Moroccan Journal of Chemistry
ISSN: 2351-812X
http://revues.imist.ma/?journal=morjchem&page=login
Lahmar & al. / Mor. J. Chem. 7 N°3 (2019) 424-430

Assessement of the Physico-Chemical Quality of Groundwater in the Sidi Yahya Region, Gharb, Morocco

M. Lahmar [1,2*], N. El Khodrani [2], S. Omrania [3], H. Dakak [2], A. Douaik [2], H. Iaaich [2], M. El Azzouzi [1], M. Mekkaoui [1] and A. Zouahri [2]

[1]Laboratory of Materials, Nanomaterials and Environment Physicochemistry Team, Faculty of Sciences, Mohammed V University, Rabat, Morocco. Email: lahmar.mbark@gmail.com
[2]Research Unit on Environment and Conservation of Natural Resources, Regional Center of Rabat, National Institute of Agricultural Research (INRA),Rabat ,Morocco.
[3]Laboratory of Spectroscopy, Molecular Modeling, Materials, Nanomaterials, Waters and Environment, CERNE2D, Faculty of Sciences, Mohammed V University, Rabat, Morocco.

Abstract
Groundwater is the most important natural resource which cannot be optimally used and sustained unless its quality is properly assessed. The aim of this work is to study the physico-chemical quality of groundwater in the water table of the Sidi Yahya region (Gharb, Morocco). We have carried out a qualitative study of the water in different sites of the irrigated perimeter of Sidi Yahya. In fact several measurements (pH and groundwater depth) and laboratory analysis (ionic balance) were conducted to determine the physico-chemical characteristics of water. We prospected 33 wells distributed into 6 zones: A, B, C, D, E, and F. Data were statistically analyzed using the analysis of variance (ANOVA). The results showed that the depth of water table varied between 6 and 96 m and that 51.5% of the wells were highly to extremely saline, thus inadequate for irrigation. The studied zones do not have the same salinity level. In fact, the B and F zones represent a significantly higher salinity compared to other zones. Similarly, the difference was statistically significant between zones for pH, electrical conductivity, calcium, and nitrates. In conclusion, the use of waters of low quality for the irrigation leads to soil degradation by an accumulation of salts. This accumulation is more or less important depending on the quality of water, the nature of the soil, the climate and the technique of irrigation.

Keywords: Groundwater, Quality, Physico-chemical, Sidi Yahya, Morocco.

1. Introduction

Water is an essential element for life of all living beings, thus, it deserves a special attention, especially because of population growth and the growing demand for foods. Accordingly it is highly threatened by human activities [1]. In fact, the agricultural sector is considered the first consumer of water in the world. Moreover, the non-rational use of fertilizers and pesticides and the lack of awareness about the environmental protection generate the pollutants, which could affect the physicochemical and biological quality of water bodies and aquifers. The groundwater is a resource of drinking water mostly required in the worldwide. Therefore, various studies [2-5] have shown that the groundwater plays a vital role, either for consumption as drinking water or of other purposes such as irrigation. However, the misuse of this resource leads to its deterioration in terms of quality and quantity, threatening food security in the world [6]. In this context, the present work is interested in the study of the physicochemical quality of groundwater of the water table of the Sidi Yahya region (Gharb,

Morocco), which is characterized by intensive agricultural activities.

2. Materials and methods

2.1. Study area

The city of Sidi Yahya is a municipality within the province of Sidi Slimane and is part of the region of Rabat-Sale-Kenitra. The geographic coordinates of the study area are 34°18′33" N for latitude and 6°18′41" W for longitude .Sidi Yahya is located about 26 km north east of the city of Kenitra. The city of Sidi Yahya is located at the South East Gharb plain, on the transition zone between the Maâmora and the Gharb water tables; it is a very low but large basin that covers an area of 616000 ha[7]. The climate of the region is marked by the oceanic influence, within a sub humid bioclimatic zone with a moderate temperature in winter and higher air humidity and lower temperature.

2.2. The prospected wells

We have prospected 33 wells, across the region of Sidi Yahiya. These wells are divided into 6 zones: A, B,C, D, E, and F (Fig.1). The depth of the water table varies between 6 and 96 m.The samples were collected during May and October 2018 with a mean annual precipitation of 537 mm. They were conditioned, and then transported in a cooler at4°C to the laboratory for analysis in the Research Unit on the Environment and Conservation of Natural Resources belonging to the National Institute of Agricultural Research in Rabat. Table 1 summarizes the whole physicochemical parameters measured as well as the methodology followed.

Figure 1. Presentation of the study area and prospected wells.

2.3. Statistical analysis

All the water parameters were processed using the one factor analysis of variance (ANOVA) to check whether there is a difference between the 6 zones.ANOVA will verify if the means of the different quality parameters for the 6 zones are statistically different [8]. The significance of the difference between the zones is expressed by the F ratio of Fisher-Snedecor as well as the corresponding probability value (p-value). The difference is considered statistically significant when this p-value is less than 0.05. When ANOVA results are statistically significant, a multiple comparison of means using the Duncan test has been done [9].

Table 1. Physico-chemical parameters measured with the corresponding methods used [10].

Paramétrés	Abreviation	Unit	Methods used
Electrical Conductivity	EC	dS/m	Conductivimeter
Hydrogen Potential	pH	-	pH-meter
Calcium	Ca^{2+}	meq/l	Complexometrywith EDTA (0.02N)
Magnesium	Mg^{2+}	meq/l	Complexometrywith EDTA (0.02N)
Sodium	Na^{+}	meq/l	Flame photometry
Potassium	K^{+}	meq/l	Flame photometry
Chloride	Cl^{-}	meq/l	Mohr's method
Bicarbonate	HCO_3^{-}	meq/l	Acido-basic titration (HCl 0.05N)
Sulfate	SO_4^{2-}	meq/l	Nephelometricmethod
Carbonate	CO_3^{2-}	meq/l	Acido-basic titration (HCl 0.05N)
Nitrate	NO_3^{-}	ppm	Steam distillation

3. Results and discussion

The results of various physicochemical parameters measured are presented in table 2. In this table, we expressed the values in means ± standard deviations.

We will detail below the results of each parameter as well as the comparison between the different studied zones. Excluded from this analysis are the Mg^{2+},Na^{+},K^{+}, Cl^{-} ,SO_4^{2-},CO_3^{2-} and bicarbonate (HCO_3^-) because they have not presented any significant difference between the zones (p value ≥0.05).

Table 2. Means ± standard deviations of the physicochemical parameters for the studied zones and the ANOVA significance test.

Parameters	Zones						Signification	
	A	B	C	D	E	F	F value	p-value
EC(dS/m)	1.58±1.14	3.38±1.95	1.10 ±1.14	0.28±0.085	0.39±0.27	2.41±3.10	3.14	0.023
pH	6.80± 0.33	7.11± 0.13	7.10± 0.26	7.25±0.12	7.26±0.037	7.27±0.42	3.35	0.017
Ca^{2+}(meq/l)	4.88±2.66	7.55±2.58	3.66±1.53	5.30±1.77	2.30±0.83	4.55±3.40	3.44	0.015
Mg^{2+}(meq/l)	2.10±1.16	4.73±1.96	3.56±2.27	2.86±0.50	2.18±0.38	5.18±4.41	2.06	0.101
Na^{+}(meq/l)	9.80±12.10	26.44±21.53	7.86±9.54	4.75±1.16	5.96±3.35	25.68±41.36	1.48	0.228
K^{+}(meq/l)	0.04±0.02	0.06±0.02	0.04±0.02	0.05±0.01	0.04±0.02	0.10±0.06	2.47	0.057
Cl^{-} (meq/l)	13.11±15.13	33.20±24.30	10.30±8.85	8.85±3.28	5.50±1.78	21.00±26.22	2.24	0.079
HCO_3^-(meq/l)	5.21±1.63	3.87±1.10	4.53±1.84	4.25±0.64	7.35±3.93	4.50±2.98	1.62	0.188
CO_3^{2-} (meq/l)	0.71±0.42	0.81±0.31	0.60±0.32	0.87±0.63	1.30±1.11	1.25±0.35	1.18	0.342
NO_3^- (meq/l)	0.88±0.63	0.36±0.61	0.15±0.20	0.01±0.00	0.01±0.00	0.13±0.22	4.84	0.003
SO_4^{2-} (meq/l)	0.25±0.45	2.73±3.43	1.01±4.28	- 0.42±0.74	- 0.26±0.70	9.91±19.30	1.43	0.244

3.1. Electrical Conductivity and Salinity of water

3.1.1. Electrical conductivity of water

Regarding the salinity, we performed a one-way analysis of variance (ANOVA) for the studied zones. The obtained results show a statistically significant difference (F=3.14; $p < 0.05$), which explains that the studied zones do not have the same levels of salinity in terms of electrical conductivity (Fig.2). Salinity, which is significantly higher in the zone B compared to the F zone, would be due to the fact that the zone B is located toward the downstream of the Sebou River. This implies that the soil in the zone B accumulates, in addition to fertilizers used locally, thos emanating from the zone F and transported by the river. The fact that the zones B and F represent a higher salinity level compared to the other zones could be explained by the proximity of the Sebou River which makes these zones more suitable for crop intensive production. This makes them more exposed to the intensive use of fertilizers and pesticides.

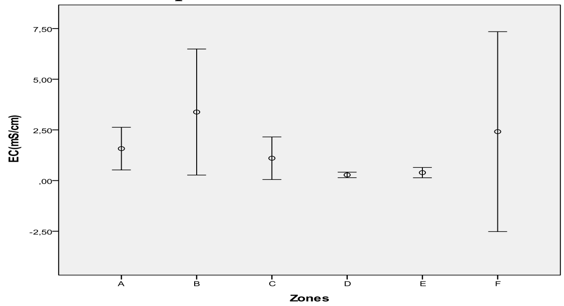

Figure 2. Repartition of means as EC in function of the zones.

Subsequently we have made a comparison of means using the Duncan test [9] which revealed the existence of three groups:

- The first group represented by zones A, C, D and E with an average of 0.84dS/m.
- The second group corresponds to the zones A, C and F with an average of 1.70dS/m.
- The third group corresponds to the zones A, B, F and with an average of 2.45dS/m.

3.1.2 Salinity of water

Table 3. Distribution of irrigation water's salinity in the Sidi Yahya region, following the USSLS standards [11].

Salinity class	symbole	EC (dS/m)	Number of wells	% wells
Non saline	C1	<0.25	9	27.30

Averagely saline	C2	0.25-0.75	7	21.20
Highly saline	C3	0.75-2.25	11	33.34
Very highly saline	C4	2.25-5	4	12.12
Extremely saline	C5	>5	2	6.04

Table 3 presents the classification of waters according to the U.S. standards for the classification of irrigation water. It is clear from these results that 51.5% of the wells belong to classes C3, C4, and C5. These waters are considered to be highly to extremely saline and therefore, unsuitable for irrigation because they have a higher potential for soil salinization and may cause significant yield reduction, especially for sensitive crops

3.2. Potential hydrogen

The pH of water is the rate of hydrogen ion concentration. It indicates the acidic or alkaline nature of water. The pH has correlation with the variables that affect the hydro-chemical interactions and the concentrations of the ions in the water such as the temperature which has a significant effect on the pH rate [12, 13]. The distribution of pH as a function of the zones revealed a significant difference ($F=3.35$; $p=0.017$) which implies that this parameter differs from one zone to the other. In fact, the results of the Fig.3 show that the water of the study zones is neutral. Subsequently we have done a multiple comparison of means using the Duncan test which revealed the existence of two different groups of zones:

-The first group contains the zones A, B, and C, with a mean of 7.0

-The second group corresponds to zones B, C, D, E, and F with a mean of 7.2

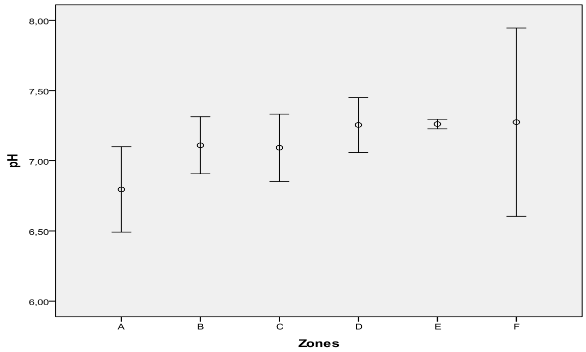

Figure 3. Repartition of means of pH as function of the zones.

3.3. Ionic balance

3.3.1. Calcium

The analysis showed a statistically significant difference ($F=3.44$; $p <0.05$). The comparison of these levels shows the existence of two groups (Fig.4) between the zones regarding calcium. It can be seen that the zone B always presents the highest content in calcium.

Calcium is present in all groundwater. Most of their concentrations in natural water might be due to the chemical weathering and the erosion of rocks and minerals containing calcium, such as limestone, magnetite, aragonite, and calcite ($CaCO_3$).

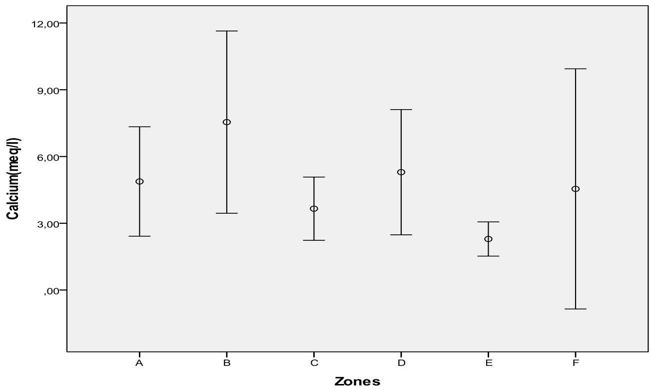

Figure 4. Repartition of means of calcium as function of the zones.

3.3.2. Nitrate

Nitrates levels are significantly different between the zones ($F=4.84$; $p <0.05$). The comparison of these levels shows the existence of two groups (Fig.5). In fact, the A zone (located toward the upstream in the Sebou river) is the most concerned by the high content of nitrates. This is due, mainly

to the misuse of nitrogen fertilizers, as well as the technique of irrigation used (surface irrigation). In fact the excess of generated nitrogen pollutes the groundwater [14-15]. Therefore, one way to stop the nitrate cycle is to use less fertilizer according to the real needs of cultivated crops.

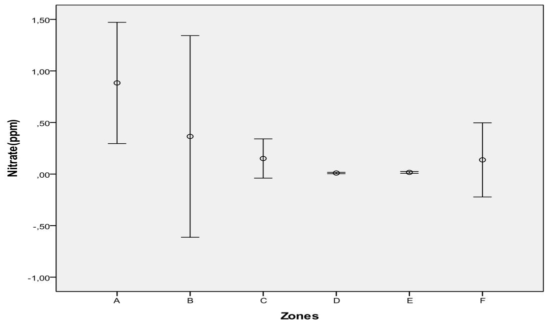

Figure 5. Repartition of means of Nitrate as function of the zones.

3.4. Water alkalinity

The use of the Richard diagram [11] allows to assign to each water a corresponding class of quality in terms of salinization and alkalinisation risks, when this water is used for irrigation (Fig.6). Table 4 gives the distribution of salinity and alkalinity classes of the studied waters. The quality classes of waters that dominate are: C1-S1, C3-S1, C2-S1, and C4-S3.

Table 4. Repartition of salinity and alkalinity classes of the waters.

Class of salinity(C) and alkalinity(S)	Number of Wells	% Wells
C1-S1	9	27.3
C2-S1	6	18.2
C2-S2	1	3.0
C3-S1	9	27.3
C3-S2	2	6.0
C4-S3	4	12.2
C5-S4	2	6.0

It follows that the irrigation water of Sidi Yahya has a high risk of salinization and a low to high risk of alkalinization. Groundwater falling in the C3-S1 and C3-S2 classes is considered to be of moderate quality to irrigate semi-tolerant crops, whereas that in high salinity classes (C4-S3) and (C5-S4) are not suitable for irrigation[16] under ordinary conditions, but may be used for salt-tolerant plants on permeable soil with special management practices [17].

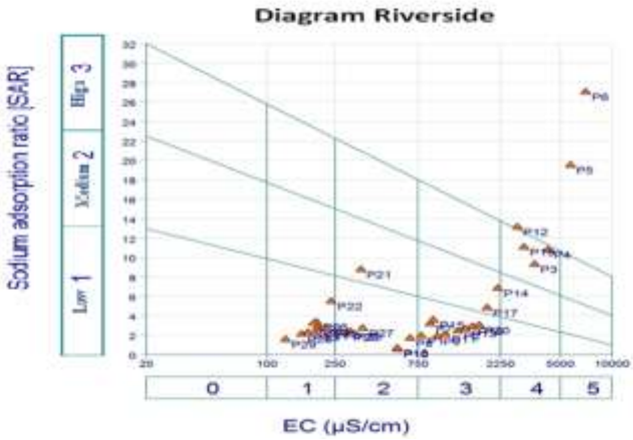

Figure 6. Diagram of salinization and alkalinisation risks of waters in the region of Sidi Yahya Gharb.

SAR: Sodium adsorption ratio ($meq^{1/2}L^{-1/2}$).

EC : Electrical conductivity to 25 °C (µS/cm).

3.5. Hydrochemistry

According to the Piper diagram we distinguish four types of chemical facies that characterize Sidi Yahya Gharb Waters (Fig.6):

- Chloride sulphated-and calcium-magnesium (29.0%).
- Sodic chloride potassium and sodicsulphate (29.0%).
- Sodium and potassium bicarbonate (16.0%)
- Calcium-magnesium and bicarbonate (26.0%)

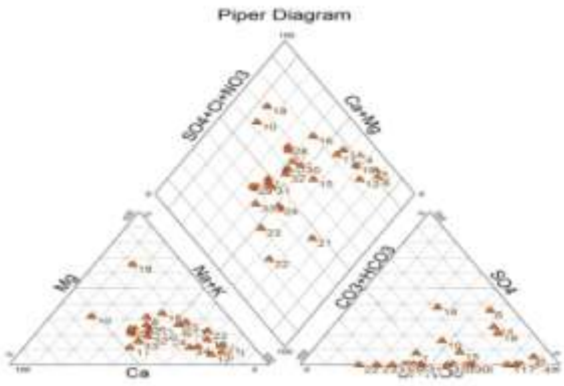

Figure 7. Piper Diagram of irrigation water of the Sidi Yahya.

4. Conclusion

The suitability of water for irrigation is based on many factors like the quality of this water, soil types, grown crops, cropping practices, etc. When dissolved ions are in excess in irrigation water, they affect harmfully plants and agricultural soils, both physically and chemically, therefore reducing the productivity. In fact the study carried out in this work has allowed us to characterize the quality of irrigation waters of the Sidi Yahya region.

It has shown:

- A higher salinity in the zones B and F compared to the other zones. This high level of salinity was more pronounced in the F zone.
- The ground waters belonging to downstream zones in the region (more than 51.5 % of water) have a higher potential for soil salinization and may cause significant yield reduction, especially for sensitive crops. This was mainly related to the influence of Sebou River waters, water depth and to the geological nature of the aquifer.
- A worrying level of contamination of groundwater by nitrates was observed in some zones. A rational use of nitrogen fertilizers will contribute to overcome this situation.
- A low to high risk of alkalinisation. In fact, 100% of the waters studied have values of SAR less than 28.
- A dominance of four classes of salinity and alkalinity: C1-S1, C3-S1, C2-S1 and C4-S3.

In order to overcome this situation of water degradation in the Sidi Yahya region, farmers should use efficiently and rationally the fertilizers as well as water saving irrigation techniques as well as salt tolerant crop.

References

[1] NshimiyimanaF.X.,ElBlidiS.,ElAbidi A.,Faciu M.E., Udahemuka J.C., Benammi F., Lazar G.,Soulaymani A., and Fekhaoui M, J .Mater. Environ. Sci, 8 (2016) 2760-2770.

[2] El Khodrani N, Zouahri A, Douaik A, Omrania S, Iaaich H, Yahyaoui A, Fekhaoui M., Journal of Materials and Environmental Science, 8(2017) 2339–2346.

[3] Dakak H, Zouahri A, Iaaich H, Moussadek R, Ekhadir M, Douaik A, Soudi B, Benmohammadi A,. Revue des RégionsArides,33(2014)75–79.

[4]Zouahri A, Dakak H, Douaik A, El Khadir M, Moussadek R., Environmental Monitoring and Assessment, 187(2015) 4184.

[5] El Oumlouki K. , Moussadek R., Douaik A.,iaaich H., dakak H., TaoufiqChati M., Ghanimi G., El Midaoui A., El Amrani M. and Zouahri A. Irrigation and Drainage, 67(2018)1-14.

[6] Matini L., Moutou J., Kongo-Mantono M, J. Afrique Sci. Rev. Int. desSci. Technol, 5 (2010) 82-98.

[7] Fathallah Z., Elkharrim K., Fathallah R., Hbaiz E M., Hamid C., Ayyach A., Elkhadmaoui A., Belghyti D.,Larhyss Journal, 20 (2014) 57-69

[8]Blanc L., Chessel D. et Dolédec S., Bull. Fr. Pêche Piscic, 348 (1998) 1 -21.

[9]Duncan D.B, « Multiple rang and multiple F tests », Biometrics, 11 (1955) 1.

[10] Rodier J. The Analysis of Water, (Paris, 8th Edition, 1996).

[11] U.S.S.L.S. (United State Salinity Laboratory Staff), US Department of Agriculture, Handbook n°60, U. S. Gov. Print. (1954).

[12] ASTM, Annual book of ASTM standards Part 31 Philadelphia, PA, ASTM, (1976) p 178.

[13] APHA, Standard methods for the examination of water and wastewater, (1989) 17th ed Washington USA. http://dx.doi.org/10.2307/3001478.

[14] Belghiti M.L.,Chahlaoui A. , Bengoumi D., El moustaine R., Larhyss Journal, 14 (2013) 21.

[15] Bouknana D., Hammouti B., Salghi R., Jodeh

S., Zarrouk A., Warad I., Aouniti A., Sbaa M., J. Mater.Environ. Sci. 5 (2014) 1039-1058.
[16] Hamadaoui F., AboubakerAlzwi S., Alibrahmi E., El kharrim K., Belghyti D., NoureddineLotfi N.,International Journal of Environmental & Agriculture Research ,4 (2018) 56-64.
[17] Khodapanah L, Sulaiman WNA, Khodapanah N. , Groundwater quality assessment for different purposes in Eshtehard District, Tehran, Iran. European Journal of Scientific Research, 36(2009) 543–553.