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Hydrogeology and Ground Water Quality of the Aquifer of Guelma in North-East of Algeria

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Abstract: Guelma area is situated about sixty kilometres in south west of Annaba, in north -east of Algeria. It's an ancient basin. A basin, which belongs to multilayer system of two aquifer levels; an unconfined aquifer and another semi-deep one. Both the aquifer level covers a 120 km^2 area of plio-quaternary covering. The geochemical study of unconfined aquifer accomplished during two campaigns (August 2006 and January 2007) has been performed by in situ measures and by analysing the major elements (anions and cations), fluorine and also nutrients elements in the laboratory. The results showed us that the ground waters are characterized by a salinity ranging from 0.40-1.42 g L^{-1}, chlorides and sulphates ions concentration, which locally exceeded the international standards, show a rising gradient from South to north of the basin. Analysis of nutrients elements has shown that the water contents in fluorine, orthophosphates, ammonium and nitrites are generally below the standard of WHO where as nitrates present concentrations high, upstream and downstream, witnessing a contamination of the unconfined aquifer. At this level, water contents, relatively higher, can have as origin cultivated land leaching containing fertilizers, industrial rejects, as well as decomposition of organic matter.

Key words: Hydrology, water quality, Guelma, aquifer, WHO

INTRODUCTION

Ground waters constitute the very important resource in the area of Guelma where superficial waters are, from now on, the direct receptacle of urban and industrial rejects. At the present time, these ground waters undergo, in full whip, the effect of pollution of the human activity which constitutes a great risk susceptible to degrade it in quality. The objective of the present study is then to determine, in the light of the obtained results concerning the waters quality of the unconfined aquifer of the studied area. This area has seen a lot of studies and research works. The main ones are those of Gaud (1988), Nouar (1997) and Djabri (1997).

Study area description: The study area belongs to basin of Seybouse average and the sub basin of Guelma. It corresponds to an ancient broken down basin of about 20 km length and to 3-10 km width (Fig. 1). In point of view climate, this area is characterized by an annual average rainfall of 562 mm, a more or less cool winter and a hot and dry summer (2006). At the structural level, this area constitutes a basin of collapse full of plio-quaternary detritus deposits (rollers, gravels and sands with clays standing on substratum constituted of Miocene marls (CGG, 1998). Here and there of Seybouse, the plio-quaternary becomes gypsies and saliferious (Chavanne, 1907; Vila, 1988). In point of view activities, Guelma area is first famous in its intensive agricultural activities. We find gardening, tree culture, cereal culture and breeding. Second, it's known by its industrial activities such as agro alimentary (sugar refinery, canning industry, dairy industries and flour milling), mechanics, brickfields and ceramics. All these activities need a huge amount of water mainly supplied by the local area aquifer and much polluted irrigation waters of Seybouse and its affluents (Nouar, 2006). Waters of these rivers are an average salinity ranging from 1.50 and 3.20 g L^{-1}.

The hydrographical network is essentially constituted by Seybouse river, Skhoun, Maiz, Zimba, Marmora and Bossora (Fig. 1). Generally, these rivers play a role to drain the aquifer.

The plio-quaternary, lithologically composed of alternances of permeable layers (rollers, gravels and sands) with a marl Miocene substratum constitute the tank of the ground waters giving birth to a complex

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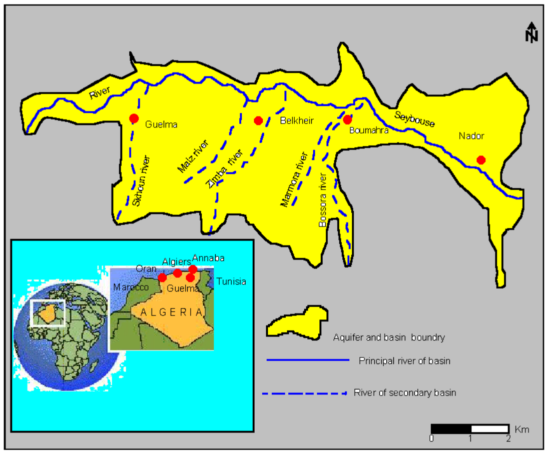

Fig. 1: Geographical situation and hydrographical network

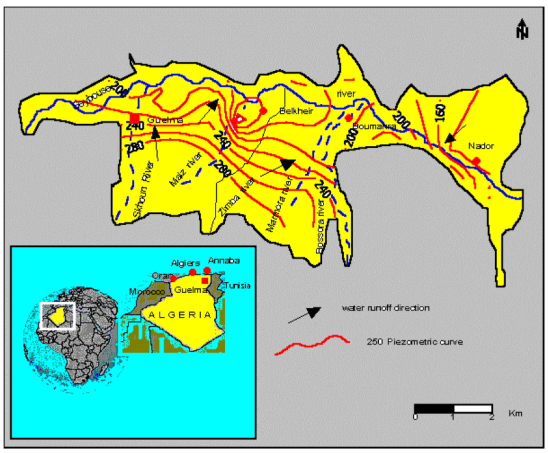

Fig. 2: Piezometric map

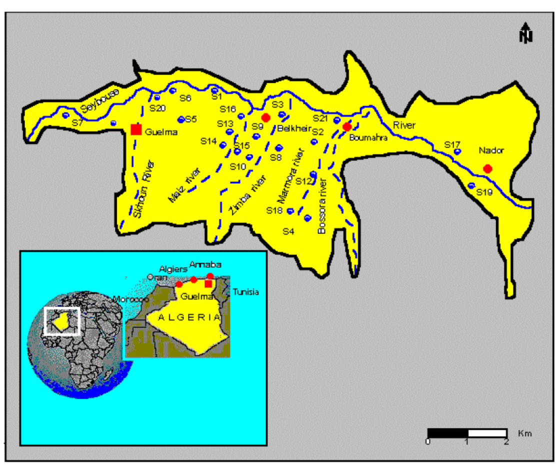

Fig. 3: Sampled water points localization

system of aquifer stocking; an unconfined and semi-deep aquifers, where the deeping of water varies respectively between -2 and -28 m. This system aquifer is connected one to the other. In fact it is only aquifer partitioned into different levels, where the very high one corresponding to the unconfined aquifer (free aquifer). These aquifers communicate between them.

At the level of exploitation, the aquifer system of Guelma is exploited by 100 wells and having depths lower than 10 m and equipped with motor-driven and by boreholes reaching 10-220 m. In 2006, exploitation has reached 90 hm^3 per year; an exploitation of about 99% of global its renewable resources estimated to 91 Hm^3 DHW (2006).

Piezometric map of this aquifer drawn up from the data collected on august 2006. Figure 2 shows a direction of global flow from the south to the north. Feeding aquifer is principally managed by precipitation, infiltration of irrigation waters and by occult feeding from fissured chalky edges.

MATERIALS AND METHODS

Test samples of ground waters from wells of depth under from 20 m has been accomplished through all Guelma basin (Fig. 3) during two campaigns, one an August 2006 and another on January 2007. Physicochemical parameters (temperature, pH and EC) are measured in situ by means of ground equipment. The samples have been taken in polyethylene's flaks: two flasks per sample, one for nutritive salts analysis (after adding some drops of chloroform) and other for major elements analysis (after adding some drops of nitric acid). Finally, these flasks are kept in ice box for the day. Water samples have been filtered at 0.45 µm and kept at low temperature (4°C). Analyses have been accomplished after three days of conserving. Water has been analysed at water chemistry laboratory of LGCH of Guelma sciences faculty, for major ions and nutritive salts.

The measure of cations has been accomplished by spectrometry of atomic absorption. Chlorides and alkalinity are proportioned by titration. Methods of dosage of nutritive elements and fluorine are as following Rodier (1984).

With the presence sodium salicylate, nitrates give sodium paranitrosalicylate, coloured in yellow and susceptible a spectrophometric dosage. Photometric determination is made at a wave length of 415 nm; ammoniacal nitrogen is proportioned by indophenols blue method based on forming in alkaline environment of mono chloramines, by reaction of ions ammonium on chlorine given by dichlorocyaniruc acid, then, indophenol's blue by reaction of monochloramine on phenol with the presence of nitroprussiate as catalyst. We accomplish spectrometric measure at a wave length of 630 nm of the obtained blue colour; in solution acid, diazotised nitrites by sulphanilamide, combined with (1-Naphtyl) ethlen-diamin, form a complex which gives an intense red colour. Colouring measure is made by means of a spectrophometer at a wavelength of 540 nm.

Table 1 : Chemical elements analysis

Station	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	NH^{+}_{4}	F	Cl^{-}	SO^{2-}_{4}	HCO^{-}_{3}	NO^{-}_{2}	NO^{-}_{3}	PO^{3-}_{4}
August 2006												
S1	165	75	210	19	0.15	0.15	436	235	125	0.30	95	0.20
S2	90	23	45	5.00	0	0	126	82	126	<0.10	36	0.13
S3	120	22	28	0.00	0	0	160	100	122	<0.10	25	0.10
S4	110	40	74	0.00	0	0	255	82	171	0	47	0.10
S5	84	43	80	4.00	0	0	150	158	195	0.12	68	0.42
S6	166	20	112	22.0	0.33	0.33	180	290	268	0.12	51	0.15
S7	158	16	84	18.0	0	0	180	170	226	0.25	85	0.35
S8	138	28	48	0	0	0	170	118	153	<0.10	33	0.10
S9	86	25	32	0	0	0	105	90	146	0	30	0.10
S10	76	14	78	1	0	0	95	128	153	<0.10	37	0.12
S12	144	26	76	0	0	0	255	94	159	0.15	50	0.23
S13	100	29	44	1	0	0	125	128	177	0.26	66	0.32
S14	92	19	170	13.0	0	0	275	110	122	0.35	70	0.35
S15	100	22	38	0	0	0	100	66	171	0.42	70	0.50
S16	250	12	110	7	0	0	160	98	207	0.37	68	0.50
S17	122	4	146	9	0.10	1.00	310	310	317	0.32	64	0.62
S18	180	32	80	0	0	0	280	52	189	<0.10	36	0.10
S19	180	60	78	11	0	0	295	142	293	<0.10	47	0.10
S20	162	42	8	7	0.30	0.30	145	320	90	0.23	62	0.26
S21	146	11	166	1.20	0.20	0.20	310	170	133	<0.1	85	0.13
January 2007												
S1	154	68	190	16	0.12	0.60	419	228	122	0.15	86	0.20
S2	96	31	51	0	0	0	175	82	171	0	32	0.10
S3	82	11	38	1	0	0	100	78	116	0	32	0.10
S4	112	26	68	1	0	0	165	8	244	<0.1	63	0.10
S5	84	12	88	1	0	0.10	100	88	214	0.1	108	0.32
S6	108	22	112	19	0.15	0.52	135	226	183	0.1	68	0.42
S7	140	34	92	10	0	0.60	125	126	311	0.1	140	0.55
S8	106	49	80	10	0	0	235	10	323	0.12	54	0.20
S9	94	25	50	1	0	0	135	72	153	0	44	0.15
S10	70	11	38	1	0	0	70	116	110	<0.1	23	0.10
S12	134	23	88	1	0	0	230	34	250	0.1	45	0.32
S13	106	16	50	1	0	0	100	130	177	0.16	75	0.45
S14	94	30	100	11	0	0	150	60	299	0.21	96	0.42
S15	72	12	52	1	0	0	70	62	122	0.26	92	0.53
S16	90	16	50	1	0	0	100	22	177	0.30	98	0.36
S17	178	23	88	19	0.1	0.87	275	130	342	0.25	46	0.21
S18	84	12	88	1	0	0	100	88	214	0	108	0.37
S19	150	42	79	10	0	0	275	88	336	0	64	0.10
S20	145	24	77	12	0.22	0.17	146	290	165	0.32	65	0.23
S21	120	32	85	9	0.10	0.20	242	69	95	0	95	0.10

In solution acid, orthophosphates react with molybdates ions to form a complex, which is reduced to molybdenum blue by means of ascorbic acid in blue coloured; photometric determination is made at length 882 nm.

Fluorine is proportioned by photometry thanks to specific electrode to fluorides ions (ISE 844098/11) setting up calibration curves linking fluoride ion concentrations to measured parameter has been necessary.

RESULTS AND DISCUSSION

Physicochemical parameters: The physicochemical parameters have been systematically measured before every sampling. Te measures have shown that waters of Guelma aquifer are characterized by a pH very little variable ranging from 7.03-8.30 and temperature ranging from 16-23°C. These waters present contents of dissolved salts which vary from 0.45-1.42 g L^{-1} in south and increase progressively towards the north with concentration ranging from 0.40-1.20 g L^{-1}. spatial distribution of salinity coincides and increase according to the flow direction (Fig. 4a and b).

Te chemical analyses results of the major elements in ground waters of Guelma basin for the two campaigns (August 2006 and January 2007) are mentioned on Table 1. A clear gradient of concentration in major elements is observed between the south and the north. These waters contents become more and more higher, here and their, on the banks of Seybouse river mainly sulphates and chlorides which locally exceeded 250 mg L^{-1} (Table 1). Fluorine is present in water points situated in the area at evaporate outcrops (halite, fluorspar and gypsum) (Chavanne, 1907; Vila, 1988). Major ions can have a geological origin.

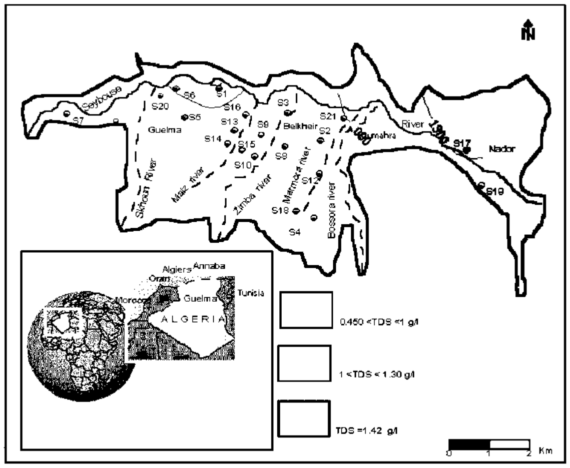

Fig. 4a: Salinity map (August, 2006)

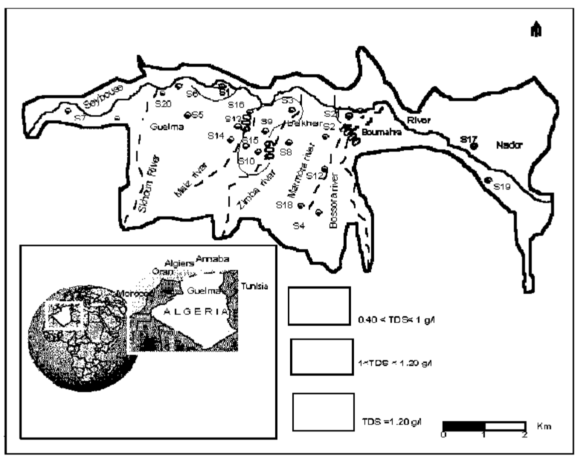

Fig. 4b: Salinity concentration map (January, 2007)

The observed salinity seems to be slow; it's due to the character of the basin which communicates with the sea. In fact, in closed basin, salt contribution by irrigation waters would be sufficient to lead to a quick salinity of soils (Gonzalez *et al.*, 2002).

Nutrient salts: Contents in orthophosphates in ground waters of the study area (Table 1) indicate a weak variation between the samples campaigns. In fact, for the campaign of august 2006, the values vary from 0.1 to 0.62 mg L^{-1} and from 0 to 0.56 mg L^{-1} for the campaign of January 2007. These concentrations are close or exceeded the threshold tolerated by WHO standard of 0.50 mg L^{-1} in drink waters. The presence of orthophosphates in ground waters can have two origins: scrubbing of agricultural lands containing phosphates fertilizers, industrial and urban rejects.

Concentrations in ammonium ion: (NH_4) in waters are very weak. Te majority of concentrations vary from 0.01-0.32 mg L^{-1} on August 2006 and from 0-0.30

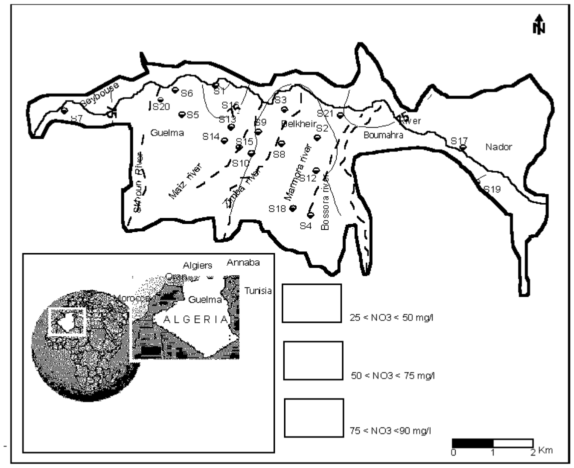

Fig. 5a: Nitrates concentration (August, 2006)

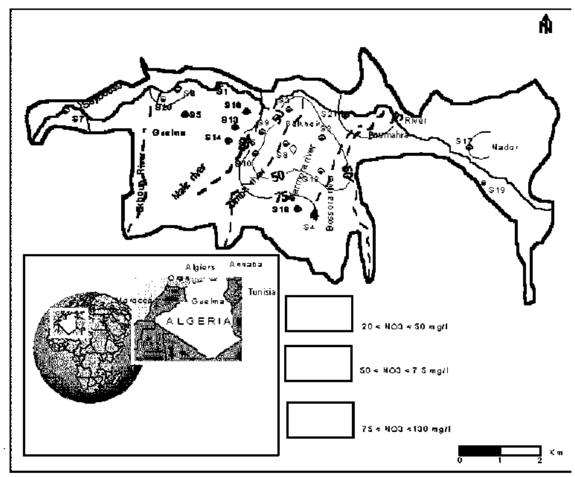

Fig. 5b: Nitrate concentration map (January, 2007)

in January 2007 (Table 1). Contents in nitrites of the studied waters record wake variations between the two sampling periods. These water contents in nitrites can have as origin industrial rejects, the urban wastewater and the non-checked rubbish dumps spread on the basin containing the organic matter. The concentrations in ammonium ions in the waters of superficial aquifer do not exceed the standard of WHO for drink waters (0.5 mg L^{-1}).

Nitrates water contents in Guelma aquifer have varied from 25-95 mg L^{-1} on august 2006 and from 23-130 mg L^{-1} on January 2007. Iso-waters contents map shows that concentrations increase from south towards north basin (Fig. 5a and b). We can distinguish a central area where water contents are ranging from 25 to below 50 mg L^{-1} and where the agricultural activity is less intensive. An area, upstream and downstream, the agricultural lands with intensive cultures. On the total number of these wells sampled in the studied area, the quasi-totality show nitrates water contents superior to 50 mg L^{-1} tolerate by the WHO (1996).

The presence in these waters points; of excessive nitrates concentrations constitute a sign of pollution and consequently, a risk for babies' health (under six months) as it can causes circulatory problems: Blue baby syndrome (Rajaqopal and Graham, 1989) as it can provoke stomach cancer (Tayeb *et al.*, 1993). Nitrates can provoke hypertension and are precursors of cancer (Castanyt, 1982).

More than this, nitrates and phosphates are also considered as secondary pollutants, for their favour development of algae to harmful consequence such lakes, water currents and the clogging of turbines upstream of hydraulic works (Levallois and Phaneuf, 1992; Beni-Akhy, 1998; Rosecchi *et al.*, 1995). We in put the presence of nutrient salts in ground waters to the spreading excessive use of fertilizer, to punctual and spread rejects of breading product and to waste waters, which have not undergone any previous treatment.

Geochemical facies: Salinity of ground waters of Guelma basin is more or less important. Classification of anions and cations according to ionic formula, has allowed us to draw many facieses: HCO3/ Ca, Cl^-/Ca^{2+}, SO^{2-}/Ca^{2+} and Cl^-/Na^+.

CONCLUSION

Drinking water supply of Guelma and its suburbs in essentially based on ground waters, mainly those of the plio-quaternary aquifer. A little bit deep, it is, on one hand, very sensitive to anthrop activities, which are very widespread at the level of the basin. On other hand, this aquifer is very vulnerable, as signs of pollution by nitrates show it. The quality degradation of water resource in Guelma basin and principally ground waters pollution by nitrates show well.

The vulnerability of the studied aquifer, this makes supplying an acceptable quality more and more difficult knowing that these are the only waters available to the daily consumption for the population of the area. To solve the problems associated to contamination of the aquifer by pollutants; we should:

- Canalise wild rejects and control industrial rejects
- Use fertilizers rationally especially in quantity and quality
- Create perimeters of water catchments protection
- Collect domestic wastes in public discharge

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