February 2010 ISSN : 0974 - 7451 Volume 5 Issue 1

Trade Science Inc.

Environmental Science

An Indian Journal

Current Research Paper

ESAIJ, 5(1), 2010 [46-50]

Sodization, a threat to coastal irrigated areas case of M'nasra (Morocco)

I.Idrissi Alami[1], A.Rhidouani[2], M.Zeraouli[3], A.Haidar[4], A.Echchelh*[4], M.Addou[1]

[1]Laboratory of Optoelectronics and of Physical Chemistry of Materials (Faculty of Sciences Kenitra), (MOROCCO)

[2]Regional Laboratory of the National Office of Drinkable Water, (MOROCCO)

[3]Laboratory of the Agro-Pedology of the Regional Office of Agricultural Development (ROAGD), (MOROCCO)

[4]Laboratory for Electrical Engineering and Energy System, Faculty of Science BP133, Ibn Tofail University Kenitra, (MOROCCO)

E-mail: echeladil@yahoo.fr

Received: 18th January, 2010 ; Accepted: 28th January, 2010

ABSTRACT

The M'nasra zone which has an agricultural land area that represents 70% of the total area and its agricultural production reach 12% of the national production is threatened by a sodization of underground waters. We know that this water table is the only ground water source available for this region. Thereby, researches that have been carried out on the field have confirmed the salinization of this water-table due to sea water intrusion and to intensive fertilization (salts) and pesticides. Sodium (Na+) is one of the most undesirable elements in irrigation water because of its negative effects and even toxic effects on sensitive crops of the region such as carrots, beans, strawberries etc. In this view, this work aims to study the spatial and temporal evolution of sodium absorption ratio (SAR), according to campaign period of 1993 and 2008 and in different places of M'nasra region. The spatial analysis has confirmed a sodization of an area of 19,800 Ha representing 37% of the total area, between 1993 and 2008. The conformity of sodium concentration is compared to Moroccan and Canadian standards.

KEYWORDS

Sodium;
Grounds water;
Salinity;
Irrigation water.

INTRODUCTION

The overexploitation of water tables affects a lot of countries, industrialized or not (Bahrain, Greece, Spain, France, Maghreb, Egypt, India, China, USA etc.). It causes degradation due to see water intrusion in the case of coastal ground waters that is to say: the water table of El Jadida[1], the Souss plain, located at the east of Agadir[2], M'nasra[3], Chaouia[4], the water table of the oasis of Fatnassa (Tunisia)[5], etc.

Thanks to assets due to water quality (plenty of ground water resources) and to soils (soils have less than 6% of clay and more than 82% of sand[6]), the coastal zone of M'nasra has known an increase of the area of irrigated zones that used to reach 5,766 ha in 1998 to 39,686 ha in 2005. Today, the irrigated zone is facing to an important diversification of vegetable crops (pepper, potato, tomato, aubergine, watermelon, cabbage, carrot, turnip…) and exotic crops (banana, strawberry, avocado…). This crop diversity is unfortunately associated with an over-use of fertilizers and pesticides that cause a nitric pollution of M'nasra's water table[7-10].

It is important to notice that the water table of M'nasra is also confronted to other kinds of pollution due to sea water intrusion and to crop intensification, especially the sodization of ground waters.

According to Peterson[11], the main problem with a big quantity of sodium is its effect on soil permeability and on water infiltration. Sodium also directly contributes to water's total salinity and can be toxic for sensitive crops such as carrots, beans, strawberries, raspberries, onions etc[12,13]. The sodization of ground waters of irrigated areas has generated a particular attention at the international scale and in different region of the world like in China[14], in Pakistan[15], in Niger and in Mali[16], in Uzbekistan[17]. In this way, this work has the objective of firstly, evaluating the sodization of the water of M'nasra's water table used for irrigation, and secondly the study of spatial and temporal evolution of this water table. To do so, 59 wells have been observed between 1993 and 2008.

MATERIAL AND METHOD

Zone of study

The zone of M'nasra is located in the west part of the Gharb plain and is the zone where the ORMVA of the Gharb works. The area is delimited by the Atlantic Ocean at the west along more than 80 km, at the south by the mouth of Oued Sebou and the city of Kenitra, at the east by rural towns of Mograne, Sidi Allal Tazi and Souk Tlet du Gharb and at the north by the zone of the ORMVAG of loukous. This zone is controlled by two Agricultural Development Centers (ADC): M'nasra and Sidi Mohamed Lahmar. The zone of M'nasra is characterized by a superficial water table, it is surrounded by low depth soils with a slightly stoned texture with a high potential of production. Sandy soils which occupied around 50% of lands are not really fertile, very permeable and confronted to erosion through wind. They are adapted to vegetable crops and to peanut. Hydromorphic soils represent 20% of lands. These soils do not fit to arboriculture, only few vegetable crops are grown in this kind of soils[18].

SAMPLING AND MEASUREMENT METHODOLOGY

Choice of wells

The choice of these wells has essentially been based on two criterions: the intensification of crops and the depth of the water table.

Figure 1 : Localization of the 159 studied wells within the zone of M'nasra

Sampling

For the sampling, water is taking directly from the irrigation water supply network for the wells that are equipped of pushback pumps. For those that are not equipped, the sampling is done thanks to a metallic ballasted container. All the samples have been prepared in flask made of polyethylene or in borosilicate glasses. The samples have been carefully identified and stored at +4°C, until their reception at the laboratory.

Measure of SAR

SAR (sodium, calcium, and magnesium are stated in meq/L) is calculated according to the following equation[11]:

$$SAR = \frac{Na^{+}}{\sqrt{\left(Ca^{2+} + Mg^{2+}\right)/2}}$$

The dosage of sodium (Na+) is realized by flame photometry. Calcium ions (Ca^{2+}) and magnesium (Mg^{2+}) are dosed by volumetric method[19].

RESULTS AND DISCUSSIONS

In order to assess the concentration of excessive sodium comparing to calcium cations and magnesium of water from our wells used for irrigation, we have

done 59 campaigns of measurement in two different periods of time: 1993 and 2008.

Punctual analysis

To avoid negative impact on crop behavior, the international standards (such as: Canadian and Moroccan) precise that the sodium absorption ratio (SAR) should be inferior to 3-4 ppm. The results related to SAR measures of waters of the years 1993 and 2008 are shown on the TABLE 1.

TABLE 1 : The average level of SAR (ppm) in water of four classes of M'nasra's wells in 1993 and 2008.

Classe of SAR in (ppm)	1993		2008		Quality
	Number of wells	SAR average ppm	Number of wells	SAR average ppm	
0 - 1	33	0,55	7	0,86	Very good
1 - 2	19	1,35	16	1,35	Good
2 - 3	4	2,34	11	2,55	Average
> 3	3	4,9	25	6,65	Bad and not usable
General mean	-	1,15	-	3,76	–

We have plotted the results of the TABLE 1 in a bar chart represented in the figure 2:

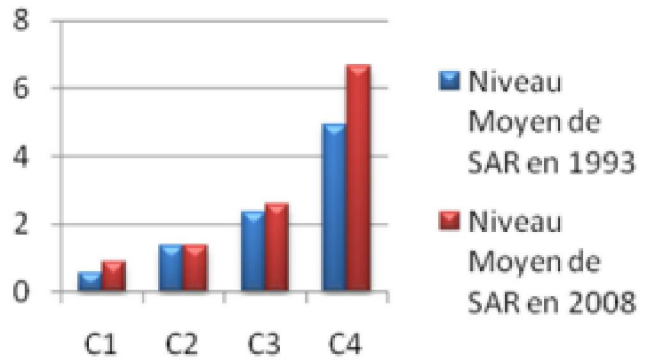

Figure 2 : Comparison of SAR average levels between 1993 and 2008

We have noticed an increase in SAR average levels for all the classes between 1993 and 2008. We highlight the fact that the number of wells has increased for the class 2, even if their SAR average levels remains constant.

Thus, the percentages of wells in each SAR class between 1993 and 2008 are reported in the figure 3:

The comparison between the percentages of wells of each SAR class between 1993 and 2008, allows us to draw the following conclusions:

* A decrease in the percentage of wells that have a very good quality i.e. diminution of (-44%) and good i.e. diminution of (-5%).

* An increase (+12%) of the percentage of wells that have a medium quality, and an increase of (+37%) for those who have a bad quality.

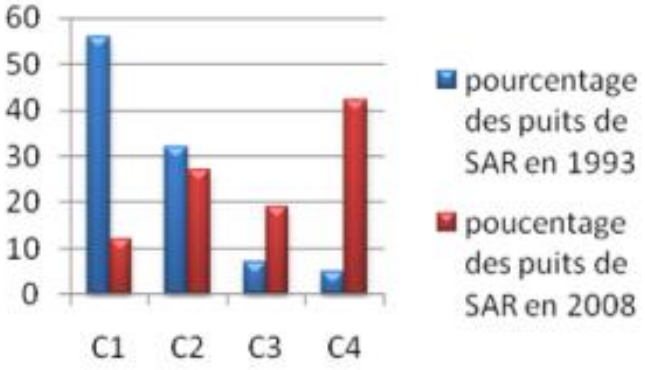

Figure 3 : Comparison of the percentage of wells in accordance to the SAR value between 1993 and 2008

We notice a sodization of 37% of the wells between the years 1993 and 2008.

Statistical analysis

The TABLE 2 shows the Min and Max values, Means and Standard deviations of SAR in 1993 and in 2008:

TABLE 2 : Max levels, min levels, means and standard deviations of SAR in 1993 and in 2008.

SAR/Year	1993	2008
Max Value	7,04	29,46
Min Value	0,07	0,76
Standard deviation	1,11	5,09
Mean	1,15	3,76
Number of samples	59	59
Moroccan standards	3 ppm	3 Ppm
Canadian standards	0 à 4 ppm	0 à 4 Ppm

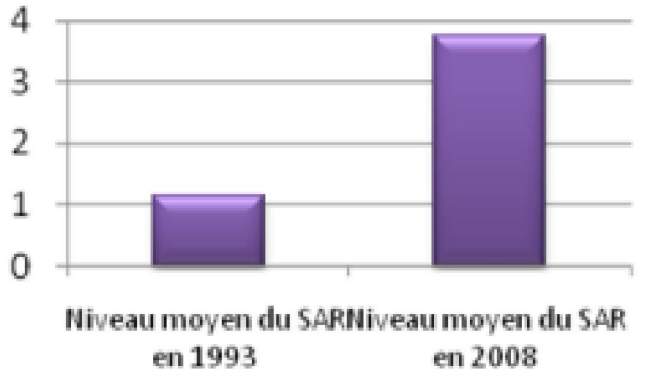

Figure 4 : Average SAR levels in 1993 and in 2008

We have presented the results in a bar chart, see the TABLE 2:

The variance analysis of the results confirms a very significant difference of SAR between 1993 and 2008. In order to better localize the most affected places concerning sodium increase in M'nasra, the studied zone has been divided in two parts:

Zone A: Situated at the North of the coordinate line Y= 430 000 m (38°30'), it represents 76 % of the whole studied wells.

Zone B: Situated at the South of the coordinate line Y= 430 000 m (38°30'), it represents 24 % of the whole studied wells.

The results of the variance analysis of the 59 wells of each zone A and B are presented in the TABLE 3:

TABLE 3 : Results of the variance analysis of the SAR of each zone A and B between 1993 and 2008.

Statistical analysis of wells from	Variance analysis of SAR Between 1993 and 2008
Zone A	HS
Zone B	S
Zone A + Zone B	HS

S : Significant difference; HS : Highly significant difference

The statistical analysis confirm that the zone at the North of the line Y= 430 000 m (38°30') is the zone which is the most affected by sodization. Indeed, it corresponds to the largest area of the sandy zone, where dunes and interior plateaus have a low relief, from 5 to 20 m high. As a consequence, the water table is very close to the surface (3 to 10 m), this explain the current intensive exploitation and the over-use of fertilizers that are often composed of salts. Thus, the Southern zone, has known a significant increase of sodization. This is mainly due to sea water intrusion in this zone[3].

Spatial analysis

According to our analytical results, we have used the Geographical Information System (GIS) Arcview, and its spatial extension analyst, to create maps of the Sodium Absorption Ratio (SAR) in 1993 and in 2008.

The area covered by the water table which has a SAR inferior to 3 ppm (acceptable according the Moroccan standard), represents in 1993: 35,093 Ha over 39,733 Ha mapped i.e. 88.32 % of the total area. Whereas the same space represent in 2008, 15,293 Ha over 39,733 Ha mapped i.e. 38.49 % of the total area (figure 6)

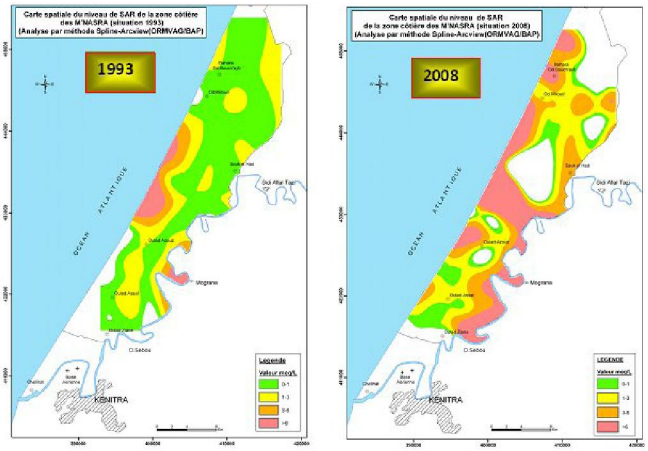

Figure 5 : Maps of the SAR in M'nasra zone (Morocco) in 1993 and in 2008: Analysis through Spline Arcview method

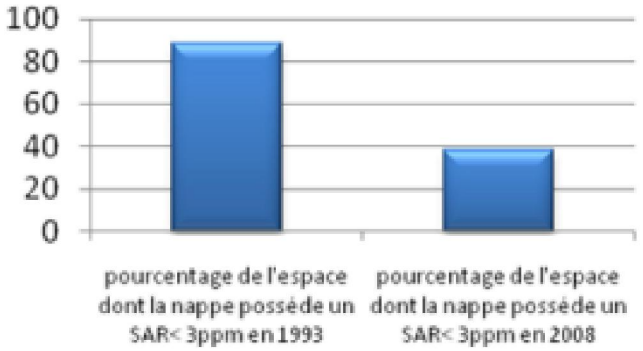

Figure 6 : Variation of the percentage of the area that the water table has a SAR< 3ppm between 1993 and 2008

The area covered by the water table that has a SAR superior to 3 ppm (not acceptable according to the Moroccan standard), represent in 1993: 4,640 Ha over 39,733 Ha mapped i.e. 11.68 % of the total area. Whereas the same space represents 24,440 Ha over 39,733 Ha mapped in 2008 i.e. 61.51 % of the total area (figure 7).

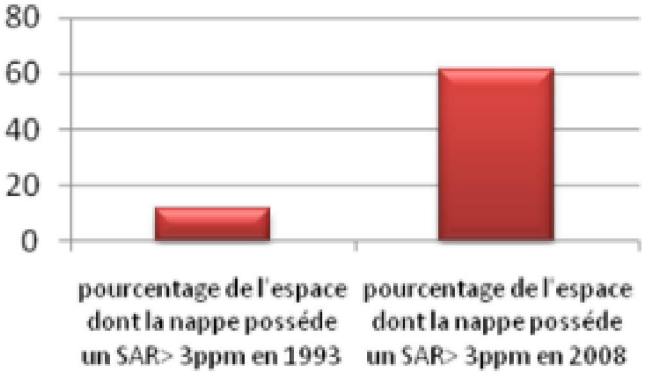

Figure 7 : Variation of the percentage of the space of the water table which has a SAR> 3ppm between 1993 and 2008

The comparison of the spatial results allows us to

confirm a decrease of 50 % in the area in which the table water has a SAR inferior to 3 ppm between 1993 and 2008.

We have noticed a sodization of the M'nasra's water table representing 19,800 Ha between 1993 and 2008.

CONCLUSION

This study has allowed us to confirm a spatial and temporal sodization process of the water table of M'nasra. A decrease of 37 % of the wells that have a Sodium Absorption Ration of 37 % inferior to 3 ppm (Moroccan standard) has been demonstrated. The analysis of the results has shown the evolution of the general average of the concentration in sodium between the years 1993 and 2008 which is respectively 1.13 ppm and 3.76 ppm i.e. an increase of 2.63 ppm. The obtained values in 2008 are definitely superior to Moroccan standards (3 ppm) and tend to the max of the Canadian standard (0 – 4ppm).

The spatial analysis of the obtained results for the same period have confirmed a sodization of an important area of 19,800 Ha representing 37 % of the total area. These results will have a negative impact at medium term and at long term on the agricultural production of this region.

REFERENCES

[1] A.El Achheb, J.Mania, J.Mudry; Processus de salinisation des eaux souterraines dans le bassin Sahel-Doukkala (Maroc occidental). First International Conference on Saltwater Intrusion and Coastal Aquifers—Monitoring, Modeling, and Management. Essaouira, Morocco, April 23-25 **(2001)**.

[2] Y.Hsissou, J.Mudry, J.Mania, L.Bouchaou, P.Chauve; IAHS publi., **244**, 73-82 **(1997)**.

[3] A.Anonyme; Agence du Bassin Hydraulique du Sebou. Coopération Allemende INWENT et MedWet pour les Zones Humides et méditerranéennes « Etude de Diacnostic de la nappe de Mnasra,Wilaya de Kenitra » **(2006)**.

[4] A.Younsi, J.Mania, E.K.Lhadi, J.Mudry; Sci.Eau., **14(2)**, 115-130 **(2001)**.

[5] S.Marlet, F.Bouksila, I.Mekki, I.Benaissa; Fonctionnement et salinité de la nappe de l'oasis de Fatnassa : arguments géochimiques. 2008. Economies d'eau en systèmes irrigués au Maghreb. Actes du troisième atelier régional du projet Sirma, Nabeul, Tunisie, 4-7 juin. Cirad, Montpellier, France, colloques-cédérom **(2007)**.

[6] B.Anonyme; SCET-MAROC : 'Etude pédologique au 1/20.000ème la troisième tranche d'irrigation (T.T.I) sur une superficie de 100.000 ha zone M'nasra' ORMVA du Gharb **(1994)**.

[7] I.Idrissi Alami, M.Zeraouli, M.Addou, A.Moukhtari, A.Soulaymani; Afriq.Sci., **03(3)**, 378-390 **(2007)**.

[8] A.Moussaoui; Pollution nitriqueactuelle et vulnérabilité de la nappe de M'nasra. Mémoire de 3ème cycle IAV Hassan II **(1994)**.

[9] C.Anonyme; SCET-Maroc. Projet de protection de l'environnement du basin du Sébou (PPBS) : Etude pour un programme d'action visant à minimiser et à contrôler l'impact des engrais et des pesticides sur l'environnement du bassin sebou. Secrétariat d'Etat chargé de l 'environnement **(1999)**.

[10] M.Zeraouli; Pollution par les nitrates, premiers résultats de la situation actuelle dans la nappe des M'nasra. Rapport ORMVAG du Gharb **(1993)**.

[11] H.G.Peterson, Water Quality Fact Sheet: Irrigation and Salinity, Agriculture et Agroalimentaire Canada, 4, **(1999)**.

[12] H.Ayadi, N.Toumi, O.Abid, K.Medhioub, M.Hammami, T.Sime-Ngando, C.Amblard, D.Sargos; Sci.Eau., **15(1)**, 123-135 **(2002)**.

[13] S.Maalej, A.Mahjoubi, A.Kammoun, A.Bakhrouf-Fadhila; Sci.Eau.,**15(1)**, 273-287 **(2002)**.

[14] B.Vincent; Remote Sensing for Spatial Analysys of Irrigated Areas. 'Water Savings in the Yellow River Basin'. L.S.Pereira, L.G.Cai, A.Musy, P.S.Minhas, Beijin, China Agriculture Press, 29-45 **(2003)**.

[15] N.Condom, M.Kuper, S.Marlet, V.Valles, J.W.Kijne; Land Degradation and Development, **10(2)**, 123-140 **(1999)**.

[16] R.Bertrand, B.Keita, M.K.N'Diaye; Cahiers Agricultures, **2(5)**, 318-329 **(1992)**.

[17] I.C.Gupta; Assessment of Auality of Irrigation Waters and Industrial Effluents Discharged on Land for Irrigation. 'Industrial Waste Waters and Environmental Pollution'. I.C.Gupta, D.C.Joshi, D.Kumar, Jodhpur, India, Scientific Publishers (India), 131-151 **(2000)**.

[18] M.Zeraouli, M.Morchid; Marocaine des Sci.et Tech.du Développement Rural, **31**, 118 **(2001)**.

[19] OMS; Organisation mondiale de la santé. Sodium, chlorures et conductivité dans l'eau potable. Rapport d'un groupe de travail de l'OMS. EURO rapports et études 2, bureau régional pour l'Europe, Copenhague **(1979)**.