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Evaluation of the Physicochemical Quality of Springs Water in the El Hajeb Area, Morocco

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Abstract
Groundwater plays an important role in the socio-economic development for all countries of the world. They thus ensure safe drinking water for rural and urban populations. However, they are sometimes exposed to various forms of pollution: agricultural, industrial and domestic. So the supervision and the quality control are of paramount interest in the fight against certain waterborne diseases because water intended for human consumption must not contain pathogenic organisms or harmful chemicals; because water contaminated with microorganisms is causing epidemics. In addition, nitrate pollution of drinking water can cause methemoglobinemia to infants and carcinogenic diseases to adults. This work is structured in the same objective, which is the evaluation of the physicochemical quality of water sources in the region of El Hajeb, which are used in the supply of drinking water for a large population of area.

Keywords: El Hajeb, springs, physicochemical quality, pollution.

Introduction
Water is an essential element for the development of life: the body of an adult human being is composed of over 60% water and a minimal consumption of 1.5 liters of water a day may be necessary [1]. Because of its vital nature, the water used must be of good sanitary quality, as it can also be effective transport agent and spread of pollution and diseases (cholera, typhoid, ...) [2]. Population growth and the development of agriculture and the use of septic systems regulations are driving significant problem of the deterioration of the groundwater resource, already in limited supply.

The province of El Hajeb contains several water sources, which are used as drinking water for much of the rural and urban population. So they are used to irrigate farmland and industry. Given climate change that the world has known in recent years and the pollution problems that particularly affect water resources, we found it useful to undertake a study to assess the physico-chemical quality of water sources in the province of El Hajeb.

Materials and methods
Presentation of the study area
The province of El Hajeb is part of the Meknès-Tafilalet region. It is located at the junction of the rich plain of Sais and the foothills of the Middle Atlas, between 33 ° 20 'and 34 ° 0' of the north elevation and between 5 ° 10 'and 5 ° 50' west longitude. It has an area of about 2210 square kilometers and a population of 240,436 inhabitants (2004 census). It consists of four municipalities (El Hajeb, Agourai, Sebaâ Ayoun and Taoujdate) and eleven rural communes (Ras Ijerri, Jahjouh, Ait Ouikhalfen, Tamchachate, Ait Yaâzem, Iqaddar, Bourzouine Ait Ait Naaman, Boubibdmane Ait Ait Harzallah, Laqsir and Bittit). It is bounded on the north by the Prefecture of Meknes, to the south by the provinces of Ifrane and Khenifra, on the east by the prefecture of the province of Fez and west by the province of Khemisset (Figure 1).

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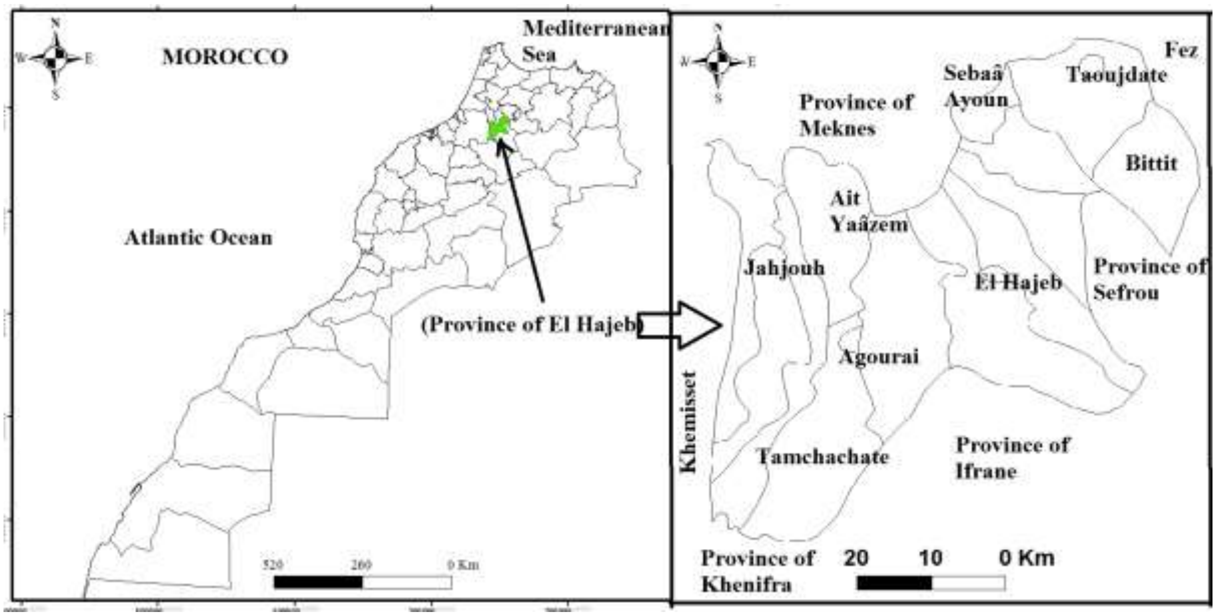

Figure 1: Location of the study area.

Climatology

The province of El Hajeb has a continental climate, hot in summer and cold in winter. Maximum temperature (July) and minimum (January) are respectively 40 ° C and -2 ° C. The rainy season begins from September to May (Figure 2), while the dry season starts from June to September. Annual precipitations undergo large variations from year to year and vary between 300 mm and 800 mm. The rainfall of 2013 is around 659 mm.

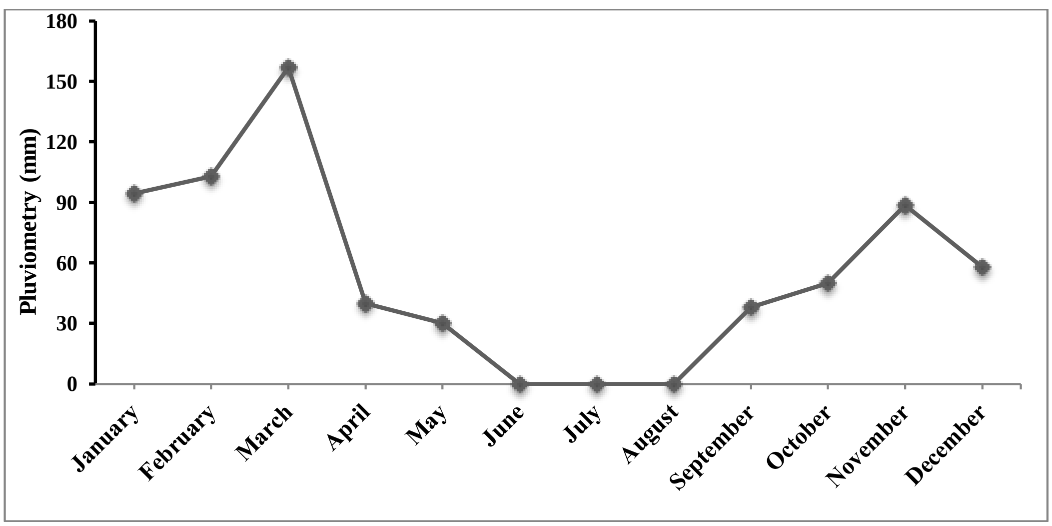

Figure 2: Monthly rainfall in the region of El Hajeb for 2013.

Piezometry

In order to know the direction of flow of groundwater in the province of El Hajeb, we developed a piezometric map representing isopleth curves during the rainy season. Measurements of water levels in the water were performed on all existing water points in the province of El Hajeb. The interpretation of the piezometric map shows that the flow of groundwater in the province of El Hajeb direction is from south to north (Figure 3 and Figure 4).

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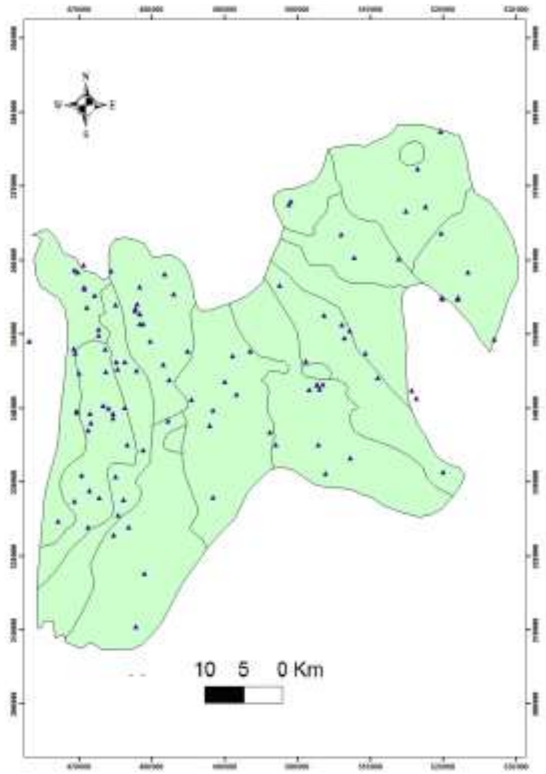

Figure 3: Location of water points studied.

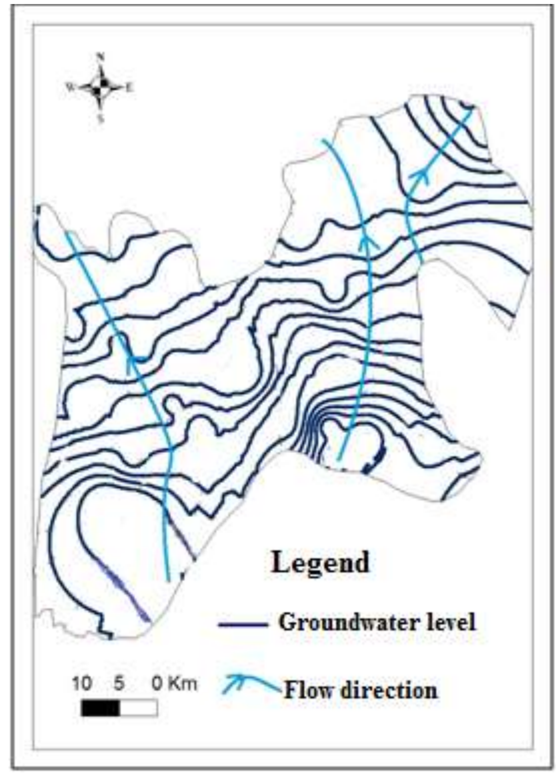

Figure 4: Direction of groundwater flow in studied area.

Sampling and physicochemical analyzes

Water Samples were collected in Polythene bottles of 2.0 litres without any air bubbles. The samples were collected from twelve water springs in the province of El hajeb (Morocco). The springs surveyed are located by the geographical coordinates and elevation using a Global Positioning System (GPS) type (GARMIN GPSmap 62) (table 1; Figure 5).

The samples were collected from all the stationsPrior to the collection, bottles were thoroughly washed and rinsed with sample to avoid any possible contamination in bottling and every precautionary measure was taken. The samples collected were kept in a refrigerator (+4°C) during transportation to hydrology laboratory at the National Institute of Hygiene (INH) in Rabat for analysis.

The analyses of various physicochemical parameters were carried out as per the method described by Jean Rodier *et al.* [3]. The temperature, potential of hydrogen (pH) and electrical conductivity were measured at the time of sample collection. pH was measured with Portable Field pH Meter, type (WTW pH 330i/SET), conductivity with Handheld Conductivity Meter, type (WTW cond 330i/SET). The temperature was measured by a thermometer built into the Conductivity Meter and the pH Meter. Nitrate (NO_3^-), nitrite (NO_2^-), ammonia nitrogen (NH_4^+) and sulphate (SO_4^{2-}) were determined by a colorimetric method using a UV/visible spectrophotometer type (JASCO V-530). Total Hardness (TH), calcium (Ca^{2+}) and magnesium (Mg^{2+}) were determined by the volumetric method with EDTA (Ethylenediaminetetraacetic-acid). The oxidizability (organic matter: OM) is determined by high temperature oxidation in acidic medium. Alkalinity (TA), total alkalinity (TAC) and bicarbonate (HCO_3^-) were analyzed by volumetric dosing with 0.1 N HCl. Chlorides (Cl^-) were determined by the volumetric method with dinitrate mercury $Hg(NO_3)_2$ in the presence of a pH indicator. Sodium (Na^+) and potassium (K^+) were determined by excitation of the atoms by flame photometer type (AFP-100).

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Table 1. Name and geographical coordinates of springs studied.

Spring Name	Code	GPS location of sampling point		District
		N	W	
Ain Ben Kazza	S1	33° 57’ 07,53”	5° 12’ 55,06”	Taoujdate
Ain Atrouss	S2	33° 45’ 31,24”	5° 13’ 50,54”	Bittit
Ain Benyoussef	S3	33° 43’ 39,69”	5° 17’ 57,93”	Ait Harzellah
Ain Khadem	S4	33° 41’ 20,66”	5° 22’ 17,04”	El Hajeb
Ain Sefa	S5	33° 41’ 22,58”	5° 21’ 45,46”	El Hajeb
Ain Jaoui	S6	33° 46’ 30,64”	5° 38’ 01,49”	Ait Yaâzem
Kasba Agourai	S7	33° 45’ 47,51”	5° 37’ 42,44”	Agourai
Ain Salama	S8	33° 50’ 25,39”	5° 40’ 3,23”	Ait Yaâzem
Ain Ouchket	S9	33° 43’ 58,16”	5° 43’ 51,95”	Ait Ouikhalfen
Ain Azza	S10	33° 37’ 9,47”	5° 42’ 36,14”	Ait Ouikhalfen
Ain Almou N’chrif	S11	33° 32’ 48,26”	5° 43’ 48,17”	Ait Ouikhalfen
Ain Mjifla	S12	33° 31’ 47,35”	5° 39’ 53,38”	Tamchachat

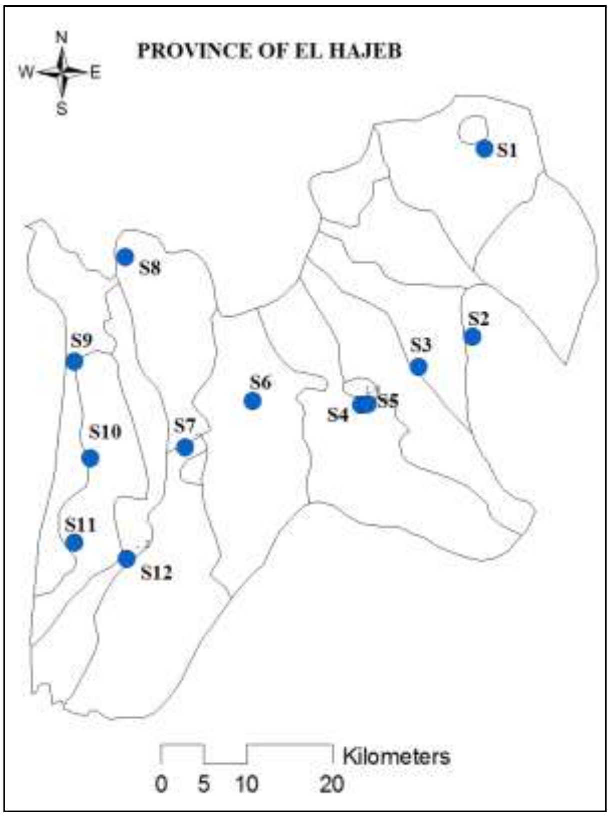

Figure 5: Location of springs water studied.

Results and discussion

Temperature (T), Electrical conductivity (EC), pH and major ion concentrations are summarized in Table 2. The pH ranges from 6.69 to 7.9, it was within the permissible limit by Moroccan standards [4]. The temperature of groundwater samples varies significantly, from 16.3 °C to 21.1 °C, with the exception of the thermal spring water S8 which has a value of 39 °C. The Total Hardness (TH) of samples was ranging from 10 °F to 40 °F. Based on these results, the groundwater in El Hajeb area is generally hard. Sodium levels range from 4 mg/l to 340 mg/l with an average of 41.81 mg/l. Potassium levels are relatively low, ranging between 0.5 mg/l to 4.8 mg/l. Bicarbonate (HCO_3^-) record values between 67.1 mg/l to 353.8 mg /l, respectively observed in the springs S2 and S11. The total alkalinity (TAC), which is a quantity used to measure the rate of hydroxides, carbonates and bicarbonates, range from 5 °F to 28.5 °F in the waters of studied area.

Furthermore, the nitrate levels range from 4.60 mg/l to 50.67 mg/l, which are recorded in the spring water S8 and S10 respectively, with an average of 28.50 mg/l. It was reported that groundwater was contaminated from nitrate fertilizers and manures used in agriculture. We reported that the concentration of nitrates in the spring water S10 exceeds the maximum allowed by Moroccan standards and WHO standards [5] for drinking water.

Pollution by organic matter (OM), which is related to sewage discharges and urban of some highly polluting food industries such as abattoirs, dairies and sweets [6], is far from being allocated to water sources studied . Indeed, we have recorded concentrations that do not exceed the Moroccan standard for drinking water and they range from 0.19 mg/l to 1.02 mg/l.

The Sulfates parameter is naturally present in groundwater in highly variable concentrations

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(important in contact with gypsum land) [7]. The values for this chemical entity observed, ranged from 2.80 mg/l to 48.22 mg/l, these values are observed respectively at spring water of S11 and S8. Chlorides were ranging 7.1 mg/l to 550.2 mg/l, respectively observed in the springs S4 and S8.

Table 2: Values of the various physicochemical parameters of spring water surveyed.

Springs	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
T (°C)	20.1	16.7	18.8	17.9	17.1	19.6	18.6	39.0	19.0	17.4	16.3	20.8
pH	8.13	7.04	7.42	7.23	6.98	7.22	7.70	6.69	8.41	7.31	7.33	7.17
CE (µs/cm)	645	459	542	581	543	713	966	2440	741	674	238	411
TA (°F)	0	0	0	0	0	0	0	0	0	0	0	0
TAC (°F)	24.0	28.5	26.5	26.5	26.5	26.5	27.5	27.0	24.0	26.0	5.0	16.5
TH (°F)	29.0	31.6	29.6	27.6	30.0	27.6	43.0	32.0	33.2	39.4	10.0	19.2
HCO_3^-(mg/l)	298.9	353.8	329.4	329.4	329.4	329.4	341.6	335.5	298.9	323.3	67.1	207.4
Ca^{2+} (mg/l)	36.9	44.9	60.1	35.3	56.1	64.1	48.9	62.5	41.6	118.6	17.6	48.1
Mg^{2+} (mg/l)	48,15	49,61	35,51	48,16	38,92	14,94	74,91	39,89	55,54	23,83	13,6	17,51
SO_4^{2-} (mg/l)	5.66	2.80	11.65	17.89	11.21	11.07	24.35	45.84	18.64	48.22	8.48	19.75
Cl^- (mg/l)	31.95	21.30	17.75	7.10	14.20	46.15	67.45	550.2	81.65	39.05	14.20	10.65
NO_3^- (mg/l)	41.46	17.72	24.59	40.43	27.74	27.37	41.11	4.60	16.90	50.67	30.40	19.09
NO_2^- (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NH_4^+ (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Na^+ (mg/l)	21	11	5	4	6	23	27	340	26	19	8	12
K^+ (mg/l)	1.0	0.5	1.0	1.0	2.0	1.0	1.0	3.0	1.3	4.8	1.6	1.0
OM (mg/l)	0.25	1.02	0.32	0.45	0.40	0.26	0.96	0.71	0.25	0.30	0.19	0.52

ND : Not Detectable

In the results of the present study, we recorded the springs water studied have similar physicochemical characteristics except geothermal spring S8. This means that these sources belong to the same groundwater. Furthermore, we found very high concentrations of nitrates in springs water S10 and S7. This pollution is certainly of agricultural origin, because the two springs are in an agricultural area. Therefore, the water from these two springs is unfit for human consumption. Because the consumption of water from the two springs, can cause very serious illnesses, especially to infants (methemoglobin) [8].

We also found that the source S8 is a thermal spring has very high values of conductivity (2400 µS/cm) and temperature (39 °C). This hot spring is a spring that is produced by the emergence of geothermally heated groundwater from the Earth's crust. So the web of the source is shallow. Therefore, it is protected against all forms of pollution: agricultural, industrial and domestic. Therefore, it stores a minimum value of the concentration of nitrates. However, it presents sulphate content and very high compared to other sources chlorides. Finally, we can confirm that the waters of the S8 source are laxative and can be potentially dangerous for patients with cardiovascular disease or kidney disease.

Conclusion

The water from all springs studied recorded values below the Moroccan standards, exception of spring water S8 and S10. Therefore, they pose no danger to the health of the population on the physicochemical level. However, a study on the bacteriological research germs indicators of fecal pollution and pathogens is required. So, the spring water S10 contains nitrate levels that slightly exceed national and international standards, so they are unfit for human consumption. As for the hot spring S8, it is strongly mineralized with a conductivity of 2440 µs/cm and chloride level is very high (550.2 mg/l). Therefore, they are laxative and they are not recommended for people suffering from heart and kidney problems.

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