Groundwater management for sustainable production of drinking water quality in Maâmora

D. Belghyti[1], H. Daifi[1], A. Alemad[1], K. Elkharrim[1], M. Elmarkhi[1], Y. Souidi[1], F. Benelharkati[1], B. Joti[1,2], Z. Elmoukrifi[1], A. Ibeda[3], Y. Azami-Idrissi[1], S. Baroud[1], F. Elkhayyat[1], O. Elrhaouat[1], S. Sadeq[1], Y. Taboz[1], H. Sbai[4], R. Naser[1], H. Chigger[5] & N. Derwich[1]

[1]Laboratory of Environment and Renewable Energy, Faculty of Sciences, University Ibn Tofail, Kénitra, Morocco
[2]National Office of Drinking Water (ONEP), Kénitra, Morocco
[3]Organization of Development, Sabha, Libya
[4]National Office of Drinking Water, Mechraa Bel Ksiri, Morocco
[5]Society of Solid Waste, Fez, Morocco

Abstract

The problem of water pollution affects the whole world including groundwater which is more susceptible to contamination by residues of industry, agriculture and domestic wastewater leading to the emergence of many serious epidemic diseases (cholera, typhoid, amoebiasis,…etc).

The purpose of this study is to evaluate the impact of agricultural intensification and discharge of untreated sewage on the physical, chemical and bacteriological water quality of groundwater Maâmora, Kénitra, Morocco.

The physicochemical parameters followed are: T°C, pH, EC, NH_4^+, NO_2^-, NO_3^-, Cl^-, F^-, HCO_3^-, SiO_2, SO_4^{2-}, Boron, Dry Residue, Turbidity, Total Hardness (TH), Dissolved O_2, Oxidisability and total and fecal coliforms of raw water from the boreholes.

This study shows that the physicochemical and bacteriological quality of the groundwater which is used as drinking water for the city of Kénitra and adjacent areas is generally good. However, high concentrations of nitrates (NO_3, NO_2) in

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some wells (over 51.55 mg/L) are worrisome because of the serious health consequences (methemoglobinemia).

For sustainable use, policymakers must protect the aquifer against the anarchic development of agriculture and spreading unreasonable amounts of pesticides and fertilizers.

Keywords: drinking water, tablecloth, bacteria, physicochemical, Nitrate, Morocco.

1 Introduction

In Morocco groundwater is an important part of the hydraulic heritage of the country REEM [1]. Groundwater, often protected geologically, is exposed to agricultural, industrial or urban pollution.

In this coastal region, in addition to marine disturbances (seawater intrusion), water resources are increasingly threatened by pollution from urban, agricultural, industrial and artisanal origin. Indeed, this urbanization has led to demands for ever increasing water and generated polluted sites that multiply without any protection of the environment. Pollution of groundwater is one of the most disturbing aspects and the use of these waters for food is a health hazard. Given the high demand for water for demographic growth and related industrial development, water pollution is increasing day by day (Laferriere *et al.* [2]). The World Health Organization (WHO [3]) estimated that 80% of diseases that affect the world's population are directly related to water, which implies the need to treat the water.

This work focuses on the study of the quality of the groundwater Maâmora, monitoring of physico-chemical and bacteriological parameters of water representing 10 samples is well done to clarify the importance of pollution and determine the cause. Ground water analyzes in the study area were made in Laboratory of the National Office of Drinking Water (ONEP) and in University Ibn Tofaïl, Kénitra, Morocco.

2 Material and methods study

2.1 Area study

Maâmora which is a 2300 km^2 basin is bordered on the north by the region of Sidi Yahia, the tablecloth Tiflète, to the east by the river Beht, and west by the Atlantic sea. North of the study area, the Gharb basin shows a very gentle terrain in its central part. In contrast, in the western and eastern part, its altitude is 20 m. The Maâmora basin has a slope of 6% to the NNW, culminates in the SE at around 250 meters and has more on the outskirts of Gharb, an altitude of 10 to 30 meters. The overall morphology is a succession of hills and valleys parallel to the shore in a mean direction N030°E and N130°E locally at 150. Maâmora is characterized by a well developed river system from West to East. The main rivers are Sebou, Fouarate, Semento, Tiflète, Touirza, Tahrest, Beht and Mellah. The Oued Fouarate with a total length of about 40 km, occupies the western valley. The area of its basin is about 285 km^2. In its upper reaches, Fouarate river management has a N150°E, and then curves to the NW with a mean direction N030°E in the downstream portion of his career, to finally throw in the Sebou river (Zouhri and Carlier [4]). The city of Kénitra is located 40 km north of the capital of the Kingdom of Morocco. It is bounded by the Sebou river in the north, Lake Fouarat in the East and Forest Maâmora in southwest. The objective of this work is to take a sample of 10 wells in 2010 (Table 1, Fig. 1).

Table 1: Drilling studied.

Wells Number	Flow (l/s)	Localizations	Profundity(m)
W1	156	Ain Sebaa, Kénitra	120
W2	50	El Menzeh, Kénitra	135
W3	150	Ain Arris (Ain Sebaa), Kénitra	110
W4	45	Ahmed Taleb, Kénitra	117
W5	40	Ain Khadra (Ain Sebaa), Kénitra	145
W6	100	Ain Taichà (Mehdia), Kénitra	120
W7	100	Sidi Taibi (Ain Sebaa), Kénitra	130
W8	40	Sidi Yahia, Kénitra	140
W9	50	(Ain Sebaa), Kénitra	146
W10	50	(Ain Sebaa), Kénitra	123

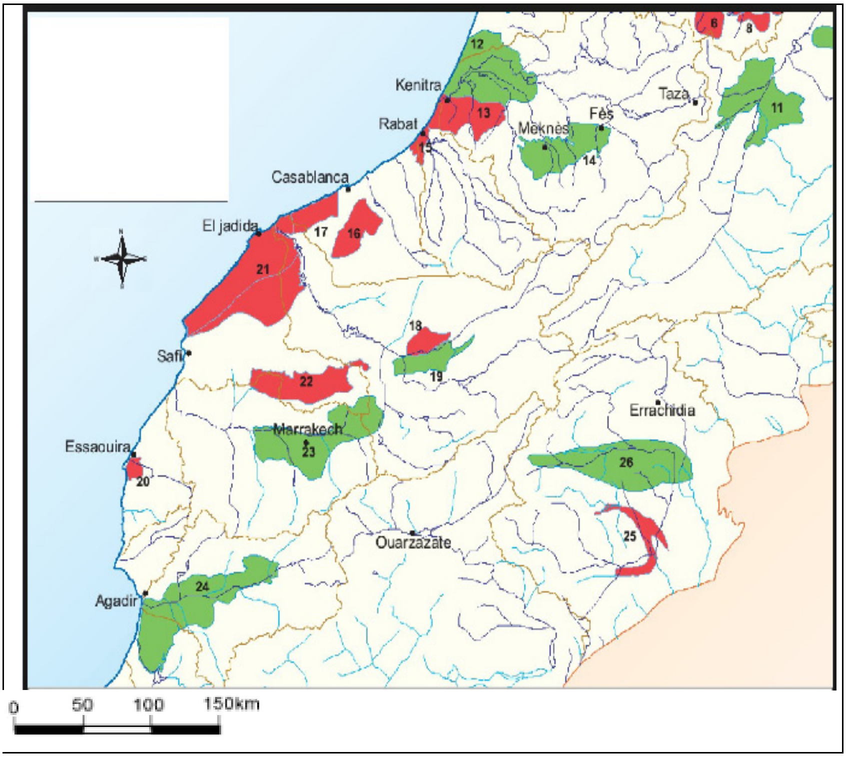

Figure 1: Maâmora (13) and other aquifers of Morocco.

2.2 Study methods

On samples of raw water of Maâmora, we conducted bacteriological (fecal coliforms, total coliforms) and physico-chemical analysis (T°C, pH, EC, NH^{4+}, NO_2^-, NO_3^-, Cl^-, F^-, HCO_3^-, SiO_2, SO_4^{2-}, Boron, Dry Residue, Turbidity, Total Hardness (TH), Dissolved O_2, Oxidisability).

The samples at the pumps are made after buckling tap and extended in order to have a permanent water quality pumping. The water samples are collected in 500 ml bottles kept refrigerated cooler (4°C) until analysis. The following physico-chemical parameters are performed using the techniques of Rodier [5]. Temperature, the potential (pH) and electrical conductivity (EC) were measured in situ using a portable multiparameter (Consort Type 835C). Nitrate (NO_3^-), Nitrite (NO_2^-), ammonia nitrogen (NH_4^+), Silicate (SiO_2), Boron (B^+), Fluoride (F^-) and sulfate (SO_4^{--}) are determined by colorimetric assay using a spectrophotometer (UV/visible Lampa 2). Hardness (TH) is measured by the volumetric method using EDTA. The oxidisability (oxidizable materials: MO) is determined by temperature oxidation in acidic medium. Bicarbonates (HCO_3^-) are analyzed by volumetric titration with 0.1N HCl. Chloride (CL^-) is determined by the solution of mercuric nitrate ($HgNO_3^-$). The title below the oxygen (O_2) determined by sodium thiosulfate solution ($Na_2S_2O_3$) 0.2 N. The dry residue determined by evaporation at 105 °C and weighed for the balance of precision 10^{-4}. Turbidity (NTU) measured by a turbidimeter: HACH brand. Model 2100N. The microbiological groundwater Maâmora is determined by the method of the most probable number (MPN) (Rodier [5]). This method is to inoculate using appropriate decimal sample to analyze a series of tubes containing nutrient broth medium for searching the total flora dilutions. After incubation for 24 h at 37°C, the tubes with a disorder are considered positive. The assessment of faecal contamination is achieved by the enumeration of faecal coliforms and faecal streptococci. Total coliforms were counted after incubation for 24 h to 48 h at 37°C, the tubes containing the medium broth lactose bromocresol purple, fitted with a Durham (presumptive test). The positive tubes (lactose fermentation and gas production) are transplanted to a confirmatory test in a selective medium containing bile salts, bile brilliant green broth with a Durham tube, and another tube containing peptone water free indole and then incubated for 24 h to 48 h at 44°C. Gas production in the first and in the second indole, is evidenced by the presence of fecal coliforms.

As for streptococci, their research is done on the Rothe medium at 37°C for 24 h (presumptive test). From tubes positive Rothe, a subculture is performed on middle Litsky at 37°C for 24 h (confirmatory test). The results are expressed as number of organisms per 100 ml following the McCrady statistical table. The results are analyzed by a statistical comparison of the mean test of Duncun [6]. From the $p < 0.05$ level, the test is taken as being significant.

3 Results and discussion

The assessment of the physico-chemical and bacteriological quality of the water Maâmora was followed through the analysis of water collected at the 10 drillings during the February and March 2010.

3.1 Temperature

We note that the temperature values remain almost constant (Table 2) and this is due to made that groundwater is protected from solar radiation and the atmosphere.

Table 2: Evolution of the temperature of the water table Maâmora.

Wells	February	March	Average (°C)	SD
W1	19.7	20.4	20.05	0.35
W2	20.1	21.2	20.65	0.55
W3	19.8	20.7	20.25	0.45
W4	19.6	20.3	19.95	0.35
W5	20	20.6	20.3	0.3
W6	19.9	20.2	20.05	0.15
W7	21.9	20.4	21.15	0.75
W8	20	20	20	0
W9	21.8	20.6	21.2	0.6
W10	21.4	20.1	20.75	0.65

3.2 pH

The pH of the water varies in the study from 6.65 to 7.89 (Table 3). The values obtained are close to neutrality, while referring to the Moroccan standards (6.5<pH <8.5) for drinking water (Table 19), we note that 100% of the analyzed waters conform to human consumption. Indeed, the waters of the Maâmora Kénitra do not require pH adjustment.

Table 3: Evolution of pH of the water table Maâmora.

Wells	February	March	Average	SD
W1	7.35	7.2	7.28	0.075
W2	6.86	6.65	6.755	0.105
W3	7.2	7.21	7.205	0.005
W4	7.16	7.2	7.18	0.02
W5	7.13	7.18	7.155	0.025
W6	6.8	6.9	6.85	0.05
W7	6.89	6.9	6.895	0.005
W8	7.21	7.65	7.43	0.22
W9	7.73	7.89	7.81	0.08
W10	7.45	7.33	7.30	0.06

3.3 Electrical conductivity

In our study the conductivity values range from 575 to 954 µS/cm (Table 4). The maximum allowable value (MAV) is set to 2700 µS/cm according to Moroccan drinking water standards (Table 19), these values are still stable and below (VMA), but the high content of this parameter is explained by the high concentration of chloride ions (Table 5).

Table 4: Evolution of the conductivity of the water table Maâmora.

Wells	February	March	Average (µs/cm)	SD
W1	671	698	684.5	13.5
W2	945	878	911.5	33.5
W3	691	732	711.5	20.5
W4	882	653	917.5	53.5
W5	736	820	778	42
W6	954	879	916.5	37.5
W7	769	765	767	2
W8	754	745	749.5	4.5
W9	575	595	585	10
W10	825	835	830	5

3.4 Chloride Cl^-

The chlorides are widespread in nature, generally in the form of sodium salts (NaCl) and potassium (KCl) and represent approximately 0.05% of the lithosphere. These are the oceans contain far the largest amount of chlorides in the environment. In our study the values of the concentration of chloride ions ranged from 81.65 to 237.85 mg/L (Table 5). According to Moroccan standards of potability of water, (Table 19) these values are still stable and lower than the maximum value set at 750 mg/L, but the high content of this parameter is explained by the conductivity which is high and the geological rock formations that are contact with groundwater.

Table 5: Evolution of chlorides concentration in the water table Maâmora.

Wells	February	March	Average (mg/l)	SD
W1	81.65	106.5	94.075	12.425
W2	102.95	102.95	102.95	0.00
W3	195.25	220.1	207.675	12.425
W4	152.65	205.9	179.275	26.625
W5	85.2	85.2	85.2	0.00
W6	213	237.85	225.425	12.425
W7	152.65	166.85	159.75	7.1
W8	113.6	124.25	118.925	5.325
W9	92.3	95.85	94.075	1.775
W10	134.9	134.9	134.9	0.00

3.5 Dissolved oxygen (O_2)

Dissolved oxygen varies during the study of 3.32 to 6.72 mg/L (Table 6). The maximum value is set between 5 $<O_2<$8 mg O_2/L according to Moroccan standards for drinking water (Table 19).

Table 6: Evolution of the O_2 concentration of the water table Maâmora.

Wells	February	March	Average (mg/L)	SD
W1	6.72	6.35	6.535	0.185
W2	6.24	6.2	6.22	0.02
W3	3.38	3.32	3.35	0.03
W4	6.48	6.5	6.49	0.01
W5	5.67	5.64	5.655	0.015
W6	4.83	4.88	4.855	0.025

3.6 Oxidisability (with $KMnO_4$)

The oxidisability by $KMnO_4$ dissolved varies during the study from 1.0 to 3.2 mg/L O_2 (Table 7). The maximum allowable value of O_2 is 5 mg/L by Moroccan standards (Table 19) for drinking water (ONEP [7]).

Table 7: Evolution of the oxidisability of the water table Maâmora.

Wells	February	March	Average (mg O_2/L)	SD
W1	2	2.08	2.04	0.04
W2	1	1.07	1.035	0.035
W3	2.2	1.93	2.065	0.135
W4	1.44	1.93	1.685	0.245
W5	2	2	2	0.00
W6	3	3.2	3.1	0.1

3.7 Turbidity (NTU)

Turbidity varies during the study of 0.78 to 3.75 NTU (Table 8). The maximum value is 5 NTU by Moroccan standards for drinking water (Table 19). We find

Table 8: Change in the turbidity of the water table Maâmora.

Wells	February	March	Average (NTU)	SD
W1	1.03	1.25	1.14	0.11
W2	1.08	1.54	1.31	0.23
W3	0.78	1	0.89	0.11
W4	1.8	1.58	1.69	0.11
W5	0.87	0.984	0.927	0.057
W6	3.75	3.54	3.645	0.105
W7	2.35	2.24	2.295	0.055
W8	2.8	2.87	2.835	0.035
W9	3.65	3.75	3.7	0.05
W10	3.25	3.22	3.235	0.015

that 100% of the analyzed waters have turbidity levels below the maximum value and that are consistent with Moroccan standards, as these groundwater have natural filtration in the soil.

3.8 Dry residue

During our study, the dry residues values range from 0.0112 and 0.1246 mg/L (Table 9). The maximum value is set at 0.5 mg/L, according to Moroccan standards of potability of water (Table 19). So these values are still lower than the maximum permissible value.

Table 9: Evolution of tenure Dry Residues in water table Maâmora.

Wells	February	March	Average (mg/l)	SD
W1	0.0553	0.0514	0.05335	0.00195
W2	0.1063	0.1246	0.11545	0 .00915
W3	0.0608	0.0245	0.04265	0.01815
W4	0.0157	0.0147	0.0152	0.0005
W5	0.0112	0.0147	0.01295	0.0051
W6	0.0624	0.0547	0.05855	0.00385

3.9 Alkalinity (HCO_3^-)

The TAC assay is the ions HO^-, HCO_3^- and CO_3^- present in the water, that is to say all of the basic species present. The alkali strength is a measurement of the water tenure of free carbonate and caustic alkali.

HCO_3^- water varies during the study from 4 to 6.2 meq/L (Table 10). The maximum value is 50 meq/L according to Moroccan standards of potability of water (Table 19). HCO_3^- is an indicator of the presence of ions carbonates, bicarbonates, hydroxides hardness of drinking water factor.

Table 10: Evolution of the concentration of HCO_3^- in water table Maâmora.

Wells	February	March	Average (meq/L)	SD
W1	4,2	4,3	4,25	0.05
W2	5	5,4	5,2	0.2
W3	5,3	5	5,2	0.15
W4	4	4,6	4,3	0.1
W5	4,3	4,4	4,3	0.05
W6	4,5	5,6	5	0.55
W7	5,4	5,5	5,5	0.1
W8	4,9	4,9	4,9	0.05
W9	5,4	5,4	5,4	0.1
W10	6,2	6	6,1	0.1

3.10 Total Hardness (TH)

TH of water varies during the study from 11.9 to 16.6 meq/L (Table 11). The maximum for Moroccan standards of potability is the value 50 meq/L (Table 19). TH is a factor indicating the presence of magnesium and calcium ions. Rock formations containing divalent metals (Mg^{2+}, Ca^{2+}) are responsible for hardness.

Table 11: Evolution of the waters TH in water table Maâmora.

Wells	February	March	Average (meq/L)	SD
W1	15.6	14.3	14.95	0.65
W2	13.7	13.4	13.55	0.15
W3	14.2	12.2	13.2	1
W4	13	14.2	13.6	0.6
W5	12	13.5	12.75	0.75
W6	15.5	16	15.75	0.25
W7	13.3	13.6	13.45	0.15
W8	13.00	13.1	13.05	0.05
W9	11.9	12.2	12.05	0.15
W10	16.6	16.2	16.4	0.2

3.11 Nitrate (NO_3^-)

The nitrate content varies during the study from 1.245 to 51.55 mg/L (Table 12). The maximum value set at 50 mg/l according to Moroccan standards (Table 19) of potability of water (ONEP [7]). Although nitrates have no direct toxic effects except at high doses, the fact that they can give birth to nitrites leads to toxicity. Nitrate levels are high for W7 which exceed the Moroccan standards.

Table 12: Temporal variation of nitrate in water level of drilling studied water table Maâmora.

Wells	February	March	Average (mg/L)	SD
W1	47.95	45.65	46.8	1.15
W2	2.02	2.21	2.115	0.095
W3	1.459	1.245	1.352	0.107
W4	32.15	33.25	32.7	0.55
W5	4.56	4.73	4.645	0.085
W6	36.48	37.22	36.85	0.37
W7	51.55	51	51.275	0.275
W8	26.15	22.45	24.3	1.85
W9	4.34	4.54	4.44	0.1
W10	5.13	4.73	4.93	0.2

3.12 Nitrite (NO_2^-)

The nitrite content varies during the study of 0.00 to 0.032 mg/L (Table 13). The VMA nitrite is set at 0.5 mg/L according to Moroccan standards (Table 19).

Table 13: Evolution of the concentration of nitrite in the water table Maâmora.

Wells	February	March	Average (mg/L)	SD
W1	0	0	0	0
W2	0.001	0.0012	0.0011	0.001
W3	0	0	0	0
W4	0.003	0.0001	0.00155	0.00145
W5	0	0.002	0.001	0.001
W6	0.0014	0.0013	0.00135	0.00005
W7	0.021	0.032	0.0265	0.0055
W8	0.019	0.012	0.0155	0.0035
W9	0.0132	0.0135	0.01335	0.00015
W10	0.052	0.057	0.0323	0.0025

3.13 Ammonium (NH_4^+)

In our study the ammonium values range from 0.00 to 0.35 mg/L (Table 14). The maximum value is set at 0.5 mg/L according to Moroccan standards of potability (Table 19).

Table 14: Evolution of ammonium concentration in water table Maâmora.

Wells	February	March	Average (mg/L)	SD
W1	0	0.01	0.005	0.005
W2	0.11	0.13	0.12	0.01
W3	0.01	0.12	0.065	0.055
W4	0.31	0.01	0.16	0.15
W5	0.12	0.1	0.11	0.01
W6	0.23	0.35	0.29	0.06
W7	0.045	0.042	0.0435	0.0015
W8	0.039	0.036	0.0375	0.0015
W9	0.040	0.041	0.0405	0.0005
W10	0.041	0.037	0.039	0.002

3.14 Sulfate (SO_4^-)

Sulfate varies during the study between 11.58 and 21.2 mg/L (Table 15). The maximum value is set at 400 mg/L. by Moroccan standards of potability of water (Table 19), so these values are still well below the maximum allowable value. This can be justified by the presence of very low sulfate levels in the soil and groundwater in the study area (ONEP [7]).

3.15 Boron

Boron varies between 0.00 and 0.026 mg/L (Table 16). The maximum value is set at 0.3 mg/L, according to Moroccan standards of potability (Table 19). Therefore these values are still well below the authorized maximum value.

Table 15: Evolution of the concentration of sulfate ion in water table Maâmora.

Wells	February	March	Average (mg/L)	SD
W1	19.7	20.4	20.05	0.35
W2	20.1	21.2	20.65	0.55
W3	19.8	20.7	20.25	0.45
W4	19.6	20.3	19.95	0.35
W5	20	20.6	20.3	0.3
W6	19.9	20.2	20.05	0.15
W7	15.04	14.56	14.8	0.24
W8	13.67	14.32	13.995	0.325
W9	14.34	15.41	14.875	0.535
W10	11.66	11.58	11.62	0.04

Table 16: Evolution of the concentration of boron in water table Maâmora.

Wells	February	March	Average (mg/L)	SD
W1	0.001	0.00	0.0005	0.0005
W2	0.002	0.001	0.0015	0 .0005
W3	0.001	0.001	0.001	0.00
W4	0.0013	0.0014	0.00135	0.00005
W5	0.00	0.00	0.00	0.00
W6	0.0003	0.0013	0.0008	0.0005
W7	0.0026	0.0032	0.0029	0.0003
W8	0.0027	0.0026	0.0265	0.0005
W9	0.0001	0.0001	0.0001	0.00
W10	0.0004	0.0003	0.00035	0.00005

3.16 Fluoride (F^-)

During our study of fluoride the values range from 0.18 and 0.26 mg/L (Table 17). The maximum value is fixed at 1.5 mg/L, by Moroccan standards of potability (Table 19).

Table 17: Evolution of the fluoride concentration in water table Maâmora.

Wells	February	March	Average (mg/L)	SD
W1	0.2	0.21	0.205	0.005
W2	0.21	0.23	0.22	0 .01
W3	0.18	0.19	0.185	0.005
W4	0.23	0.24	0.235	0.005
W5	0.2	0.2	0.2	0.00
W6	0.25	0.26	0.255	0.005

3.17 Silicate

In our study the values of silicate ranged from 0.236 and 22.08 mg/L (Table 18). The maximum value is 100 mg/L, according to Moroccan standards of potability.

Table 18: Evolution of the silicate concentration in water table Maâmora.

Wells	February	March	Average (mg/L)	SD
W1	22.08	21.00	21.54	0.54
W2	0.254	0.236	0.245	0.009
W3	0.469	0.495	0.482	0.013
W4	0.728	0.706	0.717	0.011
W5	0.834	0.817	0.8255	0.0085
W6	0.347	0.356	0.3515	0.0045
W7	0.495	0.467	0.481	0.014
W8	0.914	0.932	0.923	0.009
W9	19.46	19.53	19.495	0.035
W10	0.347	0.378	0.3625	0.0135

3.18 Bacteriological analyzes of water boreholes

Bacteriological analyzes of water from 10 wells studied reveal the complete absence of coliform bacteria: *Escherichia coli*, Enterococci and Total germs because catchment areas are protected. This is consistent with the guidance of ONEP [7].

The results of the physico-chemical analysis presented in this work showed that the pH, temperature, organic matter and sulfates can be considered eligible and have no impact on water quality. Thus, the average pH values (7.8), temperature (21.2 °C) and sulfate (21 mg/L) are consistent with the standards of supply waters REEM [1]. These results are in agreement with those obtained on the waters of groundwater M'nasra Maâmora (Bricha *et al.* [9] and Belksiri Gharb Akhiar [10]). The variation of the concentration of nitrates found between different wells may be related to the heterogeneity between different physical environments. For Saadi *et al.* [11], the large spatial variability of nitrate at Maâmora study area is due to the surface texture and lithology. However, the proportion of wells nitrate is low; the high proportion of nitrates can be caused by the use of chemical fertilizers in agriculture. The heavy rainfall and lack of vegetation cover contribute to the rapid leaching of nitrates to groundwater Maâmora. Similarly, Zilliox *et al.* [12] found that the winter period is the critical phase of leaching of excess nitrogen in groundwater in France in the Rhine valley, because of the lack of vegetation and the impact of heavy rainfall. Moreover, in the water Maâmora there are no indicators of fecal contamination, in agreement with those found in Marrakech. The comparison between the Moroccan and international standards and data carried out on samples of raw water of Maâmora shows that values of our studies are lower than the standards of Morocco, WHO, France, England and Tunisia (Table 19).

Table 19: Comparison of water table Maâmora with Standards.

Parameters	Maamora maximum	Moroccan	WHO 2007	French 1993	English 2010	Tunisian 1993
T°C	21,9	25	25	25	25	25
pH	7,89	6,5–8,5	6,5–8,5	6,5–8,5	6,5–8,5	6,5–8,5
E C µs/cm	954	2700	2500	2500	2500	2500
Turbidity NTU	3,75	5	5	5	4	5
T.H mg/l	16,6 meq	50 meq	500	500	200	500
HCO_3^- mg/l	6,2 meq	50 meq	400	400	250	400
NO_3^- mg/l	51,55	50	50	50	50	50
NO_2^- mg/l	0,032	0,5	0,5	0,1	0,50	0,1
SO_4^- mg/l	21,2	400	250	250	250	250
CL^- mg/l	237,85	750	250	250	250	250
NH_4^+ mg/l	0,35	0,5	0,5	0,5	0,3	0,5
O_2 mg/l	6,72	5–8	5–8	5–8	5–7	5–8
Oxidisability	3,2	5 meq	5	5	—	5
Boron mg/l	0,026	0,3	0, 3	0,01	1,0	0,01
F^- mg/l	0,26	1,5	1,5	1,5	1,5	1,5
SiO_2 mg/l	22,08	100	100	100	—	100
Dry Residue mg/l	0,1246	0,5	0,5	1500	—	1500

4 Conclusion

The study of these waters and analysis concluded that the threats to the resources of various types of chemicals, human activity, agriculture is very serious. Therefore, the preventive aspect should focus more on the regular monitoring of water quality and control of pollution sources that threaten the water. The implementation and management of groundwater to ensure the availability of water in sufficient quantity and of adequate quality for the benefit of all users in accordance with the aspirations of economic development, harmonious and environmentally sustainable.

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