matter, and gas exchanges between water and the atmosphere (CHAPMAN and KIMSTACH, 1996).

During our study, ammonium values range from 0,99 to 1,18 mg/l with a mean of 1,13 mg/l (±0,07) for raw water and equal to 0 mg/l for treated water. The normal rate is set at 0,5 mg/l according to Moroccan potability standards, so these values always remain lower than the maximum admissible value. This can be justified by the presence of a sufficient quantity of oxygen which promotes the nitrification operation (transformation of ammonium into nitrites then into nitrates).

The nitrite content varies during the study from 0 to 0,001 mg/l with a mean of 0,002 mg/l (±0,004) for raw water and becomes equal to 0 mg/l for treated water. The normal nitrite rate is set at 0,1 mg/l according to Moroccan standards of potability.

Since nitrite is toxic to the human body, its presence in significant quantities degrades the quality of the water. The toxicity linked to nitrite is very significant because of their oxidizing power.

Although the Gharb area is known for its agricultural activities, nitrite levels remain low and in compliance with standards, and this is due to the geology of the region consisting of an impermeable clay layer that prevents any penetration of nitrogen and phosphorus chemicals used in agriculture (fertilizers).

Nitrates are the most dominant nitrogen form in rivers and groundwater. They generally come from the decomposition of organic matter by bacterial oxidation of nitrites and are thus the ultimate product of nitrification. In the natural environment, its concentration rarely exceeds 0.45 mg/l. Higher values indicate wastewater discharges into surface and groundwater environments, and especially excessive use of fertilizers used in agriculture (CHAPMAN and KIMSTACH, 1996).

The nitrate content varies during the study from 0,12 to 0,17 mg/l with a mean of 1,136 mg/l (±0,017) for raw water and from 0,85 to 1,18 mg/l with a mean of 0,95 mg/l (±0,09) for treated water. The normal rate is set at 50 mg/l according to Moroccan standards for water potability. The nitrate content of Gharb groundwater remains low and complies with standards.

During our study, the concentrations of sulfates range from 136,5 to 210 mg/l for raw water and from 156,42 to 180,99 mg/l for treated water. The normal rate is set at 400 mg/l according to Moroccan standards of potability. The values found always remain sandy and lower than the maximum admissible value. Therefore, the waters of the Gharb aquifer are recommended for human consumption and do not present any risk to the health of consumers.

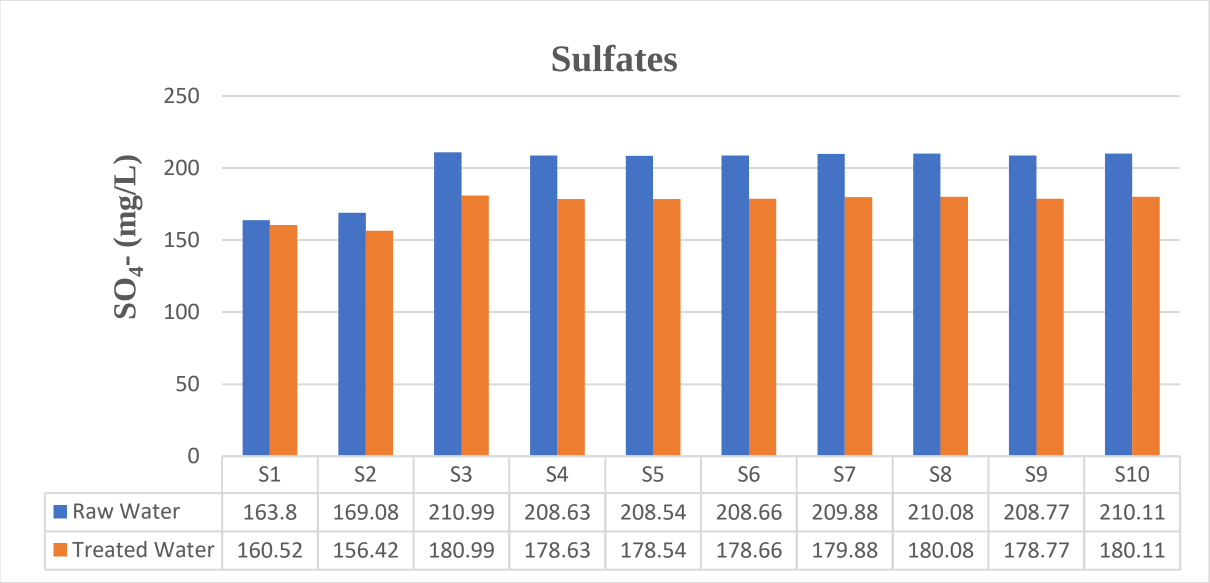
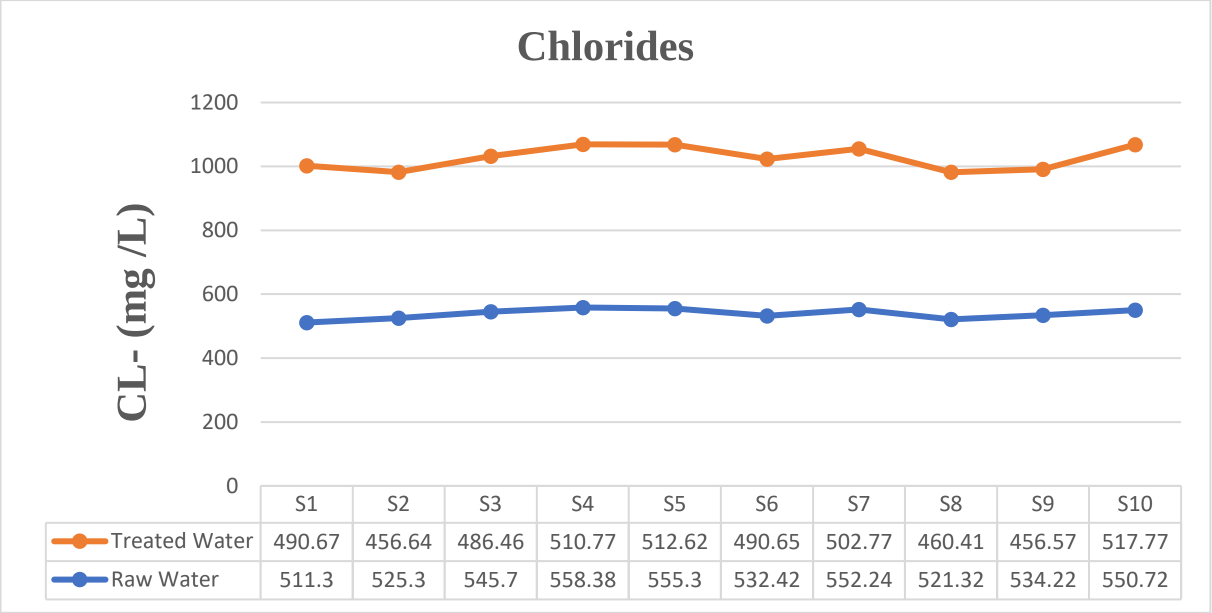


Figure 13: Variation in the concentration of sulfates depending on the nature of the raw water or treated water samples.

During our study, the concentrations of chloride ions range from 538,69 to 558,38 mg/l for raw water and from 488,53 to 517,77 mg/l for treated water, its normal rate is set at 750 mg/l according to Moroccan standards of potability (**Figure 14**). The values always remain stable and lower than the maximum admissible values. However, the high content of this parameter is explained by the conductivity which is high at the level of the Gharb water table.



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Treated Water	490.67	456.64	486.46	510.77	512.62	490.65	502.77	460.41	456.57	517.77
Raw Water	511.3	525.3	545.7	558.38	555.3	532.42	552.24	521.32	534.22	550.72

Figure 14: Variation in the concentration of Chlorides depending on the nature of the raw water or treated water samples.

CONCLUSION

The importance of water for life is no longer in doubt. This resource meets the basic needs of human life. It is a key commodity for development. It is fundamental in agriculture, fishing, energy production, industry, transport, tourism, etc. In addition, water is vital for all ecosystems in the world. However, water is a precious commodity that must be preserved and protected.

Today, the quality of water and the environment concerns us all to ensure a life in good and perfect health because most diseases are related to water. This is why water quality control is now a permanent concern for the management and protection of the environment.

The results of the analyses carried out on the groundwater of the city of Mechraa BelKsiri show that these waters require certain treatments in order to make them of good quality and suitable for human consumption.

On the physicochemical side, the waters studied present exceedances with respect to the limits set by the Moroccan standard. We highlight these exceptions for iron which exceeds 0,4 mg/l and manganese which exceeds the standard 0,1 mg/l up to 0,5 mg/l. The presence of iron and/or manganese in groundwater causes many inconveniences such as the degradation of the organoleptic quality and the color of the water (in the presence of iron, brownish coloring and in the presence of manganese, blackish). They also cause the degradation of water distribution and storage works (corrosion, clogging) or the reduction of the effectiveness of disinfection by consumption of the oxidant. It is therefore necessary to treat these two elements. The treated water always reaches the zero value and this is considered as an indicator of the effectiveness of the Mechraa Belksiri iron-demanganese removal plant.

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