ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Evaluation of the water quality of wells used in vegetable farming (Aquifer of the coastal Chaouia, Morocco).

[1] Rafik. F., [1] Saber. N., [2] Lemacha. H and [3] Benazzouz. I

1. Laboratory of geology of old chain, Department of Geology, Faculty of Sciences Ben M'sik, University Hassan II,Casablanca. Morocco.
2. Laboratory of Applied geology, geomatics and environment, Department of Geology, Faculty of Sciences Ben M'sik, University Hassan II, Casablanca. Morocco.
3. Faculty of Medicine and Pharmacy of Casablanca. Morocco.

Manuscript Info

Manuscript History:

Received: 14 January 2016
Final Accepted: 18 February 2016
Published Online: March 2016

Key words:
Coastal Chaouia, groundwater, quality, physical chemistry, statistical analyzes.

Corresponding Author

Rafik. F.

Abstract

In this work, we study the evaluation of wells water quality used for vegetable farming in reference to irrigation standards in coastal Chaouia region (Morocco), which is characterized by intense agricultural activity and low depth of groundwater. So, thirty wells were sampled and different parameters were analyzed on the physical level such as pH, electrical conductivity (EC), temperature (T), dissolved oxygen O_2. Whereas, the chemical ones such as bicarbonates (HCO^{3-}), chlorides (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), total hardness (TH), nitrate (NO^{3-}), sulfate (SO_4^{2-}) and potassium (K^+). The mean values are compared with the standards for the quality of irrigation water and treated statistically. The results obtained show that the well water is slightly acidic to alkaline trend. They are highly mineralized and very hard with slightly elevated levels of nitrates. The concentrations are classified as follows: $[Na^+] > [Mg^{2+}] > [Ca^{2+}] > [K^+]$ and $[Cl^-] > [HCO^{3-}] > [SO_4^{2-}] > [NO^{-3}]$. A strong correlation is announced between the following chlorine and parameters: Ca^{2+}, Mg^{2+}, Na^+, TH and HCO^{3-}. The typology is mainly controlled by the electrical conductivity, which permits the classification of the wells according to their physico-chemical quality.

Introduction:-

In semi-arid areas, irrigation water is one of the determinants of the agricultural expansion production, both in the direction of crop intensification, and the extension of irrigated areas. In many countries, the surface waters are the main source of irrigation water; in the places where this resource is rare or non-existent, we appealed to the groundwater. However, the success of any agricultural development will therefore depend on rational employment and the periodic control of available water resources (Achite and al., 2003).

The water of the coastal Chaouia, very productive and easily accessible, is exploited in an intensive manner for irrigation by private pumping (Zeraouli and al., 2001; Bricha and al., 2007; Najib, 2014). This uncontrolled exploitation causes a regression in the quantity (decline of static levels) and degradation in the quality of waters (Marjoua, 1997). As well as a disturbance of the natural balance between the marine waters and groundwater (Najib and al., 2015).

The groundwater which represent the only water resources in the coastal Chaouia, are generally proven mineralized: marine intrusion, evaporation, recycling of irrigation waters loaded in salts and the misuse of fertilizers (fakir, 2001; Najib, 2014).

The irrigation water by their composition can have an influence on the ground (Coutinet, 1965), which requires a continuous and permanent hydrochemical characterization of groundwater used for agricultural purposes, which is usually based on the availability of a large quantity of physico-chemical data (Aghazadeh and al., 2004; Hossien, 2004).

The physico-chemical study of groundwater depends on several factors, such as geology, the quality of the waters of the charge and of the various power sources of the aquifers. These factors and their interactions is the result of a complex quality of groundwater (Domenico et al., 1990; Guler et al., 2004; Vazquez Sunne et al., 2005).

In these last years, the area of the coastal Chaouia has experienced a significant regression in the Land intended to vegetable farming as well that these agricultural yields which is certainly due to the quality of irrigation water and the quality of the soil. This study is necessary in order to assess a very important component of the irrigation water used in the region of the coastal Chaouia through indicators of the physico-chemical quality : pH, electrical conductivity (EC), temperature (T), dissolved oxygen O_2 , bicarbonate (HCO^{3-}), Chlorides (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), title Hydrotimétrique or total hardness (TH), nitrate (NO^{-3}), sulphate (SO_4^{2-}) and potassium (K^+).

Material and Methods:-

Geographic context and hydro-climate site description:-

The study area belongs to the Chaouia low (coastal Chaouia), which constitutes the most agriculture in the coastal Chaouia, located between the cities of Casablanca and Azemmour (Figure 1), it is a Sub-atlantic plain that has developed on the edge of the Atlantic Ocean. With a total area of 1200 km², this plain is bounded at the southwest by the Oum-er-Rbia river, to the northwest by the Atlantic Ocean, in the northeast by the quartzite of El Hank and to the southeast by the Berrechid Plain. This zone is slightly inclined toward the ocean. Old and recent dunes mark the border of the ocean (ABHBCB, 2012). The climate of the Chaouia Coast region is semi-arid with oceanic influence. The mean annual temperature is 25°C with a minimum of 10°C and a maximum of 40°C. The average annual precipitation is on the order of 400 mm (300 mm in Azemmour and 500 mm in Casablanca) (Moustadraf, 2008), that makes of the coastal Chaouia one of the warmest subatlantiques Regions. This gives rise to an intensification of pumping and overexploitation of groundwater during dry seasons (Moustadraf, 2008).

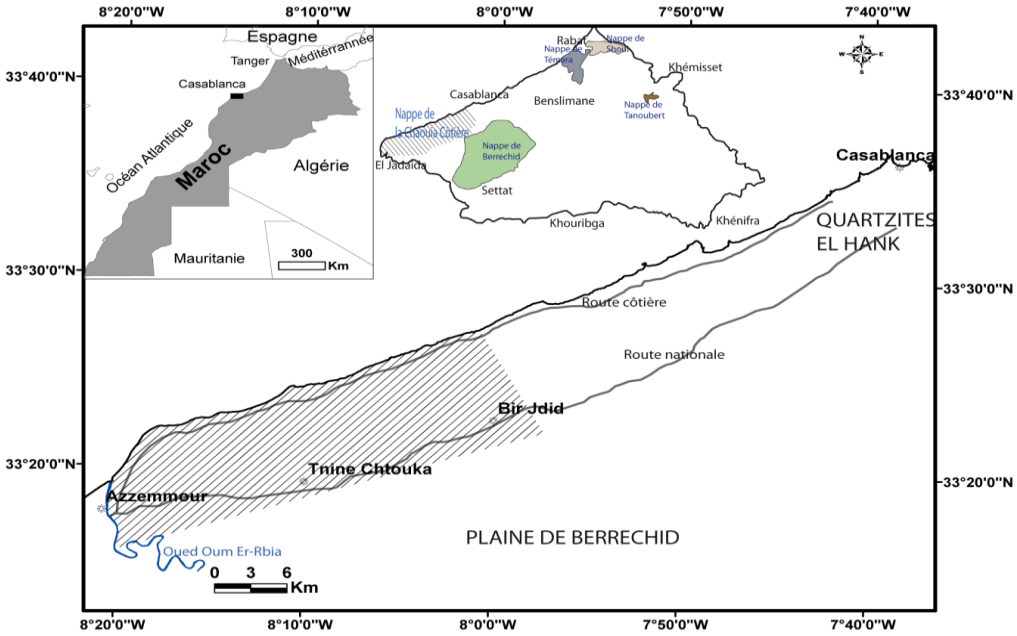

Fig. 1: Geographical location of the Chaouia Coast, Morocco (Najib, 2014).

Geological and hydrogeological context:-

The geology of the Chaouia Coast region (Figure. 2) has been presented by different authors (Lecointre and Gigout., 1949; Bentayeb, 1972; Amraoui, 1988; Marjoua, 1995). The stratigraphy includes the formations belonging to the

Paleozoic, the Cenomanian, and covered by the Plio-Quaternary deposits. The Palaeozoic bedrock consists of an impermeable or semi-permeable layer which corresponds to sandstones, schists and quartzite formations of Cambrian or Ordovician age. The upper and weathered part of the schists represents favorable conditions to groundwater flow. The Palaeozoic bedrock is overlaid by permeable calcareous sandstone and dune formations of Pliocene and Quaternary age. In the southwestern part, the Plio-Quaternary deposits overlie a marly-limestone formation of Cenomanian age and plays an important hydrogeological role. Depending on the lithological facies, the Cenomanian formation can act as an impermeable layer wherever it is composed of marls. However, at places where it is composed of limestones, it allows the circulation of groundwater. Finally, one can say that groundwater in the Chaouia Coast exists from place to place in the Palaeozoic schists, in the Cretaceous or in the Plio-Quaternary. The Palaeozoic schists, when weathered, can act as an aquifer. the thickness of the weathered schists zone varies from some meters to a maximum of 30 m. The quartzites, when fractured, can also act as an aquifer. The Cretaceous formation consists of Cenomanian marly limestones which exist in the southwestern part under the Plio-Quaternary deposits. In coastal areas the saturated thickness of Plio Quaternary becomes important, often related to the structure of the primary pedestal bowl with an effective porosity of 0.1 to 7% (DRPE, 1999). It is in these microcracked aquifers and porous areas where plioquaternaire aquifer is highly stressed by a large number of wells for irrigation of market gardening (Najib, 2014).

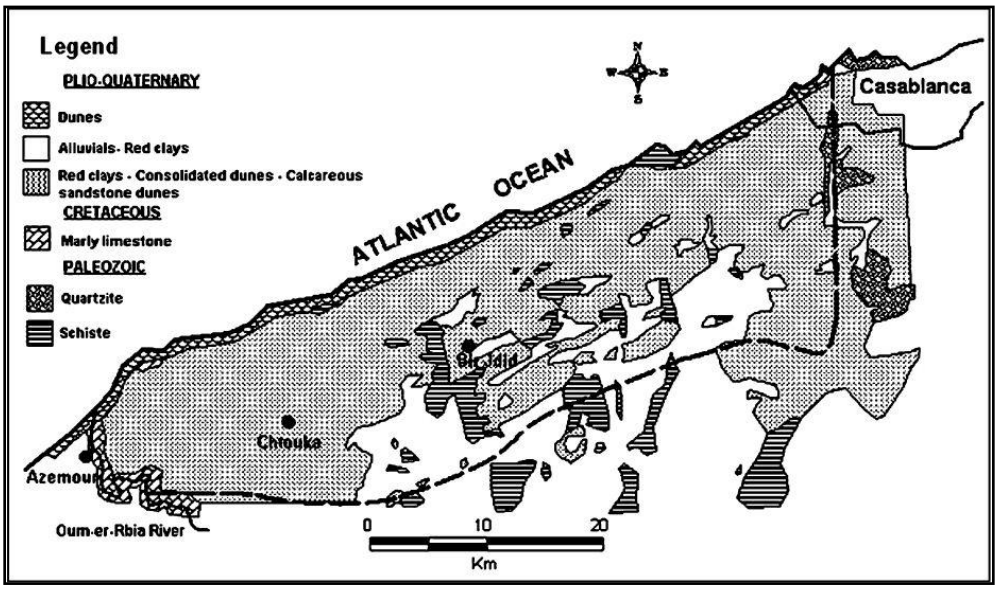

Fig. 2: Geological Map of the Chaouia basin (Fakir, 2001).

Sampling and analytical techniques:-

The samples of groundwater have been taken from the traditional wells used for irrigation of market gardening. These collected waters were sampled in plastic bottles with a capacity of 500ml well closed, appointed by codes and stored in a cooler to the maximum 48 hours, and then forwarded to the laboratory for the physico-chemical analysis. 30 samples were taken in June 2015 (Figure 3).

The physico-chemical parameters studied are: potential of hydrogen (pH), the electrical conductivity (EC), temperature (T), dissolved oxygen O2 , Chlorides (Cl-), nitrates (NO-3), bicarbonate (HCO3-), calcium (Ca2+), magnesium (Mg2+), sodium (Na+), title hydrotimétrique or total hardness (TH), sulphate (SO42-) and potassium (K+).

The temperature and the pH were determined in the field by a pH meter with a probe measuring the temperature. The electrical conductivity was measured by a conductivity meter. The dissolved oxygen was measured using an oximeter. The chlorides are measured by volumetric method of Mohr in the presence of silver nitrate. Nitrates and sulphates are dosed by a spectrophotometer uv-visible. Nitrates are dosed by the colorimetric method in the presence of sodium salicylate. The potassium and sodium have been determined by a spectrophotometer to flame. The determination of bicarbonate, calcium, magnesium and total hardness have been carried out following the method titrémétrique. The methods used are those recommended by AFNOR (1999). The physico-chemical analyzes of well

water were performed at the National Institute for Agricultural Research (INRA) and in the center of analyzes of the Faculty of Sciences Ben M'Sik.

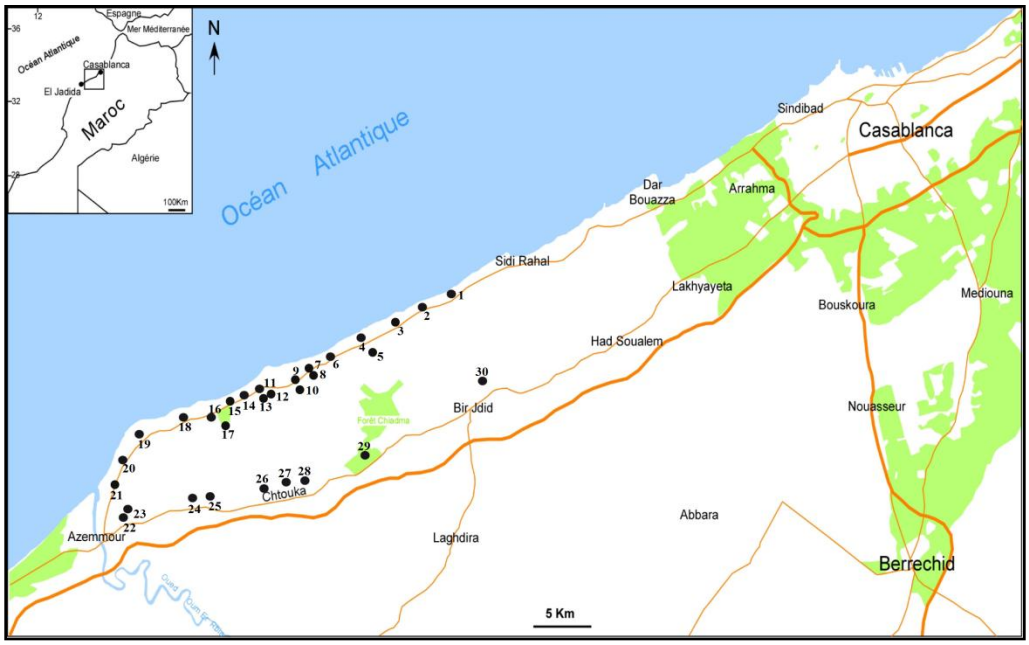

Fig. 3: Map of location of sampling points.

Results and Discussion:-

The water temperature of the Coastal Chaouia wells is between 20.7 and 27.1°C with an average of 22.80 °C and a standard deviation of 1.45°C. This indicates a low fluctuation of this parameter. This fluctuation is probably related to the depth of the wells (~90% of the wells have depths > 10 m) (Zerouali, 2001). The wells whose depths are less than 5 m are more influenced by climatic conditions. Similarly, these temperature values are lower than 35°C, considered as indicative limit value for the water intended for the crops irrigation. Concerning pH, it is around an average of 7.2 with a minimum of 6.22 (neutral) and a maximum of 8.51 (trend alkaline), these results are higher than those found in the groundwater of Sahel-Doukkala (El Achheb, 2002). The pH of the irrigation water should be between 5.5 and 7, to these values, the solubility of most Micros elements is optimal. For the electrical conductivity in our region, it is generally high and oscillates between 1123 and 9760 µS/cm with an average of 4187.83 µS/cm. These results confirm those of the ABHB (2004) and Zerouali et al., (2001) which certify the strong mineralization of the water of the coastal Chaouia. Arriving at the dissolved oxygen which is a good indicator of water pollution and the monitoring of their autoepurations (Derwich, 2008). Generally the deep waters do not contain more often than a few milligrams per liter (Rodier, 1984) a grade of 4 to 6 mg of O_2 per liter characterizes good quality water. In our study area, it is located between 3.07 and 6.09 mg/l for all samples analyzed and an average of order 4.39±0.83 mg/l (Table 1).

Nitrate ions are naturally present in the environment. They represent the most oxygenated form of nitrogen, it is very soluble, its presence in the groundwater is due to the dissolution of fertilizer rich in nitrate (Najib, 2014). They migrate therefore easily in the groundwater when the levels exceed the needs of the vegetation (Health Canada, 1992). Nitrate concentrations in our sector are slightly elevated, they vary between 2.79 and 45,26 mg/l with an average order of 39.9±7.51 mg/l which requires periodic monitoring and alternative water wells used for irrigation with the exception of the P14 which presents the most minimal value. For total hardness of irrigation waters (mainly due to the presence of salts of calcium and magnesium) that oscillates between 300 and 2600 mg/l, with an average of 1027,4±610,01 mg/l. therefore all analyzed water points have very hard water (Th <300) (Table 1).

Coastal Chaouia well waters are characterized by a high concentration of chlorides which varies between 85.09 and 1632.79 mg/l with an average of 581.22 mg/l. It finding as well as the majority of wells exceed the standards of

irrigation water laid down by the Directorate of Research and the planning of the water (DRPE). The bicarbonate and sulphates present an average of 73.2 and 49.97 mg/l.

The presence of sulphate ions in water is linked to the dissolution of the formations gypsiferous, bicarbonates result from the dissolution of the limestone rocks. While the origin of chloride is mainly related to the dissolution of minerals licks NaCl = Na+ + Cl- (Sedrati, 2011).

Table 1: Preliminary results of physico-chemical parameters dosed

Variable	Nickname	Unit	Minimum	Maximum	Average ± Standard Deviation	Standard DRPE
PH	PH	---	6.22	8.51	7.20 ± 0.55	6.5< pH <8.4
Dissolved oxygen	O_2	[mg/l]	3.07	6.09	4.39 ± 0.83	4-6
Temperature	T	[°C]	20.7	27.1	22.80 ± 1.45	35
Electrical conductivity	CE	[µ S/cm]	1123	9760	4187,83±2816,89	2500
Nitrates	No^{-3}	[mg/l]	2,792	45,26	39.9 ± 7.51	<30
Sulphate	SO_4^{2-}	[mg/l]	7.08	318,78	49,97±73,94	<250
Potassium	K^+	[mg/l]	0.37	30,12	5.42±5.99	<12
Total hardness	TH	[mg/l]	300	2600	1027,4±610,01	<300
Sodium	Na^+	[mg/l]	232.5	4637,76	1417,67±941,94	<150
Calcium	Ca^{2+}	[mg/l]	44.08	412,82	191,04±114,23	<100
Magnesium	Mg^{2+}	[mg/l]	179,76	2199,2	836,35±524,60	<50
Chlorine	Cl^-	[mg/l]	85.09	1636,79	581,22±434,84	<250
Bicarbonates	HCO^{3-}	[mg/l]	30.5	152.5	73.2±39,72	<580
Report of adsorption of Sodium	RAS	[meq /l]	1.18	20,003	9.82±4.01	<9

The most abundant cation in relation to the other is sodium which presents a variable concentrations between 232.5 and 4637,76 mg/l with an average of 1417,67 mg/l. This element is probably derived from the weathering of the rock and soil, intrusions of sea water and the dissolution of minerals licks. The Magnesium present by mean concentrations in relation to the total concentration of cations with an average of 836,35±524,60 mg/L, These concentrations are higher than the prescribed standards (<50), followed by the calcium that is located in the waters in low content. The potassium remains the cation the lowest with levels that do not exceed 30,12 mg/l.

Classification of waters "diagram of Piper":-

To highlight the type of the anion or dominant cation, it has represented the results of chemical analyzes on the diagram of Piper (Figure 4):

This diagram shows that the waters of the wells of the coastal Chaouia belong to the families of the Waters:

- chlorinated and calcium and magnesium sulphate (24 samples);
- sodic chlorinated and sodium or potassium sulphate (6 samples).

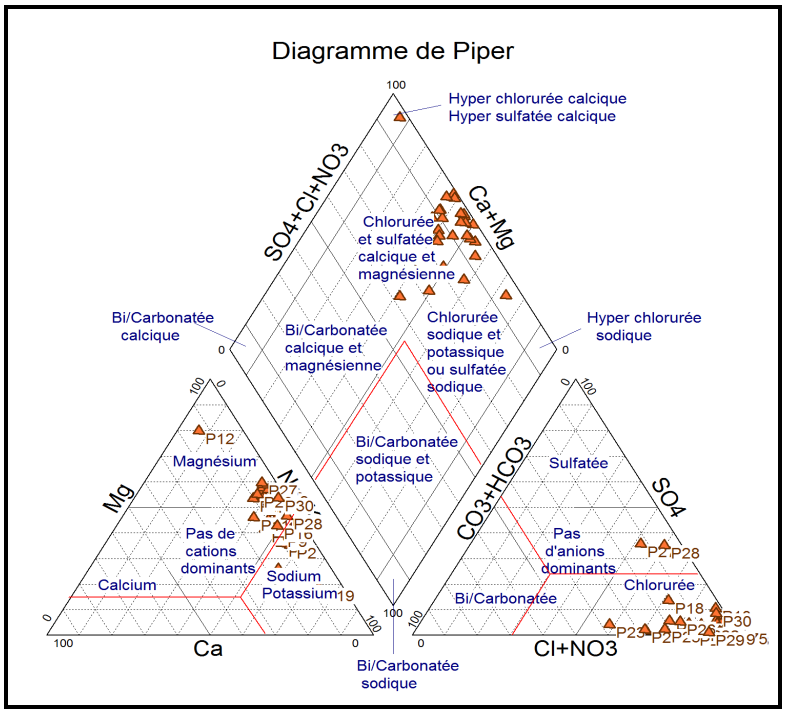

Fig. 4: Triangular diagram of Piper for wells waters of the coastal Chaouia.

These results are similar to those of (Amraoui, 2000) and (Najib, 2014) in the water of the Chaouia and those of (El Achheb, 2002) in groundwater Sahel-Doukkala basin.

In the anions diagram : the points form a cloud relatively close to the chlorine Pole, with an exception of a few points which have a tendency to move away from toward a sulfate facies-calcium. This is deducted a clear dominance of the chloride ion, these results are similar to those of (Marjoua, 1997). It also deduced the classification of the anions which is in the following decreasing order: Cl^- ; HCO_3^- ; SO_4^{2-} .

In the diagram of the cations: most of the points are located in the central area between the sodium Pole and the magnesium Pole with the exception of a point P12. From this, we deduce the classification in the following decreasing order: Na^+; Mg^{2+}; Ca^{2+}.

Interpretation of the hydrochemical differentiation of well water:-

The infiltration of rainwater is the main source of groundwater recharge Coastal Chaouia. Another groundwater supply, it's by Berrechid groundwater which contributes to a lesser extent by anastomosis, in the transition zone between the two aquifers. The natural Outfalls: composed essentially by runoff to the ocean, drainage toward the Oum Er-Rbia and sources compounds the flows to the ocean, drainage the oued Oum Er-Rbia and sources (Najib, 2014). The irrigation by pumping has been one of the major strengths of the development of cultures in the coastal Chaouia. In addition, the development of the pumps has created the overexploitation of the groundwater, its dewatering by places and therefore the advanced at a pace very accelerated the salted bevel (Marjoua, 1997). The higher hydrochemical differentiation may be interpreted by major influences which are the geology by the made that the waters of the Chaouia circulate follow the sectors in formations gréso-limestones of the plioquaternaire, in the marly limestones of the Cenomanian and in the primary land especially shaly sandstone, and quartzitiques which makes these waters highly mineralized especially in contacts with the substratum of primary shale, the climatic conditions and the high temperature of the region also play an important role in the mineralization of groundwater as well as anthropogenic factors such as fertilizers (Amraoui, 2000) . The high salinity saved is due to the appeal of salt water intrusion due to the proliferation of pumping and the reduction of inputs to the groundwater (Zerouali, 2001; Najib, 2014; Najib et al., 2015).

Correlations physico-chemical parameters of wells water:-

The principal components analysis performed on the 14 physico-chemical parameters (Table 2) shows:

- ✓ Correlations positively significant between the pH and temperature (0.7), negatively significant between the pH and electrical conductivity (-0.71) and between the pH and the sodium (-0.44).
- ✓ Correlations positively significant between Cl^- and Ca^{2+}, Mg^{2+}, Na^+ and total hardness, are respectively of (0.78; 0.8; 0.6 and 0.8). Between the total hardness and Mg^{2+}, Na^+, are respectively of (0.99 and 0.7).
- ✓ Positive correlations between Ca^{2+} and total hardness, Mg^{2+} and Na^+, are respectively of (0.78; 0.7 and 0.56).
- ✓ A correlation positively significant between Mg^{2+} and Na^+ either 0.78.

These correlations confirm the physico-chemical results of waters obtained.

Table 2: The Correlation coefficients between the different elements studied.

The variables	*PH*	*T*	*EC*	*O_2*	*SO_4^{2-}*	*K^+*	*Cl^-*	*Ca^{2+}*	*TH*	*Mg^{2+}*	*Na^+*	*HCO^{3-}*	*NO^{3-}*
PH	**1**												
T	**0.70**	**1**											
EC	**-0,71**	**-0,43**	**1**										
O_2	0.10	-0,09	0.01	**1**									
SO_4^{2-}	0.07	-0,02	-0,14	-0,04	**1**								
K^+	-0,20	-0,17	0.27	0.28	-0.12	**1**							
Cl^-	**-0,38**	-0,30	**0.46**	-0,05	0.04	-0.00	**1**						
Ca^{2+}	-0,30	-0,22	**0.36**	0.11	0.05	0.15	**0.78**	**1**					
TH	-0,21	-0,18	0.26	-0.05	0.26	-0.01	**0.84**	**0.78**	**1**				
Mg^{2+}	-0,18	-0,16	0.22	-0,08	0.29	-0,04	**0,81**	**0.70**	**0.99**	**1**			
Na^+	**-0,44**	-0,29	**0,47**	-0,15	0.31	-0,08	**0,68**	**0,56**	**0,78**	**0,78**	**1**		
HCO^{3-}	0.10	0.16	-0,09	**-0,37**	0.04	-0.005	**-0,39**	**-0,45**	**-0,40**	**-0,36**	**-0,38**	**1**	
NO^{3-}	-0,13	-0,19	-0,18	0.03	0.14	0.071	0,22	0.28	0.20	0.17	0.13	-0,28	**1**

Typology of stations: the dendrogram presents the hierarchical classification of wells (Figure 5 and Table 3) obtained from the physico-chemical data fact appear to a first level of partition three groups of stations:

Table 3: groups from the hierarchical classification of different elements studied:

Group		**Wells**	**Average conductivity**	**Concentration of sodium**	**Mineralization**
G1		P12	1340 µS/cm	232.5 mg/l	Low
G2	**2a**	P29, P25, P23, P22, P23, P10, P7 and P26.	1881,14 µS/cm	1265,23 mg/l	Low
	2b	P15, P27, P28 and P30	1702,5 µS/cm	1768,1 mg/l	Low
G3	**3a**	P20, P4, P13, P3 and P21	6063,4 µS/cm	2379,66 mg/l	Average
	3b	P19, P17, P6, P8, P14, P16, P18, P1, P2, P11, and P24	2692,30 µS/cm	1106,84 mg/l	Average

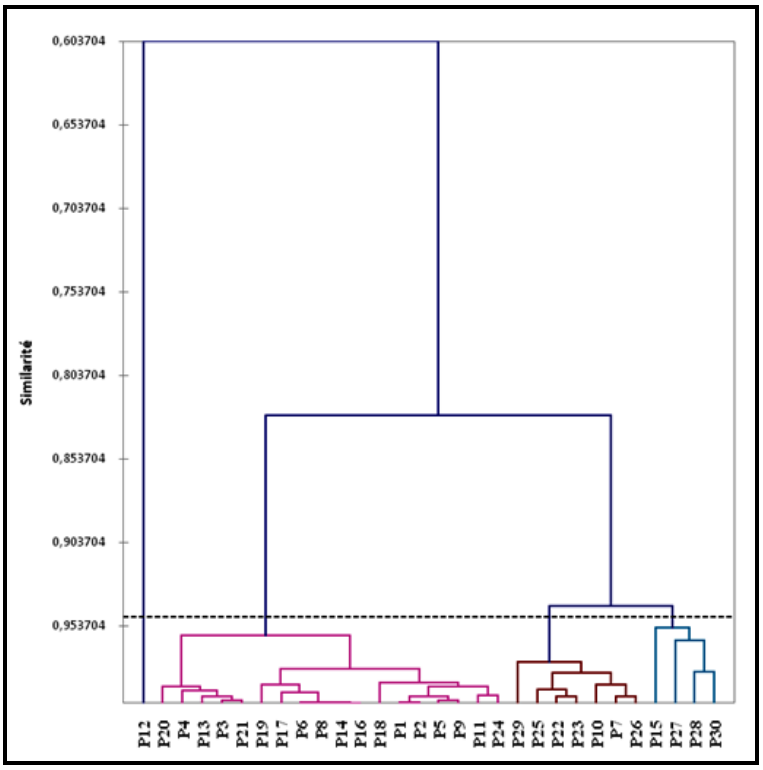

Fig. 5: Dendrogram representing the hierarchical classification upward 30 wells obtained from the physico-chemical parameters of the water.

Conclusion:-

The waters of the coastal Chaouia wells used for irrigation of vegetable crops are weakly acidic to alkaline trend, and present important variations in the mineralization. The electrical conductivity is generally high with a salinity which is primarily controlled by the chlorides and sodium. These waters are very harsh with rate slightly high in nitrates. The concentrations are classified as follows: $[Na^{+}] > [Mg^{2+}] > [Ca^{2+}] > [K^{+}]$ and $[Cl^{-}] > [HCO^{3-}] > [SO_4^{2-}] > [NO^{-3}]$. A strong correlation is reported between the chlorine and the following parameters: Ca^{2+}, Mg^{2+}, Na^{+}, TH and HCO^{3-} .

The use of Piper diagram shows that the majority of these waters have a chlorinated facies and the calcium sulfate and magnesium represented by 24 samples. The typology is mainly governed by the electrical conductivity which permits to classify the wells according to their physico-chemical quality. This qualitative study of wells waters shows that the majority of the waters do not follow the water quality standard for irrigation in terms of the whole of the parameters studied and therefore unusable for the sensitive vegetable crops. Thus, these waters require periodic and alternating control to ensure a good return. This evaluation of the physico-chemical quality of the wells water for the irrigation of vegetable crops must be supplemented by the assessment of the quality of agricultural soils of the region at the end of better appreciate and feel the effect of the degradation of these waters on the agricultural soils.

Acknowledgement:-

The authors thank the Regional Center for Agricultural Research in Settat, Morocco. We are indebted to Hamid El Haddi and Youness Elbatal for Developing and maintaining this article. We would also like to thank Hind Yaacoubi checked the English Version Provided generous and linguistic advice.

References:-

1. **Achite , Mr., Rezak, S., Benbouali, A. (2003).** Contribution to the study of the quality of irrigation water in semi-arid zone. Case of groundwater of the body of surface water of the plain of ghriss (wilaya of mascara). Laboratory of Hydrology and Water Resources Management.

2. **Afnor. (1999).** Compendium of French standards: the quality of the water. Volume 4.
3. **Agency of the Hydraulic Basin of the Bouregreg and the Chaouia. (2012).** State of the quality of water resources in the area of action of the Agency of Hydraulic Basin of the Bouregreg and the Chaouia in 2006-2007.
4. **Agency of the Hydraulic Basin of the Bouregreg and the Chaouia. (2004).** Hydrogeological Study and inventory of samplers of groundwater to the right of the water of the coastal Chaouia, unpublished report.
5. **Aghazadeh, N., Mogadam, A. (2004).** Evaluation effect of geological formation on groundwater quality in the Harzandat plain aquifer, Symposium of Geosciences of Iran, Vol. 22 (2004) 392-395.
6. **Amraoui, F. (2000).** Hydrochemical study of the tablecloths of Temara and the Coastal Chaouia (Moroccan Meseta). Bulletin of the Scientific Institute, Rabat, 1999-2000, n 22.
7. **Bricha, S., Ounine, K., Oulkhir, S., Elhaloui, N., Atrassi, B. (2007).** Study of the physicochemical quality bacteriological and of the groundwater table M'Nasra (Morocco). Afriq. Sci ., 03(3): 391-404.
8. **Coutinet, S. (1965).** Methods of analysis used for the salty soils, limestone and gypseous. Agro. Too much.
9. **Domenico, P., has, Schwartz, F, W. (1990).** Physical and chemical hydrogeology, John Wiley and Sons, New York.
10. **DRPE. (1999).** Hydrogeological Study of the slick aquifer of the coastal Chaouia, modeling of the water in the transitional regime.
11. **El Achheb, A. (2002).** Contribution to the study of the mineralization and identification of sources of groundwater contamination, application the aquifer system of the basin Sahel Doukkala Morocco **,** Phd thesis, Faculty of Sciences, El Jadida, Morocco.
12. **Fakir, Y., Zerouali, A., Aboufirassi, M., Bouabdelli, M. (2001).** Operating and salinity of the aquifers of the coastal Chaouia, Atlantic Coast, Morocco. Journal of African Earth Sciences.
13. **Gigout, Mr. (1951).** Geological survey on the Méseta Western Moroccan (rear-countries of Casablanca, Mazagan and Safi). Notes.mem.Serv.Vol. Morocco.
14. **Guler, C., Thyne, G, D. (2004).** hydrologic and geologic factors controlling surface and groundwater chemistry in Indian Wells-Owens Valley area, southeastern California, USA. Journal of Hydrology, Vol. 285.
15. **Hossien , M, T. (2004).** Hydrochemical evaluation of groundwater in the Blue Nile Basin, Eastern Sudan, using conventional and multivariate techniques. Hydrogeology Journal, Vol.12, 144-158.
16. **Marjoua, A., Olive. P., Jusserand, C. (1997).** Inputs of chemical tools isotopic and to the identification of the origins of the salinization of water: the case of the water of the coastal Chaouia (Morocco), Review of Water Sciences / Journal of Water Science, Vol. 10, No. 4.
17. **Moustadraf, J., Razack, M., Sinan, Mr. (2008).** Evaluation of the impacts of climate changes on the coastal Chaouia aquifer, Morocco, using numerical modeling.Hydrogeology Journal.
18. **Najib, S., Fadili, A., Mehdi, K., Riss, J. (2015).** Study of the evolution of the marine intrusion in the aquifer of the coastal Chaouia. Scientific Association for Water Information Systems, Journal of SAWIS, ISSN: 2351-9096, Volume - 2015 - No. 01.
19. **Najib, S. (2014).** Study of the evolution of the salinization of the aquifer of the coastal Chaouia (Azemmour-BirJdid, Morocco): Climatology, hydrogeology, hydrochemistry and electrical tomography. Doctoral thesis univ. Doukkali Chouaïb Morocco.
20. **Rodier, J .(1984).** The analysis of the water, 7 nd edition, ed. Dunod, Paris. SUBRAMANIAN v., das B.K . (1994). Nature and transport of solute load in the Cauvery River Basin, India, Wat. Res., 28(7), 1585-1593.
21. **Health Canada. (1992).** The nitrate and nitrite. Recommendations for the quality of drinking water in Canada-Documentation in support, accessible at: www.hc-sc.gc.ca/ehp/ehd/catalog/dpc_pubs/rqepdoc_support/nitrate.pdf.
22. **Sedrati, N. (2011).** Origins and Characteristics Physical-Chemical Of The Waters of the Wilaya of Biskra-Sud Algerian is. These 3th cycle, Faculty of Earth Sciences, Department of Geology.252p **.**
23. **Vazquez Sunne, E., Sanchez Vila, X., Carrera, J. (2005).** Introductory review of specific factors influencing urban groundwater, an emerging branch of hydrogeology, with reference to Barcelona, Spain. Hydrogeology Journal, Vol. 13. 522-533.
24. **Zerouali, A., Lakfifi, L., Larabi, A., Ameziane, A. (2001).** Modeling of the water of Coastal Chaouia (Morocco), First International Conference on saltwater intrusion and costal aquifers- Monitoring, Modeling, and management. Essaouira, Morocco**.**