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Impact of agricultural activities on the evolution of nitrate and nitrite levels in groundwater of Annaba plain (North East of Algeria)

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Abstract

Annaba plain (North East of Algeria) knows intensive farming of various crops. Use is made in the field, based fertilizer nitrogen mainly phosphate. A total of 29 well water samples have been analyzed for the period from December 2013 to assess the impact of these fertilizers on the quality of water resources. Given the nature of the fertilizers used, the following key parameters were targeted: nitrates, nitrites and phosphates, electrical conductivity. It is clear from these investigations those higher contents of nitrates, nitrites with respective maximum values of 130 $mg.l^{-1}$, 94 $mg.l^{-1}$, phosphorus soluble form, have lower levels to acceptable standards that exceed 5.1 $mg.l^{-1}$.

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Introduction

Agriculture can be a serious problem on physicochemical quality of water; nitrate and phosphate are the best known nutrients that have negative impacts on water supplies and ecosystems. High nitrate concentrations in water serving as a source for drinking water is a serious health problem, being known for many years as the cause of blue baby syndrome (Comly, 1945); (Gelberg *et al*, 1999) and related to increased levels of diarrhea of children (Gupta 2001). Return flows from irrigated agriculture may increase the salt, nitrate, and phosphate concentrations of the receiving water, limiting their agricultural, industrial, urban, and ecological uses. When water is too little oxygenated, anaerobic conditions can also result in accumulation of ammonia and nitrites which intoxicate fauna and flora. In countries around the Mediterranean basin, the degradation of soil and water resources is a serious threat for the human welfare and the natural environment as a result of the unique climate, topography, soil characteristics, and peculiarities of agriculture. The detrimental effects of agricultural practices on soil quality include erosion, desertification, salinization, compaction, and pollution. The resultant impacts on water resources include pollution due to nutrient and pesticide leaching and intrusion of seawater into aquifers. In order to select the appropriate sustainable strategies for preventing those impacts, research should focus on development of an accurate soil quality monitoring system at multiple scales based on a functional evaluation of soils (George Zalidis *et al*, 2002).

In the low plain of Seybouse, the chemical composition of water is often influenced by the impact of the dissolution of geological formations, industrial discharges, and agricultural activities (Djabri, 1996), (Hani, 2003), and (Habes, 2012). Thus, it is required to periodically check the water quality changes over time and space depending on the variation of the physicochemical parameters of the water. To achieve these goals, it is important to make a monthly monitoring of water (surface and groundwater), with a comprehensive analysis of physicochemical parameters to explain the origin and evolution of each element (Rouabhia *et al.*, 2010).

Materials and methods

Site Description

The study region is situated in the North east of Algeria, belongs to the Catchment of Seybouse, limited by the Mediterranean Sea in the north, the Drean city in the south, Wadi Mafragh in the east and the Lake Fetzara in the west (Fig. 1).

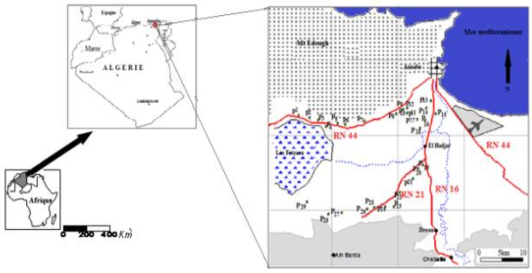

Fig. 1. Location of the study area in Eastern Algeria.

Annaba plain is supplied to the west by streams originating from the Edough mount, and from the south by water upstream. The region is subjected to Mediterranean climate with one wet season from October to May and a dry and summer. The annual average precipitations, real evapotranspiration respectively about 700, 500 mm (Halimi *et al*, 2016).

Geology of the study area

The geological studies in the region (Hilly, 1962), (Vila, 1980) and (Gleizes, 1988) show the existence of two types of terrain; metamorphic and sedimentary (Fig. 2). The study area is part of the geological entire Eastern North Algerian Tell. It is defined by geological formations ranging from Neoproterozoic Quaternary, represented by the outcrop of metamorphic and igneous rocks forming the western border and land sedimentary characterizing the southern edge and the Annaba plain.

Trainings borders consist of gneiss, schist, mica schists, of marbles, marl, metamorphic calcareous marl and clay formations-gréso. They are relatively low but potential hydraulic power supplies are areas for tablecloths (Zenati, 2010).

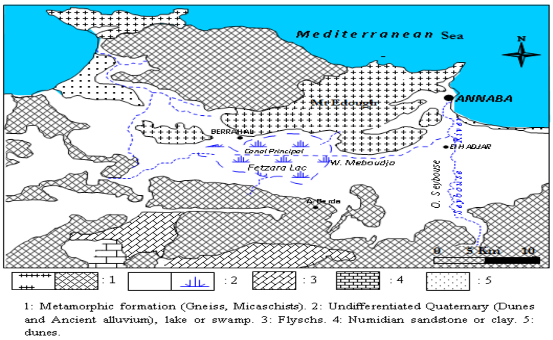

Fig. 2. Geological map of study area.

Sedimentary formations correspond to a non-uniform set where there is a marshy area, sandy dunes and fertile plains. These last two are considered potentially aquifers. They are characterized by Quaternary sediments. Quaternary alluvium of the plains is permeable and contains significant aquifer levels.

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Methodology

The hydrochimical properties of groundwater samples collected from the Quaternary aquifer system are showed in Table 1. The physicochemical parameters (pH, T°C, and conductivity) were measured in situ using a WTW multi-parameter device (Multi-line P3 PH/LF-SET). The chemical analyses were carried out by flame atomic absorption (Perkin-Elmer 11005) for Cations. Anions Cl–, SO_4^{-2} HCO^-_3 were measured using a CPM. These elements were measured in the Hydrochimical Laboratory of University of Littoral Côte d'Opale, Dunkerque in France. The sampling was carried out in December 2013.

Table 1. Variation in concentrations of nitrate in groundwater level (December 2013).

Class	Interval	Number	%
1	$200 < NO_3^- < 600$	0	0
2	$100 < NO_3^- < 200$	0	0
3	$50 < NO_3^- < 100$	12	41,38
4	$10 < NO_3^- < 50$	16	55,17
5	$NO_3^- < 10$	1	3,45

Results and discussion

Identification of chemical groundwater facies

The groundwater samples are characterized by the dominance of three chemical facies: the sodium chloride, sodium bicarbonate and calcium chlorinated (Fig. 3).The enrichment of chlorides and sulphates is very clear for all samples. The cations have the same behavior: magnesium and sodium dominate and mark all points represented the cations triangle this confirms the impact of reservoir geology and human activities on the quality of water. The groundwater in the study area have the same qualities, the observed degradation reflects a change in the water quality.

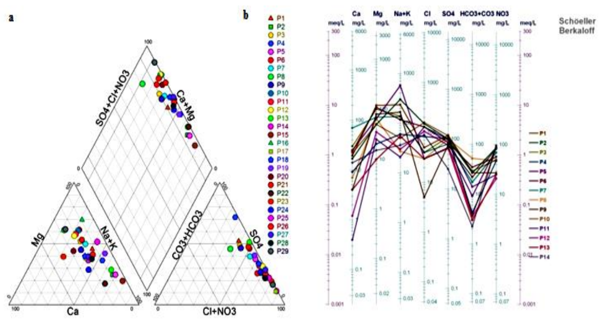

Fig. 3. Identification of chemical facies water in the study area (a Piper, b).

The representation of the conductivity and the SAR on a US salinity pattern (Fig. 4B) shows that the majority of samples are located in two classes of water: the categories C2S1 (medium salinity and low alkalinity) and C3S1 (high salinity and low alkalinity). Both categories fall in the suitable class for agriculture purposes. Two samples 5 and 15 fall in the poor zone of water quality (C3S3) so the water is unusable for agriculture.

The Wilcox diagram (Fig. 4A), relating sodium percentage, and electrical conductivity, shows that most of the groundwater samples fall in the category of good to permissible. 50% of samples fall in permissible to the doubtful category, sample numbers: 5, 9, 15, 23, 24 and 25 are in the doubtful category improper for irrigation, suggesting the involvement of human activities.

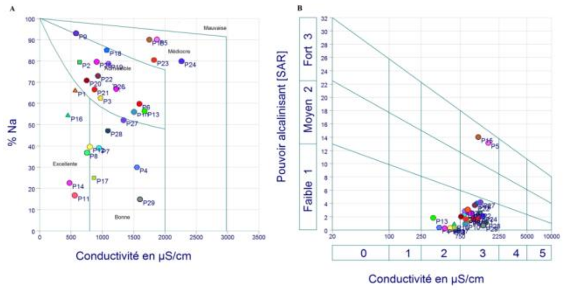

Fig. 4. Classification of irrigation water in the study area: (A) Wilcox (1948). (B) USA Salinity laboratory diagram.

Chemical evolution waters

Water chemistry of the surface layer is characterized by a wide variation of chemical elements concentrations (Fig.5): Na + and Cl^- (107.5 to 177.5 mgl-1), SO_4^{2-}, Ca^{2+}, Mg^{2+} and HCO_3^- (80, 15.2, 27.30 and 70 mg.l-1). The origin of the chemical elements is generally related to the nature: effect of the dissolution of geological formations (gypsum, cipolin, gneiss ... etc.), the NO_3^-, NO_2^- and PO_4^{-2} (52. 80, 3. 5, 3,35mg.l-1) this values (Fig.6) are greater than the standards and are respectively (0.1 mg.l-1 and 50 and 0.4 mg.l-1).

Only the nitrate has a different origin, associated with the use (chemical and / or organic) in agriculture, and to the decomposition of organic matter. The phosphorus presence is probably related to urban waste especially those that contain detergents and to intensive use of phosphoric fertilizers.

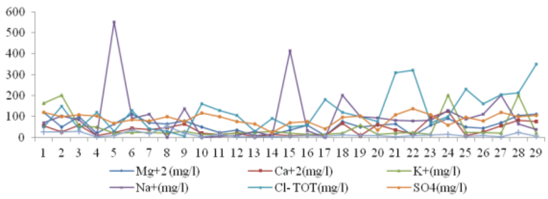

Fig. 5. Evolution chemicals elements concentrations of the groundwater (December 2013).

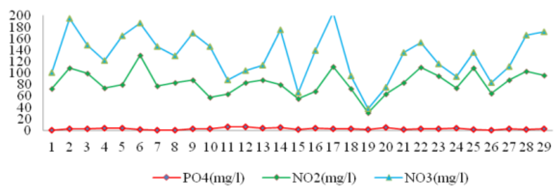

Fig. 6. Evolution of: nitrite, nitrate and phosphorus of groundwater (December 2013).

Spatial distribution of nitrate, nitrite and phosphorus levels

The variation of the concentration of nitrate levels in space is associated with agricultural activities that develop on the surface, the nature of the roof of the surface ply and redox conditions. The variation of nitrate concentrations is divided into 5 classes (Table 1). The representation of water points (December 2013) campaign of 29 wells in the plain (Fig. 7), (Fig. 8) shows that the area's most vulnerable to pollution by nitrates are in the NW part of the plain, to the metamorphic basement, this is due to the permeability of the ground (10^{-5} $m.s^{-1}$) and to local agricultural activities, often found around the well, as against to the southern and eastern part of the roof of the plain becomes more clay, which protects groundwater against infiltration of nitrate ions.

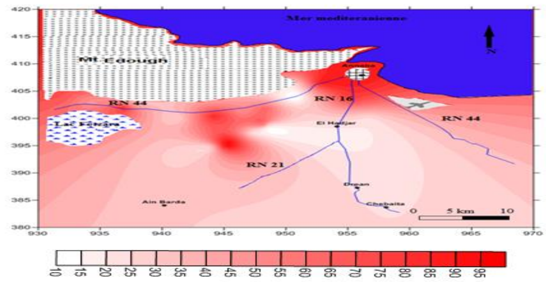

Fig. 7. Spatial variation of nitrate in the study area (Decembre, 2013).

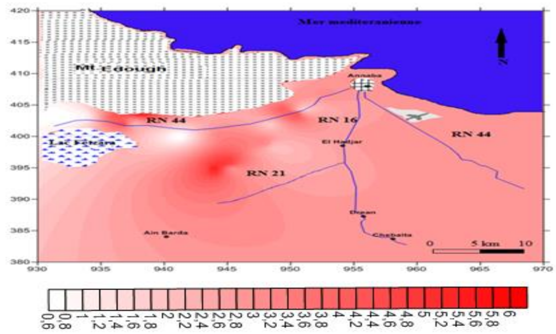

Fig. 8. Spatial variation of phosphore in the study area (Decembre, 2013).

The wells have low nitrate concentrations even in agricultural areas, where wells P15, P19 and P20.The origin of phosphates in water is related to the urban waste or dissolution of chemical fertilizers (NPK).

In groundwater of Annaba plain, phosphates concentrations are high, they exceed the permissible levels (0.5 mg.l-1) they are located in central and north of the plain (Fig. 7), (Fig. 8).

Conclusion

The interpretation of the changing forms of nitrogen as a function of the hydrodynamics of ground water leads to the following conclusions: Contamination of groundwater in the plain of Annaba is related to nitrogen fertilizer inputs in excess of the needs of plants; the waters of irrigation and those of the rain play a major role in the transport of nitrate ions to groundwater; Clay intercalations that may exist to the roof of the surface layer protects the web against the infiltration of nitrogen pollutants flow into the groundwater and promote reducing conditions, which allows the nitrate appear as ammonium.

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