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Quality of the Aquifers Groundwater of the Algerian Northern Sahara (Case of HASSI MESSAOUD).

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ABSTRACT

The objective of this study is to give an outline on the groundwater quality of the northern Sahara and giving a progress report on a particular element, the fluorine. We thus chose to start with the Eastern area of the northern Sahara, the area HASSI MESSAOUD. We started a groundwater sampling campaign in these areas and the test sample selection of water touched all the aquifers levels, whether it is in the final complex or the continental guide. We determined in laboratory the physicochemical parameters of the water samples. The results of these analyses are interpreted and compared with the standards of drinking water quality established by the World Health Organizations. We tried to demonstrate the evolution of the various biogenic salts concentrations as well as fluorine by presenting charts of these elements.
Keywords: Diagnosis, groundwater, Hydrochemistry, mineralization

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INTRODUCTION

In arid-climate developing countries, the role of groundwater is particularly important as it is often the only drinking water source and therefore vital for the development of these countries (TRAVI, 1993). For the Algerian northern Sahara, most of the resources are groundwater. The latter, contained in the continental formations of the intercalary continental (IC) and the terminal complex (CT) constitute one of the largest hydraulic reservoirs in the world (BEL and CUCHE, 1970, CDTN, 1992), whose potential mobilities are estimated at 5 billion cubic meters of water (ANRH, 1986). The lithologic, hydrodynamic and hydro-chemical conditions are varied, particularly in the eastern part of the region, and thus give particular interest to these aquifers (ERESS, 1972). In addition, a number of studies enterprised over the last 30 years have shown that this region's water are characterized by an excessive total mineralization, most often associated with high hardness and high concentrations of fluoride (ACHOUR, 1990; ABRAHAM, 1978, PINET et al., 1961). The discovery of numerous dental and bone fluorosis in different regions explain the interest, since the beginning of the century, in the presence of fluorine in natural waters. Besides reducing the number of dental caries, fluorides are rapidly fixed by bones, a quality for which fluoride is used to treat individuals with osteoporosis (O.M.S, 1985). However, the excessive intakes of fluoride in some regions (DEAN, 1942, BOUARICHA, 1971, TRAVI and LECOUSSTEUR, 1982) have shown that this beneficial effect can be reversed and adversely affect public health, what is known as dental fluorosis or more severely bone fluorosis. In Algeria, the northern Sahara, and particularly the eastern zone, is the region most exposed to fluorite risk (AZOUT and ABRAHAM, 1978, I.N.S.P, 1980).

The main objective of this study is to provide an outline of the Algerian northern Sahara's groundwater physico-chemical quality. Due to a sufficiently representative sampling of the eastern region waters nature. We are particularly focused on the excess fluoride ions presence in the waters of the most exploited aquifers.

PHYSICO-CHEMICAL QUALITY OF AEP'S WATER

PRESENTATION OF THE STUDY AREA

The region of Hassi Messaoud is located 650 km south Algiers and 86 km southeast of Ouargla it has a population of 53 000 people, it occupies a surface area of 4200 Km^2, half of this area is occupied by large sandy accumulations their altitudes exceeding 200 m. The region of Hassi Messouad is an oil refinery town, their economy is largely turned towards the exploitation of its oil field, considered by its production as one of the ten largest oil fields in the world, with 400,000 barrels per day and a lifetime of 80 years, it has more than a thousand wells, it contributes up to 10 % in the Gross National Product (GNP).

Sampling

The sampling campaign concerned the main urban areas in the region of Hassi Messaoud. We chose to take samples at each exploited aquifer level (groundwater, water tables of the sands or Mio-pliocene, limestones or Senonian water tables, the Albian water tables). Seventeen Samples in total were manually carried out in plastic bottle of 1000 cm^3 capacity. When drilling for irrigation, the sample is taken directly from the head of the borehole. But when it comes to a water tower the bleaching is stopped, the pipe is drained so that the sample is representative of the borehole water (SEDAT; TABOUCHE, 1999). Conductivity and temperature were measured in situ whenever possible. The sample must always be clearly identified and include the drilling code, the date, and if possible the depth and aquifer level.

RESULTS AND DISCUSSION

The results of the physicochemical analyzes are given in the form of tables in which we propose some examples and this for all the regions concerned by the campaign as well as all the aquifers levels exploited in the latter.

Table 1: Physico-chemical analyzes in the study area's groundwater

Locality	code	Water table	T°C	pH	CE (ms/cm)	Ca^{+2} (mg/l)	Mg^{+2} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	HCO_3^{-} (mg/l)	Cl^{-} (mg/l)	SO_4^{-2} (mg/l)
zone industrial	HMD 101	Senonian	23	7.6	2.61	128	113	179	9	174	154	751
city 1850	HMD 102		25	7.4	4.3	180	147	383	17	149	410	1103
city 314	HMD 103		24	7.5	2.41	116	169	99	8	140	101	883
city 272	HMD 104		26	7.4	2.68	130	139	163	9	143	213	790
accommodation	HMD 105		24	7.45	2.41	118	120	141	9	137	151	691
zone ENAFOR	HMD 106		25	7.35	2.45	120	143	139	9	122	220	711
Customs accommodation	HMD 107		23	7.5	2.35	114	124	139	9	131	131	779
Hyd complex	HMD 108		26	7.5	3.61	160	118	342	16	122	300	1000
city 136	HMD 109		24	7.45	2.38	122	127	132	9	128	256	596
city 1666	HMD 110		25	7.45	9.2	139	128	170	9	163	209	690
base 24 feb	HMD 111		23	7.45	3.2	142	222	250	18	128	580	651
town center	HMD 112		24	7.15	6.28	234	191	701	25	128	1075	1191
city 120	HMD 113		26	7.25	1.45	110	120	98	8	142	100	740
city 442	HMD 114	Mio-pliocene	25	7.45	4.84	200	130	537	28	207	482	1191
town center	HMD 115		23	7.6	4.46	174	83	497	25	140	492	917
city 1850	HMD 116		24	7.35	5.14	196	116	556	29	95	704	1000
city 1856	HMD 117		25	7.45	5.46	200	128	573	36	95	797	1000

Temperature

The temperature of water is an important factor in organic production. That is because it affects the physical and chemical properties of it; in particular its density, its viscosity, the solubility of its gases (in particular that of oxygen) and the speed of chemical and biochemical reactions (HCEFLCD, 2006). In the study area, the results obtained show that the degree this temperature does not show large variations from one well to another is from 23 to 26 ° C.

pH

The pH depends on the origin of the water, the geological nature of the substrate and the watershed crossed (Dussart 1966, Bermond and Vuichard 1973). This parameter conditions a large number of physico-chemical equilibria between water, dissolved carbon dioxide, carbonates and bicarbonates which constitute buffered solutions conferring on aquatic life a favorable development. In most natural waters, the pH is usually between 6 and 8.5, whereas in warm waters it is between 5 and 9 (HCEFLCD, 2007). In the case of the study area, the pH values of the aquifer waters show no significant variation, with a minimum of 7.35 at the 1850 city well and a maximum of 7.6 at the industrial zone well, it indicates a slight alkalinity in the environment.

Electrical conductivity

The electrical conductivity of water reflects the capacity of water to conduct electrical current between two metal electrodes (Platinum) of 1cm^2 surface and separated from each other by 1cm. It is the opposite of the electrical resistivity. Its units are Siemens per meter [S/m]. Conductivity gives an idea of a water mineralization and is therefore a good marker of the Origin of water (HCEFLCD, 2006).In fact, the measurement of the conductivity makes it possible to esteem the quantity of dissolved salts in the water, thus of its mineralization. The values recorded during the study period vary from 2.35 to 9.2 ms / cm the minimum recorded at the 1666 cite well and the maximum recorded at the base well (labdouane). The electrical conductivity depends on the charge of endogenous and exogenous organic matter, generating salts after decomposition and with the phenomenon of evaporation concentrates these salts in water, it also varies according to the geological substrate crossed.

Total hardness

The total hardness of water is produced by the calcium and magnesium salts it contains. We distinguish: carbonate hardness that corresponds to the carbonates and bicarbonates content of Ca^{+2} and Mg^{+2} and a non-carbonated hardness produced by the others salts. The hardness is measured by French degrees expressed in °F it results mainly from the contact of the groundwater with rock formations. Calcium is derived from dissolved CO_2 by limestone rocks (dolomites) or dissolution as sulphate in gypsum. The hardness of natural water depends on the geological structure of the soils, in the samples analyzed (Table 2), this parameter presents a large variation from one well to another which would be related to the lithological nature of the geological formation of the water table and in particular its composition in magnesium and calcium.

Table 2: Water hardness of the study area

locality		Sample's name	Exploited water table	TH° F	TAC° F
zone industrial		HMD101	Senonian	79	14
city 1850		HMD102		105	12
city 314		HMD103		99	12
city 272		HMD104		90	74
accommodation		HMD105		79	11
zone ENAFOR		HMD106		89	10
Customs accommodation		HMD107		80	11
Hyd complex		HMD108		89	10
city 136		HMD109		87	11
city 1666		HMD110		87.2	14
base 24 feb		HMD111		127	11
town center		HMD112		138	11
city 120		HMD113		77	12
city 442		HMD114	Mio-pliocene	103	17
town center		HMD115		78	12
city 1850		HMD116		97	8
city 1856		HMD117		102	8

According to the water quality standards established by the O.M.S (Table 3), it is noted that for all samples taken, the minimum hydrotimetric titre exceeds 54 ° F; which shows that the eastern region water of the northern Sahara is very hard.

Table 3: Standard of hardness in drinking water according to W.H.O (1972)

TH (°F)	0-7	7-22	22-32	32-54	54
Water hardness	soft	Moderately soft	Slightly soft	hard	Very hard

Sulphates

Sulphates (SO_4^{2-}) come from runoff or Infiltration into gypsum soils. They also result from the activity of certain bacteria (chlorothiobacteria, rhodothiobacteria, etc.). This activity can oxidize hydrogen sulphide (H_2S) toxic to sulphate (HCEFLCD, 2006). According to the results of the analyzed samples (Table 1), the recorded values remain higher than the guide value (400 mg / l) of the Algerian standard relating to the water quality intended for drinking water production.

Fluoride

In south of Algeria, dental fluorosis is a "silent" epidemic, that the local population suffers from. Tha Physico-chemical analyzes of the northern Sahara waters show that fluoride levels frequently surpass WHO standards (Messaitfa, 2007). The risk of fluorosis would increase if the intake of fluoride induced by the very specific diet of the study area (consumption of tea and dates) is taken into account.

According to the fluoride concentration results in drinking water from the exploited aquifers of Hassi Messaoud, the Senonian aquifer waters surpass WHO standard by more than 45% (Table 4).

Table 4: fluoride concentration in the study area's groundwater

locality		Sample's name	Exploited water table	Fluoride (F^-)
zone industrial		HMD101	Senonian	0.61
city 1850		HMD102		1.19
city 314		HMD103		1.58
city 272		HMD104		1.95
accommodation		HMD105		1.55
zone ENAFOR		HMD106		1.48
Customs accommodation		HMD107		1.72
Hyd complex		HMD108		1.5
city 136		HMD109		0.04
base 24 feb		HMD111		0.26
city 120		HMD113		2.02

Chemical facies of the water tested

We used the Piper diagram (Figure 1) to represent the water samples chemical facies. It is composed of two triangles to represent the cationic facies and the anionic facies and a rhombus synthesizing the global facies.

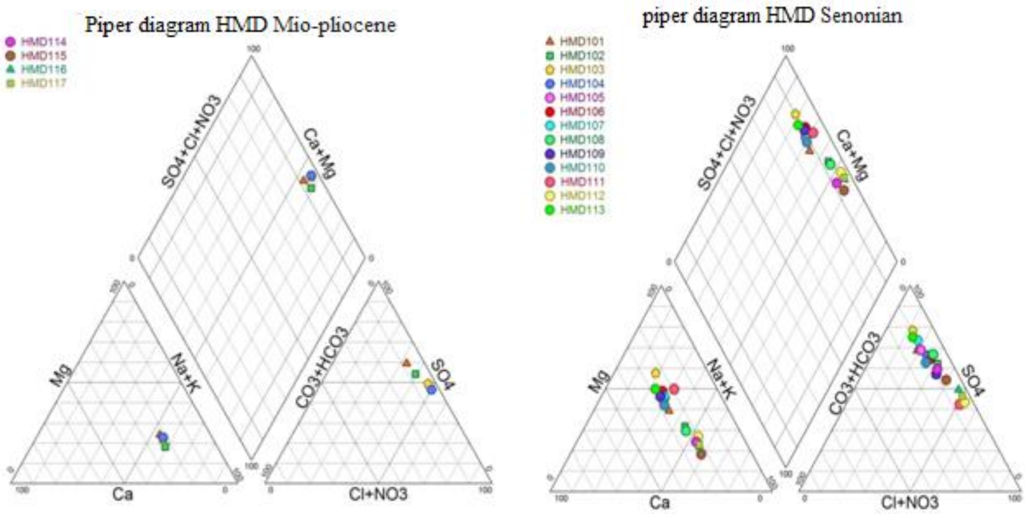

Figure 1: Piper diagram of tested water from the region of HASSI MESSAOUD

Table 5: Chemical facies of groundwater in the study area

Hassi Messouad	Mio-pliocene water table	sulphate chlorinated, sodium, calcium, magnesium Ca++>Mg++ > Na+ Cl- > SO4-- > HCO3
	Senonian water table	chlorinated, sulphated calcium and magnesian Ca++>Mg++ > Na+ Cl->SO4-- >HCO3

Mineralization

The mineralization corresponds to all the dissolved salts contained in water. We have determined it from the conductivity of the samples taken, all the measured conductivity values indicate a high mineralization because they are all globally greater than 1000 µs / cm. In addition, they correspond to total mineralization values exceeding the W.H.O standard of 1500 mg / l. To follow better the evolution of these concentrations in the various exploited aquifers, we opted to represent in table 6 the mineralization (concentrations of dissolved salts in mg / l) in each aquifer and in all the studied regions.

Table 6: Groundwater Mineralization in the Study Area

locality	Water table	Name F	TDS (mg/l)	Dry Residue at 110°C
zone industrial	Senonian	HMD101	1941	1448
city 1850		HMD102	3264	2582
city 314		HMD103	1829	1622
city 272		HMD104	2034	1664
accommodation		HMD105	1829	1466
zone ENAFOR		HMD106	1860	1554
Customs accommodation		HMD107	1784	1422
Hyd complex		HMD108	2740	2108
city 136		HMD109	1806	1638

city 1666		HMD110	2016	1616
base 24 feb		HMD111	2558	2130
town center		HMD112	4767	3948
city 120		HMD113	1751	1404
city 442	Mio-pliocene	HMD114	3674	3384
town center		HMD115	3385	2474
city 1850		HMD116	3901	2912
city 1856		HMD117	4144	3164

For the Mio-pliocene water table in the study area, the concentrations vary between a minimum of 3.38 g / l and a maximum of 4.14 g / l. According to SCHOELLER (1948), for the chloride, sulphated sodi-calcic and magnesium families as well as for the chloridic sodium and potassium family, the lithology of the aquifer is finer, the circulation of water is difficult, the contact time water- rock increases hence salinity increase and the influence of clays becomes more marked. This interpretation reflects the phenomenon of concentration by dissolution. Most of the water in the senonian water is moderately mineralized, with salt concentrations varying from 1.75 g / l to 2.74 g / l.

CONCLUSION

At an international level, the demand for good quality drinking water is growing. The population is growing and the water needs of industry and agriculture is also increasing. To meet the needs, we must use water from its various sources: superficial and groundwater. In addition, the chemical quality of water is directly related to the geological nature and the physicochemical characteristics of the soils that it is in contact with. Many minerals are essential to the organism: Ca^{2+}, Mg^{2+}, Na^{+}, Cl^{-}, F^{-}, ... etc. On the other hand, excess intake of these substances can have negative effects on health.

This campaign has concerned the northern Sahara two main aquifers, in the region of Hassi Messouad. We used a variety of analytical methods to determine the mineral elements. We have been able to study the evolution of the physicochemical quality main parameters from both a geographical and geological point of view. Particularly, the conductivities are variable according to the region considered and decrease with the aquifer depth from the mio-pliocene to the Senonian aquifer. The dominant ions are most often chlorides, sulphates as well as calcium, magnesium and fluoride. In general, the mineral characteristics of the study area water have appeared generally mediocre with values that do not comply with the potability standards, especially in regard to the most exploited aquifer (Senonian water table).

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