

Study of groundwater chemistry in the Lower Valley of Oued Bounamoussa (El Tarf- Algeria)

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ABSTRACT

Water plays a crucial role in the life and development of humanity. Since time immemorial, people have settled near water points, which have always been a source of life and well-being. For thousands of years, it has been celebrated and recognized as a sacred resource. Today, due to rapid population growth, economic development and other challenges that affect natural resources, water has become a precious commodity. To this end, the objective of our work is to know the chemism of the groundwater of the lower valley of Oued Bounamoussa Willaya of El Tarf (North East Algeria) and to diagnose the origin and intensity of the pollution that degrades this water resource. A sampling of water was carried out in February 2021 on all the length of Oued Bounamoussa (Upstream, Center and Downstream), of which several physico-chemical parameters were carried out such as; pH, EC, SS, NO_3^- , NO_2^- , Cl^- , P_2O_5 . The results obtained show the presence of a very important pollution rate in the groundwater of Oued Bounamoussa, which pollution has several origins namely urban, agricultural and industrial. So this water resource has become a danger and risk on the health of living beings and on the intoxication and it disturbs the sustainable development.

Key words: Pollution, Groundwater, Danger, Health, Chemistry

Introduction

Water resources are essential to the survival and well-being of mankind whose availability is one of the main factors of development of civilizations (Ancil *et al.*, 2008); also they are essential to the functioning of many sectors of the economy, such as

agriculture, industry and domestic uses (drinking water supply) (Oudini and Tebib, 2019). The deterioration of the quality of water resources is currently a major threat; groundwater formerly of good quality, is currently threatened by various sources of point and diffuse pollution (Elarfaoui and *al.*, 2005). Also the industrial world is increasingly faced

with the problem of controlling the emission of toxic substances into the environment, especially in the form of liquid effluent (Forstner and Wittman, 1990). Industrial pollution affects our environment in many ways and is a major cause for concern. The large amount of waste generated by industries leads to the pollution of resources such as air, water and land (Bougherira, 2015).

This constitutes a threat to the quality and quantity of water resources available in Algeria, where it records a water deficit of 1 billion m³ by the year 2025 (Remini, 2010)

The present work is oriented towards the evaluation of the quality of current groundwater resources in the lower valley of Oued Bounamoussa (El Tarf, North East Algeria), to ensure proper water management and preservation. Indeed we measured several physico-chemical parameters during the year 2021 all along this river (upstream, center and downstream) to assess and characterize the degree and origin of pollution that affects this natural resource.

Materials and Methods

Oued Bounamoussa is one of the main rivers of the Wilaya of El-Tarf which is located in the extreme North-East of the country. The watershed of Bounamoussa covers an area of 575 km² and a perimeter of 175.67 km (Bouhadeb, 2019).

These limits are: the Mediterranean Sea to the north, south and southwest by the wilayas of Souk-Ahras and Guelma, west by the wilaya of Annaba and east by the border Algerian-Tunisian (Fig. 1) (Zaoui, 2017).

The Bounamoussa watershed is characterized by a Mediterranean climate and belongs to the Subhumid bioclimatic stage (Bouhadeb, 2019).

Water sample collection and analysis

For the sampling of groundwater we conducted a sampling campaign in February 2021 on three (03) samples. These sampling points were chosen according to a distribution that covers the entire study area (all the Wadi). The sampled points are located: 1st point upstream of the Wadi whose area is called: Bouhadjar, the 2nd point is the center, whose area is called: Asfour and the 3rd point is the downstream, whose area is called Ben M'Hidi (Fig. 1).

The sampling method was carried out according to the recommended recommendations. we followed the sampling standards "filtration (filter 0.45 µm), acidification (5 ml of HCl or HNO₃) and preservation (4 %C)" (AFNOR, 1997).

Then the following physico-chemical analyses were performed

Hydrogen potential (pH), electrical conductivity (EC) were determined by direct reading in situ using a multi-parameter (Type: WTW pH/ Cond

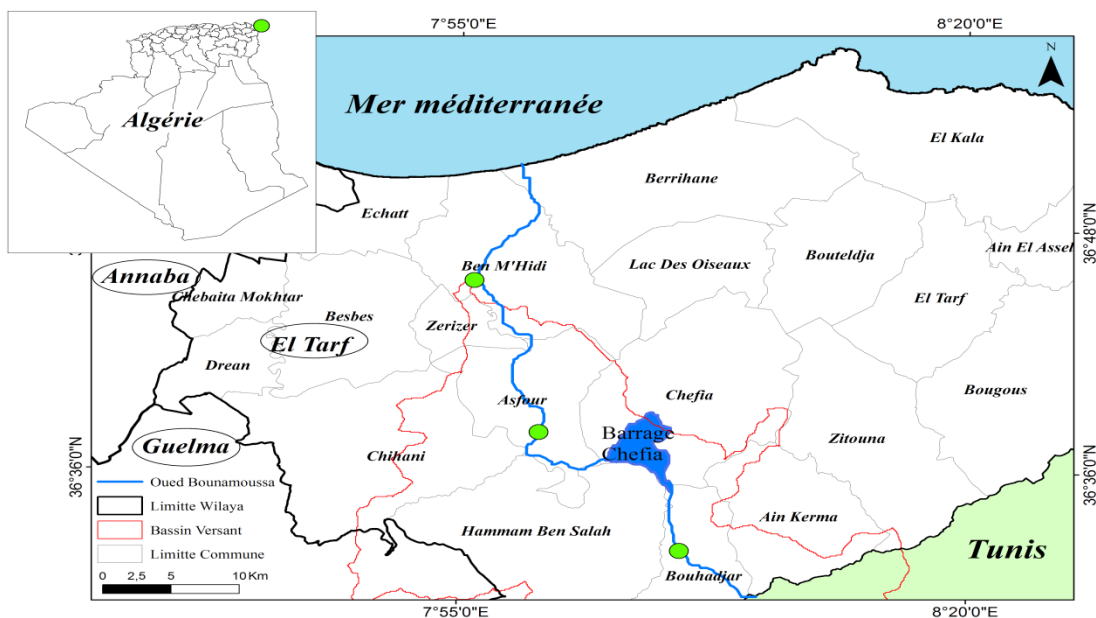


Fig. 1. Presentation of the study area.

340i/SET), Suspended solids (SS) by filtration; other physico-chemical parameters such as: Nitrate (NO_3^-), Nitrite (NO_2^-), Chlorides (Cl^-), Phosphate (P_2O_5) are recommended by the standards of (AFNOR, 1997) and by the protocols of (Rodier, 2009).

For the statistical analysis

All the results of the work were analyzed using the statistical software SPSS. Before proceeding with all the analyses, the normality and homogeneity of the variance were verified. The effect of water pollution along the entire length of Oued Bounamoussa (Upstream, Central and Downstream) on the physico-chemical parameters (pH, EC, TSS, NO_3^- , NO_2^- , Cl^- , P_2O_5) was evaluated by a single criterion analysis of variance (ANOVA) and the means were compared using Tukey's HSD test ($P < 0.05$).

Results and Discussion

The results below summarize and show the sources and types of pollution discharged into the Oued de Bounamoussa, Tarf (North East Algeria).

The hydrogen potential (pH)

It is a chemical parameter characterizing the acidity or basicity of an environment. It results from the ionic composition of water, and essentially from the presence of carbonates resulting from the exchange of carbon dioxide (CO_2) at the water-air interface, as well as from the dissolution of limestone (Aminot and K  rouel; 2004).

The values of the hydric hydrogen potential of this wadi vary between 7.22 and 8.25 (Fig.2), we note that the groundwater of Oued Bounamoussa has a neutral pH which tends towards a basic pH.

Water pollution had a very high significant effect

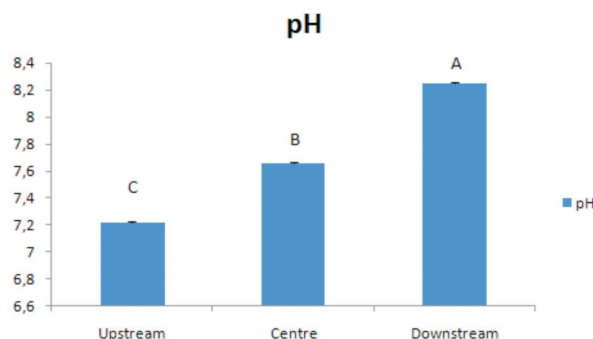


Fig. 2. Spatial Variation of pH

($F=8013.00$, $P=0.000$) on the pH of the water sampled from three parts of Oued Bounamoussa (Upstream, Central and Downstream).

Electrical conductivity (EC)

The conductivity of a solution is defined as the conductance of a column of water between two metal electrodes of 1 cm^2 surface area and separated from each other by 1cm (Rodier, 2009). The electrical conductivity gives average values that increase from upstream to downstream (1000/cm and $1300 \mu\text{S/cm}$) (Fig. 3). This increase can be explained by the effect of intense industrial and agricultural discharges in this region; thus reflecting highly mineralized waters (Rodier, 2015).

Regarding electrical conductivity, analysis of

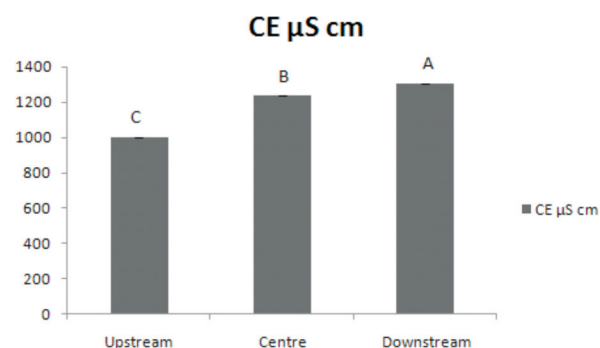


Fig. 3. Spatial Variation of CE

variance (Anova) revealed a very highly significant difference ($F=42323.31$, $P=0.000$).

Suspended solids (SS)

The composition of suspended solids (SS) is very variable, it depends on the discharges, the terrain crossed by the flowing water, the rainfall ...etc (Rodier *et al.*, 2009).

The analyses show that the TSS content is moderately high all along the Wadi. The maximum values are recorded at the level of Ben M'Hidi (downstream) (0.45 mg/l) (Fig. 4), this is due to industrial and domestic discharges, and to the leaching of agricultural soils which brings a significant amount of chemical fertilizer.

The statistical study showed that water pollution had a very highly significant impact ($F=448$, $P=0.0000$) on SS.

Nitrate (NO_3^-)

Nitrate occurs naturally in nature at concentrations of a few milligrams per liter of water because nitrate

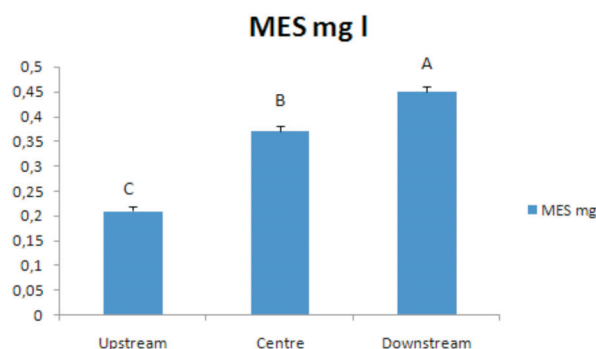
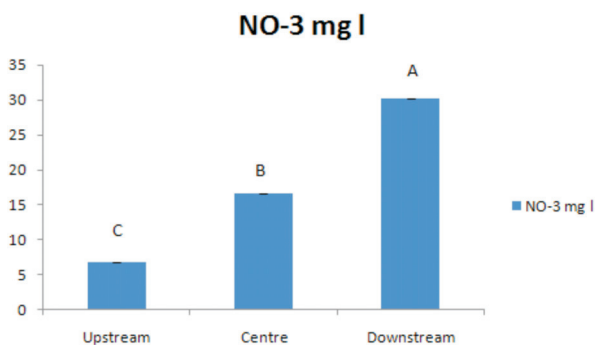


Fig. 4. Spatial Variation of MES

is a highly soluble pollutant and is the most oxidized form of nitrogen (Salamon, 2003). The results of our analysis show that nitrate levels are between 6.80 mg/l and 30.22 mg/l (Fig.5). The increase in nitrate levels in Oued Bounamoussa waters and its presence in groundwater are related to the intensive use of fertilizers (chemical or organic) (Lgourna *et al.*, 2014).

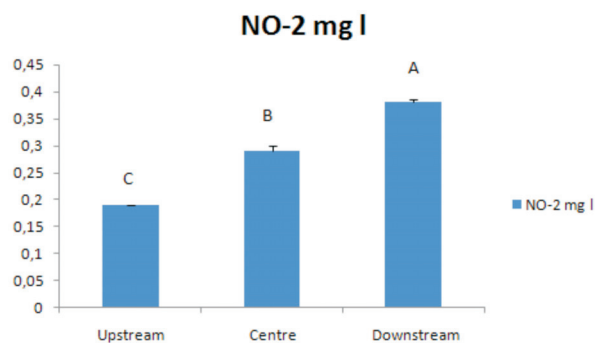
The presence of pollution showed a very highly

Fig. 5. Spatial Variation of NO₃⁻

significant effect ($F = 2488768.80$, $P = 0.000$) on nitrate (NO₃⁻) levels in Oued Bounamoussa.

Nitrites (NO₂⁻)

The nitrite (NO₂⁻) or nitrous nitrogen, represent a less oxygenated and less stable form, it shows the form of the passage between nitrates and ammonium, it is a toxic form (Debieche, 2002). At the level of Oued Bounamoussa, the nitrite content recorded in the upstream is 0.19 mg/L, for the center is 0.29 mg/L and 0.39 mg/L for the downstream (Fig. 6). They exceed the standard in fresh and natural water which is 0.1mg/l ((Decree 11-125 Water Quality) So it is constant that the waters of Oued Bounamoussa

Fig. 6. Spatial Variation of NO₂⁻

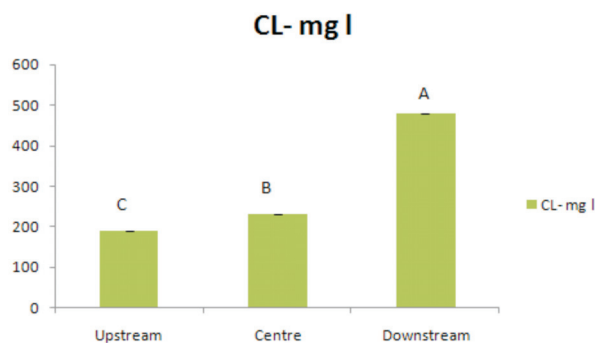
are slightly loaded by nitrites especially downstream of the Wadi where agriculture is very responded in this area (Larba, 2014).

However, the analysis of variance showed a very highly significant effect ($F = 652.75$, $P = 0.000$) on the level of nitrite (NO₂⁻) all along Oued Bounamoussa.

Chlorides (CL⁻)

Chlorides are important inorganic anions contained in variable concentrations in natural waters. The origin of this element is primarily related to the dissolution of salt formations and may be to chemical plant effluents, wastewater, and irrigation runoff (Kachi, 2015). Chloride contents are generally high, its concentrations are included between 190 mg/l and 480 mg/l for the groundwater of Oued Bounamoussa (Fig. 7). This evolution is noticed especially downstream, it indicates the contribution of an anthropic contribution which can be of urban or industrial origin.

On the other hand, the analysis of variance

Fig. 7. Spatial Variation of CL⁻

showed a very highly significant effect of pollution ($F = 664396.00$, $P = 0.000$) on the chloride ion (CL⁻).

Phosphate (P_2O_5)

Phosphates are elements whose excess causes disturbances in the life of a watercourse; they are indicators of water productivity (Lamy, 1995).

The values of phosphates obtained from our samples exceed the European standards (0.5 mg/l is the pollution threshold), the reasons can be explained by the cultivation practices of farmers in the region and the addition of chemical fertilizers with intense quantities (Fig. 8).

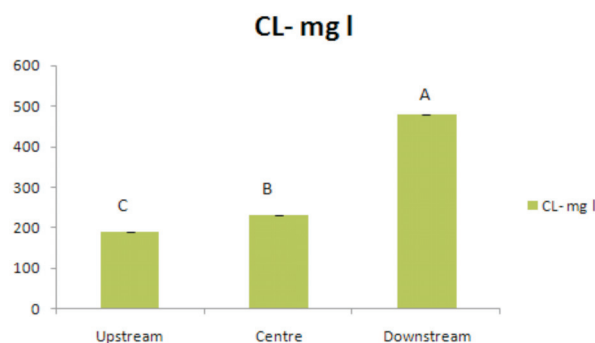


Fig. 8. Spatial Variation of P_2O_5

Also the increase of the phosphate content in water leads to a development of the algal flora, and thus a phenomenon of eutrophication of the aquatic environment (Lacaze, 1996). It is in fact the acceleration of a natural phenomenon, an accelerated and increasing fertilization of water related to domestic activity (Lamy, 1995).

Statistical analysis showed a significant impact ($F=7894.43$, $P=0.000$) of pollution on the total phosphorus content (P_2O_5).

Conclusion

In the objective of the study of the physico-chemical quality of the groundwater of Oued Bounamoussa (El Tarf, North East Algeria) and to determine the degree and the nature of the pollution existing in this Oued, the various results obtained from the physico-chemical parameters measured at the level of groundwater (upstream, center and downstream) revealed the presence of an important pollution which is manifested by a very high concentration of several pollutants such as: nitrates, nitrites, chlorides and phosphates, a remarkable rate of suspended matter with a very high electrical conductivity.

This situation can disturb the biological balance of the water environment and harm the life of the

flora and fauna in this watercourse as well as the disturbance of the health and the life of the man in general.

It is therefore necessary to establish a program of control and continuous monitoring of the various sources of pollution and their effect on the environment.

To carry out a study of modeling of the underground flows to know the mechanisms of transfer of the pollutants, which can help a lot in the protection of the groundwater against pollution.

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