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Quantitative and qualitative diagnosis of water resources in the Saf-Saf river basin (north east of Algeria)

Fayçal Khelfaoui[a,*], Derradji Zouini[a], Larbi Tandjir[b]

[a]*Faculty of Earth Sciences, Department of Geology, Annaba University, Annaba, Algeria*
Tel. +213 661 494 670; email: khelfaouifaycal@yahoo.fr
[b]*Faculty of Sciences, Department of Biology, Skikda University, Skikda, Algeria*

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ABSTRACT

Efficient and fair management of water resources is one of the most important challenges faced by the Saf-Saf river basin. The rapid economic growth of the city of Skikda and the intensive urbanization of the alluvial Saf-Saf valley have induced a fast growing water demand of urban and socio-economic sectors including agriculture and industry. Moreover, the quality of water resources are threatened by different pollutions types not only from petrochemical industries, but also, agricultural pollution resulting from some agricultural practices (fertilizers and pesticides). This study presents an optimization approach for the integrated and sustainable demand management of water resources, including quantitative and qualitative diagnosis of the water potentialities in the Saf-Saf basin.

Keywords: Saf-Saf river basin; Quality; Pollution; Integrated water resources management; Water demand

1. Introduction

For each domestic, industrial or agricultural use, water needs are highly variable in quantity and quality, depending on the sectors and especially on seasons. The water needs in the Saf-Saf river basin are estimated at around 66 million cubic meters per year (hereinafter mcm/yr). With a population estimated at 460 thousands persons (2007), domestic consumption is the largest consumer of all sectors with a rate of 47% of the total basin water needs.

The irrigation water needs for supplying the Saf-Saf perimeter are estimated at 25 mcm/yr, that is, the rate of 38%. As for industrial water needs, they represent only 15% of the total basin water needs. Increasing and higher economic growth is resulting in rapidly increasing water demands by the socio-economic sectors. This growth is also creating water-use conflicts between sectors, and water resources prove to be insufficient in the future, this constitutes the biggest challenge for Saf-Saf river basin decision-makers.

2. Study area

The Saf-Saf river basin is a Mediterranean watershed of 1,158 km^2 located in the northeast of

*Corresponding author.

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Algeria. It is bordered by the Guebli river basin from the west, the Hajar Mountain from the south, Kebir west river basin from the east, and finally the Mediterranean sea from the north (Fig. 1) [1,2].

3. Quantitative diagnosis of water resources

Water resources efficient and equitable management implies a perfect knowledge of the resource availability and its variability in time and space, and as much it can propose scenarios for analysis risk and crisis management in a future, where human impacts are not well controlled. The Saf-Saf river basin is not an exception, water resources available are more or less limited, and this limitation is first natural, but it is always accentuated by the fast growing demand of urban and rural populations, demand of socio-economic sectors including agriculture and industry, and also by the different types of pollutions threatening the basin.

3.1. Water resources mobilization and allocation

The annual average rainfall is estimated at more than 660 mm over the entire basin, and which reflects a very important contribution of 765 mcm/yr, this huge water potential is unfortunately confronted with serious problems of maintenance and management of hydraulic structures in place, reducing the amount of mobilization nearly 50 mcm/yr in the basin [3] (Fig. 2).

Generally, the mobilized water resources in the Saf-Saf river basin are estimated at 35 mcm/yr, that is, 74% of the available water resources. The surface waters with a mobilized volume are estimated at 30.25 mcm/yr (95%) [3] (Table 1).

3.2. The confrontation supply/demand in the Saf-Saf river basin

Because of the increasing water needs resulting from the agricultural and industrial development, the Saf-Saf basin potential water resources seem to be insufficient in the horizon of 2030, while the costs related to their mobilization become more and more heavy and the offices in charges are unable to rationally manage the resource. We have to remind that the renewable water potentialities estimated at 138 mcm/yr, are being reduced to only 47.5 mcm/yr (34%) as actually mobilized [3].

A situation that requires a reaction and an answer of some society categories (users, decision-makers,

Fig. 1. Geographical location of Saf-Saf river basin.

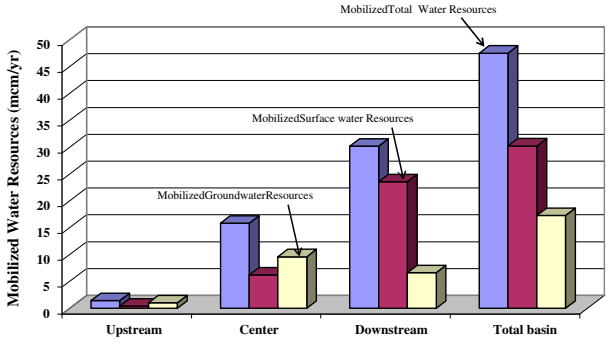

Fig. 2. Distribution of mobilized water resources in the Saf-Saf river basin (2007).

administrators, etc.), to solve or at least to reduce these problems, by the setting in work of a new strategy based on the demand water management, by incitement of the users to the economy of water by different instruments of regulations (financing, pricing) [3,4] (Fig. 3).

Table 1
Water resources potential in the Saf-Saf river basin (2007)

Water resources	Recognized potential (mcm/yr)	Available resources (mcm/yr)	Mobilized resources (mcm/yr)
Surface water	25.89	30.25	28.64
Ground water	30.47	17.29	6.35
Total	56.36	47.54	34.99

4. Qualitative diagnosis of water resources

In spite of the incontestable importance of the quantitative aspects, the questions of water quality are into the heart of the future stakes of integrated water resources management in the Saf-Saf river basin [5]. Its water resources are so threatened in their quality, as a result of pollution that they suffer, the intensive industrial and agricultural practices. As well as, continuing domestic pollution.

4.1. Surface water quality

The Saf-Saf river is the main water stream in the basin, the quality of its waters varies from upstream towards downstream. A follow-up of some chemical elements allowed to visualize an alteration and deterioration of the valley water quality, with increased concentrations of chemical elements from upstream to downstream, generated by the different types of pollutions threatening the basin (Table 2).

The electric conductivity and the M.E.S range from 690 to 1,090 µs/cm and from 60 to 153 mg/l, respectively. The analysis has been showing that, electric conductivity, M.E.S, and all the other chemical elements increases from the upstream toward the downstream basin (northern part), except for the sulfates (SO_4), they decrease from upstream (149.33 mg/l) toward downstream (56.64 mg/l) (Fig. 4).

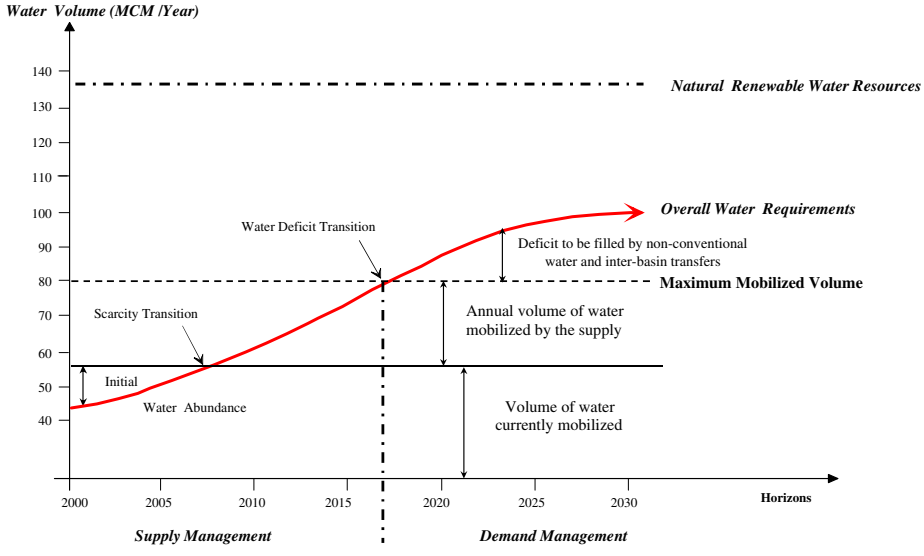

Fig. 3. Curve of the confrontation supply/demand in the Saf-Saf river basin [3].

Table 2
Spatial variation of water chemical elements in the Saf-Saf river basin (May 2007)

Elements (mg/l)	Conductivity (µs/cm)	MES (mg/l)	Ca (mg/l)	Mg (mg/l)	Na + K (mg/l)	Cl (mg/l)	SO_4 (mg/l)	HCO_3 (mg/l)	DBO_5 (mg/l)	DCO (mg/l)
Saf-Saf upstream	690	60	61.17	27.75	41.5	52.5	149.33	158.67	5.05	30.96
Saf-Saf downstream	1,090	153	276.9	155.48	35.8	106.6	56.64	372.1	93	139

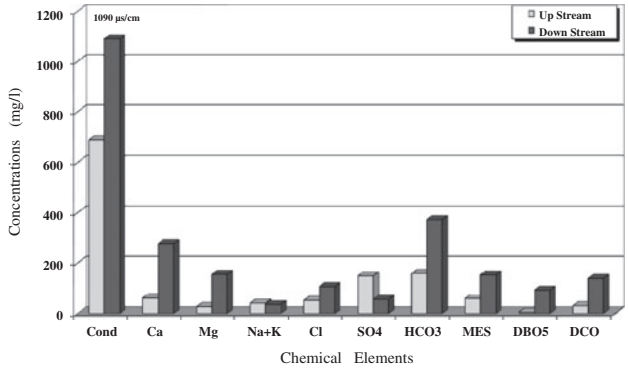

Fig. 4. Concentrations of chemical elements in surface water of the Saf-Saf river basin (May 2007).

4.2. Groundwater resources quality

The hydro-chemical study shows that groundwater acquire their composition from aquifers that contain them.

Water samples analyzed were collected at the humid season (May 2007). A total of 34 groundwater samples were collected from different sources and wells in the upstream and downstream Saf-Saf river basin [3].

In the upstream, two hydrochemical facies could be identified sulfated calcic facies; P3, P4, S3, S5, and S8 samples (predominant water type in the clay and sandstone-rocks aquifers), and calcic bicarbonate facies (P2, S6, S7, S9) are derived from limestone rocks. [6]. Water types were defined by use of the trilinear plotting technique (Piper diagrams, 1944); the trilinear diagrams are shown in Fig. 5.

However, from the analysis, downstream groundwater samples have identified chlorinated sodium to chlorinated magnesium facies, which are shown in Fig. 6.

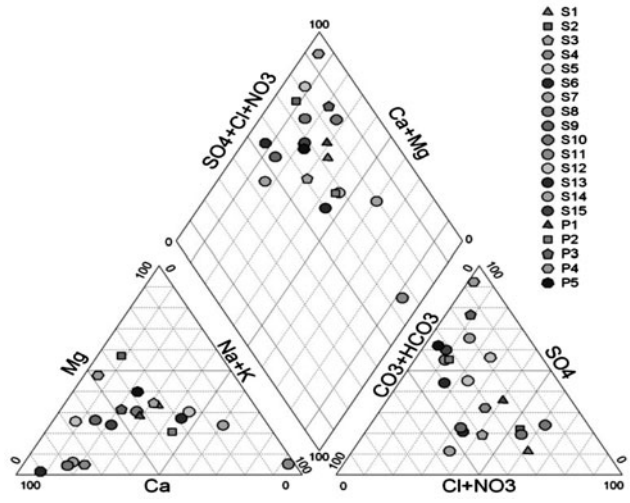

Fig. 5. Piper diagram of the groundwater resources in Saf-Saf upstream (May 2007).

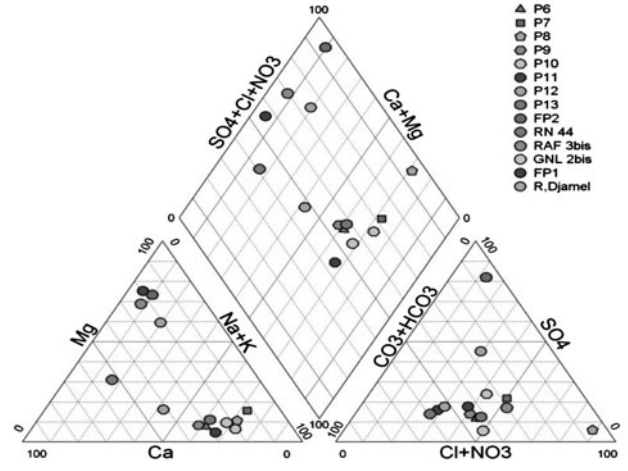

Fig. 6. Piper diagram of the groundwater resources in Saf-Saf downstream (May 2007).

4.3. Vulnerability map

The Saf-Saf alluvial plain vulnerability map drawn up through the DRASTIC method shows three different vulnerability horizons, an area of low vulnerability ($I < 100$) near El Hadaeïk, located in the middle plain. Much of the land is characterized by a medium vulnerability. However, areas of high vulnerability are located in the north of the basin, around Skikda city and in Ramdane Djamel region [7] (Fig. 7).

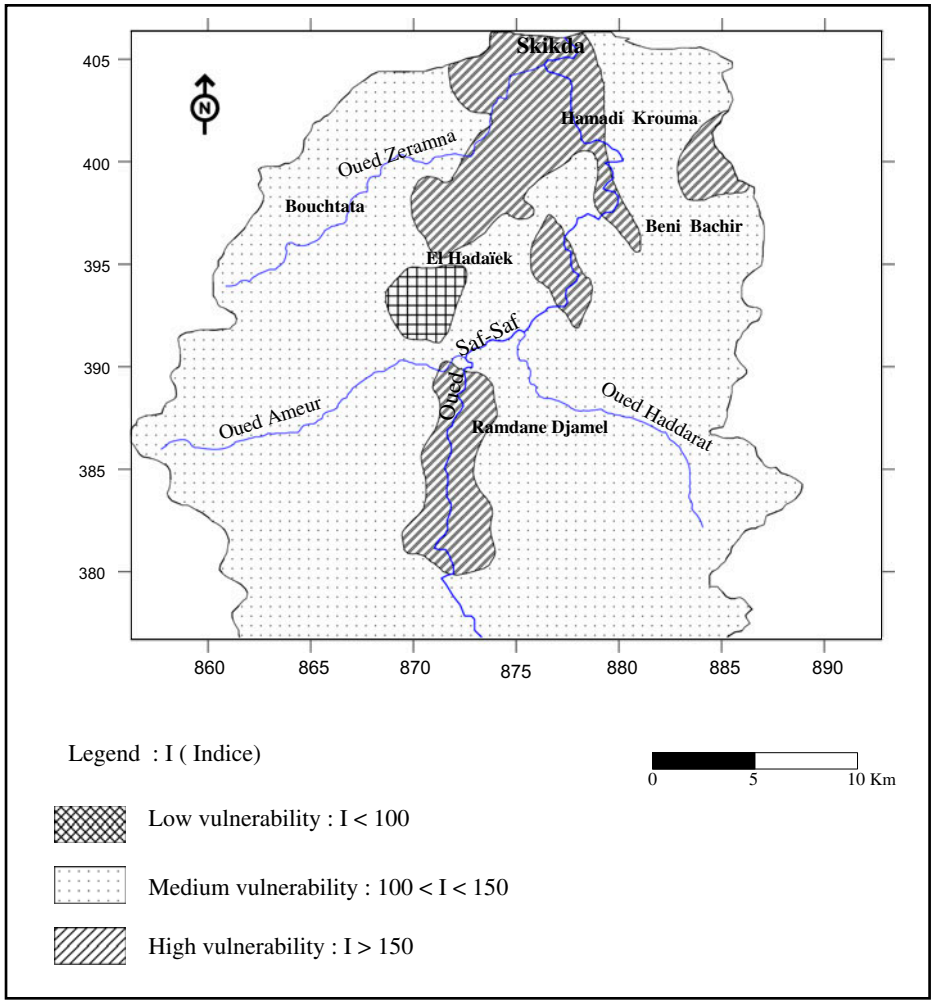

Fig. 7. Vulnerability map in the Saf-Saf alluvial plain [3].

5. Conclusion

The demand pressure made concurrently exercised by both agricultural and industrial sectors, yet more strongly by the unceasingly increasing population will be more and more strong, as well as the different types of pollution threatening the basin have generated considerable pressure on water resources in the basin of Saf-Saf.

A situation that requires a reaction of some Saf-Saf river basin categories (users, decision-makers, administrators, etc.), to solve or at least to reduce these problems, by the setting in work of a new strategy based on the demand water management, by incitement of the users to the economy of water by different instruments of regulations (financing, pricing) and the development of scientific research in the water sector and undertake vast programs of information and sensitization of the users to water economy.

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