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Hydrochemical and bacteriological study of two fresh water: Ghara and Atrous (Basin of Sais, Morocco)

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ABSTRACT

The study presents changes in the distribution of physicochemical parameters and microbiological water sources Ghara and Atrous (Ribaa sector) (Basin of Sais, Morocco). 8 measurement campaigns were conducted in 2015, in order to gain a better understanding of the functioning of these systems niches. Chemical analysis of the water taken from the two sites shows a variability in physicochemical characteristics in space and in time. Furthermore these waters present a bacteriologists degradation manifested by the presence of indicator bacteria of fecal contamination. which exceeds the OMS guidelines and the Moroccan drinking water standards (NM.03.7.002.2011).
Keywords: Physicochemical quality, bacteriology, sources, Basin of sais, indicator bacteria.

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INTRODUCTION

Water is a vital resource limited. It is the subject of a growing demand for domestic, agricultural and industrial [1]. Groundwater is the main source of drinking water for half of the world's population. It is important that developing countries can protect these groundwater resources, which are often limited. Water resources must be managed in a strategic and sustainable manner [2].

The Sais basin, also known as the Meknes-Fes basin, is one of the strategic areas as reservoirs of water resources. These wetlands are genuine reservations of phreatic waters which are used for the supply of drinking water and irrigation. They are also habitats that contain a wide variety of life forms. Unfortunately these water resources are strongly subjected to pressure anthropogenic causing pollution to multiple origins (chemical, bacteriological...) often incurable. Because once the groundwater is polluted, decontamination is a costly and long-term task [3].

Ghara (Gh) and Atrous (Ribaa sector) (Atr) sources are among the most coveted resurgences of the basin of sais, their waters are used for irrigation and drinking water supply. These wetlands have large biological features and occupy a privileged place among the Moroccan regions of major interest for the conservation of wetlands. However, their strong occupation as well as their sustained operation likely to endanger and compromise the functioning of these ecosystems.

Thus, a more complete diagnosis of the current situation of quality physicochemical and bacteriological water and rigorous monitoring of its evolution, proved a great necessity for the preservation of these ecosystems. It is in this perspective that fits our work whose main objectives are:(1) a physico-chemical characterization of water sources, to provide a comparative analysis of the different parameters studied in connection with other sources of sais bassin already studied. (2) identification of the different risk factors that would impair the quality of these waters. (3) an assessment of the quality of these waters with reference to the standards of drinking water or irrigation.

MATERIAL AND METHODS

Study sites

The source Ghara (Gh)

This resurgence of an average flow of 357 (l/s), is located 22 Km South West of the city of Fez **(Figure 1**). The deaf of the Lias limestone formations source, it is part of the hydrogeological unit Fez-Meknes [4]. The aquifer are lacustrine limestones, silt and sandstone. Given the good quality of its waters, the Ghara station is subject to measures of abstraction for drinking water, irrigation. watering of livestock and household chores are also highly dependent on socio-economic activities of this crenal system.

The source Atrous (Ribaa sector) (Atr):

The source Atrous is located 18 Km North East of the town of El Hajeb **(Figure 1)**, it emerges from the liassic formations of basin Fez-Meknes. Its waters are used for irrigation and for drinking water supply[4]. The annual average volume taken to meet the needs in waters of the cities of Meknes and El Hajeb is 90610 m 3. In a sustainable development context, it appears appropriate to think about the good management of this ecosystem heritage, the first step would be a permanent observation of the quality of its waters.

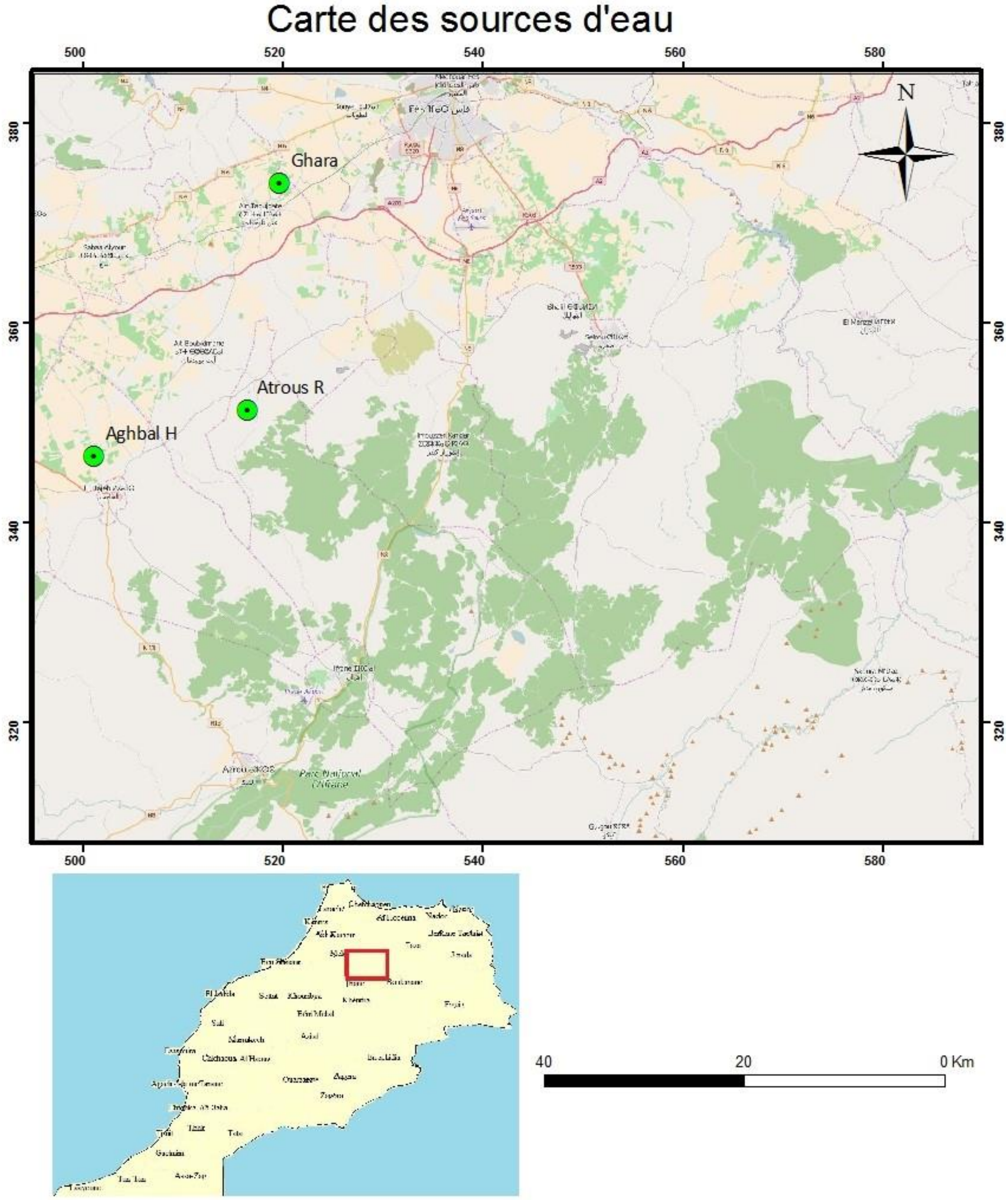

Figure 1: Location of the different study sites

Sampling

Physicochemical parameters:

To better understand the operation of the study sites, with anthropogenic pressures, climatic hazards and also its influence as an abiotic environment, the waters of the two sources were the subject of a physicochemical study following a seasonal periodicity. During each season, two samples has been made, leading a total of 8 companions of sampling covering the year 2015. According to standardized methods [5](**Table 1**), 11 variables were the subject of a physico-chemical monitoring. Water samples were collected using own plastic bottles, previously rinsed with water from the station. Measurements of temperature, pH, and conductivity were conducted in situ using a multi-parameter CyberScan PC10 Analyzer. The rest of the evaluations made by metering or spectroscopic assays according to the methods described by Rodier (2009), in the laboratory of functional ecology and environment of the Faculty of science and technology of Fez.

Table 1: Chemical component analysis method

Parameters	Unit	Measuring equipment and method of analysis
Temperature	° C	Analyzer multi parameters Cyber Scan
Conductivity	µS/cm	Analyzer multi parameters Cyber Scan
pH		Analyzer multi parameters Cyber Scan
Dissolved O_2	mg/l	Winkler method
Total hardness	mg/l	EDTA Complexometry of with eriochrome black
Calcium hardness	mg/l	EDTA Complexometry of with calcone
Magnesium hardness	mg/l	Difference between total and calcium hardness
Alkalinity	meq/l	Volumetric dosing with sulfuric acid and methyl orange
Organic matter	mg/l	Oxidizability of hot potassium permanganate
Chlorides	mg/l	Metering,with Mohr method
sulphates	mg/l	absorption spectrometry at 650 nm
Orthophosphates	mg/l	absorption spectrometry at 750 nm

Microbiological analyses.

Microbiological water characterization, is part of the commonly practiced analyses. Indeed, the purpose of a bacteriological study is to identify the presence or not of fecal contamination, sought microorganisms are the FMAT, fecal coliforms, total coliforms and faecal streptococci.

The sampling of water made in situ in sterile bottles. Filtration and seeding, petri dish, were made the same day. The methods used in this follow-up meet Moroccan drinking water standards (NM.03.7.002.2011). Different culture media recommended for the bacteriological analysis of water are explained in table 2. After incubation, the colony forming units (CFU) were counted macroscopically in each Petri dish.

Table 2: Method of sampling and enumeration of bacteria

	Technique	Sampling volume	Culture medium	Incubation temperature
FMAT	Incorporation in solid medium	1 ml	**Yeast extract agar**	20°C et 37°C
Total coliforms	Filtration	100ml	**Agar lactose to the TTC**	37°C
Fecal coliform	Filtration	100ml	**Agar lactose to the TTC**	44°C
Faecal streptococci	Filtration	100ml	**Agar Slanetz**	37°C

RESULTS AND DISCUSSION

Physical parameters

It is recognized that the temperature variations are dwindling with the depth and the phreatic water temperature is stable [6]. We note a remarkable homothermia in the two sampling points, the thermal variations are very minimal, the temperature is around 16 ° C (Atr) and 18,7 ° C (Gh), a slight decrease marks the winter period , The minima are recorded in February 2015 with successively 15 and 18.1 in the sources Atr and Gh (Figure 2).

The pH is an important parameter to know, it indirectly allows the evaluation of the chemical aggressiveness of the waters; In the study stations it is generally greater than 7. At station Atr, the hydrogen potential (pH) is slightly neutral to alkaline, both during rainy and dry periods, its average content is 7.37 and the standard deviation of 0.2 shows the small variations of this parameter during the year. Referring to Moroccan standards [7]. The waters of this kennel system may be considered acceptable. Contrary to this resurgence, the Gh source is characterized by a rather remarkable variation of the hydrogen potential between the summer season and the winter season, the standard deviation is 0.408. This low alkalinity can be explained by the abundance of dissolved CO2 in aquifers.

The electrical conductivity is directly related to the formations traversed in the hydrogeological basin of the griffins. The data show very slight sawtooth fluctuations and do not undergo any significant variations. The conductivity of the Atr station has the same tendency as those of Gh. The averages recorded are of the order of 571.25 µs / cm and 578.875 µs / cm respectively for Atr and Gh (Figure 2). Moreover, the comparison of the conductivity in the two resurgences with the Moroccan norm fixed at 2700 (µs / cm) places these waters in the excellent grid.

Figure.2: Spatio-temporal variation of the physical parameters (T, pH and EC) of the waters of Atrous sources (sector ribaa) and Ghara (2015).

Chemical parameters.

Groundwater mineralizes to varying degrees because of soil / rock-water interactions, which led to the dissolution of some minerals and chemical elements. The degree of dissolution depends on the length of the path, time of stay and the solubility of the minerals from the soil.

The calcium and magnesium.

Calcium and magnesium are the dissolution of carbonate rocks (limestone and dolomite). The Ca / Mg ratio is characteristic of the groundwater path. Its strong value translated depletion simultaneous water Mg2 + and enrichment of Ca2 + [9]. Figure 3 illustrates a similar evolution of calcium and magnesium in the two study stations; The average magnesium contents are in the range of 30.29 (mg / l) to Atr and 24.83 (mg / l) to Ghara. The average value of calcium is 115.46 (mg / l) for the Atr source, while the crenal system Gh is marked with an average content of 118.58 (mg / l). (Figure 3).

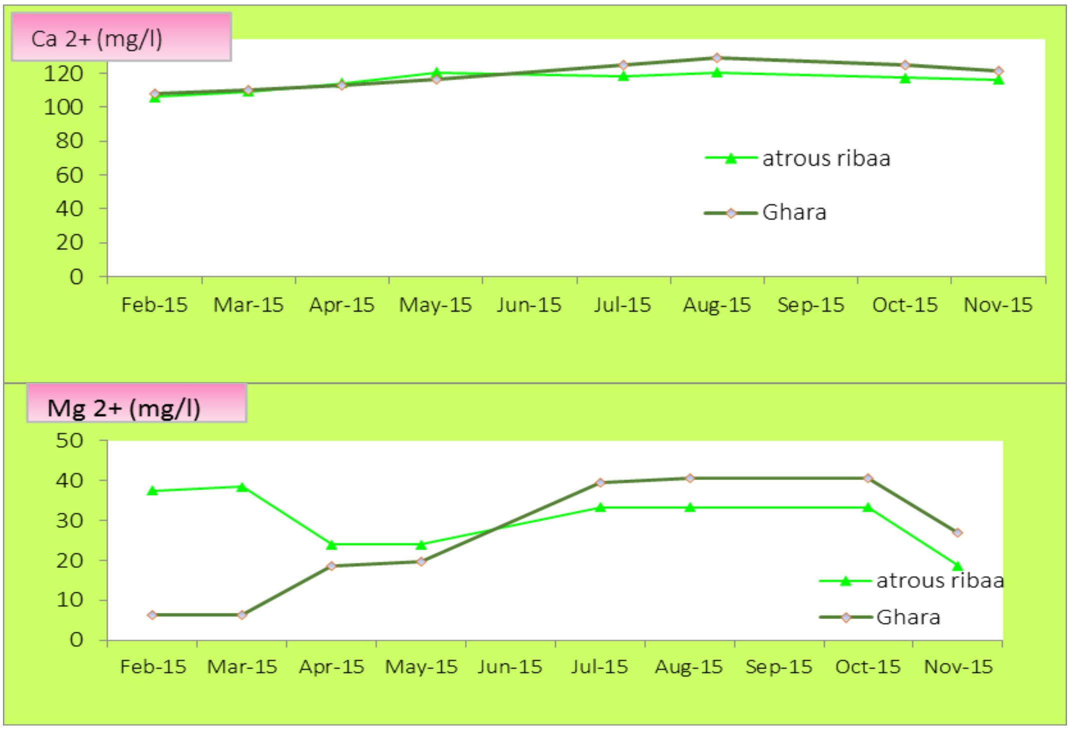

Figure.3: Spatio-temporal variation of the physical parameters (Ca2 + and Mg2 +) of the waters of the sources Atrous(sector Ribaa) and Ghara (2015)

The Full Alkalimetric Title (FAT)

The results relating to the temporal variation of the (FAT) (FIG. 4) make it possible to obtain sawtooth curves marked by slight fluctuations in both rain and dry periods, and their values oscillate around the respective averages of 2, 84 (meq / l) and 2.46 (meq / l) for Atr and Gh. This is explained by the presence of the carbonate geological formations that cross the waters. The increase in concentrations is to be related to the circulation on the gypsum levels which allows the solubilisation of the carbonates.

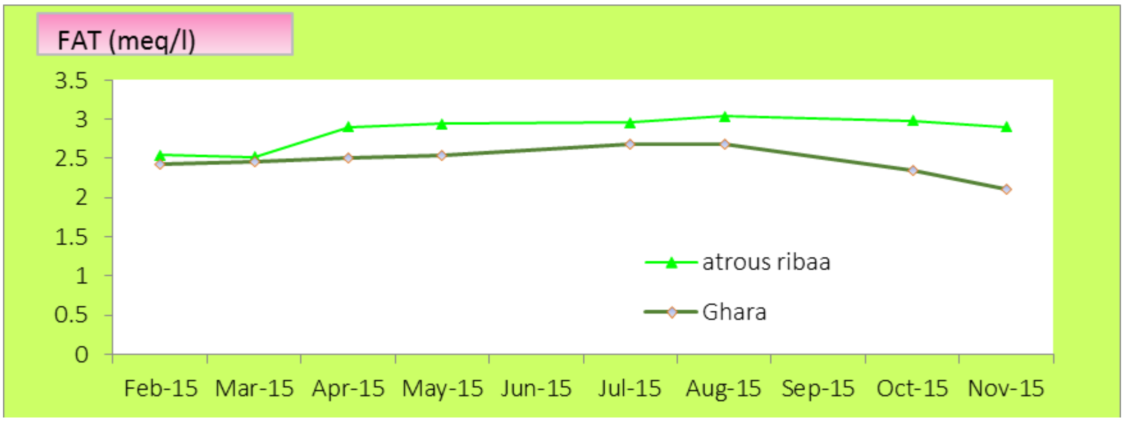

Figure.4: Spatio-temporal variation of the TAC from Atrous (Ribaa sector) and Ghara during the year (2015)

The chlorides

The waters rich in chlorides are laxative and corrosive [9]. The concentration of chlorides in water also depends on the terrain traversed. On the basis of the results of the analyzes carried out for the water samples, the chloride contents are of the order of 28.88 (mg / l) for Atr and 58.79 (mg / l) for Gh. These results are in agreement with those of [10], at the level of the study region. The chloride levels are strictly lower than the Moroccan standards for drinking water which are 200 (mg / l) (Figure 5).

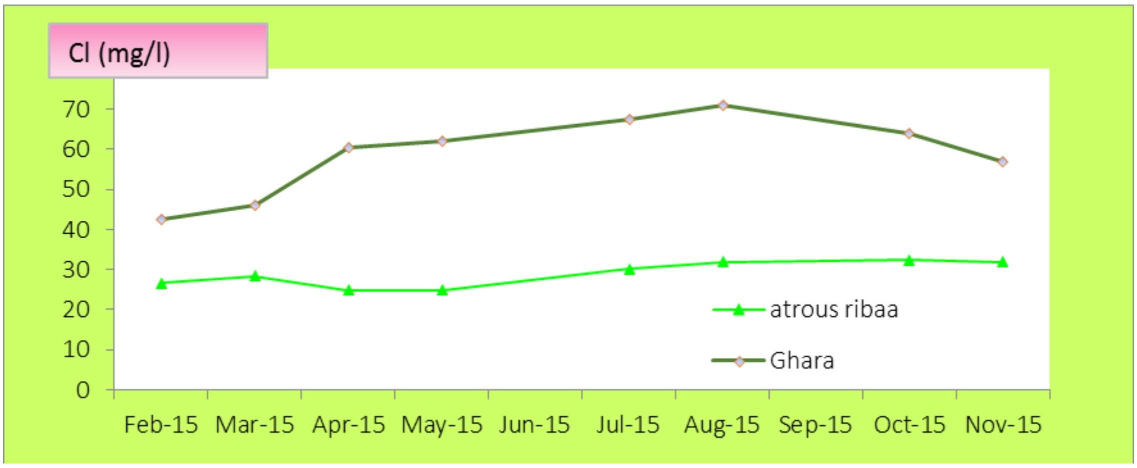

Figure. 5: Spatio-temporal variation of Chlorides in (mg / l) of Atrous source waters (Ribaa sector) and Ghara during year (2015)

Sulphates

Sulphates (SO42-) come from runoff or infiltration into gypsum grounds. They also result from the activity of certain bacteria. According to the results of the samples analyzed (Figure 6), the values recorded are still lower than the guide value (VG = 200mg / l) of the Moroccan standard relating to the quality of water intended for the production of drinking water. They are 11.59 (mg / l) and 23.82 (mg / l) respectively for the Atr and Gh sources. These grades are in the same ranges of some resurgence of the region prospered in 2014 [11] (Figure 6).

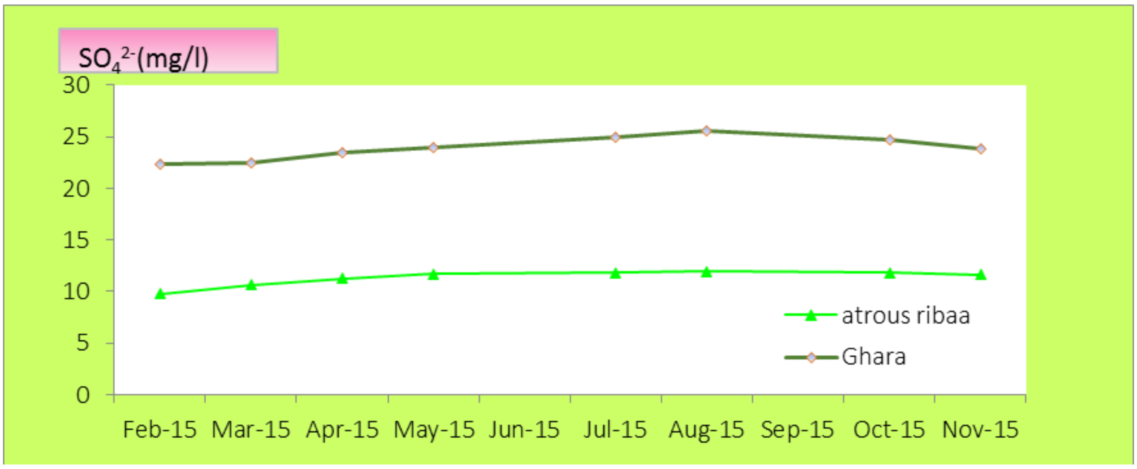

Figure.6: Spatio-temporal variation of sulphates in (mg / l) of Atrous source waters (Ribaa sector) and Ghara during year (2015)

Orthophosphates

Surface water generally contains very little phosphate. [12] estimate that the natural PO43 content of watercourses is less than 0.025 mg / l and depends mainly on the nature of the geological substratum. Source water quality records showed orthophosphate concentrations to be significantly lower than sulphate concentrations, with averages of 0.0003 (mg / l) and 0.0002 (mg / l), respectively, for Atr and Gh (Figure 7). The work of [11, 13] revealed that the orthophosphate contents are at a distance of about 100 km from the study area and are less than 1 (mg / 1). There is no quantified data of this chemical element in the neighboring sources. Concentrations of orthophosphates in the waters of both sources are well below the tolerable threshold of 0.4 (mg / l).

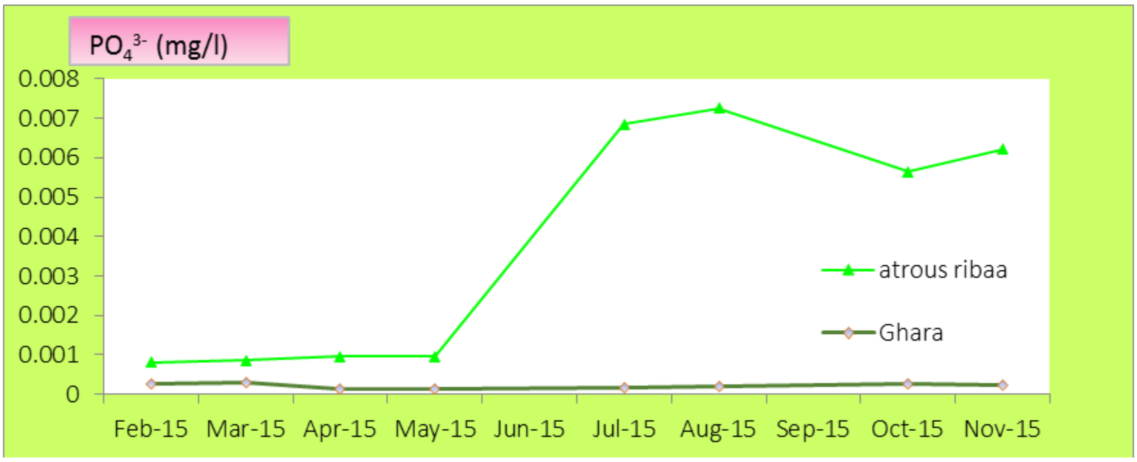

Figure.7: Spatio-temporal variation of orthophosphates in (mg / l) of the waters of the Atrous sources (Ribaa sector) and Ghara during the year (2015)

Dissolved oxygen

The temporal profiles of dissolved oxygen revealed that the contents of this parameter are higher during the wet period than in the summer period. Indeed, all recorded maxima mark the cold season, they are 10.41 (mg / l) in The station (Atr) and 10.6 (mg / l) in the source (Gh) in March. This would be mainly due to the decrease in water temperature; Because cold water contains more dissolved oxygen than warm water [14]. It should nevertheless be pointed out that the year 2015 experienced a delay in precipitation, which led not only to a decrease in the flow of the sources but also to an increase in anthropogenic activity. These factors have consequently caused a decrease in the availability of oxygen (FIG. 8). Overall, the dissolved oxygen regime in the study area is far from being deficient. These results show that the waters of the two study stations fit into the excellent grid [7].

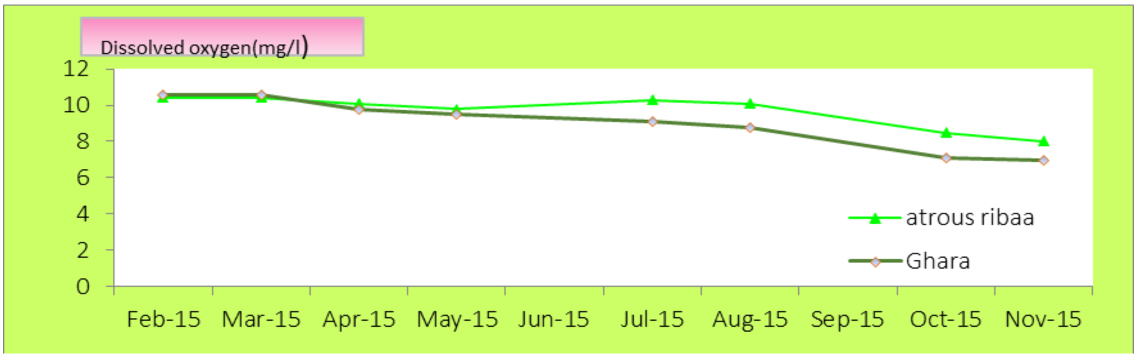

Figure.8: Spatio-temporal variation of dissolved oxygen in (mg / l) of the waters of the Atrous sources (Ribaa sector) and Ghara during the year (2015)

Index of permanganate (PI)

The index of permanganate (PI) is a quantity which allows to estimate the concentration of organic matter in surface waters and drinking water . It is therefore an important parameter to characterize the overall pollution of a Water by organic compounds. PI levels in the studied waters ranged from 0.19 (mg / l) to 3.42 (mg / l) at Atr, in turn Station Gh, recorded fairly significant fluctuations ranging from 0.39 (Mg / l) to 4.34 (mg / l). Concentrations recorded during the winter period are significantly lower than those for the two summer and fall seasons. This inventory would be due to the climatic vagaries characterizing the year of study. As noted above, drought resulted in an increase in organic load to the levels of both outbreaks.

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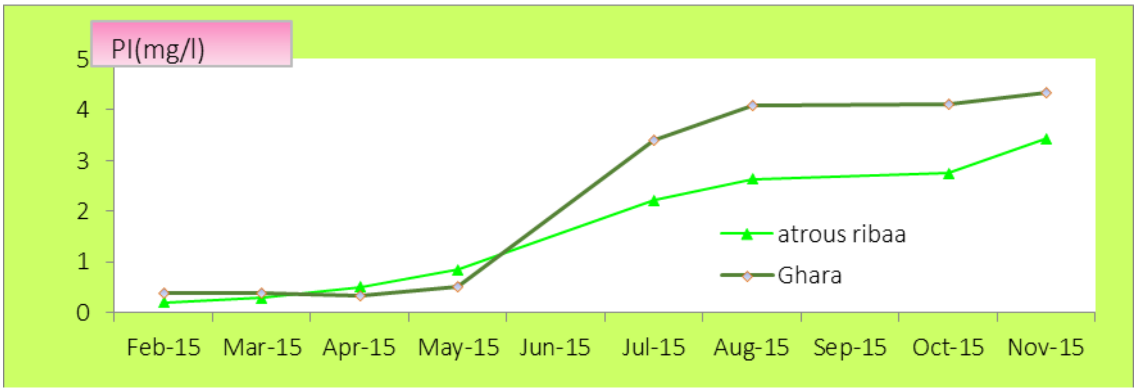

Figure.9: Spatio-temporal variation of the permanganate index in (mg / l) of the waters of the Atrous sources (sector ribaa) and Ghara during the year (2015)

Statistical analyses of the physico-chemical data by CAP

In order to visualize and analyze existing correlations between the different variables through their behaviors and orientations, to identify the main factors responsible for the quality of the waters of the searched environment, we statistically processed all the data by component analysis principal (CAP). This statistical method to transform the initial quantitative variables, all more or less correlated between them in new variables quantitative, uncorrelated, called principal components. This method is widely used to interpret the hydrochemical data [15]. The statistical study by ACP with Unscrumbler 9.2 software gives many results presented in table 3, where the eigenvalues are logged.

Table 3. Eigenvalues of the CAP Pourcentage cumulé, Pourcentage de variance, Valeur propre

N° composante	Eigenvalue		Percentage of variance		Cumulative percentage	
	Atr	Gh	Atr	Gh	Atr	Gh
1	**5,37**	**6,62**	**53,67**	**66,20**	**53,67**	**66,20**
2	**2,90**	**2,57**	**29,01**	**25,71**	**82,68**	**91,91**
3	**1,27**	0,50	**12,72**	4,96	**95,40**	96,87
4	0,20	0,15	2,02	1,55	97,42	98,42
5	0,17	0,13	1,67	1,27	99,09	99,68
6	0,07	0,02	0,66	0,23	99,75	99,91
7	0,03	0,01	0,25	0,09	100,00	100,00
8	0,00	0,00	0,00	0,00	100,00	100,00
9	0,00	0,00	0,00	0,00	100,00	100,00
10	0,00	0,00	0,00	0,00	100,00	100,00

The C1 component, explains a variance of 54% and 66% (respectively for stations Atr and Gh). On the other hand, to know the number of components for the ACP from each source was based on the Kaiser criterion which says that, during a standard PCA on retains the components whose values are greater than 1. Thus, for the source of Ghara we considered the first two because these components express 89,79% and 91,91% respectively. On the other hand, for the source of Atrous, we will remember the first 3 which the explained variability is equal to 95.40%.

Studies correlations between physicochemical parameters

The analysis of the variables of the ACP in the plane formed by the two components C1 - C2 is presented in figures 10, 11

a. Source of Atrous (Ribaa sector)

The circle of correlation formed by the lines C1 and C2 (Figure 10) giving 83 percent of the total information shows, axially C1 (54%), on the one hand heavily laden in major elements, on the other hand, it brings together the variables dissolved O2 and Mg2 + but in the negative axis c1and part a third group consisting of pH and electrical conductivity indicating a high mineralization.

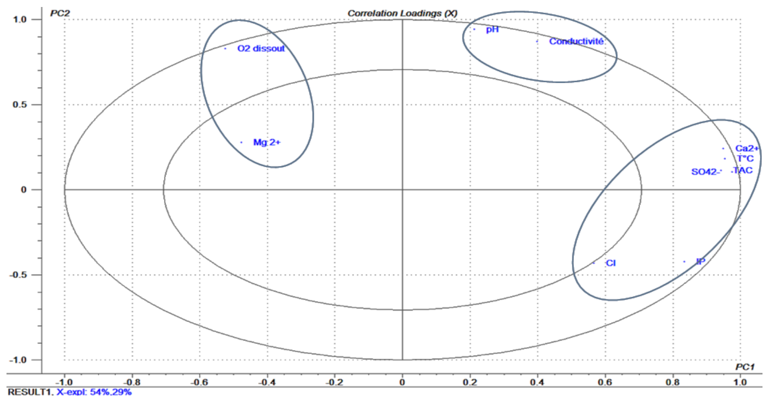

Figure 10: Space variables of the C1 - C2 plan for station Atrous (Ribaa sector)

b. Source Ghara.

The analysis of the variables of the ACP in the C1 - C2 plan is presented in figure 11. This graph highlights three main groupings of the parameters studied in water points. The first grouping that takes into account-Cl, Mg2 +, Ca2 + and and T translated strong mineralization of waters from the source this and a high organic load. The second grouping contains dissolved O2, which highlights well oxygenated water, and finally a third formed group of pH and the TAC reflecting waters of alkaline trend.

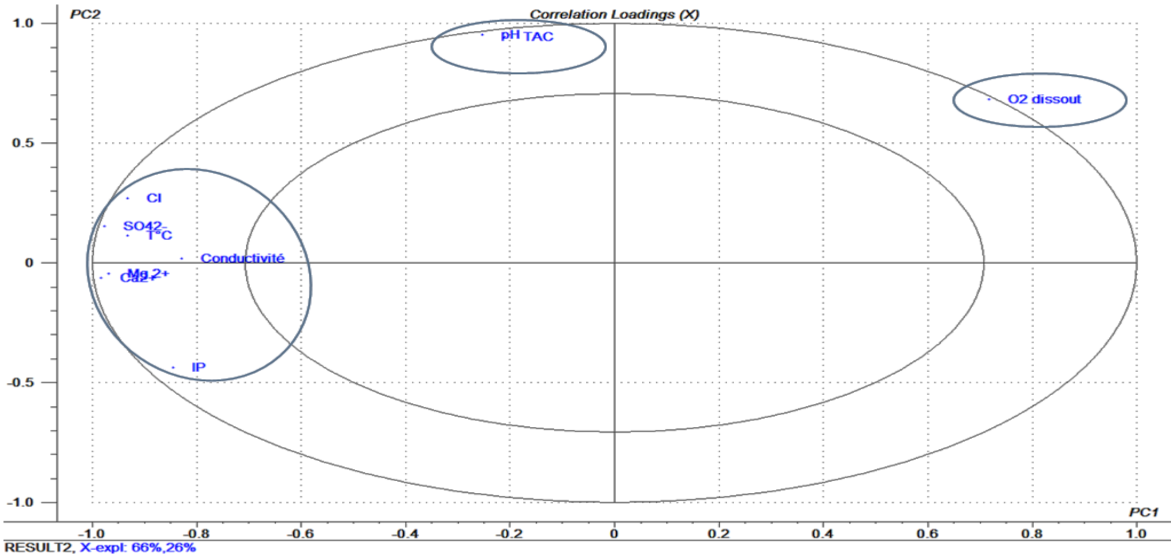

Figure 11: variables Space of the C1 - C2 plan for station Ghara

According to a later study by [16] the resurgences in question are based on a calcareous and dolomitic facies and this constitutes an environment favorable to the processes of the chemical dissolution of the rocks. This confirms that the lithological nature of the region has a direct impact on water chemistry.

Influence of the factor "season".

The Figures 12 and 13 reflect clearly the implication of the phenomenon of seasonality in the hydro-chemical nature of the Atr and Gh resurgences although it is commonly known that the chemical composition of well and source water is mostly acquired during the crossing of Soil and its stay in the reservoir [15].

For the source Gh, four groups of readings are differentiated. The first consisted of summer surveys ranging in warm and dry months, the second group formed mainly by the cold and wet months (winter surveys), this was negatively correlated with the first grouping. And two other groups, spring and autumn. The effect of the season factor is therefore clear.

Like Gh, we note an implication of the seasonality in the distribution of the physicochemical parameters of the source Atr, with the presence of three summer, autumnal and winter groups, except for the month of April which was marked by Floods. An implication that is confirmed by the work of [11] in two Regrag and Sidi Bouali resurgences in the Sefrou region, about 45 km from the Gh source.

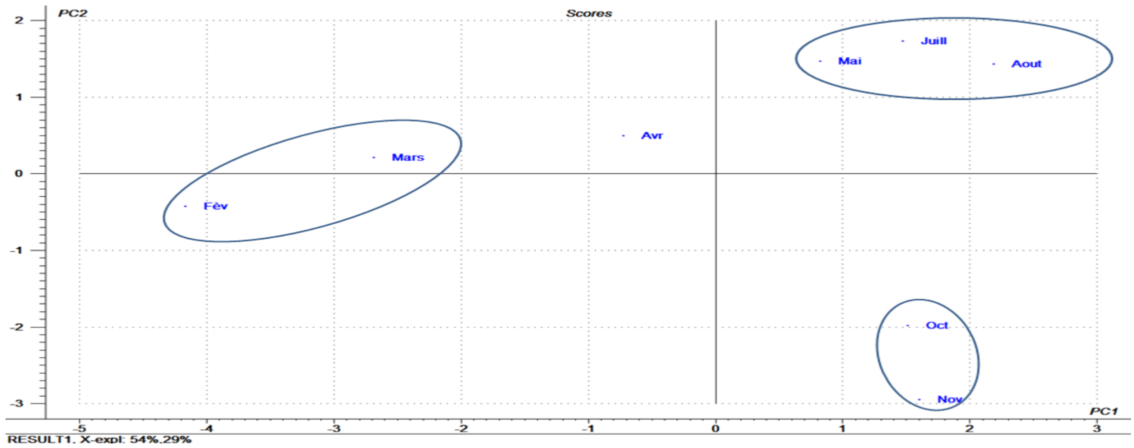

Figure 12: Monthly distribution graph for Atr station

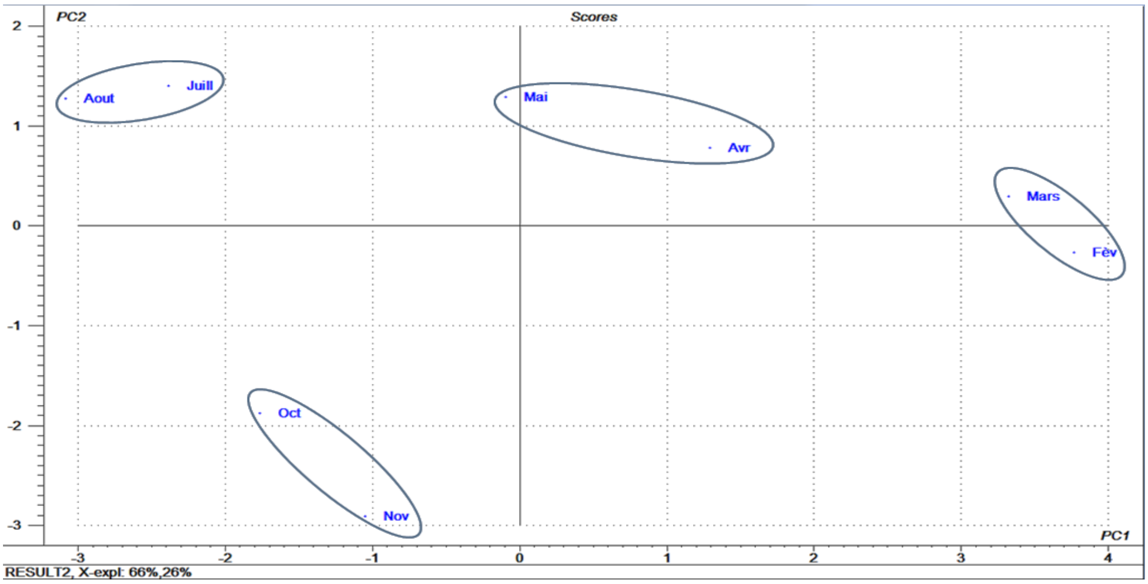

Figure 13: Month distribution graph for station Gh

Bacteriological analysis

The results of the microbiological analyzes are given in Table 4.

Table 4: Results of microbiological analyzes for Ghara and Atrous sources

	FMAT(UFC/100ml)	TC (UFC/100ml)	FC (UFC/100ml)	FS(UFC/100ml)
Ghara	2500	880	340	10
Atrous	70	840	180	20

Total coliforms (TC)

Total coliforms are enterobacteria that include bacterial species that live in the intestines of homeothermic animals, but also in the general environment (soil, vegetation and water). This bacterial group is used as an indicator of the microbial quality of water because it contains, in particular, bacteria of fecal origin. Enumeration of total coliforms in water revealed a concentration of 880 CFU / ml at Gh and 840 CFU / ml at Atr. Such values undoubtedly indicate fecal contamination of these two resurgences.

Fecal coliform (FC)

Fecal coliforms and enterococci are caused by animal or human faecal pollution and demonstrate the potential presence of pathogenic organisms capable of causing enteric diseases. None of these must be present per 100 ml of drinking water so that the water is safe for consumption.

The bacteriological analysis of the water samples from the two study stations indicated the presence of CF at a rate of 340 CFU / 100 ml at Gh, 180 CFU / 100 ml in the Atr. This presence of fecal coliforms indicates that there is contamination by faecal matter (manure, septic tank or waste from animals).

Faecal streptococci (FS)

The detection of fecal streptococci in water samples revealed their presence in the Gh source at a rate of 10 CFU / 100 ml and 20 CFU / 100 ml in the Atr source.

The microbiological analysis of the waters of the two resurgences studied revealed that they possess bacterial loads well above the threshold of 0 CFU / 100 ml fixed by NM 2011. This same observation was made by several authors who carried out similar work [16; 17; 18]. The high density of E. coli, the most specific indicator bacteria of fecal pollution in the waters analyzed, clearly indicates their contamination by faecal germs and consequently the potential epidemiological risk represented by the waters.

CONCLUSION

Across the world, aquifers are facing an increasing risk of pollution with urbanization, industrial development and agricultural activities. The various analyzes carried out on the water samples of the two study stations revealed the behavior of certain parameters descriptive of the physicochemical quality of the waters. Indeed the concentration of each element is not constant in time, some elements are more abundant than others (in particular Ca2 +, HCO3 and Cl-), the curves of the chemical constituents are not superimposable, although the rhythm Of their evolution is identical (Ca2 + and Mg2 +), (Cl- and electrical conductivity). It is also important to note that the waters of both sources are highly mineralized, very hard. The waters of both sources are weakly chlorinated. By comparing these results with the standards of potability advocated by Morocco, the waters of the two sources remain well below tolerable limits. The results of this study also show that the waters of the resurgences prospected carry considerable unusual loads of bacteria, indicative of considerable fecal pollution. In relation to the low socio-economic development of built-up areas in the vicinity, as is the case in some countries, the establishment of a program for monitoring the quality of source water is a necessity given the vulnerability of and Importance of these two wetlands.

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