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The quality of groundwater in several sites of Tangier Tetuan Region (Morocco)

Hikmat DOUHRI[1], Ihssane RAISSOUNI[1], Badia DOUHRI[2], Asmae ZAOUJAL[3], Mohamed BENCHAKHTIR[3], Saloua TAZI[1], Dounia BOUCHTA[1], and Faiza CHAOUKAT[1]

[1]Materials and interfacial systems Laboratory, Department of Chemistry, Faculty of Science, Abdelmalek Essaadi University, BP 2121, Tetuan, Morocco

[2]Biology and health Laboratory, Department of Biology, Faculty of Science, Abdelmalek Essaadi University, BP 2121, Tetuan, Morocco

[3]Regional Epidémiologic Laboratory, Regional Direction of health, Tetuan, Morocco

ABSTRACT: The Region of Tangier-Tetuan (Northern of Morocco) experienced an important urban development in the last decade. For this reason, groundwater's quality is highly susceptible to deterioration by liquid and/or solid waste pollutants. Nevertheless, rural and some per urban residents are still pending on springs supplies for drinking water, irrigation and domestic activities without any treatment, so they are exposed to water diseases.
In order to evaluate the hygienic quality of these springs, a study was conducted during 2013. Fifteen springs were selected for the investigations on chemical and bacteriological parameters.
The physicochemical results showed that the majority of the studied springs are considered acceptable, except some springs that don't meet the standards recommended. Our study revealed also a serious contamination of groundwater by microbial agents, the concentrations of different microbial indicators differed, dependent on the spring's location with respect to the different sources of contamination.
Monitoring the chemical and bacteriological quality of drinking water is essential to prevent the population to health risk.

KEYWORDS: Tangier-Tetuan, drinking, springs, chemical, bacteriological, groundwater, health risk.

1 INTRODUCTION

Water is an essential element to human life, but it can be a carrier of multiple illnesses. In fact, the quality of drinking water is an important environmental determinant of health [1-2-3]. Besides, accessibility to safe water is crucial for sustainable development [4].

Urban development has a negative impact on groundwater quality [4-5]. Actually, human activities can change the ecosystem and the groundwater use become unsafe [6-7].

Morocco faces a major challenge in term of water quality over the near and medium terms [8-9-10]. Groundwater resources must be judiciously managed and protected [11].

Nowadays, groundwater quality is seriously vulnerable to domestic and industrial waste and/or phytosanitary products [12-13].

In Tetuan-Tangier Region, groundwater supplies are used by a large part of suburban and rural population as a source for their drinking, domestic activities, animal drinking and cultures irrigation.

Previous researches have showed a relationship between water quality and urban development [14-15]

Safe drinking water must have an acceptable quality in terms of its physical, chemical and bacteriological parameters [16]. These parameters have been used to determine the general quality of drinking water worldwide [17].

Currently, the assessment of the groundwater quality is very important. This work focuses on the determination of the chemical and bacterial quality of some springs in the northen area of Morocco.

2 MATERIALS AND METHODS

2.1 FIELD SAMPLING

Groundwater samples were collected during 2013, twice a year (wet and dry seasons), from fifteen selected locations with different degrees of environmental quality at Tangier-Tetuan Region (Northen of Morocco).

The chosen sites (S1: Ain Sekkouh; S2: Ain Lahcen; S3: Ain Benkarich; S4: Ain Bouanane; S5: Ain Melloul ; S6: Ain Rass Louta ; S7: Ain Hawma Kahla ; S8: Ain Mae Labyad ; S9: Ain Khandeq Jamaa ; S10: Ain Diwana ; S11: Ain Dchar ; S12: Ain Mae Alah ; S13: Ain Roumane ; S14: Ain Tine ; S15: Ain Puente) are represented in Figure 1.

Samples were transported in cold boxes (at 4°C) to be subjected to some bacteriological and chemical parameters measurement within 24 hours in the laboratory. Standard methods were followed in collection, storage and analysis of the water samples.

2.2 LABORATORY ANALYSIS

2.2.1 MICROBIAL INDICATORS

The samples were collected in sterile glass bottles, kept at 4°C and analyzed within 24 hours in the laboratory. Faecal bacteria were enumerated by the membrane filter technique using specific media (Tergitol and Slanetz) and different incubation conditions (44 °C for faecal coliforms and 37 °C for both total coliforms and faecal streptococci).

After 24 hours, number of bacteria was calculated and expressed in Colony-Forming Units per 100 ml (CFU/100 ml).

2.2.2 PHYSICOCHEMICAL PARAMETERS

Water physicochemical analysis was conducted using methods described by Rodier [18]. Field analyses were made for the parameters pH, temperature and electrical conductivity which were all measured by adequate sensors. The other parameters were analyzed in the laboratory after completion of the sampling.

3 RESULTS

3.1 DETECTION OF FAECAL BACTERIA

The results of microbiological analysis of water samples from different springs of Tangier-Tetuan Region are presented in figures 2 and 3. Data fell into two clearly defined periods (wet and dry seasons).

Microbiological results indicated that faecal coliforms, total coliforms and faecal streptococci values were higher than the required values in all studied springs.

In wet season (fig. 3), total coliforms values varies between 5 and 254 CFU/100 ml, faecal coliforms values between 0 and 53 CFU/100 ml and faecal streptococci values between 0 and 240 CFU/100 ml.

In dry season (fig. 2), total coliforms values varies between 4 and 240 CFU/100 ml, faecal coliforms values between 0 and 75 CFU/100 ml and faecal streptococci values between 0 and 240 CFU/100 ml.

In rainy season, the ratio FC/FS is more than 4 in S8 and S13 (human pollution) and less than 1 in S1, S2, S4, S5, S7, S11, S12, S14 and S15 (animal pollution).

In dry season, the ratio FC/FS is more than 4 in S13 (human pollution) and less than 1 in S1, S2, S3, S4, S5, S10, S11, S12, S14 and S15 (animal pollution).

3.2 PHYSICOCHEMICAL ANALYSIS

The results of physicochemical analyses are presented in Tables 1 and 2 and compared with the reference values of the drinking water (NM 03.7.001) [19].

In the dry season (table 1), the pH value in S11 were lower than the reference limit (pH = 5,96). On the other hand, the dissolved oxygen values don't meet the standards recommended except the values in S8, S11 and S15 (respectively 5,89 mg/l, 5,68 mg/l and 5,14 mg/l). However the others chemical parameters did not exceed the reference values of the drinking water regulation.

In the wet season (table 2), the dissolved oxygen values don't meet the standards recommended except the values in S1, S8, S11 and S15 (respectively 5,6 mg/l, 6,02 mg/l, 6,04 mg/l and 5,55 mg/l). However the others chemical parameters did not exceed the reference values of the drinking water regulation.

4 DISCUSSION

Chemical and microbiological indicators were used to assess the groundwater quality in some springs of Tangier-Tetuan Region [19].

In the dry season, chemical analyses have shown that the pH of the water samples significantly varied from 5,96 to 8,5 and was lower than the reference limit (pH = 5,96) in sample S11. This may be due to impact of sewage water on groundwater. On the other hand, the dissolved oxygen values ranged from 2,99 (mg/l) to 5,89 (mg/l) and don't meet the standards recommended except some springs S8, S11 and S15 (respectively 5,89 mg/l; 5,68 mg/l and 5,14 mg/l).

In the wet season, chemical analyses have shown that the pH of the water samples significantly varied from 6,8 to 8,5. Moreover, the dissolved oxygen values ranged between 3,11 (mg/l) and 6,04 (mg/l) and don't meet the standards recommended except the values in S1, S8, S11 and S15 (respectively 5,6 mg/l; 6,02 mg/l; 6,04 mg/l and 5,55 mg/l).

The others chemical parameters did not exceed the reference values of the drinking water regulation.

Our results are in agreement with the investigations of Belghiti et al in Meknes Region [16] and Bricha's et al in M'nasra's groundwater [22].

Microbiological results show that there is a seasonal variation (dry and rainy season) in the bacteria concentration and exceeds the standard of drinking water in all studied springs, this is probably due to wastewater infiltrations, human and⁄or animal pollution. Similar results were found by many investigators such as Tazi et al in Casablanca [20], Arnade in Florida [21], Belghiti et al in Meknes Region [16] and Bricha's investigation in M'nasra's groundwater [22].

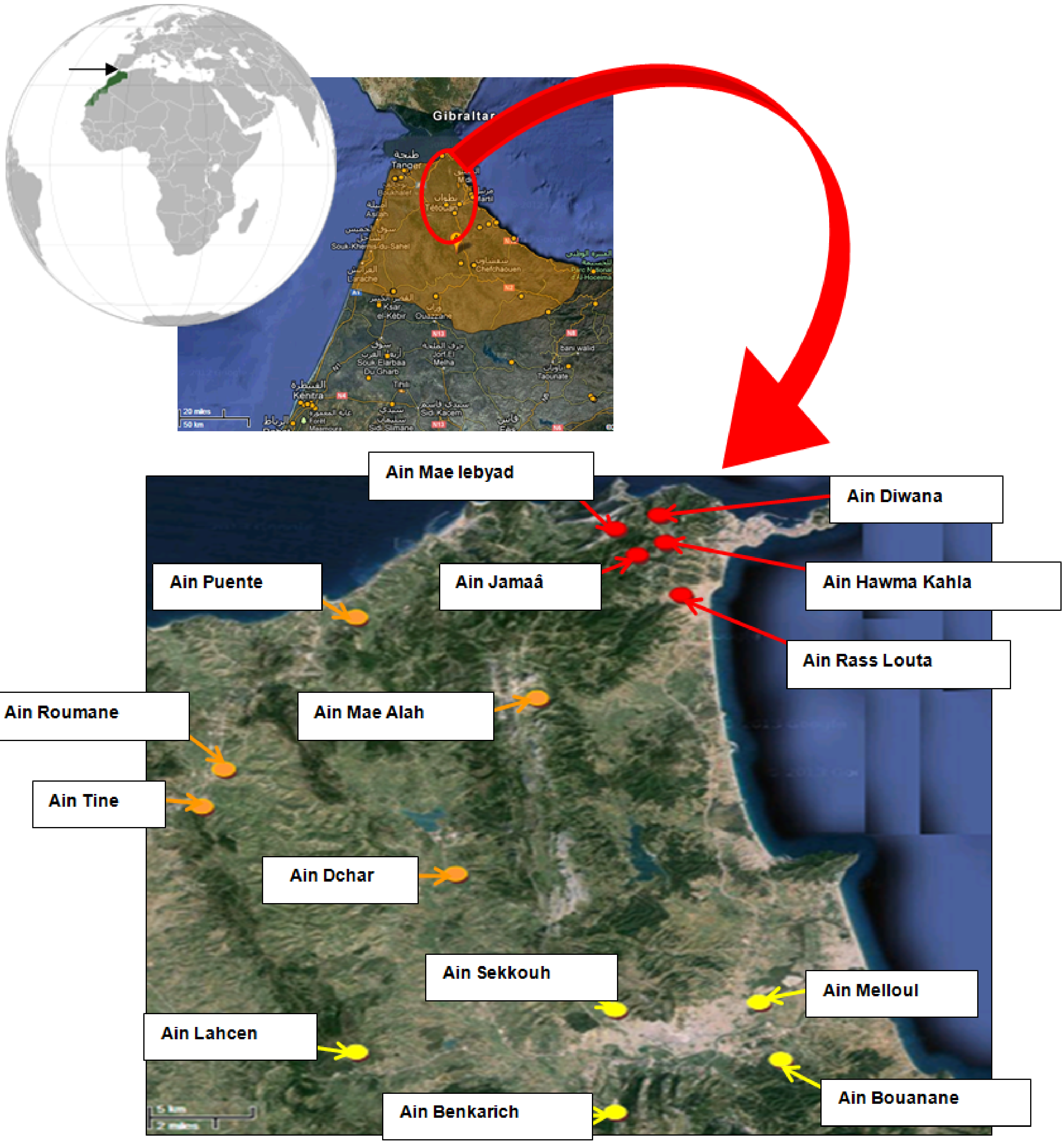

Gibraltar
Ain Mae lebyad
Ain Diwana
Ain Puente
Ain Jamaâ
Ain Hawma Kahla
Ain Rass Louta
Ain Roumane
Ain Mae Alah
Ain Tine
Ain Dchar
Ain Sekkouh
Ain Melloul
Ain Lahcen
Ain Bouanane
Ain Benkarich

Fig. 1.

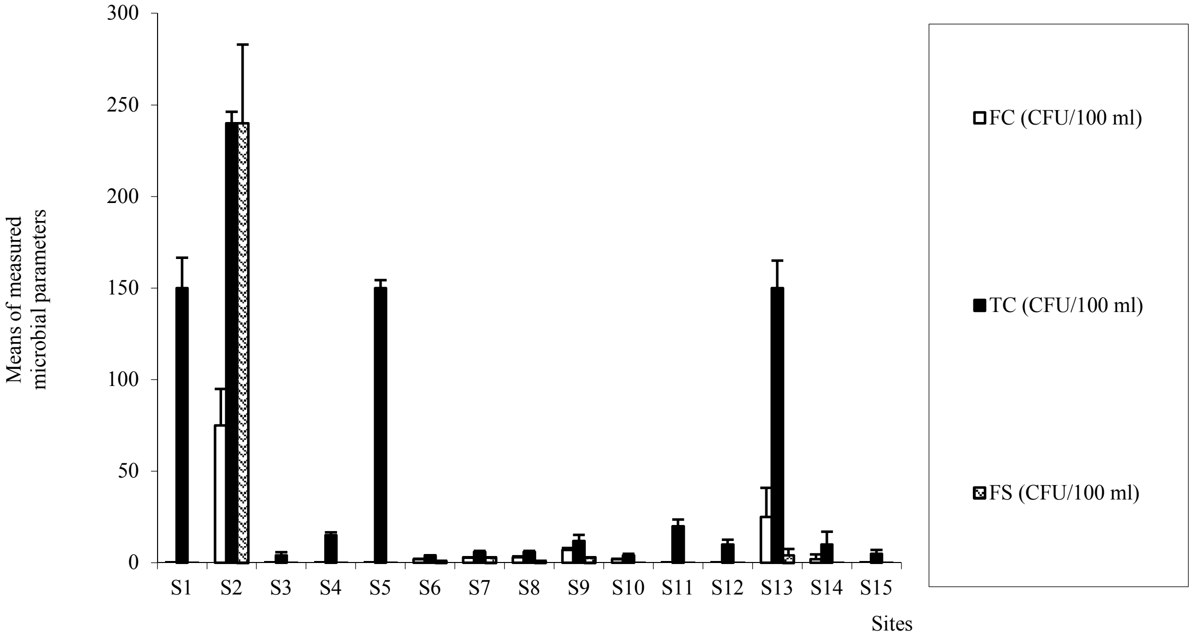
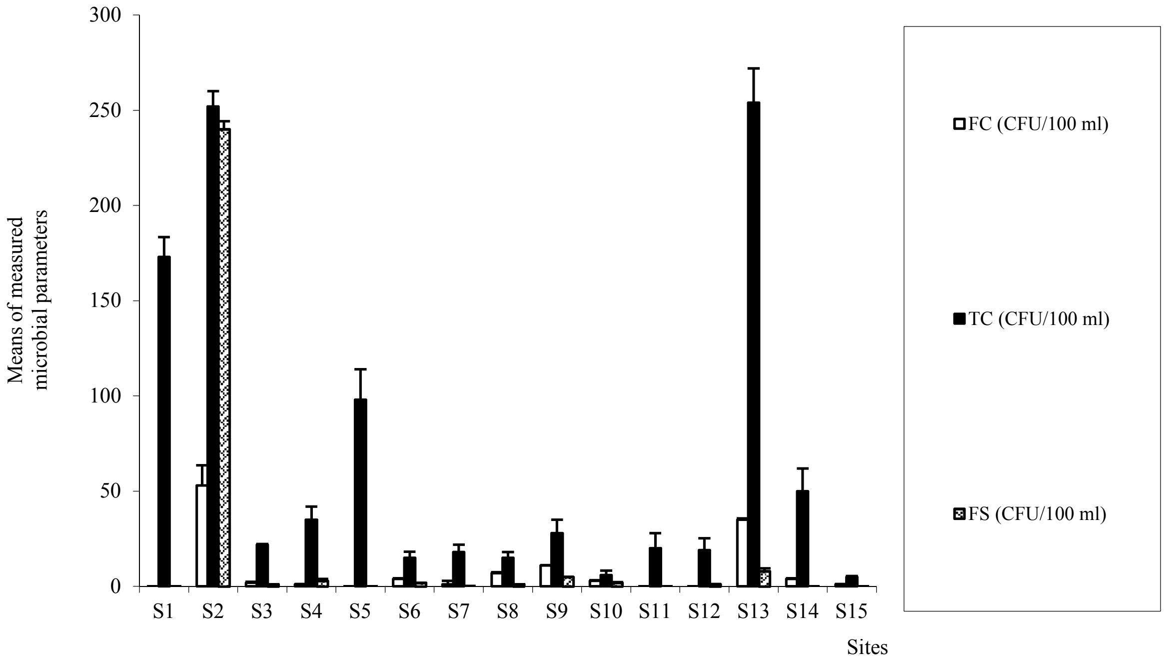

300
250
200
150
100
50
0
Means of measured microbial parameters
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
Sites
FC (CFU/100 ml)
TC (CFU/100 ml)
FS (CFU/100 ml)

Fig. 2


300
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Means of measured microbial parameters
S1
S2
S3
S4
S5
S6
S7
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S9
S10
S11
S12
S13
S14
S15
Sites
FC (CFU/100 ml)
TC (CFU/100 ml)
FS (CFU/100 ml)

Fig. 3

Table 1

Parameters	Sampling sites														
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**
Temperature (°C)	21	20	19,5	20,5	21	20	19	20	18,5	21	22,5	17	20,0	20	24,6
Turbidity (NTU)	0,66	4,31	0,15	0,74	0,77	0,28	0,3	0,16	0,20	0,28	3,9	3,5	3,6	1,8	2,9
pH	6,65	7,2	7,1	7,15	6,65	7,2	8,5	8	7,4	8	5,96	6,8	6,8	6,8	7
Electrical conductivity (µs/cm)	1264	251	651	633	1232	533	470	226	508	305	342	614	512	302	382
Mg^{2+} (mg/l)	2	0,24	2,72	2,4	1,24	1,5	2	0,51	2,5	1	2,10	1,88	1,2	2,7	0,98
Ca^{2+} (mg/l)	6,8	0,88	4,2	4,4	7,8	3,4	6,1	1,2	5	2,5	2,94	2,28	1,3	3,32	2,7
Cl^- (mg/l)	163,3	46,15	42,6	49,7	49,7	40	34	24	22	36	118	156	176	88	74
So_4^{2-} (mg/l)	63,3	15,12	16,25	20,4	120,2	21	14,7	15	17,2	14	42,5	47,7	65,6	78,2	23,8
No^{2-} (mg/l)	0	0,45	0	0	0	0	0	0	0,04	0	20,1	0,12	0,22	0,15	0,18
No^{3-}(mg/l)	1	2,8	0,9	2,6	0,1	1,7	0,5	0,5	1	0,3	10,3	2,8	5,42	8,26	2,2
NH^{4+} (mg/l)	0	0	0	0	0,12	0	0	0	0	0	0,2	0	0	0,1	0,12
Dissolved oxygen (mg/l)	3,3	3,55	3,7	3,45	2,99	3,5	3,22	5,89	3,65	3,1	5,68	3,97	3,5	4,65	5,14

Table 2

Parameters	Sampling sites														
	S1	**S1**	**S1**	**S1**	**S1**	**S1**	**S1**	**S1**	**S1**	**S1**	**S1**	**S1**	**S1**	**S1**	**S1**
Temperature (°C)	20	16,3	16	16,4	20,4	18	17	18,5	17	19,5	19	17	20	20	21
Turbidity (NTU)	0,61	5	0,55	0,9	0,85	0,44	0,53	0,47	0,73	0,49	3,9	4,6	5	2,05	3
pH	7,6	8	7,2	7,5	7,8	7,2	8,5	7	7,4	8	6,8	7,1	6,9	7	6,8
Electrical conductivity (µs/cm)	1163	187	703	570	1077	533	454	212	488	300	321	602	505	300	403
Mg^{2+} (mg/l)	2	0,22	2,75	2,4	1,44	1,75	2	0,50	2,55	1,5	2,22	2	1,42	2,33	1,02
Ca^{2+} (mg/l)	5,56	1	4	5	7,8	3,5	6,1	2	5	2,5	2,94	2,28	1,8	3,72	2,7
Cl^- (mg/l)	152,1	45	42	47	42	37	29	23	20	34,5	108	153	160	68	54
So_4^{2-} (mg/l)	60	12	16	18,5	99,5	20	12,5	14	17	12	42	45	63	72	22
No^{2-} (mg/l)	0	0,41	0	0	0	0	0	0	0,04	0	0,09	0,12	0,22	0,16	0,2
No^{3-}(mg/l)	1,5	3	0,9	2,6	0,3	1,6	0,7	0,5	1,5	0,4	12	2,8	5,42	8,27	2,2
NH^{4+} (mg/l)	0	0	0	0	0,14	0	0	0	0	0	0,21	0	0	0,2	0,15
Dissolved oxygen (mg/l)	5,6	3,85	3,97	3,67	3,11	3,74	4,53	6,02	3,65	3,5	6,04	4,01	3,96	4,83	5,55

5 CONCLUSION

The results of bacteriological analysis show that the groundwater in Tetuan-Tangier Region present risks to human health. There is a need to improve the microbial quality of these waters.

The decrease of dissolved oxygen concentrations indicates inorganic (heavy metals) and/or organic (organic matter, hydrocarbons) contaminations. We suggest that additional research should be conducted. This work is now in progress.

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