

Physicochemical quality of groundwater and pollution risk in arid areas: the case of Algerian Sahara

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Abstract In urban areas, population growth generates significant amounts of wastewater which are treated in specialized treatment stations or rejected directly without control in the case of short water Bechar River. Because of their diverse backgrounds, these waters are often loaded with organic elements, minerals, and microorganisms; some of which could be harmful to health and is heavily involved in the degradation of groundwater that may be irreversible. The study was conducted on two boreholes located next to the Bechar River (north and south) by influencing wastewater localized on the course of the Bechar River. A work plan has been adopted; it is early to make a monthly monitoring of two wells during the period from January 2007 to April 2014, with a comprehensive analysis of physicochemical parameters, to determine the various anthropogenic contributions to polluting nature in the region and analyze their physicochemical composition, to explain the origin and evolution of each element. The analyses revealed the levels of Cl, NO₃, NO₂, NH₄, and phosphates that can be passed to the groundwater by the water surface runoff of the river; the wastewater undergoes a slow percolation through the layers Triassic. This is confirmed by the high levels of chlorides, ranging from 180 mg/l in 2007 to 216 mg/l in 2014 for drilling north and 199 to 336 mg/l for drilling south

of the river, which explains the values of the conductivity of 990 μS/cm ranging up to 1050 μS/cm. Nitrate concentrations ranged from 11 mg/l to 28 mg/l for the drilling located north of the river.

Keywords Algerian Sahara · Arid climate · Groundwater · Physicochemical parameters · Relation river-aquifer · Pollution

Introduction

The town of Bechar located in an arid Saharan region has a total contribution of average rainfall of 72 mm, and the volume of wastewater discharged through the drainage network of the city is estimated to 54,800 m³/day. It is known that in all Algerian cities, pollution problems of surface and groundwater are mainly caused by the following:

- The discharge of wastewater into nature without purification
- Lack of sewage and wastewater treatment systems
- Irrigation of agricultural land by polluted wastewater

The supply of drinking water for the town of Bechar is provided by surface water and groundwater from aquifers and other groundwater unrecognized in the vicinity of the river source water discharges (risk of infiltration) (Kendouci 2012; Kendouci et al. 2013; Debieche et al. 2001).

The Bechar River was born in catchment areas of the Antar Mountain (1960 m) and Horreit (1461 m) (Bendida et al. 2013).

The Bechar River, by its infer flux on its path from north to south, crosses the outcrops of the following courses: Quaternary alluvium of old (of variable thickness between 5

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Table 1 Characteristics of drill holes

Characteristics of drill holes	Drilling north	Drilling south
Date of entry into service	1982	1994
Depth	150 m	150 m
Static level	31.3 m	12.55
Dynamic level	36.8 m	32.1
Theoretical flow	25 l/s	12 l/s
Operating flow	22 l/s	12 l/s

and 10 m), the limestones of the Eocene said Barga II (greater than 60-m thick), the Turonian limestones said Barga I (25 to 45-m thick), the interbedded limestones and sandstones of the Carboniferous Westphalian, and, finally, a lateral contact with the alluvium of the Namurian (Kendouci 2012; Bendida et al. 2013).

Materials and methods

The measured physical parameters are pH, salinity, conductivity, and total dissolved solid (TDS). The chemical parameters determined are chloride, nitrate, nitrite, and phosphate

according to standard analysis techniques. The assay methods used are as follows:

- pH, salinity, TDS and conductivity, potentiometric method (consort 861).
- Nitrate is determined by the potentiometric method (HI 121) using a specific electrode.
- Ammonium AFNOR T90-015 on a filtered sample, blue method indophenols.
- Nitrites, AFNOR 1986; phosphates, AFNOR NF T90-023 on a filtered sample by colorimetric method.

Sampling campaigns

The river is along the city of Bechar both sides along its entire length, where the wastewater is discharged into several discharge points. The study was conducted on two boreholes located next to the Bechar River:(drilling north and south) (Table 1) by influencing drilling wastewater localized on the course of Bechar River (Kendouci 2012; Kendouci et al. 2013).

A work plan has been adopted; it is early to make a monthly monitoring of two wells during the period from January 2007 to April 2014.

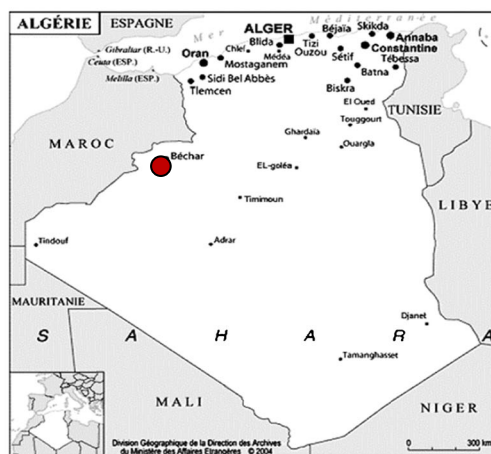
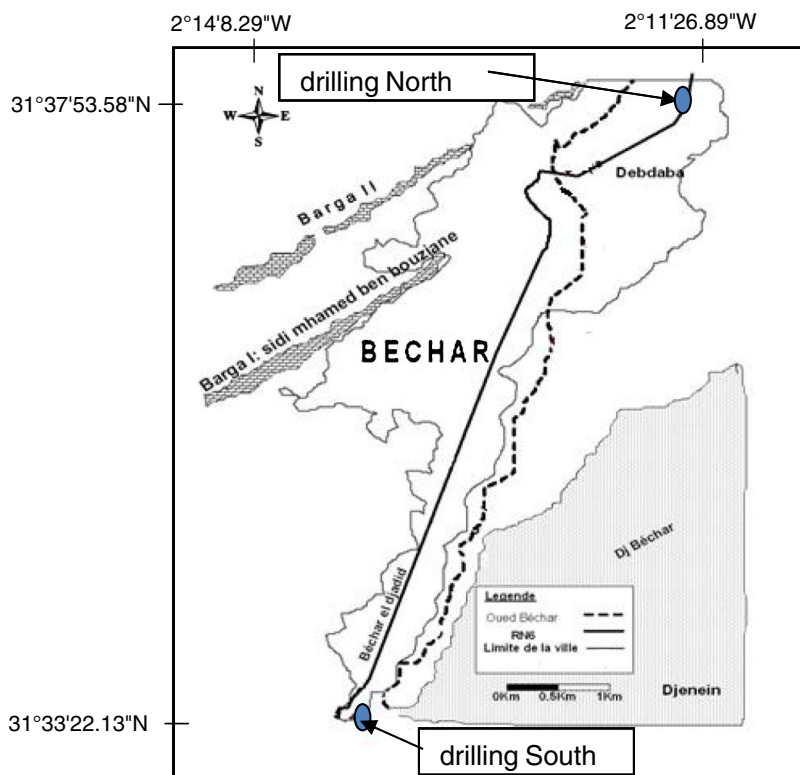
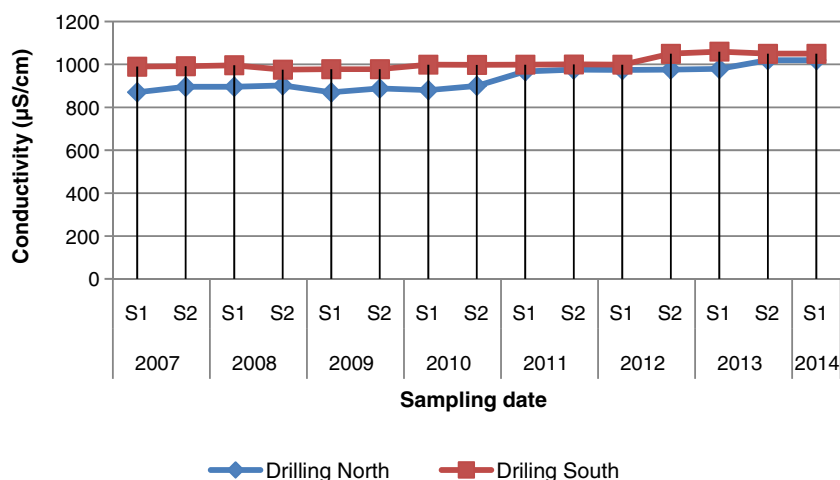


Fig. 1 Study site

Fig. 2 Changes in conductivity during the period 2007 to 2014



The choice of sites was set a preliminary study of physico-chemical parameters, and the direction of the flow of the river is from north to south (Fig. 1).

Parameters (temperature, conductivity, pH, and salinity) were measured in situ using a multiparameter (consort 861) (Rodier 2005; Al Shaibani 2008; Degremont 1978; Franck 2002).

Results and discussion

The results of this study are explained in discussing the parameters measured, including in situ measurements and those made in the laboratory. We quote the average results for the two semesters each year, S1: first half (winter) and; S2: second half of the year (summer).

Conductivity

Conductivity is related to the presence of ionic species in solution. The years 2013 and 2014 shown in Fig. 2 show the largest conductivities, 1060 µS/cm for the drilling north and 1020 µS/cm for the drilling south; electrical conductivity increases from 870.2 µS/cm (2007) to 1020 µS/cm (2014), with the rate of increase to 25 % for drilling in the north and 16 % in the south, during 7 years.

Potential hydrogen (pH)

All drillings show alkaline pH; there is a slight variation in pH of both drilling and this may be due to the origin of the sandy terrain (Kendouci 2012) (Fig. 3).

Fig. 3 Changes in pH (2007–2014)

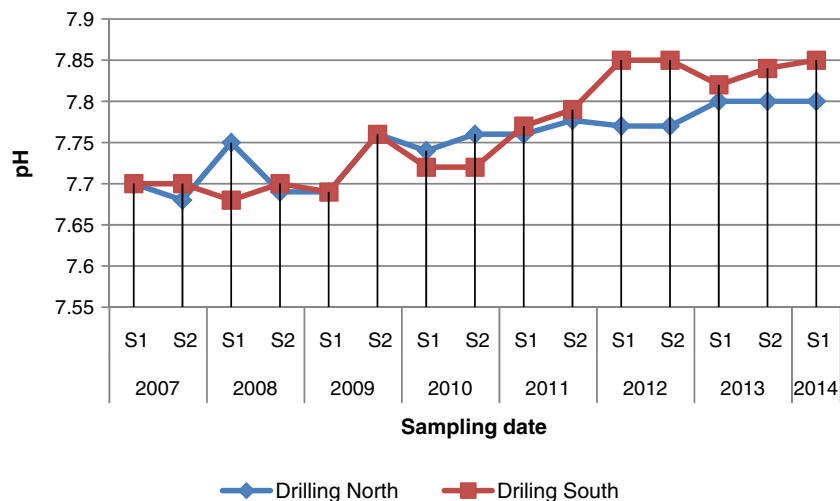
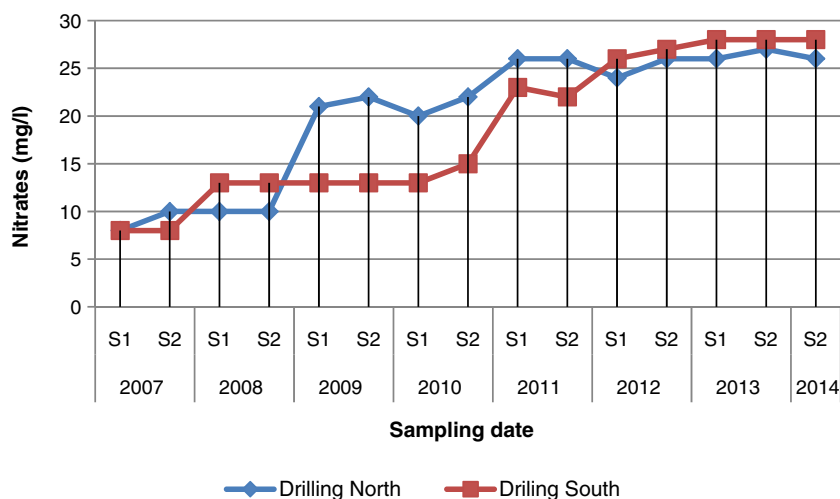


Fig. 4 Changes in the concentrations of nitrates (2007–2014)



Nitrate

Nitrate represents the highest form of oxygen with nitrogen as a highly soluble form. Its presence in groundwater is related to the intensive use of chemical fertilizers. The years 2012, 2013, and 2014 shown in Fig. 4, show the most important levels, respectively, 26 mg/l for drilling north and 28 mg/l for drilling south; the content of nitrate in 2007 was 8 mg/l. The rate of increase during the last 7 years is around 70 %; this increase is related to the effect of urban waste and the effect of stagnant water in the river (Fehdi et al. 2009; Abdelkader et al. 2012).

Nitrite

The passage between nitrate and ammonium is a toxic form. We note the absence of nitrite in both drilling during the first 4 years of the study; the highest average values are observed in

2011, a level of 0.025 mg/l in drilling north and 0.02 mg/l in drilling south (Fig. 5) (Tandia et al. 1999; Kendouci et al. 2013; Li et al. 2008).

Ammonium

Ammonium results from human activities, agricultural wastes, or discharges and industrial waste. The maximum values are recorded in 2013, 0.02 mg/l for drilling south and 0.025 mg/l for drilling north of the river (Fig. 6).

Chloride

The concentration of chloride undergoes an increase of 180.7 mg/l in 2007 to 218 mg/l in 2014 for drilling north and a value of 290 mg/l for drilling south (Fig. 7). The increase in the contents of south drilling due to the infiltration of

Fig. 5 Changes in the concentrations of nitrite (2007–2014)

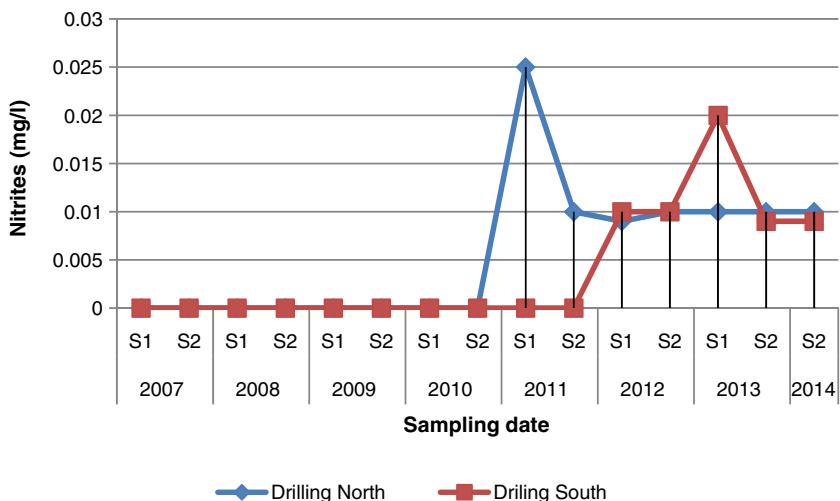


Fig. 6 Variation of ammonium concentrations (2007–2014)

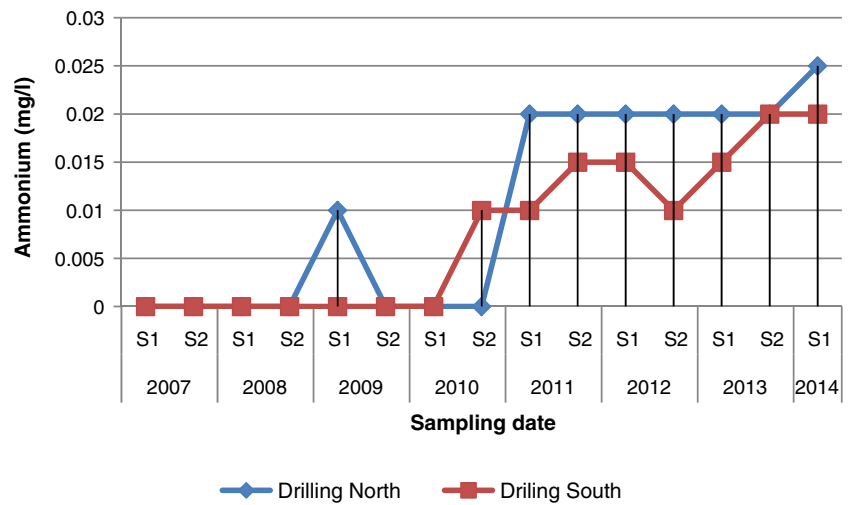


Fig. 7 Variation of Cl⁻ levels (2007–2014)

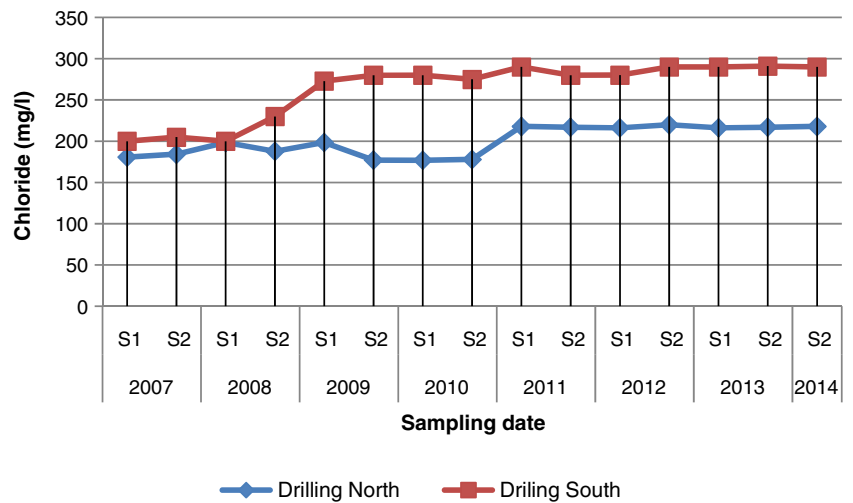
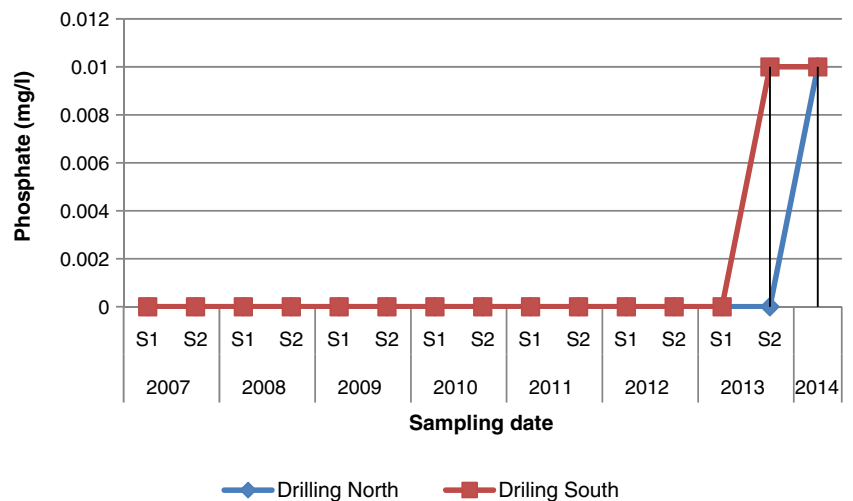


Fig. 8 Change in the concentrations of phosphate (2007–2014)



wastewater in the river to the groundwater (Fehdi et al. 2009; Elouazzani 2005).

Phosphate

Total phosphorus is largely due to domestic activities and agricultural and industrial activities. Drilling south recorded maximum values of total phosphate in 2013 and 2014 (0.01 mg/l). Drilling north takes one value of 0.01 mg/l in 2014 (Fig. 8). The presence of phosphate is related to the effect of urban discharges and the effect of stagnate water in the river (Hazourli et al. 2007; Kendouci 2012).

Conclusion

The results obtained in this study (physicochemical analysis) show that the majority of groundwater contamination by sewage from the river is by caused infiltration process that depends likely on soil and climatic environmental factors, and that treatment of urban waste is essential to protect groundwater and the ecosystem.

With maximum levels of 28 mg/l nitrate, 0.02 mg/l nitrite, and 290 mg/l chloride, this study allowed us to demonstrate the existence of several chemical pollutants in groundwater.

Groundwater is subjected to several effects of pollution by the natural effect of salinity with high concentration of Na^+ , Cl^- , and Ca^{2+} and agricultural pollution is marked by the high concentration of NO_3 and also by the relation river-aquifer allowing infiltration of the river to the groundwater.

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