DETERMINATION OF THE CONTAMINATION LEVEL IN GROUNDWATER IN THE SEBKHA OF ELMAHMEL AREA, NORTH EASTERN OF ALGERIA

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ABSTRACT. – Determination of the contamination level in groundwater of the Sebkha of El-mahmel NE Algeria. The study area is located in the municipality of El-Mahmel located in the extension East and North east of the Aurès Nemamcha mountains in the city of Khenchela, Northern east of Algeria. This study is related to a research on groundwater pollution from anthropogenic emissions and secondly by the migration of salt water intrusion from the Sebkha in response to intensive pumping. The physico-chemical characterization of water by measurements on site and laboratory analysis allowed defining the degree of saltwater contamination and its spatial spread. This salt contamination of groundwater would be accentuated by the discharge of wastewater into the Sebkha, the irrational use of chemical fertilizers, pesticides and intensive pumping. By this action, we alerted the government to the need to build a wastewater treatment plant, the need for a delineation of protection areas or would be prohibited to establish drilling. Finally, make farmers of El Mahmel aware of the risk of deterioration in the water quality monitoring of disease outbreaks and soil infertility by the accumulation of salts (alkalization and sodization of soil) with the disappearance of all cultures if they not reduce pumping water.

Keywords: pollution, groundwater, contamination, Sebkha, Algeria.

1. INTRODUCTION

Water pollution represents a serious problem for the environment of the studied area due to the wastewater discharged into the Sebkha wetland; these contaminated wastewaters represent the main source of groundwater pollution, to which are added those from agricultural activity and the high salinity of the waters of the Sebkha. A water can be polluted from both naturally or anthropic causes, becoming unfit for all uses, being a threat to the environment.

Taking into account this concept, all natural causes of groundwater quality degradation or deterioration could lead to the different levels of pollution if the concentrations of some water components exceeds certain level of some eligible standards which have been widely established by WHO - World Health Organisation.

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An underground water has a geochemical heritage of natural origin which evolves according to the nature of the geological reservoir. The degree of pollution is appreciated by the extent of the gap or the changes between the natural chemistry of water in its natural reservoir and newly chemistry acquired during the alteration of underground path through the negative intervention of human on the environment (Rodrigue and al., 2016). The requirements on the content of some salts, such as chlorides, sulfates or sodium are less severe in arid zones that in wetlands. In the Sahara, people consume water with up to 3 g/L of salt, which is not the case for the inhabitants of the areas in the north which are less adapted and vulnerable to very salty water. The aim of the present study was to identify the different sources of pollution from the plain of El Mahmel as well as to asses the salt water intrusion from Sebkha to fresh waters. To achieve these objectives, have been analyzed several physico-chemical parameters including nitrates and nitrites, nitrates being used as an index of pollution (Athamena, 2006). To put into the evidence the spatial distribution of the polluted area, have been utilised specific software while for the chemical facies the software diagramme. The results clearly evidence a contamination of the area bordering the Sebkha.

2. STUDY AREA

The Sebkha is located in the municipality of El-Mahmel located in the extension East and Northeast of the Aures Nemamcha mountains in the city of Khenchela (Fig.1). The population of the commune of El Mahmel was 42725 in 2012, with a rate of increase of 2.50%.

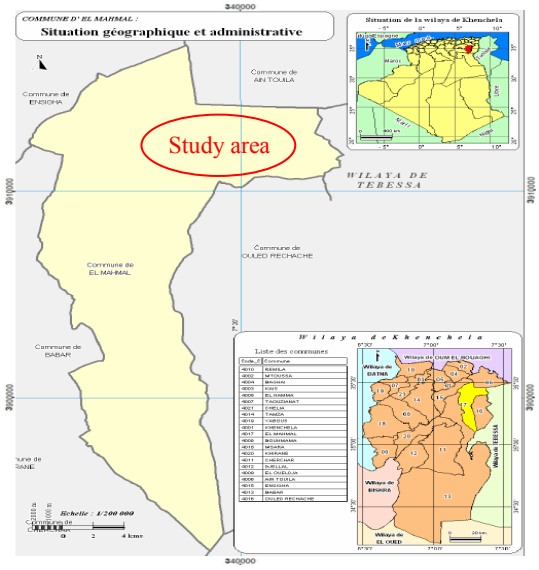

Fig.1. ***Geographic position of the study area***

The geological and structural features of the study area are clearly distinguished, but most of it is dominated by the Intramontagnic Atlases plain (fig. 2), and the soils encountered in the Sebkha region are mainly saline soils (Mebarki, 2005). Regarding hydrogeology and groundwater, current knowledge on Sebkha area is limited and therefore does not allow to draw objective and relevant conclusions in this field, but the region is crossed by many wadis which converge in majority toward the Sebkha, meaning the quantity of groundwater is not negligible. The economic activity revolves mainly around the agriculture and livestock due to its large size, despite the difficulty caused by the type of salty soils.

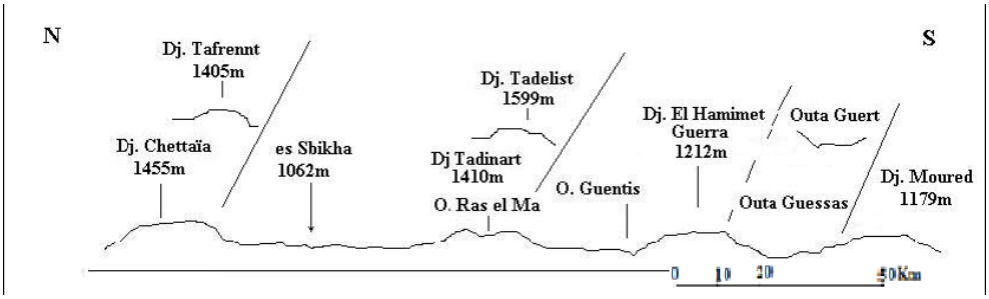

Fig. 2. ***Topographic profile N-S Through the commune of El Mahmel***

Through a general climate study of 14 years (1998-2012), at the scale of the region studied, we noticed that precipitations were very variable in time, and temperatures trend showed a gradual increase, reflecting the global warming which constitutes the current agenda of meteorologists around the world. The region is part of the semi-arid climate, confirmed by the calculation of the De Martonne's aridity index (I= 18,02). The ombrothermal diagram show that the dry periods are longer and prevail much on wet periods, while the potential evapotranspiration, very important in the region, it is nearly three times than the actual evapotranspiration reflecting a very important agricultural deficit at the end of the calculation of the water balance.

3. MATERIAL AND METHOD

The working methodology followed a classical approach, consisting in the following activities: documentation, application field for representative sampling, in situ determination of some parameters, laboratory analysis of other chemical parameters, data analysis and interpretation using specific software.

For the present study have been established 13 representative points for sampling for Sebkha (P1÷P13) such as: 2 points in the Sebkha; 2 wells near the Sebkha; 8 wells far from it, and the wastewater (R) (Fig. 3). The samples were collected in May 2013, some physico-chemical parameters being measured: in-situ

temperature (T °C), pH, electrical conductivity (EC) and dissolved oxygen by a multi-parameter of type "consort C931", while for the cations (Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}) and the anions (Cl^{-}, SO_4^{2-}, HCO_3^{-}, NO_2^{-}, NO_3^{-}) analyzes were performed in the laboratory LACIP (Ain M'Lila). After collection, water samples have been filtered to eliminate all suspended matter, which is always present in the natural water in the form of mineral particles, organic or biological (Rodier, 1996). During this study have been used specific methodology from the national literature (Attoucheik, 2006; Debieche, 2002; Farhat and Ben Mammou, 2001; Zereg, 2010 Boualla and al., 2011) and the international literature (Innocent and al., 2013; Iosub et al., 2015, 2016; Jora and Romanescu, 2011; Romanescu and Cojocaru, 2010; Romanescu et al., 2014, 2015, Breaban et al., 2016).

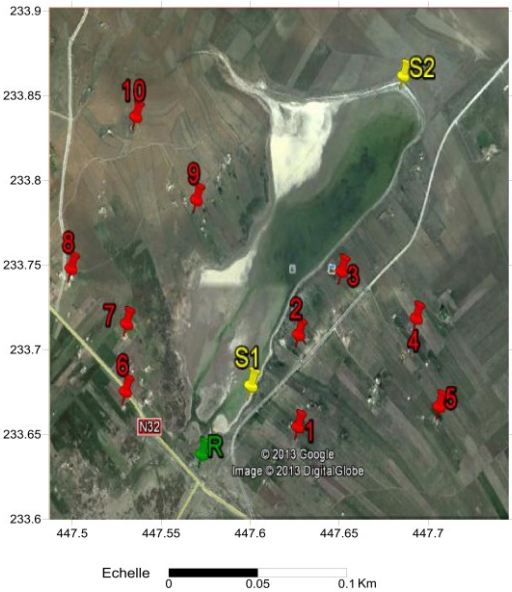

Fig 3. ***Distribution of samples in the study area***

4. RESULTS AND DISCUSSION

For the parameters measured in situ (Table 1), such as the electrical conductivity, salinity and the TDS (Total Dissolved Solids) have been noticed to have a similar spatial distribution, the highest values being measured at the Sebkha and nearby wells P2 and P3, which largely exceeds the WHO standards value, values that are decreasing along with the distance from the source (dilution). For temperature, it depends on the climatic conditions (temperature of the air, sunshine etc.) and does not present any anomaly for all the samples. The pH ranges between 7.5÷ 8.0, the slightly alkaline values being recorded in the waters of the Sebkha due to evaporation, while dissolved oxygen levels vary between 0.08 mg/L in R,

2.30 mg/L in S2, 3.20 mg/L in S1, and 4.85 mg/L in P1, clearly showing the pollution area due to discharges from the "R" point, an outfall of the pipe of waste water, affecting the surface waters (S1 and S2) of the Sebkha. The dissolved oxygen concentration explain the pollution present in the Sebkha, which is degraded by microorganisms. The groundwater levels (P1-P10) of dissolved oxygen is lower than the Algerian and European standards (5 mg/L dissolved oxygen) ranging between 3.52 - 4.85 mg/L, classified as average quality.

Table 1. ***Physicochemical characteristics of the water of Sebkha lake and wells (May-2013)***

Points	S1	S2	R	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
T (°C)	24	23.2	19.6	17.4	16.8	20	17.8	16.2	18	18.3	16.3	17.5	16.9
pH	8.0	7.87	7.59	7.70	7.62	7.63	7.62	7.60	7.53	7.50	7.55	7.71	7.53
CE (µS/cm)	34500	24400	1922	2300	8900	21400	1235	1025	1933	2160	1209	1473	1361
TDS	23500	33600	1266	1348	6000	15400	790	617	1200	1295	772	942	848
Salinity	24.5	25.5	1.3	1.4	6.2	16,1	0.8	0,6	1.2	1.3	0.8	1.0	0.9
O_2 (mg/L)	3.20	2.30	0.08	4.85	4.21	4.64	4.19	4.25	3.52	3.66	4.74	3.23	4.18
Ca^{++} (mg/L)	760	1130	192	240	1280	560	148	140	205	236	180	172	164
Mg^{++} (mg/L)	1386	1220	33.1	97.7	267	893	30.6	32	56.2	71.2	31.2	38.9	35
Na^{+} (mg/L)	19000	17800	174	204	855	6375	73	69	157	200	87	118	108
K^{+} (mg/L)	140	120	80	2	2	9	1	1	2	1	1	1	3
Cl^{-} (mg/L)	1100	1200	23.43	62.48	355	923	21	19.52	25.3	31.59	16.68	36.56	33.37
SO_4^{--} (mg/L)	1278	1088	91.8	80.4	486.4	629	80	63.6	82.6	108	89.7	61.5	80.3
HCO_3^{-} (mg/L)	307.44	306	653	263	219	434	261	390	410	434	263	244	173
NO_3^{-} (mg/L)	5	92	75	7	40	3	12	52	110	168	53	64	32
NO_2^{-} (mg/L)	0.13	0.37	0.08	0.02	0.24	0.05	0.06	0.07	0.03	0.08	0.06	0.32	0.19

Concerning the chemical elements, three situation can be noticed. The first one refer to the major cations (Ca^{+2}, Mg^{+2}, Na^{+}) and some anions (Cl^{-} and SO_4^{-2}) which have a very similar spatial distribution (fig. 4, 6), with a high concentrations in the Sebkha and the nearest wells (P2, P3) and relatively lower values of concentrations to those located further, explained by the leaching of these elements in the watershed followed by the accumulation in the Sebkha and contamination of the surrounding area through diffusion.

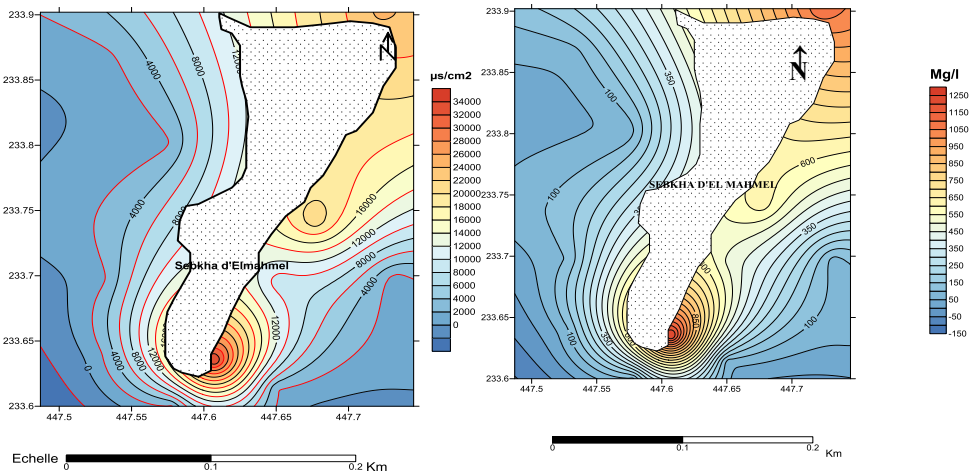

Fig. 4. ***Electric conductivity and SO_4^{-2} spatial distribution***

The second one shows the potassium distribution, presenting variable concentrations (140÷1 mg/L) from highest in S1 and S2 and much lower in the wells, P3 recording the highest value for the wells (9 mg/L K+) adjacent to the Sebkha (table 1). The last one take into consideration just anions HCO3-, NO3- and NO2- (fig. 5). Due to the excessive anthropic activities, areas of contamination are well localized, wells P6 and P7 having the highest value for both bicarbonates (410÷434 mg/L) as well as for nitrates (110÷168 mg/L) due to the use of fertilizers, while the northern area is characterized by increased values for the nitrites resulting from the reduction of nitrates from fertilizers due to the lack of oxygen, high values characterizes also the center-south region (P2).

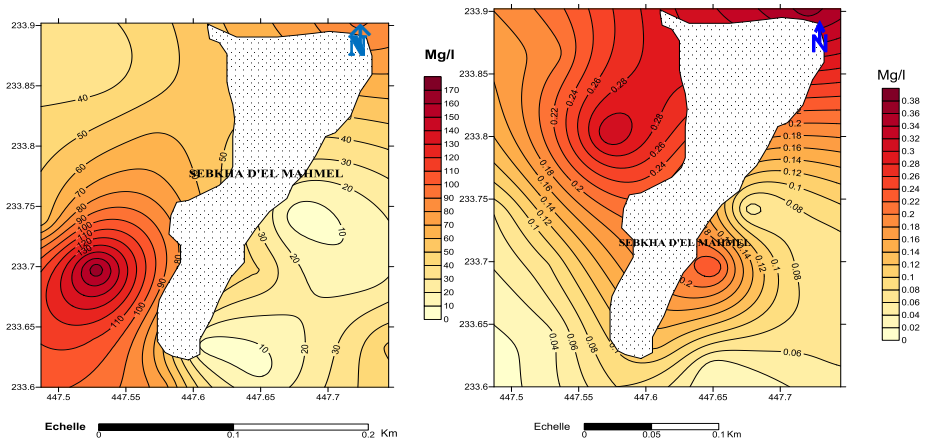

Fig. 5. ***Nitrates and nitrites spatial distribution***

In terms of chemical facies of waters figure 6 shows that all wells have the same facies (calcium – bicarbonate) due to the similar geological composition of the Sebkha surroundings, that led to the hypothesis that probable the origin of the waters is similarly,

but this need to be demonstrates by the detailed geochemical analysis in order to established the changes appeared in water composition by the contamination of Sebkha with domestic waste discharge.

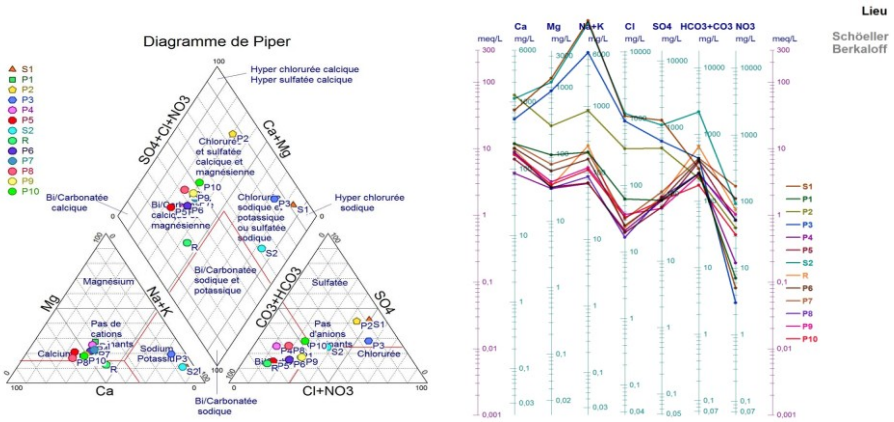

Fig. 6. ***Chemical facies of samples the Sebkha area (May-2014)***

5. CONCLUSIONS

The aim of this study was to identify various sources of pollution in the Sebkha area and the physico-chemical analysis of surface and ground waters in order to asses the impact of the domestic wastewater, the agricultural activities and the salinity of the Sebkha on the quality of water resources in the region. The Sebkha site is considered as one of the most important wetlands in Wilaya of Khenchela, located in the high plains of Constantine, at 1100 m altitude. The study include 13 water samples of groundwater (P1-P10), surface water (S1-S2) and wastewater R.

The data analysis obtained in this study led to some remaks such as:

- have been put into evidence three different origins of water pollution in the region: i) Sebkha salinity, ii) domestic discharge; iii) agricultural activity.

i) the Sebkha salinity affects the groundwater situated at the edge of the shore (P2-P3) indicated by the high level of electrical conductivity, salinity TDS, Ca^{+2}, Mg^{+2}, Na^{+}, Cl^{-} and SO_4^{-2};

ii) this type of waters are very contaminated with organic pollutants reflected in the lower level of dissolved oxygen, the level being lower for groundwaters than for surface waters;

iii) the piezometric water table situated at 40m depth explain the highly contamination level of wells situated near the agriculture-used surfaces (P5, P6, P7, P8, P9) with nitrates and nitrites provided by the intensively use of fertilizers and manure in agriculture activities.

- with the increasing distance from the contamination source (Sebkha), the groundwater quality becomes better: P5, P8, and P10 present for all parameters values bellow the maximum allowable concentration.

To increase the groundwater quality and to protect this wetland area, a wastewater treatment plant for discharges from multiple sources must be built as soon as possible: industrial, agricultural, domestic. It is also neccesary to ban the drilling in the proximity of Sebkha.

The authors would like to believe that this work could contribute to the protection of water resources, especialy the grounwaters in Algeria.

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